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INDONESIAN WOOD RESEARCH SOCIETY**

**“Contribution of Scientific Profession Society on the Development of
Wood Science and Technology in Indonesia”**

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Preface

The Indonesian Wood Research Society (IWoRS) or Masyarakat Peneliti Kayu Indonesia (MAPEKI) was founded in August 1996. Members of the society have reached 385 and come from 46 institutions in Indonesia. The focus of research activities and research field of its member are wood science and technology, forest product technology and other related sciences.

Since 1998 IWoRS has organized 12 national seminars which were conducted annually at different institutions of the members. Through the seminars members of the society could share and exchange information, knowledge and current research activities by presenting and discussing scientific papers. The papers presented in the seminars are then published in seminar proceedings or in the Journal of Tropical Wood Science and Technology published by the society.

In order to be able to get scientific papers that have international standard quality, we organized the First International Symposium of the IWoRS on 2 - 3 November 2009. Those papers hopefully could be published in some national, regional and international scientific journals.

The objective of this activity is to increase scientific role of IWoRS as a profession organization through the organization of the international symposium that could select excellent scientific papers that are publishable in some reputable national, regional and international scientific journals.

Bogor, April 6, 2010

Prof. Muh. Yusram Massijaya
Chairman

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Biodiversity and Forest Environment in Indonesia

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Abstract

Indonesia is the world's largest archipelago with 18,000 islands laid on the Oriental and Australasian plate enriched with Wallacea lines. Indonesia is a unique biotic and geographic area with high levels of species richness and endemism. Indonesia is renowned for its biological diversity. Indonesia's rich biodiversity is being rapidly degraded and increasingly under threat from rapid landscape change, pollution and over harvesting. The country is in an environmental crisis but has a hope that the environmental crisis can be abated if the appropriate measures taken. Communities throughout Indonesia are increasingly cognizant of the nature of this crisis through their witnessing and experiencing the considerable loss of life, health and economic hardship, due to devastating land slides, floods, loss of potable water and pollution and degradation of many ecosystems. The increasing empowerment of local governments and communities through decentralization laws also offers some hope that governments and local communities will now purposively respond to this crisis at both the legislative and ground level. More province and district aware on the important of conservation by establishing ex situ conservation sites, botanical garden. Furthermore, Biosphere Reserve Concept as a tool to harmonize conservation and economic development supported by research and development has emerged. Biodiversity loss could be reduced significantly while the economic values of species and landscape ecosystem for the prosperity of nation developed.

Morphological Understanding of Wood Degradation and its Prevention

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The largest component of biomass on the earth is wood resources, which are continuously produced through photosynthesis using energy from the sun. The wood components are composed of carbon, oxygen and hydrogen, but approximately half of the dry-weight of wood is carbon. The oldest wooden structure in the world is said to be Horyu-ji temple in Nara Prefecture, Japan, which was built at the 7th century. The carbon locked and fixed in the timber used in this temple was converted from atmospheric carbon dioxide present several hundred years before the 7th century and has remained trapped as ligneous constituents in the timber until present.

The high-performance utilization of wood and wood products for a long service life is assumed to be important from the view point of not only structural and utility reliability, but also elongation of the period of carbon fixation which is attributable to prevention of global warming. However, wood is occasionally degraded and decomposed by the biological agents of decay fungi and termites, and weathering effects of sunshine and rain fall, resulting in the diminishing of the fixed carbon.

This paper describes the morphological characteristics of the degradation of wood and wood-based materials and their resistance against decay fungi, termites and weathering effects for better understanding of the mechanism and process of wood decomposition and protection.

Bending Performance of Particleboards Exposed to Fungal Attack (Imamura, Y. and K. Nishimoto, 1984)

To understand the mechanical performance of particleboards in structural use, the boards measuring 50 x 350 x (board thickness) were subjected to bending creep tests under the progressive fungal-attack with a brown-rot fungus *Fomitopsis palustris* and a white-rot fungus *Trametes versicolor*, and deflection of the boards was measured regularly as a criterion of their expected performance.

Deflection-time curves for particleboards exposed to decay fungi showed significant patterns which enable evaluation of strength reduction caused by the action of fungi. A rapid increase of deflection in tested boards during the relatively early stage was assumed to be due to active fungal invasion onto the surfaces of wood particles and consequent glue failures. The fungal attack, consisting of a mycelial invasion prior to wood decay, was supported by the fact that bending strength losses ranging from 10 to 20% occurred with little or no weight losses in static bending tests of the particleboards inoculated with decay fungi.

Board resistance detected in creep tests while under fungal attack varied depending on the manufacturing conditions and adhesives used as well as the species of raw materials and inoculated fungi. The phenol-formaldehyde-type (PF) particleboard lasted longer until fracture and was found to be less susceptible to decay than the urea-melamine-formaldehyde (UMF) board. A white-rot fungus delayed the time for creep fracture and caused the higher weight losses in the sample boards before inducing substantial strength reductions as compared to a brown-rot fungus.

Scanning electron microscopic observations of the fractured surfaces presented visible evidences of the process of particleboard deterioration which was expected from the mechanical tests (Fig. 1).

Phenolic Resin Treatment of Wood for Improving Biological Resistance (Ryu.J-Y., Y. Imamura, M. Takahashi, H. Kajita, 1993)

Treatment of wood with aqueous solutions of phenol formaldehyde (PF) resin-forming compounds gives bulked products in wood structures by forming the insoluble polymers which will not leach out in water. The effects of the molecular weight of resin on biological resistance were evaluated in relation to the bulking of the cell walls and dimensional stabilization as well as biological resistance.

Test blocks of sapwood of Japanese cedar (*Cryptomeria japonica*) were dried and vacuum-impregnated with the aqueous solutions of PF-resins of three types with the number average molecular weights (Mw) of 369, 621, and 1143. After vacuum impregnation with PF-resin until saturation and maintained in the solutions to allow the resin to penetrate the wood structure, and then wood blocks were air-dried and oven-cured, raising the temperatures to 150°C to ensure polymerization of the resins.

The wet unsterile soil-burial test in a fungus cellar has been characterized as accelerating the microbial deterioration of wood samples through their exposure to soil micro flora containing a wide range of decay fungi. For all

resins tested, weight loss by fungal attack decreased with increases of resin loading (RL). Treatment with low-molecular weight resins of PF-369 and PF 621 yielded greater decay resistance than with other resins; namely, PF-1143. PF-369 and PF-621 completely eliminated decay in the soil burial test at more than 5-10% RLs, however PF-1143 was not effective in reducing fungal attacks even at high RLs.

The molecular weight of the resin was proven to affect the biological resistance as well as dimensional stabilization in relation to the bulking of the wood cell walls, and resin with a molecular weight below 500 was evaluated to provide sufficient dimensional stability and biological resistance yielding a polymer within the wood cell walls.

Scanning electron microscopic observations confirmed that the small-molecular weight PF-resin easily penetrate the wood and led to the deposit of polymers within the cell walls, resulting in a high resistance to decay attacks. In contrast, it was revealed that the limited levels of penetration of the large-molecular weight PF-resin into the cell-walls led to formation of polymer bodies in the cell lumens or the partial surface coatings which contributed little to the decay resistance.

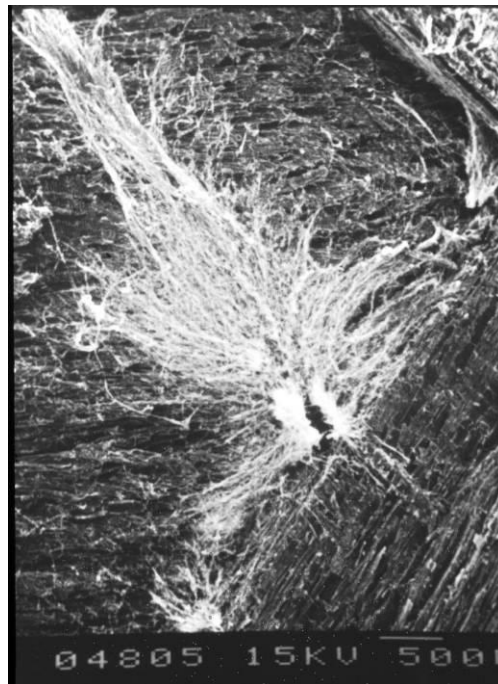


Fig. 1. SEM of the fractured surfaces of the decayed particleboard bonded with UMF resin, showing the invasion of the fungal mycelium on the surfaces of particles prior to wood decay.

Morphological Changes in Acetylated Wood Exposed to Weathering (Imamura, Y. 1993)

As with other chemical modifications, acetylation involves the reaction of accessible hydroxyl groups, which are the most abundant reactants in wood. Several previous reports have examined the enhancement of biological resistance and the improvement of physical properties by acetylation, such as dimensional stability or mechanical strength while wet.

Wood which has been exposed outdoors undergoes photochemical degradation primary in its lignin component by ultraviolet light. A cross-section of the cell walls showed a roughly eroded and rounded appearance, and cellulose microfibrils might become so friable that they degrade after the decomposition of embedded lignin substances (Fig. 2). Chemical modification reportedly stabilizes lignin against photolytic degradation, and may prevent wood from turning yellow and degrading of cell-wall components. One chemical modification, acetylation, can prevent the formation of phenoxy radicals, since the phenolic hydroxyls can be blocked by esterification.

Weathering led to early disintegration and enlargement of bordered pits, extensive separation of the latewood tracheid walls in the middle lamella and checking oriented along the microfibril angle of the S2 layer. The appearances of diagonal microchecks during weathering may be the result of local concentrations of tensile stresses at right angles to the fibril direction of the S2 layer. These characteristic patterns of cell-wall erosion due to weathering were essentially the same in both untreated and acetylated wood.

However, scanning electron microscope observations revealed that more extensive microscopic and macroscopic checks leading to distortion of the cell alignment appeared in untreated wood and wood which had been

treated with a low-level acetylation. For highly acetylated wood, severe intra- and inter- cell wall erosion was limited, and consequently degradation of the cell walls was reduced and the original cell alignment was maintained for a long period after exposure to natural weathering.

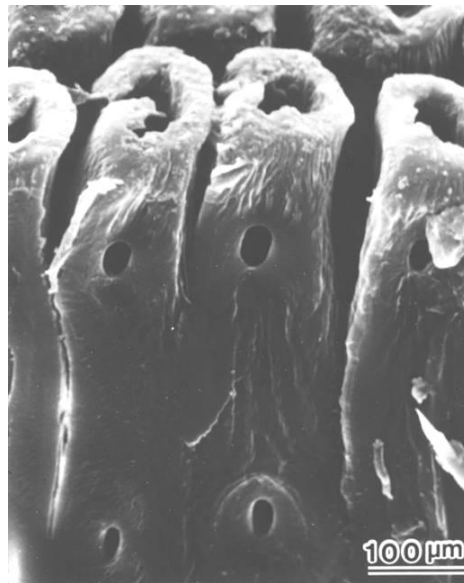


Fig. 2. Cross-sectional view of sugi latewood tracheid walls showing the deep erosion of the middle lamella and the rounded appearance of the cell tips after exposure to sunshine and rain-fall.

Improvement of Liquid Penetration of Wood by Precompression Treatment (Watanabe, U, Y. Imamura, I. Iida, 1998)

Impregnating wood with liquid chemicals is a common technique for enhancing various physical and biological properties, such as dimensional stabilization and decay resistance. However, it is not always easy to impregnate the liquid evenly and deeply into refractory wood specimens. Although several pretreatment processes have been developed to increase the permeability of wood, none are particularly practical or economical, except the conventional methods such as incision.

A new system for enhancing the penetration of liquid into wood using a precompression treatment was designed, and the effects of compressive deformation and recovery on liquid uptake were evaluated. Precompression with large deformation under appropriate moisture conditions, with optimum press schedules effectively increased the penetration of liquid into refractory wood samples of practical sizes without producing any strength reductions. Fracture of pit membranes during compression with little damage to unpitted cell-walls was believed to improve liquid penetration with negligible compression defects. When the precompressed specimens were recovered by water immersion, negligible compression defects were observed along unpitted cell walls, though only traces of micro corrugations were seen.

SEM showed the radial cell walls were largely bent and collapsed around the pit region, suggesting that severe damage or changes occurred on the pit membranes or the pit borders (Fig. 3). Morphological observations revealed a fractured pit membrane of Japanese cedar of sugi in which the torus is visibly separated from the outer surface of the pit border, and is clearly cracked at the boundary between the torus and margo, resulting in the peculiar detachment of the torus from the pit border. The disproportional structure of pit in wood cell walls may be deflected by a moment exerted by the external compressive loading in radial direction.

For the development of precompression treatment to accelerate liquid penetration into refractory woods, cyclic loading is an effective and practical means. The 25mm thick lumbers with the moisture content of around 20 to 40% were precompressed at 20 and 30% deformation ratios by roller-press machine in which five pairs of power-drive rollers were installed to sandwich and press the lumbers and free-drive side-rollers were vertically set to avoid the collapse. After pressure-impregnation with the wood preservative of ACQ, remarkable increases of ACQ retention were recognized in the roller-pressed lumbers, and an improvement in chemical impregnation was evidently detected for Japanese cedar and Douglas fir.

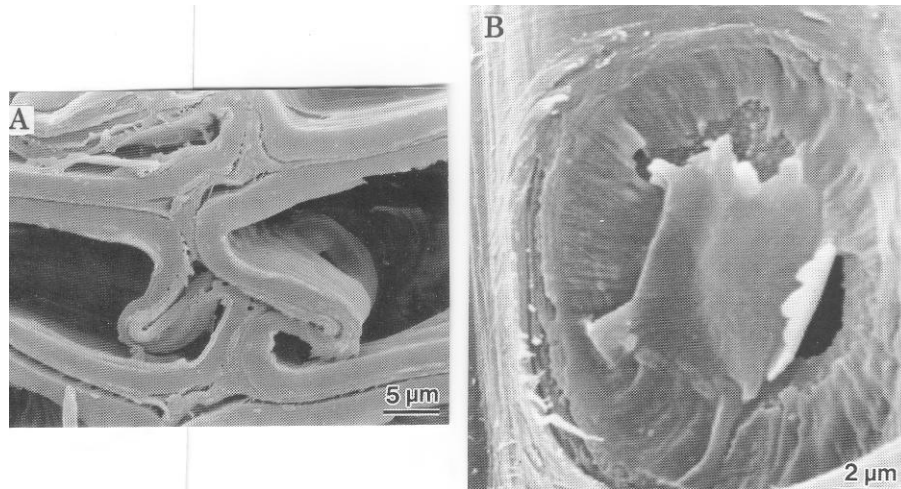


Fig. 3 Cell wall deformation around the pit region by compressive loading in the radial direction of Japanese cedar (A), and fracture of pit membrane (B).

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Recent Trend of Forest Products Research in the World

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Research in forest products industries in the world is aiming at deriving productive benefits from the forest resource by economical and environmental sound utilization. It should be dynamic to respond to the changing demands and the industrial capabilities. In this context, there are lots of interesting and exciting research projects going on in the world. In this presentation, recent research trends and advances in nanotechnology, bioenergy, and wood-based biomaterials will be summarized with the author's point of view.

1. Nanotechnology

1.1 Cellulose

Since cellulose micro/nanofibrils and nanocrystals have good mechanical properties with low density, they have attracted great attention as alternatives to glass, carbon, and other polymeric fibers. Cellulose microfibrils are the smallest structural units of the plant fiber, which are bundles of stretched cellulose chain molecules with Young's modulus of 130-140 GPa and tensile strength of 10 GPa. These properties are comparable to those of glass, carbon, and aramid fibers, which are well-known high strength fibers. Furthermore, they can be biodegradable and renewable and have good biocompatibility and nontoxicity.

Three methods have been developed to obtain cellulose micro/nanofibrils and nanocrystals: 1) Subjection of biomass to strong acid hydrolysis - cellulose nanocrystals have been obtained from wood fibers (Candanedo et al., 2005), tunicate mantles (Sturcova et al., 2005), sugart beet pulp (Dufrense et al., 1997), and potato tuber cells (Dufrense et al., 2000) by this method; 2) Preparation of cellulose microfibrils by the defibration of biomass at a high pressure using a refiner and passing through a micro-gap up to 30 times; and 3) Preparation of cellulose microfibrils using high shear refining and cryocrushing (Chakraborty et al. 2005) or a supergrinder (Taniguchi, 1998). Several preparation examples, especially, combined method of hot-compressed water treatment and wet-state mechanical milling process will be presenting.

1.2 Cellulose Nanocomposite

Cellulose nanocrystals and micro/nanofibrils can be used to process nanocomposite materials using a polymer as the matrix. Nanocomposites are a relatively new class of composites that exhibit ultrafine phase dimensions of 1-1000 nm. Because of the nanometric size effect, these composites have some unique outstanding properties compared to their conventional microcomposite counterparts. Like any other multiphase materials, the properties of these cellulosic nanocomposites depend on those of the two constituents, namely micro/nanofibrils and matrix in addition to morphological aspects and their interfacial compartments (filler/matrix interactions).

The production of nanocomposites with cellulose micro/nanofibrils of a high aspect ratio for load-bearing applications is fairly new. In particular, the possible field of application for cellulose micro/nanofibrils separated from wood pulp was hardly investigated. Although there are several studies on the separation of cellulose micro/nanofibrils from natural fibers or special sea animals, several problems are not sufficiently solved. Another problem is the dispersion of cellulose micro/nanofibrils in polymer matrices, especially when they are hydrophobic.

Representative researches on cellulose nanofiber-reinforced nanocomposites will be presenting and are briefly summarized as follows;

Iwamoto et al. (2005) reported on optically transparent composites reinforced with plant fiber-based cellulose microfibrils. They also demonstrated a web-like network of bacterial microfibrils from *Acetobacter xylinum* as a reinforcement material for optically functional composites (Yano et al. 2005). Ljungberg et al. (2005) reported on nanocomposite materials reinforced with cellulose nanocrystals in atactic polypropylene. Nanocomposite films were prepared with atactic polypropylene as the matrix and either of following three types of cellulose nanocrystals having various surface and dispersion characteristics as the reinforcing phase: aggregated without surface modification, aggregated and grafted with maleated polypropylene or individualized and finely dispersed with a surfactant. Sripayo et al. (2005) reported on preparation and characterization of alpha-chitin nanocrystal-reinforced poly (vinyl alcohol) nanocomposite films with or without heat treatment. Thermal stability of the as-cast nanocomposite films was improved

from those of the pure PVA film with increasing nanocrystal content. The presence of the nanocrystal did not have any effect on the crystallinity of the PVA matrix. The tensile strength of alpha-chitin nanocrystal-reinforced PVA films was increased at the expense of the percentage of elongation at break. The tensile strength of the pure PVA film was initially increased as the nanocrystal content increased but it was leveled off when the nanocrystal content was greater than or equal to 2.96 wt%. Dufresne (2005) reported on dynamic mechanical analysis of the interphase in bacterial polyester/cellulose nanocrystal natural composites.

2. Bioenergy

High demand of energy, lack of petroleum sources, and concern over global climate change have accelerated the development of the new alternative energy that can replace fossil transportation fuel. (Himmel et al. 2007, Labbe et al., 2008, Lee et al., 2009 c,d,e, Teramoto et al., 2008, 2009a) With these concerns, many countries have initiated extensive research and development programs in bioenergy, particularly in liquid transportation fuels. Among liquid fuels, researches on bioethanol have been most actively conducting. Recently, Farrell et al. (2007) reported in "Science" that bioethanol from lignocellulosic resources is much less petroleum-intensive than current gasoline and can contribute to reduce greenhouse gas emission. They also made clear, however, that a new lignocellulosic technology is still required for large-scale use of bioethanol for liquid fuel. The enzymatic saccharification and fermentation has attracted a great attention as the most promising way to produce economically feasible bioethanol. There have been developing a large number of pretreatment methods to increase enzymatic accessibility of lignocellulosic biomass and the clear objective now is how to make these methods cost-competitive in today's biofuel markets.

However, the recalcitrance of lignocellulosic cell wall structures against biological and chemical treatments is a high barrier for converting them into bioenergy. Therefore, intensive studies on the technology developments to overcome this biomass recalcitrance and high cost involved in bioethanol production have been carried out (Matthews et al., 2006; Nishiyama et al., 2002).

Solid sources for bioenergy as wood pellet and charcoal will be discussed (Kim and Hanna, 2006; Kwon et al., 2006, 2007, 2009; Kwon et al., 2009a; Lehtikangas, 2001; Relova et al., 2009; Ståhl et al., 2004; Pulido-Novicio et al., 2001a, b; Ishimaru et al., 2007)

3. Bio-based Materials

The environmental problems caused by synthetic polymeric materials also became prominent recently. These polymeric materials are used everywhere in our daily lives and a huge amount of the related wastes is being produced daily. There are difficulties in the disposal of these wasted polymeric materials. Incineration of them causes air pollution linking to the greenhouse effect and their landfill will result in the lack of the reclaimed land because of their non-biodegradable properties. In addition, they contain noxious or toxic components having possibility to generate even the environmental-hormones. Since the most polymeric materials are generally based on fossil resources, being non-reproducible, there is a fear of the exhaustion of feedstocks.

Under these circumstances, there is occurring a strong demand for developing environment-friendly bio-based polymeric materials from renewable resources, especially lignocellulosic materials, which is most abundant among the renewable resources, as the alternatives to the present polymeric materials. (Kusumi et al., 2009, Teramoto et al., 2009b) The utilization of these resources has numerous advantages such as the fixation of carbon dioxide, the save of the petroleum stock, low cost, and an appropriate raw material from the standpoint of the green chemistry.

This presentation is summarizing several research activities on the development of bio-based polymeric materials from lignocellulosics. In particular, several studies involving structural designing and functionalization of environment-friendly bio-based polymeric materials will be introduced, which have been attracting much attention to prevent or reduce environmental pollution. To expand their usage for wide-ranging applications, a novel functionalization of these polymers has been actively conducting. Most of researches are aiming at demonstrating a chemical designing and estimation of high-functional bio-based materials from biomass and its components and at formulating the correlation between molecular and supramolecular structure and material properties of the obtained products, which will be contributing greatly toward establishing a general scheme of their characteristics, coupled with expanding their practical usage.

Multi-compositional cellulose/lignin graft copolymers and molecular composite of lignin will be the representative research topic. (Teramoto et al., 2009b) Copolymerization and polymer blending of lignocellulosics and their components with aliphatic polyesters, polyester-carbonates, polyester-amides, and polyester-imides can produce multi-compositional biodegradable polymer. (Lee and Wang, 2006) The intimate incorporation of different polymer ingredients at a hyperfine structural level will lead not only the improvement of general material properties but also the desired control of the susceptibility to biodegradation. For example, the ring-opening copolymerization of cyclic lactones, aliphatic cyclic carbonates, and polyamides such as ϵ -caprolactam onto polysaccharides will be the major

pathway for the synthesis of multi-compositional graft copolymers. The obtained copolymer would give rise to a diversity of degradation phenomena according to the degree of graft substitution onto the carbohydrate backbone and the total composition, in addition to the chemical sorts of selected polymeric constituents. The utilization of lignin as biopolymer, especially residual lignin after bioethanol production is also interesting topic. Here, lignin-alkyl esters/polycaprolactone blend will be focused on.

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Forest Products Research Achievement and Trend in Indonesia

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Abstract

Logs supply for wood industries during the last five years was 5-31 million m³ per year and the logs from plantation forest reached about 60 % which was exploited from industrial plantation forest, Perum Perhutani as government enterprise, community forest and other officially licenced. Comparing to the years before 2000, it was changed logs supply from natural forest to plantation forest, and brought changing in wood species, cutting cycle, logs diameter and wood properties, and fast growing species has been dominating supplying wood demand of industries. Research concerning utilization of fast growing species, small logs diameter, lesser used species and other lignocellulosic material has been intensively doing by some research institutes and universities, and the topics were related to wood properties, wood properties enhancement, wood chemistry, bio-composite, wood engineering, and also non timber forest products.

Key words: Wood properties, wood properties enhancement, wood chemistry, bio-composite, wood engineering, non timber forest products.

Introduction

Indonesia occupies only 1.3% of the earth's land surface, but 10% of the world's plant species can be found in its territory, as well as 12% of all mammal species, 16% of all reptiles and amphibians, and 17% of all species of birds. Totally the country contains not less than 25,000 species of Malesian flowering plants, of which 10,000 are tree species (FAO, 2005). Concerning endemism, it is estimated that more than 1,300 species of trees, 430 species of birds, 200 species of mammals and about 155 dipterocarp tree species are endemic to Indonesia (Ekayani, 2004). Numerous wild plants and animals are harvested for domestic or commercial consumption as food, medicines, building materials, handicrafts and other uses.

The Tropical Rain Forest is covering 108.3 million hectares area which is containing more than 4,000 wood species with diameter at breast height more than 40 cm. From those species, about 400 species has been utilizing for any purpose (Martawijaya *et al.*, 2005). Forestry sector contributes 14 % export revenue to government earning and creating job opportunities for 2.5 million people directly and 2 million people indirectly (Nurrochmat and Hadi, 2005). Wood industries contribute forestry sector through industries of plywood, sawn timber, block board, particle board, fiber board, pulp and paper.

Logs production reached 31.4 million m³ in 2007 and during the last five years the logs has been supplied about 60 % from plantation forest, it is different from the years before 2000 whereas the logs was mostly supplied from natural forest (data calculated from Ministry of Forestry, 2008). The changing of logs supply from natural forest to plantation forest brings the changing of wood species, logs diameter, wood maturity, and wood characteristics consequently, and this phenomenon also brings wood industry changing in kind of products, handling and processing of raw materials, machine maintenance, and equipment improvement.

Research on wood from plantation forest becomes more intensively done including for silviculture system, wood properties, wood properties enhancement, wood utilization for energy, timber, building material, furniture, panels, fiber products, bio-composites and many other purposes. On the other hand, substitute of wood from lignocellulosics materials is also an alternative for raw material supply enrichment regarding to logs supply difficulties.

Timber as raw material for building is also as a topic to get effective and efficient utilization. The determination of physical and mechanical properties becomes important, and non destructive testing is an alternative method because the properties of sample can be estimated and it can be used as well. For structural materials, some products were developed utilizing wood from plantation forest and also small diameter logs, and the timber or other products can be tested using small clear specimen or full scale specimen.

This paper informs recent research activity conducting by several universities, research centers from some ministries, Indonesian Institute of Science, training centers, and the industries who involved in wood science and

technology, non timber forest products, and lignocellulosics materials in Indonesia. Most of them are member of *Masyarakat Peneliti Kayu Indonesia (MAPEKI, Indonesian Wood Research Society)*.

Forest Products and the Industry

Before 1968 logs were produced with traditional techniques in term of felling, skidding, transportation, and wood processing as well. Since forest concession has been opened for foreign investment, the production of logs was significantly increasing because mechanization using heavy vehicle for log extraction was applied.

In 1969 logging was operated by 34 forest concession units in natural forest, and in middle of 1980s more than 500 forest concession units were active covering more than 50 million ha. After 30 years log extraction, forest area and standing stock were reduced significantly, and logging activity was reduced also. In 2007 only 324 forest concession units were still active covering 28.27 million ha forest area.

During 1990s logs production was 19-29 million m³ and most of them extracted from natural forest, and since 2000 became 5-31 million m³ but the logs supply from plantation forest reached about 60 % per year which was produced from industrial plantation forest, Perum Perhutani as government enterprise, community forest and other officially licenced. Logs production from the forests during the last five years is shown in Table 1.

Table 1. Logs Production in the Last Five Years (million m³)

Year	Natural Forest	State Own Enterprise	Industrial Plantation Forest	Other Official Licenced	Total	Plantation Forest	Plantation Forest (%)
2003	5.0	0.98	5.3	0.06	11.1	6.1	55
2004	5.1	0.9	7.3	0.2	13.5	8.4	62
2005	9.3	0.8	12.8	1.3	24.2	14.9	61
2006	9.0	0.3	11.5	1.0	21.8	12.8	59
2007	9.5	0.1	20.6	1.3	31.4	22.0	69

Source: Ministry of Forestry (2008)

The most harvested species in Java was jati (*Tectona grandis*) reaching to 516,284 m³, meanwhile outside Java the species harvested were varies among provinces and the most harvested species were meranti (*Shorea* sp), keruing (*Dipterocarpus* sp), nyatoh (*Palaequum* sp), damar (*Agathis* sp), mahogany (*Swietenia* sp), sengon (*Paraserianthes falcataria*) and acacia (*Acacia mangium*, *Acacia crassicaarpa*). Regarding to plantation forest, in 2007 there were 143 units of licensed industrial plantation companies controlling a total of 7.12 million ha. However, the actual planted forest in 2007 only 334,838 ha, and until 2007 the total developed plantation forest is 3.7 million ha. In Jawa island, community forest has been developing well and right now about 1.7 million ha was established with productivity about 6 million m³ per year, and some of them already get sustainable forest management certificate from Lembaga Ecolabel Indonesia or Forest Stewardship Council, and the logs were supplied to some big wood industries, e.g. Kutai Timber Indonesia, Sumalindo group, and others in Java and other islands (MOF 2008).

The wood is processed to be sawn timber, plywood, woodworking, blockboard, veneer, particleboard, chipwood, pulp, moulding, dowels and other products. The production during the last five years 2003 – 2007 is shown in Table 2.

Table 2. Processed Wood Production in the Last Five Years

Year	Plywood (mill. M ³)	Sawn-timber (mill. M ³)	Block Board (1,000 M ³)	Veneer (1,000 M ³)	Particle Board (1,000 M ³)	Chip-wood 1,000 M ³	Pulp (1,000 Tons)	Other (1,000 M ³)
2003	6.1	0.76	436	289	93	127	4,662	1,047
2004	4.5	0.43	277	156	244	316	2,593	1,004
2005	4.5	1.47	403	1,012	124	352	988	636
2006	3.8	0.68	189	255	40	556	3,370	142
2007	3.4	0.52	204	299	n.a	1,103	4,881	n.a

Source: Ministry of Forestry (2008)

The main processed wood is plywood and the related products, followed by pulp-paper, and sawn timber. The wood as raw material is supplied from natural forest, plantation forest, community forest, and import as well. The logs from natural forest are *Shorea* spp, *Dipterocarpus* spp, *Calophyllum* spp, *Litsea* spp and more species are used also. Woods from plantation forest become more popular as raw material, e.g. *Gmelina arborea* and *Acacia mangium* woods from industrial plantation forest and *Paraserianthes falcataria* from community forest are commonly used for

core and inner layers of plywood. *Hevea brasiliensis* wood is commonly used for face layer of fancy plywood for flooring and furniture, and Teak (*Tectona grandis*) from Perhutani State Enterprise is used for fancy veneer, and then it used for fancy plywood (more dominant), fancy particleboard and fancy medium density fibreboard. Imported wood, e.g. *Quercus* spp, *Fagus* sp and *Betula* spp are for fancy veneer. The veneer is used for fancy plywood (more dominant), fancy particleboard and fancy medium density fibreboard (Sutigno and Hadi 2006).

The products of plywood are classified to primary products and secondary products, and primary products are very dominant, i.e. plywood and blockboard for general purpose, plywood for concrete panel, plywood for container flooring, structural plywood, preserved plywood, low emission formaldehyde plywood, moulded plywood and laminated veneer lumber. Secondary products are fancy plywood and blockboard, paper overlay plywood and blockboard, and film faced plywood. The plywood is used for any purpose, e.g. furniture, building materials, packaging, and music instruments. About 90 % of plywood is exported to Japan, USA, Asian countries, Europe and Middle East. Plywood was imported from some Asia countries (e.g. Malaysia, China), Europe (e.g. Italy, Germany), New Zealand, Australia and USA. Some of imported plywood is used for secondary products manufacturing, e.g. fancy plywood and paper overlay plywood, and some of them are for export commodity.

Non timber forest products are rattan (raw rattan), gum resin, damar resin, turpentine, gaharu, cajuput oil, honey, silk, sagoo, copal, charcoal, sirak, tannin, gondorukem, agarwood and other products. Production at the last five years of some products is shown in Table 3.

Table 3. Non-Wood Production in the Last Five Years

Year	Rattan (Ton)	Gum resin (Ton)	Damar resin (Ton)	Turpentin (Ton)	Gaharu (Ton)	Cajuput Oil (Lt)	Honey (Ton)	Silk Yarn (Ton)
2003	127,295	4,592	4,401	544	n.a.	28,138	1,949	8 9
2004	1,880,503	38,435	2,722,866	7,684	6,175	31,978	3,841	5 5
2005	221,381	27,098	9,131	36,958	2 31	275,192	1,568	6 9
2006	24,554	3,210	11,087	5,152	6 68	20,010	1,421	1 4
2007	3,153	850	648	n.a.	n.a.	324,019	n.a.	n.a.

Export of forest products comprises processed wood and non timber forest products. The first two is divided into eight groups, namely sawn timber, plywood, wood charcoal, pulp, veneer sheets, particle board and fibreboard. Whereas export of non timber forest products consists of among other sirak, gum, agarwood, tannin, turpentine, and rattan wickerwork. The products are exported mainly to Asian countries such as Japan, Australia, Hongkong, China and South Korea, as well as to European and US markets.

The import of forest products consists of among others are log or roundwood, veneer, sawnwood, plywood, wood charcoal, pulp, particle board and fibreboard. The products are mainly imported from Asian countries such as China, Malaysia and Japan, and also from New Zealand, Germany, United States of America, Brazil and Sweden.

Research Activities

Research concerning wood, non timber forest products and related matters is done by university, research center from some ministries, Indonesian Institute of Science, training center, and the industry. The subjects for investigation including wood properties, wood properties enhancement, wood chemistry, biocomposites, wood engineering, and non timber forest products aspects. Some results of these aspects are described as follow.

Wood Properties

Research on wood properties has been done for a lot of species since more than five decades, covering from natural forest and plantation as well. Some information concerning this matter is published in Specific Gravity of Indonesian Woods and Its Significance for Practical Use (Seng 1964), Indonesian Wood Atlas volume 1 and volume 2 (Matrawijaya *et al.* 1981, 1984) and volume 3 (Abdurochim *et al.*, 2004), and other publications. The publications inform commercial, local and botanical names, habitat, stand distribution, tree characteristics, wood anatomy, chemical composition, physical-mechanical properties, processing characteristics and the usages for each species.

Wood species were mostly from natural forest, but recently woods from plantation forest become an interesting object because the government has been developing plantation forest and the logs supply from plantation forest becomes more important. Woods from plantation forest are more inferior for physical and mechanical properties because most of them are fast growing species and the cutting cycle is short about 10-15 years only. Information concerning wood species from plantation forest has been published by some institutions, and the species including sengon (*Paraserianthes falcataria*), mangium (*Acacia mangium*), mahagony (*Swietenia* sp), ruber wood (*Hevea*

brasiliensis), gmelina (*Gmelina arborea*), Indonesian pine (*Pinus merkusii*), african wood (*Maesopsis eminii*), tisuk (*Hybiscus macrophyllus*), suren (*Toona sureni*), *Eucalyptus* sp, sengan buto (*Enterolobium cyclocarpum*), mindi (*Melia azedarach*), kisereh (*Cinnamomum purrectum*), and puspa (*Schima walichii*).

The specific gravity of woods from natural forest varies from 0.22 to 1.16 depend on the wood species and site of the stand. Mostly woods belong to strength class I to V or all classes are represented, from very strong class I to very weak class V. The lower strength class i.e balsa (*Ochroma bicolor*) and merkubung (*Macaranga* sp), and the higher strength class including Ebony (*Dyospiros celebica*) and Bangkirai (*Shorea* sp). Woods from plantation forest have specific gravity about 0.28 to 0.73 with average of 0.53, and mostly belong to strength class III to V, some species have higher specific gravity e.g. puspa (*Schima walichii*) belongs to strength class II, and most of wood from plantation forest for light construction, some can be use for structural materials (Martawijaya *et al.* 1984, 1989, and Hadjib *et al.* 2007a, b).

The three volumes of Indonesian wood atlas described wood properties of 92 species and some publications for the other species. Most of them belong to hardwood from natural forest and some from plantation forest, and the conifers are *Pinus merkusii* and *Agathis borneensis*. Wood from plantation forest has light to medium density and more juvenile wood content, Hidayati and Siagian (2009) and Praptoyo (2009) stated that sukun wood (*Artocarpus communis*) and mindi wood (*Melia azedarach*) have low dimensional stability and they still juvenile. Yuniarti and Pari (2009) using XRD-Diffraction found that microfibril angle and crystallinity of sengan (*Paraserianthes falcataria*) 18° and 64.6 %, sungkai (*Peronema canescens*) 18.4° and 41.6 %, teak (*Tectona grandis*) 11.7 ° and 59.3 %, and keruing (*Dipterocarpus* sp) 10.4° and 52.4 % respectively. Furthermore Martawijaya *et al.* (1984, 1989) stated that chemical properties of keruing, sengan, sungkai, teak as follow cellulose content 51.4%, 49.4%, 48.6% and 47.5% respectively, pentosan 16.8%, 15.6%, 16.5% and 14.4% respectively, ash content 0.9%, 0.6%, 1.6% and 1.4% respectively, silica content 0.6%, 0.2%, 0.4% and 0.4% respectively, extractive soluble in alcohol benzen 3.9%, 3.4%, 4.0% and 4.6% respectively, extractive soluble in cold water 0.3%, 3.4%, 1.1% and 1.2% respectively, extractive soluble in hot water 3.2%, 4.2%, 5.3% and 11.1% respectively, and extractive soluble in NaOH 11.7%, 19.6%, 11.3% and 19.8% respectively.

Wood Properties Enhancement

Researches on wood properties enhancement are including wood drying and wood preservation. Research on wood drying has been doing for wood from natural forest and plantation forest as well using air drying, solar drying, kiln drying and dehumidifier. Kiln drying is the most populer used by the wood industry, and the drying schedules are mostly for conventional kiln drying with regulating temperature, humidity and air velocity. Most of important wood species from natural and plantation forests have the drying schedule, and for wood species which is difficult to dry the steam treatment before drying as an alternative (Basri *et al.* 2009).

Wood from plantation forest and lesser known wood species are objects for research activity. Suranto *et al.* (2009) used melina wood (*Gmelina arborea*) for air drying and solar drying with thicknesses of board 2 cm, 4 cm and 6 cm, and resulting drying periods of each board by solar drying were 22.7 days, 61.2 days and 94.4 days, and by air drying were 35.2 days, 84.3 days and 118.3 days respectively. On the other hand Yuniarti and Basri (2009) observed five lesser known wood species from west Java with air drying and solar drying, and resulting solar drying could shorten the drying period of all species but with lower grade of quality. Furthermore Basri and Yuniarti (2007) stated drying schedule for 3-4 cm thickness of mahogany wood is 55-85 °C with 31-77 % relative humidity, and for 2.5 cm thickness of coconut wood applying 40-60 °C with 20-45 % relative humidity.

Research on termite biology has been doing since more than fifty years ago covering *Coptotermes curvignathus*, *Macrotermes gilvus*, *Cryptotermes* spp, *Microtermes* spp, *Schedorhinotermes* spp, *Neotermes* spp, *Glyptotermes* spp, *Odontotermes* spp, *Nasutitermes* spp, *Hospitalitermes* spp. The research was intensive concerning population size, spatial distribution, foraging area (attack area), preference consumption, digest system, biology potential and nest architecture in Sumatra, Java, Bali, Kalimantan and West Papua.

Hoesin (2007) stated that subterranean termites which attack wood in Indonesia are mostly belong to family Rhinotermitidae and Termitidae, and the genera are *Coptotermes*, *Odontotermes*, *Microtermes* and *Macrotermes*. Dry wood powder beetle is another organism attacking the wood, they mostly belong to Coleoptera. Generally we can found species such as *Lyctus brunneus*, *Minthea rugicollis*, *Heterobostrychus aequalis* and *Dinoderus minutus*, and for dry wood termite mostly *Cryptotermes cynocephalus* and *Cryptotermes dudleyi*. Rilatupa (2009) mentioned that in the high buildings such as mansions in Jakarta are intensively attacked by *Macrotermes gilvus* and *Coptotermes curvignathus* subterranean termites even though until the 25th highest floor.

The test of wood resistance to termite attack can be done in the field and in laboratory as well. Test under the stand is better done in the field because the humidity of soil can be maintained. On the other hand, to do test of wood resistance to subterranean termite in the laboratory mostly using *Coptotermes curvignathus* Holmgren, and for dry

wood termite test mostly using *Cryptotermes cynocephalus* Light, and testing procedures is described in Indonesian National Standard SNI 01.7207-2006 concerning test of wood and woody products resistance to bio-deterioration.

Research on decay biology has been doing for several species, and for test of wood resistance to decay can be used *Schizophyllum commune* Fr; *Pycnoporus sanguinus* or *Dacryopinax spathularia*. Even though the numbering system is not yet developed, but in the field those decays can be easily found especially for *Schizophyllum commune* (SNI, 2006). Other research activity in the fungi concerning possibility entomopathogen fungi as agent for bio-control of *Coptotermes curvignathus* termite population was intensively investigated by Desyanti *et al.* (2005) and Yusuf *et al.* (2005).

Preservative which used for electrical pole was CCA (cuprum-chrom-arsen), and it was effective to reduce bio-deterioration attack, and for sawn timber were used NaPCP (natrium penta chlor phenol) or borax, but NaPCP was banned because of environmental aspect. Recommended preservatives for timber regarding to Indonesian Standard SNI 03-3528-1994 are CCA, CCB (cuprum-chrom-boron), CCF (cuprum-chrom-flour) and BFCA (boron-flour-chrom-arsen) (Hoesin 2007).

Another way to increase wood resistance to bio-deterioration with chemical modification, this way makes wood having another chemical characteristics. Hadi *et al.* (2008a) used wood vinegar as alternative for wood preservative, and furthermore Hadi *et al.* (2005, 2008b, 2009) made furfurylated, smoked, polystyrene and acetylated woods to increase its resistance to bio-deterioration. All treatments can increase the wood resistance to bio-deterioration, but it still needs an effort to fix vinegar and smoke becoming bounded agents, and for furfuryl, polystyrene and acetylated woods already have compound with the wood.

Some researchers are interested in extractives for termicide, e.g. extract from seed of *Areca catechu* (Tarmidi *et al.* 2009), from wood of *Caesalpinia sapan* and *Vitex pubescens* (Wardenaar *et al.* 2009), extract from bark of *Shorea venulosa* (Husni 2009), extract from leaf of *Abrus precatorius* (Setiawan *et al.* 2009), extract from root of *Derris elliptica* and leaf of *Azadirachta indica* (Priadi and Agusta 2009), and extract from leaf of *Nicotinia tabacum* and seed of *Pangium edule* (Prianto *et al.* 2009). All extractives from seed, leaf, wood, root, and bark are effective increasing wood resistance to bio-deterioration. Another method using bait system with hexaflumuron and bistrifluron (Rismayadi *et al.* 2009) for subterranean termite and hydromethylon (Indrayani 2009) for dry wood termite was effective to reduce termites attack.

Wood Chemistry

Researches on wood chemistry are focusing on exploration, extractive, pulping, and wood modification. Rosamah *et al.* (2009) mentioned extractive solubility of laban bark (*Vitex pubescens*) in methanol, n-hexane, diethyl ether and ethyl acetate were 6.03 %, 0.27 %, 0.39 % and 0.47 % respectively, and phytochemical analysis soluble matter in n-hexane and diethyl ether contained steroid, flavonoid and carbohydrates, while in ethyl acetate fraction contained triterpeoids and carbohydrates. Thin layer chromatography test of laban bark extract showed the active compounds of stilben, amine, quinone, aldehyde, keton and flavonoids. Another research by Sisillia *et al.* (2009) mentioned that rambai bark (*Baccaurea motleyana*) is used in traditional medicine for the treatment of eye diseases, the extracts soluble in aqueous and ethanol were used to determine the antibacterial activity on *Staphylococcus aureus*, *S. epidermidis* and *Pseudomonas aeruginosa*, and resulted that aqueous extracts was more inhibited the growth of these bacterias and the minimum inhibitor concentration of the extract ranging 5.40 to 6.82 mg/ml.

Sukatoni *et al.* (2009) investigated wood extractive from secang stem (*Caesalpinia sappan*) for anti fungi. The extractive was effective to reduce fungi growth of *Aspergillus niger*, *Fusarium oxysporum* and *Penicillium canescens*, and it is potential for paint additive to prevent wall stain by fungi. Another researcher Astuti *et al.* (2009) did research on extract leaves of tahongai (*Kleinhovia hospita*) and resulted that ethanolic extract was the highest free radical scavenger activity 86.97 % and fraction ethyl acetate extract was 84.34 %, and further chemical analysis found that the antioxidative compound was flavonoid, alkaloid, saponin, steroid and carbohydrates.

Haroen and Sudarmin (2009) study of utilization sea weeds as pulp raw material, and pulping process on circulation digester used sodium at temperature of 100-110 °C duration time 60-90 minutes, with bleaching process using hydrogen peroxide and quality of brightness pulp 50-70 % ISO, the result showed that physical handsheet properties of sea weeds pulp were compared to culture paper of strength properties was low, however sea weeds pulp have good superiority process on transparent, print ability, formation and high density. Marsoem *et al.* (2009) investigated legi bamboo (*Gigantochloa alter*) for pulp raw material using mechano-organosolv process, recovery was 40.3 % with kappa number 26.8, freeness 647, tensile index of pulp sheet was 2.1 Nm/g, tearing index 1.06 mN.m²/g and bursting index 0.22 Kpa.m²/g.

Another research was conducted by Suwinarti *et al.* (2009) using mangium wood (*Acacia mangium*) with acetosolv pulping process using variation of cooking time 1-3 hours and concentration of chloric acid 0.5-1.5 % as catalyst, the results showed that uncooked wood 2.43-7.90 %, total yield 53.7-68.5 % with value of kappa number was

19.77-23.50, and the optimum value was 3 hours of cooking time and 1.0 % chloric acid with yield 68.5 % and kappa number 21.1. Another researcher Yahya (2009) did mangium wood from PT Musi Hutan Persada in South Sumatra using kraft pulping method with active alkali 16 %, sulfidity 25 %, ratio chemical to wood was 4-time, time to and at maximum temperature of 170 °C were 75 and 50 minutes respectively, and the results showed that recovery was 45.1 % and consumed alkali was 14.1 %, and kappa number 22.4.

Bio pulping is another investigated topic, Fatriasari *et al.* (2009) tried bio pulping of betung bamboo by using white rot fungi *Pleurotus ostreatus* and *Trametes versicolor* for 45 days with kraft and soda pulping process, and the results showed that fungi species affect kappa number and degree of freeness at sample cooked using kraft process, and species of white rot fungi did not affect pulp yield but affect kappa number. Furthermore it can be mentioned that bamboo treated with *Trametes versicolor* incubated for 45 days and cooked using kraft process produced the best pulp quality with high pulp yield. Wistara *et al.* (2009) did pyrolysis of black liquor at several temperatures 100-750 °C, and it was found that calory value and bonded carbon content increased but moisture content and volatile matter content decreased with increasing pyrolysis temperature, the calory of black liquor was 2,700-4,700 cal/g.

Biocomposites

Research on bio-composites was conducted covering the subjects of adhesive, plywood, particleboard, binderless particleboard, cement board, and wood plastic composites. Natural adhesive is more important for future because it is renewable resource, Ruhendi (2000) reported that the shear strength of three-layer meranti (*Shorea* sp) plywood using wood liquid of *Agathis* sp, *Pinus* sp and their mix with husk powder up to 10 % fulfilled the SNI 01-2704-1992 requirements. Meanwhile Ruhendi (2008) also reported his research results that kenaf liquids fortified 45 % with melamine formaldehyde for 20 % glue spread produced particleboard with 0.7 g/cm³ density, 6.6 % moisture content, 55.6 % water absorption ability, 16.6 % thickness swelling, 641 N screw holding strength, 0.86 N/mm² internal bond, 2131 N/mm² MOE and 15.3 N/mm² MOR.

Tannin from gambir (*Uncaria gambir* Roxb) as adhesive was used for particleboard from palm oil stem by Kasim *et al.* (2007), and 10 % paraformaldeyde was added, the board was 0.7 g/cm³ density, 147.8 kg/cm² MOR and 8.3 kg/cm² IB. Another researcher Santosa (2009) used mangium bark (*Acacia mangium*) as tannin source for adhesive purpose, and the glue can be applied for exterior plywood, laminated lumber, laminated bamboo and particleboard manufacturing.

Logs supply for plywood industry has been changing from natural forest to plantation forest, from big to small diameter logs, and also from mature wood to a lot of juvenile wood. Concerning this matter some research on utilization of small diamter logs and plantation forest became a topic, Hadjib *et al.* (2009) did research on identify suitable wood species and evaluate mechanical properties for biocomposites products, 24 wood species were from natural forest and 14 species from plantation forest. Sulatiningsih (2009) made plywood from kihantap (*Sterculia oblongata*), kibuluh (*Gironniera subaequalis*) and sengon (*Paraserianthes falcataria*) with bamboo veneer as cross veneer resulting higher density and improving mechanical properties of plywood.

Related to research on particleboard, Subyakto *et al.* (2005) investigated mangium bark (*Acacia mangium* Willd) for particleboard with adhesive content 6 % and 8 % at 0.9 g/cm³ board density fulfilled JIS A 5908 for internal bond and modulus of rupture but failed for MOE and thickness swelling, and IB for 6 % glue reached 6 kg/cm². Subiyanto *et al.* (2004) made particleboard from empty trunk oil palm with phenol formaldehyde glue, and the result showed that 10 % glue content fulfilled JIS A 5908 1994 for internal bond and MOR but thickness swelling was failed, and pretreatment with hot water for two hours or with cold water for 24 hours was recommended.

To improve bending strength of particleboard some researchers did overlay at outer layers, Erniwati *et al.* (2007) made composites from sengon wood (*Paraserianthe falcataria*) with polyurethane glue and bamboo matings were used for outer layers, the product was better in mechanical properties in both length directions. The similar investigations were done by Massijaya *et al.* (2007) using urea formaldehyde and melamine formaldehyde with wood waste and Suhasman *et al.* (2007) used recycled cartoon, waterbased isocyanate polymer with sengon wood (*Paraserainthes falcataria*) and both investigations resulted satisfied products improving mechanical properties.

To get environmental friendly product, some researchers tried to make binderless particleboard, Hermawan (2007) made binderless particleboard from core kenaf (*Hibiscus cannabis*) and resulted that steaming for 30 minutes and 30 minutes hot press produced a good particleboard. Widyorini (2008) immersed bagasse particle in 80 °C hot water for three hours and immersion in 50 °C ethanol benzene for 24 hours to remove silica and other extractives, and binderless particleboard with ethanol treatment was better. Furthermore, Widyorini (2009) core kenaf could be made for binderless particleboard with steam injection pressing and no delamination for the board with density above 0.6 g/cm³. The other researcher Suhasman *et al.* (2009) made binderless particleboard from bamboo and resulted oxydation with hydrogen peroxyde treatment was better than steaming the particles.

Strandboard was another object for research, Sumardi *et al.* (2009) made strand board from mangium wood (*Acacia mangium*) and bamboo as for outer layers at several levels of glue content, the board with higher glue content was better in MOR, IB and dimensional stability, and urea formaldehyde was not appropriate for the board manufacturing. Hemawan *et al.* (2008) made oriented strand board from mangium wood (*Acacia mangium*) and africa wood (*Maesopsis eminii*) at various oriented strand angles, the best board was randomized outer layer with 45° oriented core layer, and Febrianto *et al.* (2008) made OSB from mangium wood with pretreatment with immersion in 80°C hot water for 2 hours, and the board was better in mechanical properties.

For fiberboard research, Jufriah (2009) made medium density fiberboard (MDF) from mangium wood (*Acacia mangium*) mixed with waste from wood industry and the board fulfilled FAO (1966) standard except thickness swelling. Ismadi *et al.* (2009) used sisal fiber and pretreatment with 4 % NaOH immersion for MDF manufacturing, and the board from 12 hours immersion gave the best properties compared to 24, 38 and 48 hours immersions. The other research by Darmawan *et al.* (2009) mixed fiber charcoal to wood fiber at amount 10, 20 and 30 % based on the dry weight of fiber stuff, and the results show that the greater amount of charcoal added yielded greater adsorption capacity, and the fiberboard properties with charcoal addition 10 % was the same with the control and fulfilled the standard of type-25 JIS except for internal bond and MOE type-15 only.

Concerning inorganic board, Hermawan and Suryana (2009) made gypsum-cement board from mangium wood (*Acacia mangium*) with 1 g/cm³ board density and weight portion of gypsum-cement to wood particle to water was 2.5 to 1 to 1.25 respectively, and gypsum substitution was 10-50 % to cement, the result showed that the board with higher gypsum content was worse quality and the board with 10 % gypsum content was not different to the control, but Iskandar (2009) made gypsum-cement from pith coconout stem resulting board of 40 % mixed gypsum to cement was better than the board containing more cement. Another reserachers Rosita *et al.* (2009) mixed mahang wood (*Macaranga gigantea* Muell Arg.) with rice husk (*Oryza sativa* Linn), the result showed that the cement board with higher rice husk content was worse quality and 25 % rice husk was recommended to be mixed. Suhasman *et al.* (2009) made cement board of three wood species from community forest namely sengon (*Paraserianthes falcataria*), gmelina (*Gmelina arborea*) and kemiri (*Aleurithus moluccana*), the result showed that the board from stem part was better than branch part, but MOE from branch was better than stem and MOR was similar from both parts.

Wood plastic composites becomes populer topic, Setyawati *et al.* (2009) made composites from coconut choir with recycled plastic, the optimal press temperature for polypropylene was 180 °C and for polyethylene 145 °C while press period 15 and 20 minutes were not different. Risnasari *et al.* (2009) made composites from oil palm stem with recycled polypropylene, the board with 0.85-0.95 g/cm³ density had 3.89 % thickness swelling, 315.9 kgf/cm² MOR and 24.1 kgf/cm² MOE, while Nuryawan *et al.* (2009) made composites from choir nut oil palm at 0.8 g/cm³ board density, 180 °C press temperature, and resulted that the best ratio of choir to polypropylene was 70:30 comparing to ratio 50:50 and 60:40. Subyakto *et al.* (2009) stated that composites from bamboo micro fiber or sisal fiber mixed with polypropylene were not significantly different, and the best ratio fiber to plastic was 40:60.

Wood Engineering

Mechanical properties of wood are needed to develop wood engineering, and the structure compounds from wood are reliable used for certain purpose. The research concerning mechanical properties of wood was intensively done to commercial timber and lesser known species from natural forest, plantation forest and community forest as well. Bamboo, coconut wood and bio-composites are also raw material for panel or structural purposes, and research on densified wood was also done to get stronger materials.

The objects of the research including beam, column, trusses, roof structure, cooling tower, wooden bridge, wooden boat, woody light plane, and other woody stuctures. Knot, check, joint, and other failure make wood weaker supporting the load, the strength prediction for such timber was calculated through various testings, and it is explained in some formulas. The standardization of timber has been formulating since 2002 in Indonesian National Standard based on load and resistance factor design.

Non destructive test for wood materials has been doing for timber. Surjokusumo (2003) developed a machine test called "Panther" to estimate strength class through modulus of elasticity (MOE) prediction of timber, the test is done with putting the load in the center of timber in the certain span and the deflection magnitude is converted to the MOE, the factors of thickness and width of timber were calculated for estimation. The machine was simple and handy to use and very easy to estimate MOE, and it is very useful to sort the timber quality. Another test was conducted by Karlinasari *et al.* (2006) using ultrasonic method to determine ultrasonic velocity and dynamic modulus of elasticity at several tree positions from teak (*Tectona grandis*), african wood (*Maesopsis eminii*) and sengon (*Paraserianthes falcataria*), and the result mentioned that no significant significant influence was found on vertical tree position in both ultrasonic velocity and dynamic modulus of elasticity

Laminated veneer lumber (LVL) and glued laminated lumber (glulam) are designed for structural component, even though wood from plantation forest has small diameter logs but it can be made for a larger timber. Sulistyawati *et al.* (2009) using mangium (*Acacia mangium*) wood with diameter 20-28 cm cutting from eight-year stand made for 7-layer glulam sized 6 cm width by 15 cm height by 280 cm length and glued with polyurethane-isocyanate, and the glulam had MOR 45-60 MPa, MOE 10,000-11,000 MPa. Abdurahman *et al.* (2008) made 3-5 layers glulam from mangium and sengon (*Paraserianthes falcataria*) sized 6 cm by 12 cm and 10 cm by 10 cm in cross section by 300 to 350 cm length with tannin-resorcinol-formaldehyde resulted MOR 32-44 MPa and MOE 8,305-9,189 MPa, and the products is recommended for coloumn, beam, trusses and non structural purposes.

Non Timber Forest Products

Non timber forest products covering a lot of commodities, e.g. rattan, bamboo, gum resin, damar resin, turpentin, honey, silk, essential oil, vegetable oil, charcoal, medicinal plant, and decorative plant. Research was conducted in term of exploitation, storage, processing to get products, and modifying equipment.

Research on rattan was conducted regarding to properties and useful of lesser used species (Jasni *et al.* 2008). Six rattans namely sadak rattan (*Plectocomia melleri*), sangau rattan (*Korthalsia chep*), sanjat rattan (*Calamus pasapalanthus*), mawang rattan (*Calamus nemathospadix*), marau rattan (*Korthalsia rigida*) and mata pelanduk rattan (*Ceratolobus concolor*) were indentified for anatomical-physical-mechanical-chemical properties, resistance to powder post beetle *Dinoderus minutus* Fabr., bench properties, polish and cleavage properties. The rattans can be used for polished rattan, partial processed rattan (bark or inner part), and furniture. Sadak and marau rattans are for furniture, and the other sangau, sanjat and mawang rattans are for matting after sliced (bark and inner parts), and mata pelanduk rattan is for matting directly.

Research on essential oil was intensively conducted for sandal-wood oil, kemiri (*Aleurithes molucana*) oil, masohi oil, kilemo (*Litsea cubeba*) oil, and also gaharu and pine resin. Extraction from sandal wood with soxlet system resulted recovery 6.5 % and with immersion 10.3 %. Alpha-santalol, betha-santalol and total santalol contents with soxlet system were 45.6 %, 19.1 % and 64.7 % respectively, with immersion were 34.6 %, 23.3 % and 57.9 % respectively, and with refraxion system were 51.3 %, 25.6 % and 76.9 % respectively and this system resulted the best quality of santalum oil (Wiyono *et al.* 2006).

Winarni (2008) mentioned that stem and leaf from masoi tree (*Cryptocarya massaia*) were extracted with methanol 90 % for 72 hours, and resulted recovery from leaf and stem were 16.9 % and 3.65 % respectively, and active component at stem was lactone acid with amount of 63.1 %, and at leaf was benzyl benzoat with amount of 28.3 %. Research on kemiri and kilemo oils is still on going to find out effective utilization of these oils.

Natural and artificial inoculations of gaharu were investigated to get more gaharu extract, some fungi were inoculated to the stem, and gaharu can be exploited with special bor (Endriana and Soewardi 2006). Gaharu oil extracted with steam during eight hours resulting 1 cc of light yellow gaharu oil from 1 kg gaharu raw material. Sylviculture research on gaharu is done using seedling and stump with *Gyrinops verstegii* in Pusuk Lombok island, and the result was from under canopy in the natural forest.

Pyrolysis has been doing to wood from plantation forest, e.g. sengon (*Paraserianthes falcataria*), mangium (*Acacia mangium*), rubber-wood (*Hevea brasiliensi*), bamboo, and information concerning moisture content, ash content, volatile matter, tar carbon, destilate, specific gravity and calory value are observed at 500 °C temperature. Pari and Hendra (2009) made charcoal bricket from mangium bark with characteristics 7.5 % moisture content, 32.3 % ash content, 31.9 % volatile matter, 80 kg/cm² compression strength, 0.67 g/cm³ density, 35.8 % carbon content, and 5,633 cal/g calory value which fulfill to Indonesian National Standard for charcoal bricket.

Dissemination

Research activity by scientist and institution can be published in the journal from scientific society, journal from institution, annual report, technical notes, or seminar, and it will be more valuable if it is published in the reputedated international journal. Journals in Indonesia which can publish wood science and technology for instance Jurnal Ilmu dan Teknologi Kayu Tropis (Journal of Tropical Wood Science and Technology) by Indonesian Wood Research Society, Indonesian Polymer Journal by Polymer Society, Forum Pascasarjana by Graduate School Bogor Agricultural University, Journal of Forestry Research by Forest Research and Development Agency Ministry of Forestry, Jurnal Ilmu Kehutanan (Journal of Forestry Science) by Faculty of Forestry Gadjah Mada University, Jurnal Penelitian Hasil Hutan (Journal of Forest Products Research) by Forest Products Research Institute Ministry of Forestry, Jurnal Penelitian Pemukiman (Settlement Research Journal) by Settlement Research Institute, Jurnal Perennial by Faculty of Forestry Hasanuddin University, Jurnal Teknologi Hasil Hutan (Journal of Forest Products Technology) by Faculty of Forestry Bogor Agricultural University, Jurnal Teoritis dan Terapan Bidang Rekayasa Sipil (Journal of Theory and

Applied in Civil Engineering) by Faculty of Civil Engineering and Environment Bandung Institute of Technology, Majalah IPTEK Jurnal Ilmu Pengetahuan Alam dan Teknologi by LPPM Institut Teknologi Sepuluh Nopember, and Rimba Kalimantan (Jungle of Kalimantan) by Faculty of Forestry Mulawarman University.

For international journal it can be applied to Additives for Polymers, Agriculture-Ecosystems and Environment, Analytica Chimica Acta, Bio Cycle, Biological Control, Biological Journal of the Linnean Society, Biomass and Bioenergy, Bioresource Technology, Biotechnology Advances, Building and Environment, Carbon, Carbohydrate Polymers, Carbohydrate Research, Cement & Concrete Composites, Cement and Concrete Research, Chemical Engineering Science, Colloids and Surfaces, Combustion and Flame, Composites, Composites Science and Technology, Composite Structures, Comptes Rendus Chimie, Computational Materials Science, Computers and Structures, Construction and Building Materials, Current Applied Physics, Diamond and Related Materials, Engineering Fracture Mechanics, Engineering Structures, Environmental Modelling & Software, Environmental Pollution, European Polymer Journal, Fluid Phase Equilibria, Forest Ecology and Management, Forest Products Journal, Holzforschung, Industrial Crops and Products, International Biodeterioration & Biodegradation, International Journal of Adhesion & Adhesives, International Journal of Fatigue, International Journal of Refractory Metals and Hard Materials, International Journal of Solids and Structures, International Journal of Thermal Sciences, Journal of Analytical and Applied Pyrolysis, Journal of Archaeological Science, Journal of the European Ceramic Society, Journal of Biological Sciences, Journal of Invertebrate Pathology, Journal of Materials Processing Technology, Journal of Structural Biology, Journal of Tropical Forest Science, Marine Pollution Bulletin, Mechanics Research Communications, Marine Structures, Materials and Design, Materials Letters, Materials Science and Engineering, Mechanics of Materials, Molecular Crystals and Liquid Crystals, Molecular Phylogenetics and Evolution, Plastics Additives & Compounding, Precision Engineering, Process Biochemistry, Nuclear Instruments and Methods in Physics Research, Physica, Polymer, Polymer Degradation and Stability, Polymer Testing, Progress in Polymer Science, Radiation Physics and Chemistry, Reinforced Plastics, Reliability Engineering and System Safety, Resources-Conservation and Recycling, Supramolecular Science, Surface and Coatings Technology, Structural Safety, Thin-Walled Structures, Thermochimica Acta, Ultrasonics, Waste Management, and Wear. Notification of international publication by each researcher from certain institution will be recorded and can be upload at www.scopus.com (author preview).

Future Findings

Ministry of Forestry designed plantation forest will be the source for logs supply, and then the plantation forest including community forest has been developing until reached the target area, and production of the logs will supply wood demand of industries. Each area will develop plantation forest according to certain species which match to soil and climate conditions, this matter affecting some wood properties variety may be found even though for the same wood species from various forest sites. Regarding to the matter, research on wood from plantation is still needed, and substitute for wood as raw material must be found to support wood supply in the future.

Sylviculture research on fast growing species has been doing especially to develop new strain of species to get higher increment and shorter cutting cycle. If possible the research is improved through DNA engineering to develop new strain of wood species which accomodate sylviculture development and wood properties requirements can be developed by related scientists.

In the near future exploration on lesser used tree species, plantation forest, community forest, small diameter log and other lignocellulosic materials is still needed to get data on basic properties. The data can be in more detail regarding to more modern equipment availability, such scanning electron microscope, X-Ray Diffraction, Differential Thermal Analysis and others, and more information can be informed such as micro fibril angle, crystallinity, solid chemical component, nano carbon, conductivity and diffusivity.

Regarding to changing of main logs supply from natural forest to plantation forest including community forest and wood from estates re-plantation, changing in wood as raw material characteristics also is happened, especially such as small diameter logs, lower wood density, juvenile wood, and the wood will be inferior in physical mechanical properties and lower wood durability. Wood properties enhancement through timber sawing, wood drying, wood preservation and other techniques becomes important to get more effective and efficient raw material utilization. The woods can be utilized for timber, pulp, paper, wood composites, and structural building material, and research concerning this matter becomes a special topics.

Concerning to wood chemistry, the chemical component from lesser used species, fast growing species and other lignocellulosic materials is a topic to be continued investigated. The fiber can be utilized for pulp, paper, and other fiber products with specific pretreatment or special process. On the other hand chemical modification effort or other technique is a way to make wood having a better water adsorption, dimensional stability, and mechanical properties, appropriate chemical or certain technique used is very important to be choosen.

Wood composite is a promised products because of no special requirement for wood raw material but the product can be used for many purposes. Utilizing of small diameter logs, wood from plantation forest, wood from community forest, wood from land clearing of estates, and other lignocellulosic materials for bio composite products are the topics for research, and improving product quality is also as another topic. For wood plastic composites, some topics for research are composition of wood to plastic, additive for certain purpose, mixed of wood species, utilization of recycled plastic, and utilizing of other lignocellulosic materials.

Concerning to non timber forest products, utilizing and appropriate process of commercial and lesser used rattan are still needed for some rattan species. Concerning to pyrolysis process, the topics are pyrolysis at more than 900 oC or high temperature with spark plasma cintering for raw material of battery, biocensor and mobile phone, also utilizing of wood vinegar and wood smoke. For active charcoal, the research is still done of active charcoal for water purifier, norit, and cosmetic. In general improvement of products, raw material handling, process, are additive are the topics to better utilizing of non timber forest products.

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The role of Art, Spiritual, Science, Engineering and Technology (ASSET) for Improving the Quality of the Indonesian Wood Research (IQIWR)

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Abstract

This paper presents the role of Art, Spiritual, Science, Engineering and Technology (ASSET) to support the Programs of Education & Training (E&T) and Research & Development (R&D) in Indonesia. The programs of E&T and R&D must be related with the modern ASSET. Improving the Quality of the Indonesian Wood Research (IQIWR) is related with the prosperity of the human resources. The prosperity of the human resources have four aspects: Physical aspects, Intellectual aspects, Emotional and Spiritual (PIES) aspects. There are three basic requirements for developing PIES aspects: Material, Energy and Information (MEI). Social welfare and increase of life quality are desired output that must be attained from the MEI aspects. Current standard of living of human being, should be reported as feedback information in the programs of (E&T) and R&D activities. In global communication, developed countries and developing countries should build several attractive and sound symbiosis bridges, for IQIWR.

Key words : ASSET E&T, R&D, IQIWR, PIES, MEI, human standards of living.

Introduction

The development of ASSET to support the Programs of Education & Training (E&T) and Research & Development (R&D) represent forces that strongly affect man, life, and civilization. It means that those can be good and can also be evil. The goodness or evil is determined by the purpose and utilization.

The purpose of the ASSET is to support the programs of the E&T and R&D are to improve the human development efforts, thus they constitute parts of the development while they also constitute the driving force for speeding up development.

The objectives of the programs of the E&T and R&D are aim to increasing the quality of human life. Sustainable development must be supported by health economics. In an expose on health economics, the health industries are highly labor-intensive. Therefore health development is tied closely with the redistribution of income seen from two different aspects, namely with regard to equitable distribution of the results of development, and with regard to expansion of employment opportunities. The expansion of job opportunities cannot be separated from the programs of the E&T and R&D particularly in the rural area. In this connection, one should keep in mind that in developing the IQIWR to support the programs of the E&T and R&D, one must pay heed to the local condition, such as tradition, customs and usages, standard of the ASSET and quality of infrastructure.

It is now generally accepted that the principle of the appropriate ASSET comprises:

1. Low-cost, in proportion with the income level of the local population.
2. Providing job opportunities.
3. The tools and equipment used must be required only a few and simple maintenance.
4. The equipment and material should be locally available or only small quantities need to be imported.
5. In harmony with the local socio-cultural conditions.
6. Not needing any intricate infrastructure.
7. A high added value compared with ASSET being applied.

The increase of added value shall be achieved through application of the ASSET in that word's widest sense. The ASSET developed must be adapted to social conditions, natural resources and environment.

The main constraint of the ASSET development in developing countries is the fund, material and manpower. In this connection, it will be necessary to adapt the existing ASSET and bring them into harmony with the local conditions in the countries. That is why it is necessary to emphasize the main managerial aspect that must cover the ASSET for existing tradition, customs, and desires of community with regard to the local skills.

Improving the Quality of the Indonesian Wood Research (IQIWR)

There are two approaches that must be considered in the IQIWR:

1. Prosperity Approach,
2. Security Approach.

The prosperity approach will be mainly discussed in this paper. There are four aspects that must be accounted for. They are Physical, Intellectual, Emotional and Spiritual (PIES) aspects:

1. Physical aspect,
2. Intellectual aspect,
3. Emotional aspect and
4. Spiritual aspect.

The physical basic needs are MEI:

1. Material,
2. Energy,
3. Information.

The Subsystems of the Social System are:

1. Demography (human resources),
2. Natural Resources,
3. ASSET,
4. Law and order,
5. Infrastructure.

The IQIWR should be related with the programs in the:

1. Education & Training (E&T),
2. Research and Development (R&D),
3. Industry and manufacturing,
4. Implementation and application of ASSET,
5. Repair, maintenance, and rehabilitation.

The programs of the E&T and (R&D) in developed countries are for innovation for the new ASSET, but in general, in developing countries they are for importation and utilization of the ASSET only.

Basic Requirements and Development Considerations

The first human basic need is material: food, clothing, housing, health, and education. We need to greatly increase the productivity of food production. We need to use the latest and modern ASSET for modern production, so that marketable surplus far exceeds the amounts.

The second large area for further investment in the ASSET infrastructure for energy, information, and infrastructure development and natural resources utilization.

In industrial R&D, for development and expansion of the ASSET facilities, efforts are being made to make the industrial ASSET appropriate solutions to the various problems. The needs for communication and transportation infrastructure which includes sea transportation, air transportation, land transportation, and postal and telecommunication services and a network of radio and television are also important to be concerned.

To implementation of progressive manufacturing plans requires that the industrial manufacturers adopt an active and even aggressive attitude towards the acquisition of ASSET. They cannot remain passive and static waiting for the ASSET to be passed on to them. In order to help develop this dynamics and active posture they must be sustained and supported by the ASSET institutes, providing the ASSET services relevant to the production processes and the ASSET intended to be acquired. This will become the focus of planned efforts to transfer, adapt and develop the ASSET appropriate and useful for the creation and expansion of productive processes throughout the nations.

Defense-related the ASSET is the third area in which additional investments are to be made. The need to strengthen the ASSET to support national's defense and security capability is obvious given her strategic location, her abundance of resources and her unique geographic features. One nation must be able to control her area of jurisdiction and defend it against actions endangering her sovereignty, the achievement of the Objectives of her National Development, such as equitable distribution, growth, stability, and the progress of her efforts at nation building.

One nation has to be ready to commit resources to utilize defense technologies relevant to the strengthening of her People's Defense System adapted to the national cultural, geographic, and the ASSET conditions, and to the manufacture of the weapons system appropriate to this system.

Lastly, a people committed to transfer, adapt, and further develop even the most modern ASSET and apply these in already existing cultural environments must take measures to prevent the application of the new ASSET from eroding and destroying those cultural values upon which its national identity rests. As is the case in other societies, a nation's identity is exemplified by her own unique way of working and living together and by distinctive ways social order is created and maintained. For some developing countries, they already possess ancient cultures long before she became a modern state. For the purpose of maintaining an orderly-balance between established cultural values and the new values inherent in the modern ASSET, in the social sciences, in culture and in it's philosophies of life has been designated as the fifth but perhaps the most important area in which infrastructure is to be strengthened. The development of the ASSET infrastructure in this area is geared towards the maintenance of the ability of a nation's people to preserve the compatibility of its cultural values with the progress of the ASSET in the first four areas discussed previously.

To achieve this stage of development, the ASSET and skills are indispensable. Without the ASSET, no one country will be able to develop her economic potentiality.

Successful transfer and development of the ASSET can only take place through the vehicle of consistently executed realistic and concrete programs of production which incorporate a systematic, step by step increase in the degree of comprehension and mastery of successively the more sophisticated ASSET. Only through these kinds of progressive manufacturing plans can a society develop itself into a productive power and hence a credible and respected member of the family of nations existing in the world today and in the future.

Policies on the ASSET

The policy on the ASSET must be directed toward developing national capabilities in the ASSET as necessary for the national development in accordance with the needs and priorities of national development.

The global policies on the ASSET can in broad outlines reach their targets, when the definite ASSET programs can be implemented according to plan.

However, it will still be necessary to study and formulate the supportive ASSET programs, to achieve a convergence between the plans and the results we hope for. Special attention must be given to the following:

1. Inter-institutional coordination and interaction, and particularly the optimal distribution and utilization of the available information on the ASSET.
2. The provision of funds and of skilled staff in accordance with the ASSET, whereby the development and participation of the regions in accordance with the development and participation of the regions in accordance with the development conditions must be further increased.
3. Proper inducements and remuneration for the ASSET staff who show superior performance, must be planned and formulated as a policy which shall be increasingly introduced in our society.
4. Supportive policies are also needed to distribute and popularize the modus operandi for the ASSET transfer from overseas, through involving national manpower and materials, in a programmed, systematic, and effectively phased program.
5. In taking benefit of the foreign ASSET capacities through bilateral, regional or multilateral collaboration, a mutually beneficial institutional must be pursued.
6. In determining the objectives of the ASSET programs, the results and utilization should be institutionalized harmoniously in stages.

This is appropriate, as the development of the ASSET has been funded from taxes and other government revenues raised by the community, and therefore the interests of the community should be given proper attention.

Relations between Industry and University

The Educational and Training (E&T) purposes are as follows:

1. Have obtained a firm foundation in the ASSET basis to their fields.
2. Have begun to acquire a working knowledge of the current ASSET in their area of interest.
3. Have begun to understand the diverse nature and history of human societies as well as their literary, philosophica and artistic traditions.
4. Have acquired the skills and motivation for continued self-education.
5. Have had an opportunity to exercise ingenuity and inventiveness on a research project.
6. Have had an opportunity for engineering synthesis on a design project.
7. Have developed oral and written communication skills.

8. Have begun to understand and respect the economic, managerial, political, social and environmental issues the surrounding ASSET development.

A good vision for the universities-industries cooperation should have some distinctive features including the followings:

1. Innovative and future-oriented.
2. Utopian enough to lead to a clearly better future for the organization.
3. Fitting in with the organization's culture, values and history.
4. Reaching out for new dimensions.
5. Setting standards of excellence and reflecting high ideals and aspirations.
6. Clarifying purpose and direction, including measurable objectives.
7. Inspiring enthusiasm and encouraging Commitment.
8. Reflecting the uniqueness of the organization, its identity and core competencies.

Industry can get the following advantage from its cooperation with research institutions:

1. A redefinition of industry's role, causing it to be increasingly oriented towards need and demand.
2. Consultation and counseling services on industrial property laws, design and development of products, quality control and suchlike.
3. Testing facilities.
4. Assistance in negotiations with projects and equipment suppliers.
5. Techno-economic forecasting.
6. Exchange of the ASSET information
7. Establishing communications with the overseas ASSET institutions, etc.

The factors, which encourage cooperation between the ASSET institutions, and industrial world include:

1. The improvement of communication lines, contributing to better harmony between resources and needs.
2. The involvement and responsibility of personnel, supported by a satisfactory remuneration system.
3. The mobility of personnel between the ASSET institutions and the industrial world.
4. The beneficial effect of the development projects.

Concluding Remarks

It is concluded that:

1. The development of the ASSET represent forces that strongly affect man, life, and civilization.
2. With the ASSET, most countries will be able to develop her economic potentiality.
3. The policies on the ASSET shall be directed toward developing national capabilities in the ASSET, as necessary for the national development in accordance with the needs and priorities of national development.
4. The spirit of the cooperation among scientists/academics inter-universities should very high.
5. The exchange programs are very useful for scientists, academics and engineers in order to discuss and share the latest development in the ASSET.
6. E&T and R&D activities supported by ASSET will IQIWR.

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Wood Anatomy and Fiber Quality of *Platea* spp. (Icacinaceae)

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Abstract

The demand for pulp and paper always increases, so it is important to increase the availability of raw material. Although all lignocellulosic material could be used for pulp and paper, wood is still the main source. *Platea* spp. a lesser-known wood species that has not been use yet, which could be found at some regions of Indonesia, has a potential as raw material for pulp and paper, because according to a previous study *Platea latifolia* Bl. has quite long fibre (3,280 µm). Since the previous study use only one sample, further investigation should be carried out in a more comprehensive way. Four species of *Platea* were studied, i.e. *P. excelsa*, *P. kinabaluensis*, *P. latifolia*, and *P. montana* for their macro- and microscopic features, along with their suitability for pulp. The result showed that the main microscopic characters of *Platea* spp. are: 1) growth rings boundaries indistinct, 2) vessel diffuse and mostly solitary, 3) perforation plate scalariform, 4) intervessel pits scalariform and opposite, 5) vessel diameter 90-115 µm, 6) parenchyma diffuse in-aggregates, 7) rays of 2 distinct sizes, 8) fibres very thin walled and with distinctly bordered pits; length 2,900 µ, diameter 66 µ, wall thickness 8.9 µ. Based on the fibre quality criteria by Rachman and Siagian (1976), the quality of *Platea* fibre belong to the quality class II, which means moderately good for pulp and paper. Then, based on all parameters analysed (fibre length, Runkel ratio, felting power, Muhlsteph ratio, flexibility ratio, and coefficient of rigidity), the best species for pulp and paper is *Platea latifolia*.

Key words : *Platea*, *Platea latifolia*, Icacinaceae, lesser-known species, wood anatomy, fibre quality, pulp and paper

Introduction

Indonesia is favored with mega diversity in flora and fauna. More than 4,000 tree species grow in Indonesian tropical rain forest. According to Lestari and Yoswita (2003), only 10% of these wood species have important role in wood and pulp industries. Whereas, demand for pulp and paper both domestically and internationally increases due to increasing of population, prosperity rate, and science technology development. Pusat Grafika Indonesia (2008), reported that paper consumption in Indonesia were 5.31 million ton in 2003, 5.4 million ton in 2004, 5.61 million ton in 2005, and approximation in 2009 is 6.45 million ton.

The most important factor affecting pulp and paper production is the quantity of raw material. The raw material has to be available as well as sustainable. There are various kinds of lignocellulosic material could be used for pulp and paper manufacturing like wood, bamboo, agricultural plant, clump, ragweed, etc. However, wood is still the main source of material (Sofyan *et al*, 1993).

Indonesia has 14 pulp factories with production capacity 6.7 million ton/year and 79 paper factories with production capacity 10.3 million ton/year. The realizations of pulp and paper production in 2007 were 5.8 million ton and 8.2 million ton respectively. The investment of pulp and paper national industry up to the present time reached 16 billion USD or 58% of 27.7 billion USD of total industry value of Forestry sector. In Asian market, the price of long fibre and short fibre are 760-780 USD/ton and 750-780 USD/ton in May 2008. The paper price increases (1.100 USD/ton) due to the upswing of pulp price (Hamzirwan, 2008).

According to Mandang (1996), average fibre length of *Platea latifolia* Bl. is 3.280 µ. Thereby, this wood species has a big potential as material for pulp and paper manufacturing. This led to study some other species of *Platea* wood. In addition to its long fibre, the yellow color of *Platea* spp. wood indicated that the wood has low extractive content so it will support its possibility to be used as pulp and paper raw material.

Platea spp. could be found at some regions of Indonesia. Sosef *et al* (1998) mentioned that the local name of *Platea excels* Bl. are balunan (in Batak, Sumatera), gempel (in Java), or mandalaksa (in Sunda area), whereas the

local name of *Platea latifolia* Bl. are kaci pako (in Batak, Sumatera), wuru (in Java), or ki kadanca (in Sunda area). Based on its potentiality, comprehensive research about wood anatomy and fibre quality were needed to ensure its possibility as material for pulp and paper. This information is very important because fibre dimension influence strength, and surface quality of paper (Rachman and Siagian, 1967).

The objective of this research was to study the anatomical structure of *Platea* spp. for wood identification database, and for the evaluation of their suitability for pulp and paper raw material.

Materials and Methods

Four species of *Platea* were studied, i.e. *Platea montana* Howard., *Platea latifolia* Bl., *Platea kinabaluensis* Sleumer., *Platea excelsa* Bl. Samples were provided by Xylarium Bogoriense. The selected samples are listed below.

Table 1. List of the selected samples

No.	Scientific name	Registration number	Origin
1	<i>Platea montana</i> Howard	26785	Jayapura, Papua
		29403	Serui, Papua
		29424	Serui, Papua
		3585	West Sumatra
		3587	West Sumatra
2	<i>Platea latifolia</i> Bl.	3596	West Sumatra
		32669	Balikpapan, Kalimantan
		29608	Serui, Papua
3	<i>Platea kinabaluensis</i> Sleumer	26415	Jayapura, Papua
		10000	South Sumatra
		5008	Nias Island, Sumatra
4	<i>Platea excelsa</i> Bl.	33538	Gunung Bunder, Bogor

Wood sample 1.5x1.5x1.5 cm in size were prepared and waterlogged with aquadest for one night, and then submerged into 50:50 alcohol and glycerin for 2-3 days. Then, the samples were sliced with a rotary microtome to obtain 15-25 μ thick of cross, radial and tangential section. Five best slice washed with aquadest to leach glycerin, stained with safranin, dehydrated with alcohol series (30%, 50%, 70%, 96%, and alcohol absolute), and cleared with carboxylol and toluene. The material was mounted on a glass slide with entelan and observed under a light microscope for anatomical features listed by IAWA Committee (Wheeler *et al*, 1989).

Fibre Dimension Observation

Wood chips were macerated by the use of Franklin's method (Ella, 2000), using a mixture of equal parts of 60% glacial acetic acid and hydrogen peroxide (20% by volume), heated at 80°C for 1-2 days or until the sample colorless and soft,. Macerated material washed with flowing faucet water until become acid free. The separated fibers stained with safranin for 3 hours. The fibres washed with distilled water and placed with glycerin drops into a glass slide, then arranged properly in order that they are not pile up to each other, covered and measured the fibre dimension under a light microscope. The dimension was measured comprised fibre length ($n = 50$), fibre diameter ($n = 25$), and lumen diameter ($n = 25$). Fibre quality was determined based on the Indonesian fibre quality criteria by Rachman and Siagian (1976). Fibre dimension derivative values were calculated by using the following formula:

$$\text{Runkel Ratio, } RR = \frac{2w}{l}$$

$$\text{Felting Power, } FP = \frac{L}{d}$$

$$\text{Muhlsteph Ratio, } MR = \frac{(d^2 - l^2)}{d^2} \times 100\%$$

$$\text{Flexibility Ratio, } FR = \frac{l}{d}$$

$$\text{Coefficient of Rigidity, } CR = \frac{w}{d}$$

where , w = wall thickness
 l = lumen diameter
 L = fibre length
 d = fibre diameter

The quality of fibre was classified based on the criteria as shown in the table 2.

Table 2. Fibre quality criteria for pulp and paper raw material

Criteria	Class I		Class II		Class III	
	Requirement	Score	Requirement	Score	Requirement	Score
Fibre length (mm)	> 2.000	100	1.000-2.000	50	< 1.000	25
Runkel Ratio (RR)	< 0,25	100	0,25-0,50	50	0,50-1,0	25
Felting Power (FP)	> 90	100	50-90	50	< 50	25
Muhlsteph Ratio (MR)	< 30	100	30-60	50	60-80	25
Flexibility Ratio (FR)	> 0,80	100	0,50-0,80	50	< 0,50	25
Coefficient of Rigidity (CR)	< 0,10	100	0,10-0,15	50	> 0,15	25
Interval	450-600		225-449		< 225	

Source: Rachman dan Siagian (1976)

Results and Discussion

The macro and microscopic features of *Platea* is described below. Photos of transverse, radial and tangential section are presented in figure 1 to 4. Details of several quantitative properties are presented in table 3.

Description

Gross features

Color : wood pale yellow or straw colored, indistinct whether heartwood or sapwood
 Texture : coarse and even
 Grain : straight
 Gloss : wood surface lusterless
 Feel : rough
 Hardness : soft

Microscopic features

Vessel : diffuse-porous, mostly solitary, solitary vessel outline angular, diameter 90-115 μ , frequency 11-16 per mm², length 1937-2058 μ ; scalariform perforation plate with ≥ 40 bars; intervessel pits scalariform and opposite (Figure 5); opposite intervessel pits dimension 12-17 μ , vessel-ray pits with distinct borders, similar to inter-vessel pits in size and shape.

Parenchyma: apotracheal, diffuse in-aggregates, with 2-21 cells per strand

Rays : of two distinct sizes, uniseriate and multiseriate, larger rays commonly 3-7 seriate, uniseriate ray composition is homocellular with 2-21 rows of upright ray cells, multiseriate ray composition is heterocellular with body ray cells procumbent with 2-10 rows of upright and/or square marginal cells. Height 1505-1907 μ with frequency 7-8 rays per mm.

Fibres: with distinctly bordered pits (Figure 6), septate and nonseptate fibres present, very thin- to thin-walled.

Intercellular canal: absent

Mineral inclusion : absent

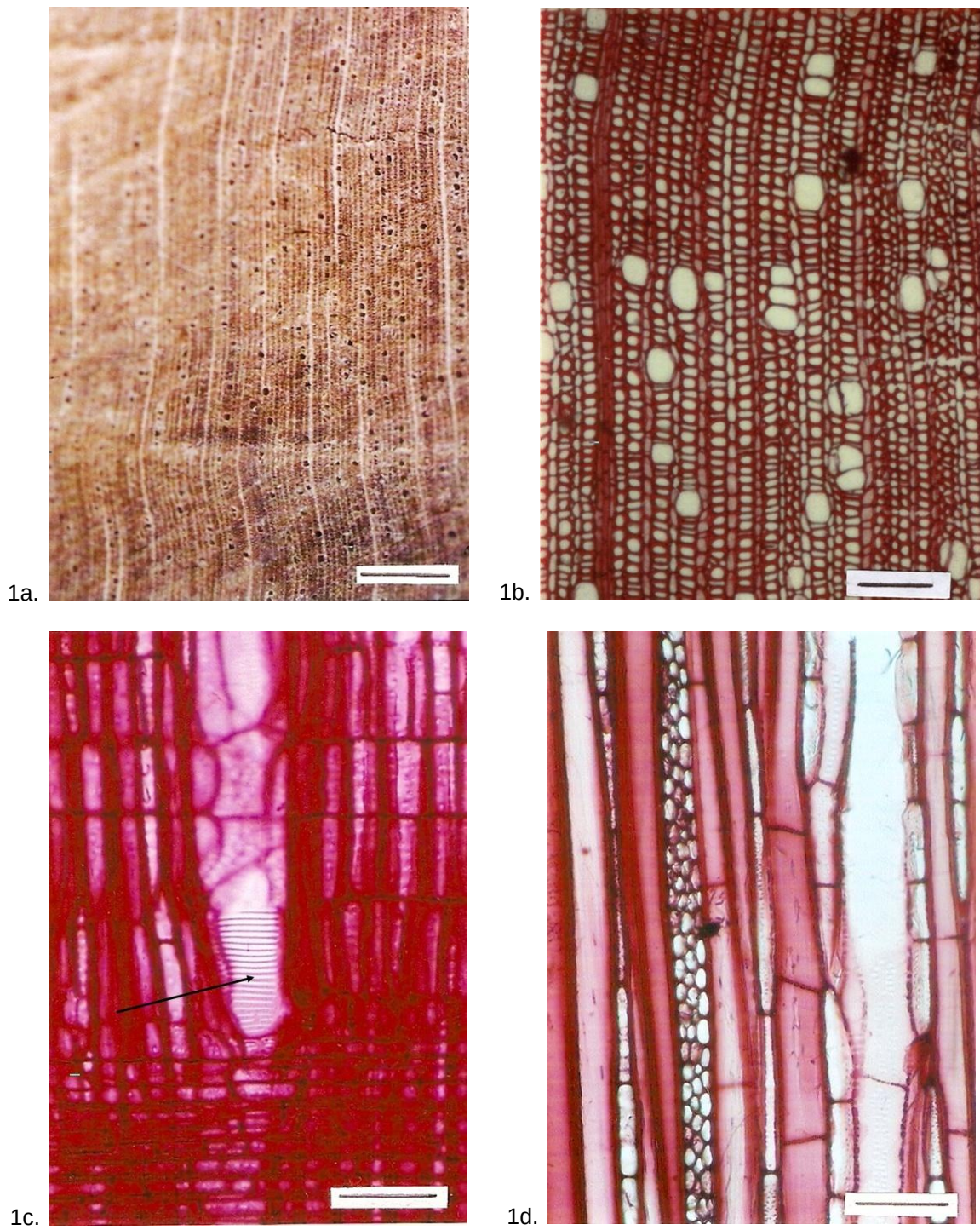


Figure 1. *Platea montana*: a) transverse surface (scale bar 1 mm), b) transverse surface (scale bar 200 μ), c) radial surface (scale bar 100 μ), and d) tangential surface (scale bar 100 μ), $\rightarrow$: scalariform perforation plate.

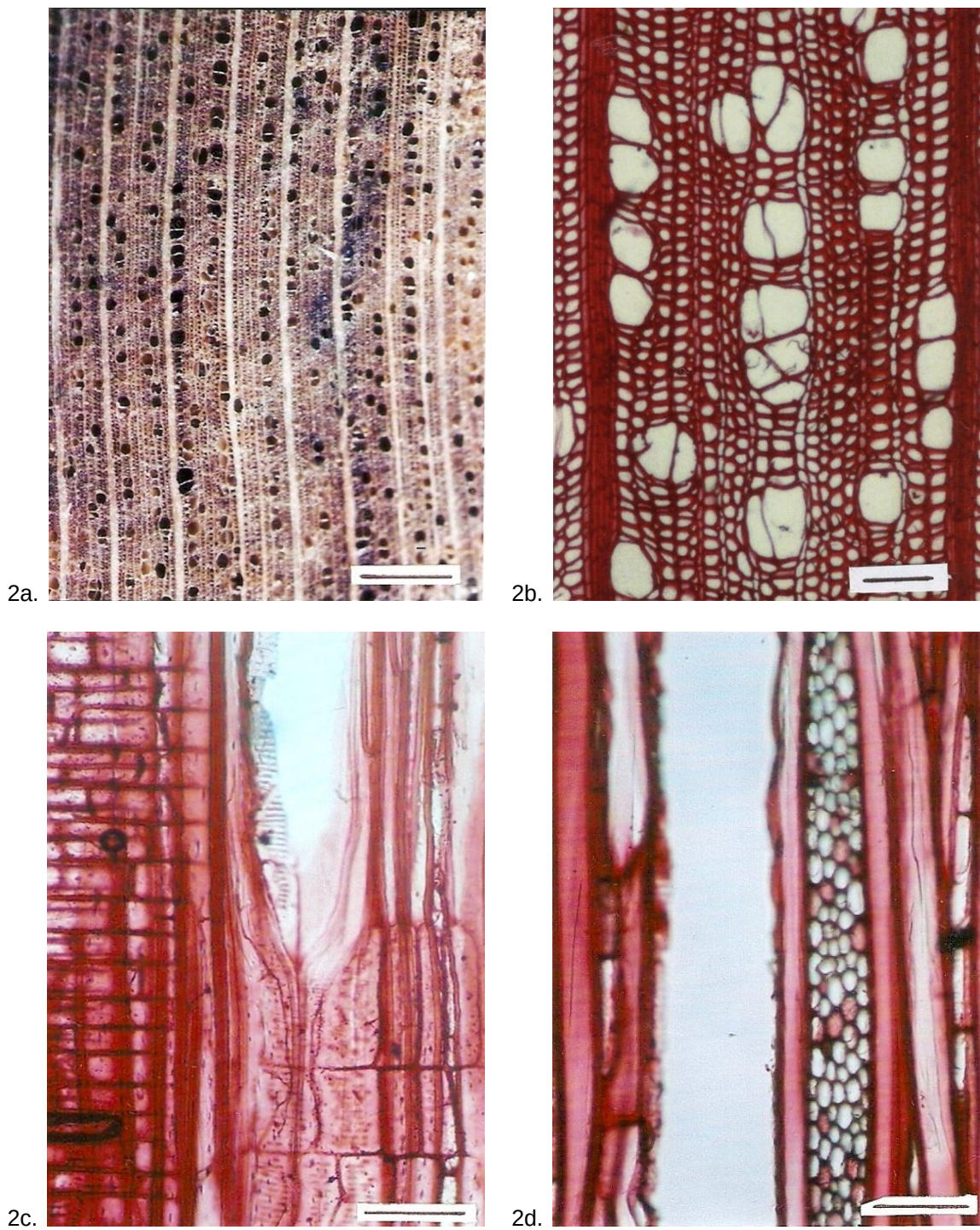


Figure 2. *Platea latifolia*: a) transverse surface (scale bar 1 mm), b) transverse surface (scale bar 200 μ m), c) radial surface (scale bar 100 μ m), and d) tangential surface (scale bar 100 μ m)

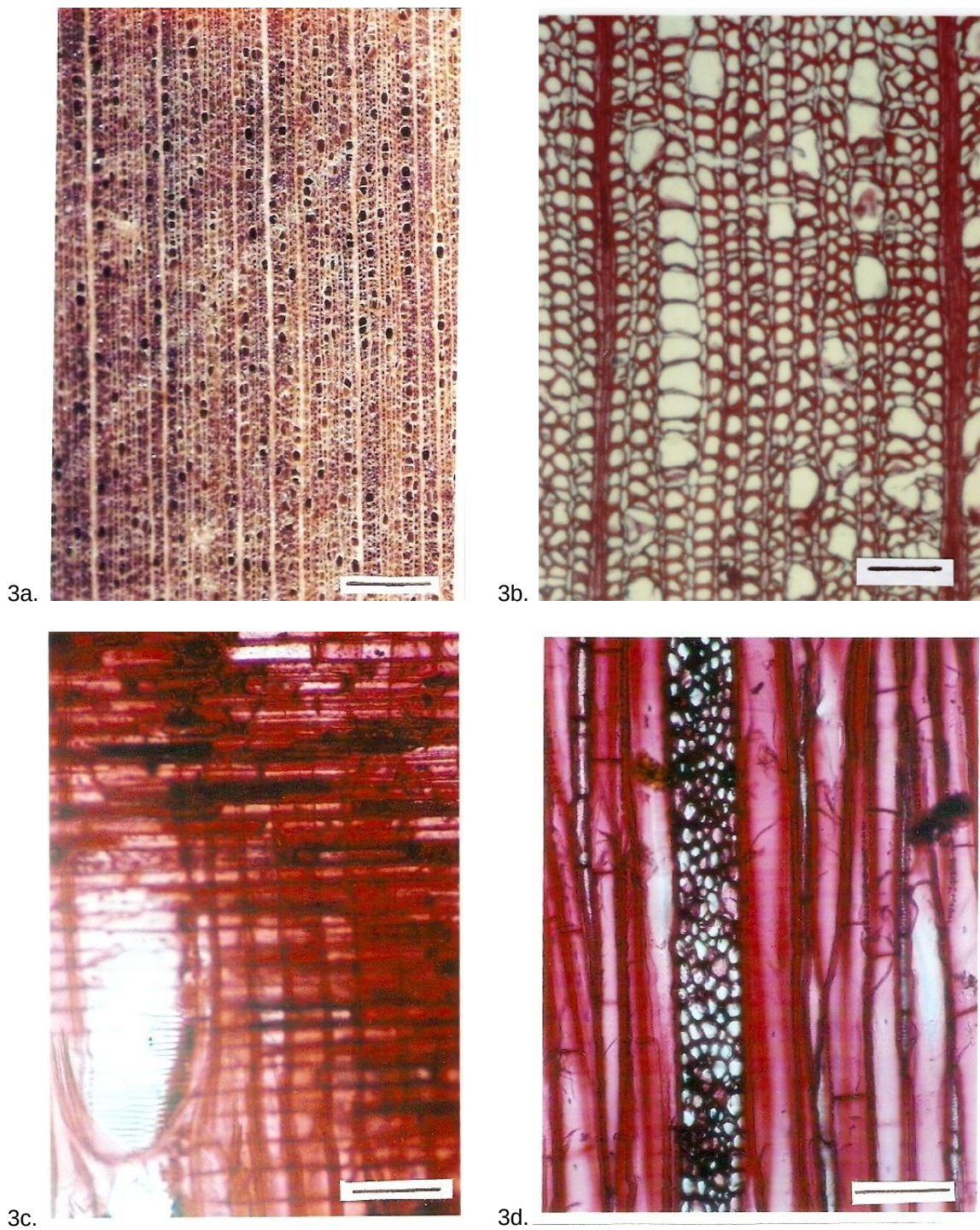


Figure 3. *Platea kinabaluensis*: a) transverse surface (scale 1 mm), b) transverse surface (scale bar 200 μ), c) radial surface (scale bar 100 μ), and d) tangential surface (scale bar 100 μ)

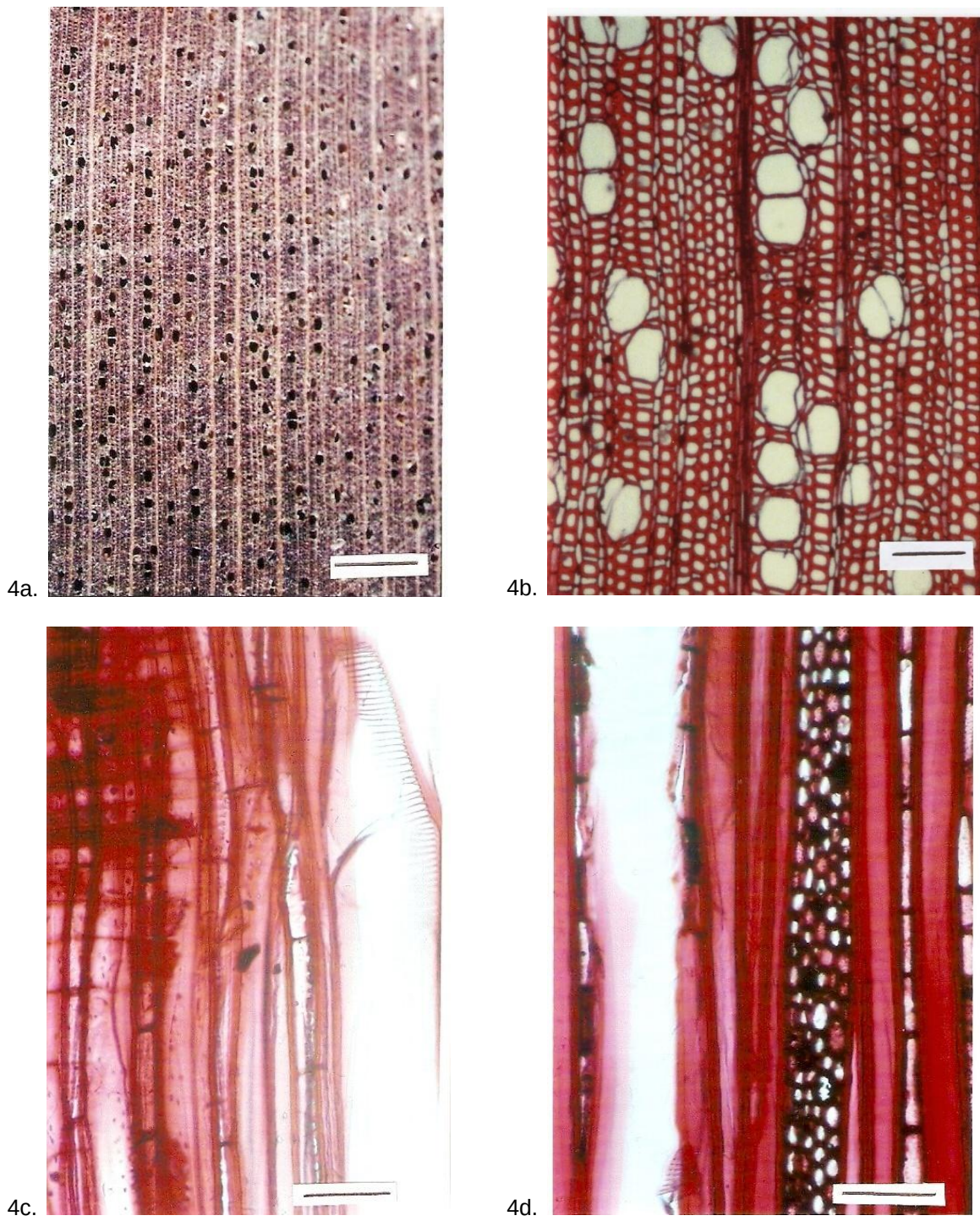


Figure 4. *Platea excelsa*: a) transverse surface (scale bar 1 mm), b) transverse surface (scale bar 200 μ), c) radial surface (scale bar 100 μ), and d) tangential surface (scale bar 100 μ)

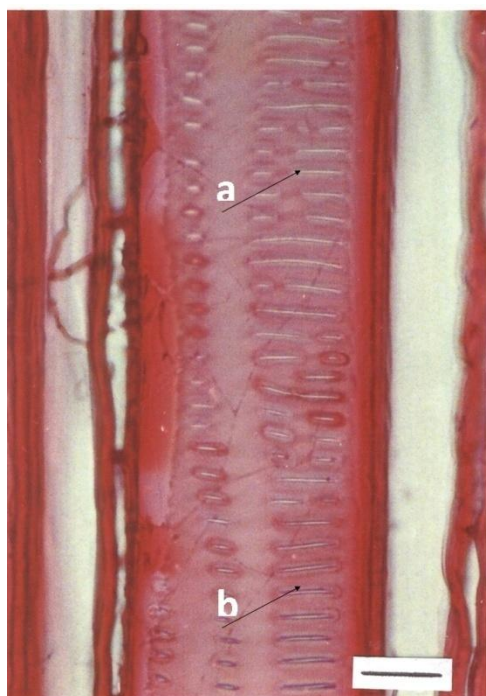


Figure 5. Intervessel pits (scale bar 40 μ):
a. opposite, b. scalariform

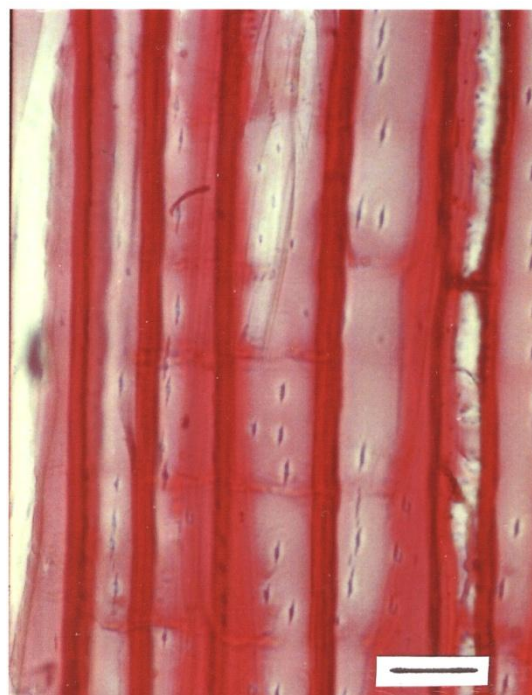


Figure 6. Fibers with distinctly bordered pits
(scale bar 40 μ)

Table 3. Comparison of several quantitative features among four species of *Platea*

Number	Anatomical features	Species			
		<i>Platea montana</i>	<i>Platea latifolia</i>	<i>Platea kinabaluensis</i>	<i>Platea excelsa</i>
Vessel:					
1.	Diameter (μ)	92±4,7	115±3,3	90±5,8	105±7,0
2.	Vessels per mm²	12±1	11±1	16±1	16±2
3.	Mean vessel length (μ)	2049±80	2058±123	1937±122	2044±138
Parechyma:					
4.	Cells per rows	3-10	5-15	2-21	6-11
Rays:					
5.	Ray height (μ)	1505±197	1907±264	1798±286	1564±293
6.	Rays per mm	7	7	7	8

Fibre Quality

Fibre length

Based on the fibre quality criteria by Rachman and Siagian (1976), fibre length value of all species included in to class quality I, even though the longest is *Platea montana*.

Table 4. Fibre length of *Platea* spp.

Species	Fibre length (μ)	Score	Quality Class
<i>Platea montana</i>	2.979	100	I
<i>Platea latifolia</i>	2.946	100	I
<i>Platea kinabaluensis</i>	2.847	100	I
<i>Platea excelsa</i>	2.830	100	I

Runkel Ratio

Based on the Indonesian fibre quality criteria by Rachman and Siagian (1976), the Runkel ratio value of *Platea* fibre included in to class quality II. The best quality is *Platea latifolia*.

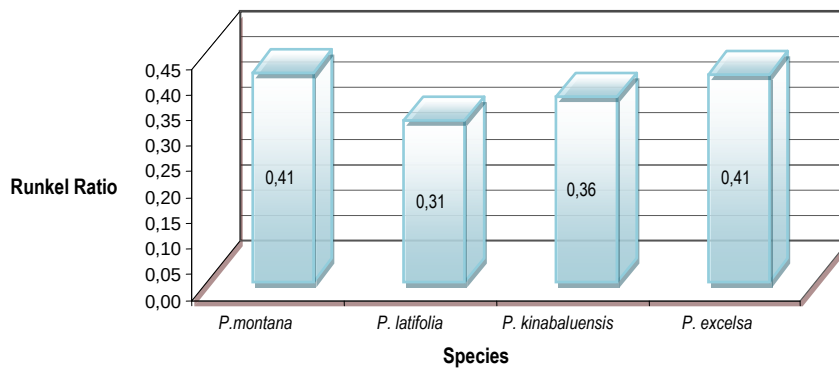


Figure 7. Runkel ratio value diagram

Felting Power

Based on the Indonesian fibre quality criteria by Rachman and Siagian (1976), the felting power value of *Platea* fibre included in to class quality III. The best is *Platea montana*.

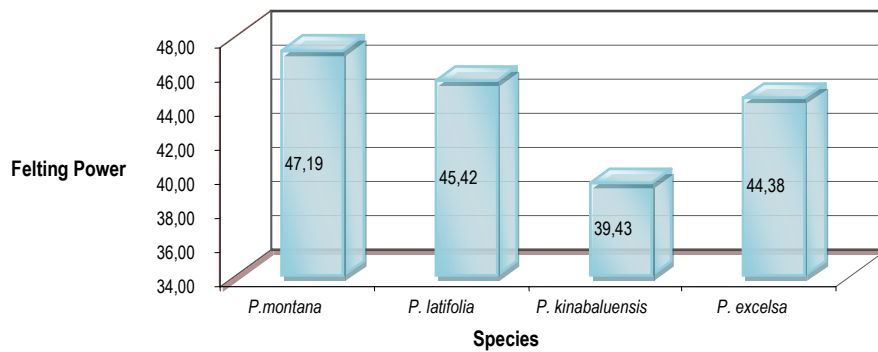


Figure 8. Felting power value diagram

Muhlsteph Ratio

Based on the Indonesian fibre quality criteria by Rachman and Siagian (1976), Muhlsteph ratio value of *Platea* fibre included in to class quality II. The best is *Platea latifolia*.

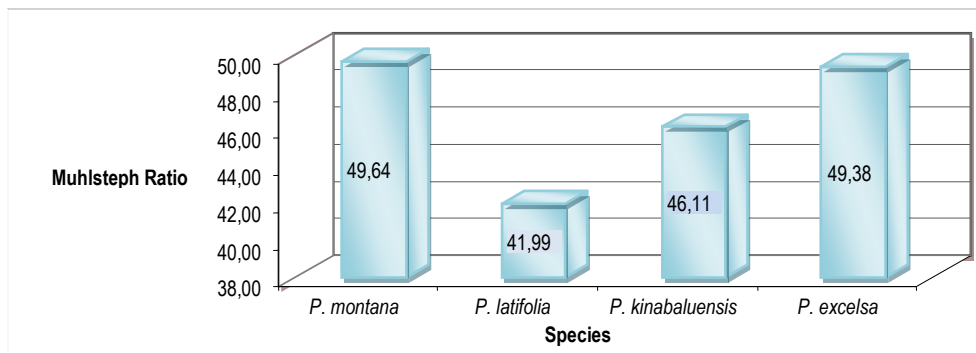


Figure 9. Muhlsteph ratio value diagram

Flexibility Ratio

Based on the Indonesian fibre quality criteria by Rachman and Siagian (1976), the flexibility ratio value of *Platea* fibre included in to class II. The best is *Platea latifolia*

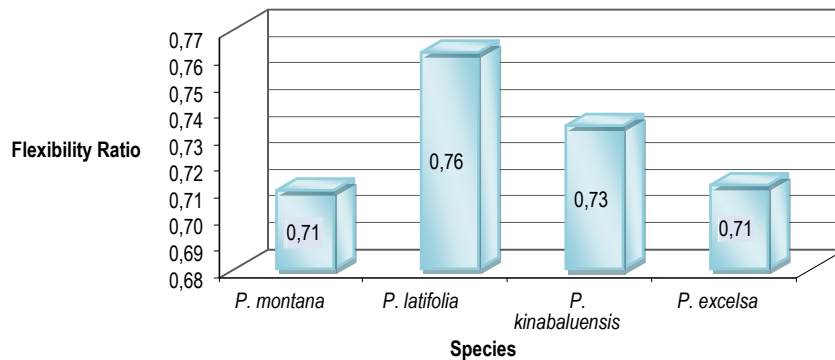


Figure 10. Flexibility ratio value diagram

Coefficient of Rigidity

Based on the Indonesian fibre quality criteria by Rachman and Siagian (1976), coefficient of rigidity value included in to class II. The best is *Platea latifolia*.

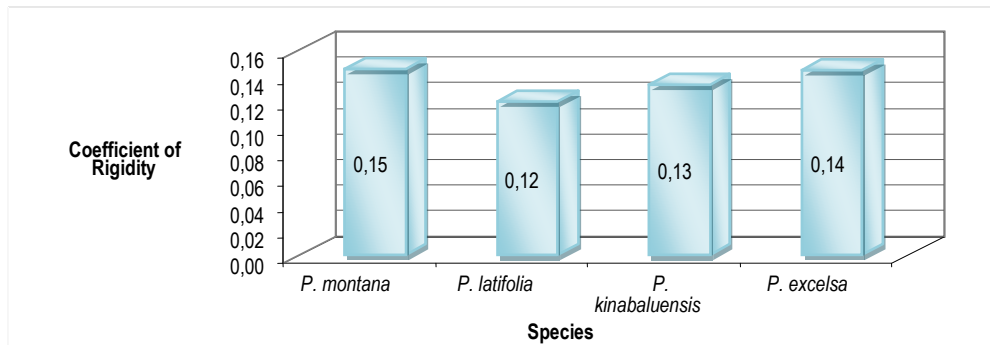


Figure 11. Coefficient of rigidity value diagram

Based on all parameters analysed (fibre length, Runkel ratio, felting power, Muhlsteph ratio, flexibility ratio, and coefficient of rigidity), the best species for pulp and paper raw material is *Platea latifolia*. Therefore, *Platea latifolia* is recommended to be cultivated for pulp and paper raw material.

Fibre quality class II has moderate tear resistance, crack resistance, tensile strength. It is because the fibres are easy to be flattened in pulp sheet making (Rachman and Siagian, 1976).

Comparison of Fibre Quality between *Platea latifolia* and *Acacia mangium*

Table 5. Comparison of fibre quality between *Platea latifolia* and *Acacia mangium*

Characteristics and Fibre Derivative Dimension	<i>P. latifolia</i>	Score	<i>A. mangium</i> *	Score
Fibre Length (μ)	2.946	100	1017,5	50
Fibre Diameter (μ)	64,9	-	20,3	-
Lumen Diameter (μ)	49,3	-	11,8	-
Wall Thickness (μ)	7,8	-	4,3	-
Runkel Ratio	0,31	50	0,73	25
Felting Power	45,42	25	50,12	50
Muhlsteph Ratio	41,99	50	66,21	25
Flexibility Ratio	0,76	50	0,58	50
Coefficient of Rigidity	0,12	50	0,21	25
Total	-	325	-	225
Quality	Quality Class II		Quality Class II	

Note: * Sahri *et al.* (1993)

Table 5 shows that *P. latifolia* and *A. mangium* are both under the same quality class, but the scoring showed that *P. latifolia* is better than *A. mangium*.

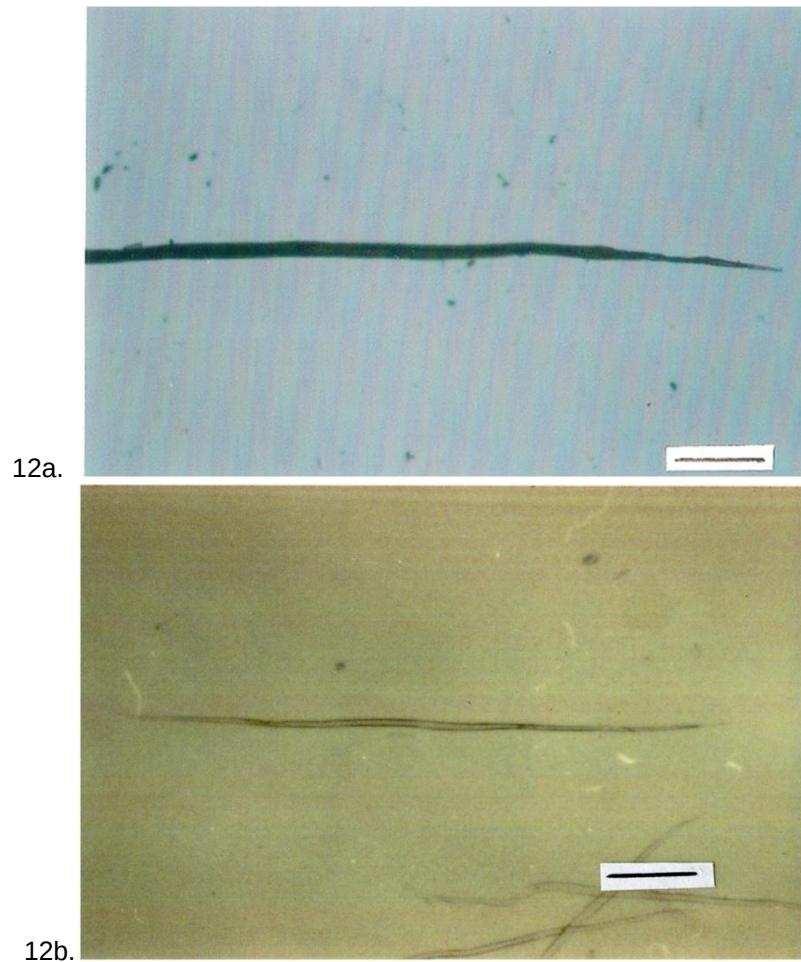


Figure 12. Fibres: a) A part of *P. latifolia* fibre (scale bar 200 μ), and b) A whole fibre of *A. mangium* (scale bar 200 μ)

Conclusion

The sapwood and heartwood of *Platea* spp. wood are both yellow or straw colored difficult to be distinguished one from the other; texture coarse and even, grain straight, and the hardness is soft.

The main microscopic characters of *Platea* wood are: 1) growth rings boundaries indistinct, 2) vessel diffuse mostly solitary, 3) perforation plate scalariform, 4) intervessel pits scalariform and opposite, 5) vessel diameter 90-115 μm , 6) parenchyma apotracheal diffuse in-aggregates, 7) rays of 2 distinct sizes, 8) fibres with distinctly bordered pits, very thin walled; length 2,900 μ , diameter 66 μ , wall thickness 8.9 μ .

The fibre quality of *Platea* spp. included in to class quality II which mean moderately good. However, among the four species studied *Platea latifolia* is considered to be the best.

Recommendation

1. Further research is needed to study pulp and paper quality of *Platea latifolia* trough experimentation on pulp and paper making.
2. Sylvicultural research on *Platea latifolia* is needed to anticipate it's utilization in wide scale.

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Microfibril Angle and Degree of Crystallinity of Several Woods

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Abstract

The aim of this study was to use *XRD-Diffractometer (Shimadzu, XRD-7000)* to determine microfibril angle and degree of crystallinity of several wood with different specific gravity. Several wood are keruing wood (high specific gravity 0.7), jand sungkai wood (middle specific gravity 0.6) and sengon (low specific gravity 0.3). Sample from slice wood were 40 μm thick, 1 cm length and 0.5 width. The Experimental condition were : symmetric transmission configuration, horizontal goniometer and the 002 reflection. The results show that specific gravity were corellation negatif with MFA (sengon wood, 18°, sungkai wood 18.4°, jati wood 11.71° and keruing wood 10.38°), but tendency specific gravity were not influenced degree of cristallinity. The degree of cristallinity was influenced cell wall density. Cell wall density keruing wood (1331,418 kg m^{-3}), jatii wood (1375,896 kg m^{-3}), sengon wood (1413,986 kg m^{-3}). The degree of cristallinity was increased (keruing wood 52,44 %, jati wood 59,32 % and sengon wood 64,62 %) with high cell wall density.

Key words : MFA, Degree of cristallinity, Specific gravity, Cell wall density

Introduction

The effort known wood quality were as wood for construction many to explain, the other considered with specific gravity. Variation of specific gravity were much influenced by type and proportion cell so the other wood quality parameter were necessary to considered especially for stiffness (Modulus of Elasticity (MOE)). The other wood quality parameter was Microfibril Angle (MFA), degree of crystallinity and cell wall density.

MFA of a cellulose fiber is defined as the angle of cellulose fiber with the stem axis (Butterfield, 2003 : Evans, 1998 : Stuart & Robert, 1994). MFA has an influence mechanical properties, physis properties and chemistry properties particularly density, *tensile strength*, *stiffness*, swelling and shrinkage (Stuart & Robert, 1994 : Butterfield, 2003). Relationship with MFA and MOE was negative correlation, high values in MFA, low value's MOE. Degree of crystallinity was most important mechanical wood properties (Peura et al., 2007). The cell wall of fiber consists of cellulose, hemicellulose, lignin etc (Panshin and de Zeeuw, 1980 ; Sjostrom, 1993). Respectively chemistry component in cell wall has different volume and density until would influence cell wall density. The cell wall were increased when cellulose content and degree of crystallinity were increased (Kellogg et al., 1975 cited Saranpää, 2003). The cell wall density has an influence mechanical properties especially stiffness.

Methods of measuring MFA have been used in angiospermae and gymnospermae, such as XRD (X-ray diffraction), SAXS (Small angle X-ray scattering), WAXS (Wide angle Scattering), PLM (Polarisation microscopy), EW (Early wood) dan LW (Late wood). XRD could be measured degree and dimension degree of crystallinity cellulose (Andersson, 2006). At this moment has not been measured MFA and degree of crystallinity on hardwood from Indonesia. The research aim were to known MFA and degree of crystallinity of hardwood on several specific gravity (sengon wood, jati wood, sungkai wood and keruing wood) used X-ray Diffractometer. Information about MFA and degree of crystallinity were to knowledge use wood for construction.

Materials and methods

Sample Preparation

That wood sample were result from collection Division of Anatomy, Research and Development Forest Product, Ministry of Forestry, Bogor. The fourth species were choice cause specific gravity : high (keruing wood, 0,7), middle (jati and sungkai wood, 0,6) and low (sengon wood, 0,33). Slice wood were prepared by cutter. A finished sample size was thick 40 mikron, width 0.5 cm and length 1 cm.

Measured MFA and Degree of Crystallinity

X-ray Diffractometer, (Shimadzu, XRD-7000) were measured for microfibril angle and degree of crystallinity. The experimental conditions were : symmetric transmission configuration, horizontal position goniometer and 002 reflection.

a. Measured of Microfibril Angle

Meylan (1967) cited Stuart and Robert (1994) found that the microfibril angle was connected to the T of parameter by equation below :

$$\text{MFA} = 0.6 T$$

T Values is calculated from The FWHM (Full Width at Half Maximum) with zero intensity line and slope of the diffraction arcs with inflection point, See Figure 1.

b. Degree of crystallinity Measurement

Degree of crystallinity is combination of crystalline and amorphous material on cellulose. The calculated degree of crystallinity at X-Ray diffraction is the peak area ratio of the two kinds of components. Figure 2. Degree of Crystallinity Calculation Result Screen.

c. Methods were measured cell wall density :

% Cellulosa x Cellulosa density kg m^{-3} = a kg m^{-3}

% Hemicellulosa x Hemicellulosa density kg m^{-3} = b kg m^{-3}

% Lignin x Lignin density kg m^{-3} = c kg m^{-3}

Cell wall density is a + b + c kg m^{-3}

Results and Discussion

X-ray Diffraction measurements of MFA and degree of crystallinity from keruing wood, jati wood, sungkai wood and sengon wood were forwarded in Tabel 1. This research is preliminary study, MOE values were taken from Martawijaya et al. 1989. Cell wall density were measured with several research before.

Saranpää (2003) stated that cellulose density is 1557 kgm^{-3} , lignin density is 1347 kgm^{-3} and hemicellulosa density is 1622 kgm^{-3} and Martawijaya et al (1989) stated that chemistry component of wood have cellulose, hemicellulose and lignin content, respectively : keruing wood (cellulosa 51.4 %, hemicellulosa 16.8 %, and lignin 19.2 %), jati wood (cellulosa 47.5 %, hemicellulosa 14.4 %, and lignin 29.9 %), sungkai wood (cellulosa 48.6 %, hemicellulosa 16.5 %, and lignin 26.7 %) and sengon wood (cellulosa 49.4 %, hemicellulosa 15.6 %, and lignin 26.8 %) , cell wall density are respectively see Table 1.

Many research were recommended MFA relationships with length of tracheid/fibre, The explanation was tilted that moreover length tracheid/fibre was narrow MFA. The other relationship, MFA of latewood were smaller than MFA of earlywood (Stuart & Robert, 1994). Cell wall of latewood was thick than cell wall of earlywood so MFA was negative correlated with thick cell wall. High specific gravity has dense cell wall than low specific gravity. It is therefore high specific gravity would influence MFA. See Table 1. MFA of sengon, jati, sungkai and keruing is knowledge to small when specific gravity is increases, influence cell wall density.

Herman et al., (1999) is indicates that relationships between MFA and growth tree. Norway spruce is fast-grown have MFA (29°) higher than MFA of slow-grown (21°). The trees have early growth trend low specific gravity cause cell wall thickness. The tree fast growing were lower specific gravity/density cause thin cell wall and larger void the cell, automatically larger MFA. This research, MFA of sengon wood (fast growing) were larger than MFA of jati, sungkai and keruing (slow growing). MFA was correlated negative with cell wall density.

The values for degree of crystallinity from this research are describes pattern with specific gravity. Moreover specific gravity was lower degree of crystallinity apart from sungkai wood. The cell wall density was influenced of cellulose content and degree of crystallinity (Kellogg et al., 1975 in Saranpää, 2003). Cellulose content of keruing wood was higher than cellulose content of sengon wood and cell wall density of sengon wood was lower than keruing wood. Relationships of degree of crystallinity, degree of crystallinity of sengon wood were higher than keruing wood. This research was positively correlated to degree of crystallinity correlation and cell wall density.

The parameter of wood quality such specific gravity were used to construction very important. There were depended of cell wall density and not direct by cellulose crystallinities in cell wall. Crystallinities cellulose is most important factor to adding to mechanical properties of wood such as stiffness (Peura et al., 2008) Mechanical properties of wood (stiffness) were influenced of cell wall density than specific gravity, like that MFA were influenced stiffness more than specific gravity (Barnett & Bonham, 2004).

MFA and degree of crystallinity values (Table 1.) of keruing wood, sungkai wood, jati wood, and sengon wood were negatively correlated with modulus of elasticity, that's means sengon wood was elastic (not inflexible) than keruing wood or MOE per unit weight sengon wood were lower than jati and keruing wood. MFA has negatively correlated with dry weight cell wall, stiffness and shrinkage longitudinal (Stuart & Robert, 1994).

Beside of degree of crystallinity, dimensions of cellulose crystallinities is also suitable for studying in used wood for construction. Length of cellulose crystallinities were influenced properties of elasticity. Some wood have short length of cellulose crystallinities and regular make that's wood more elastic than wood have long length of cellulose crystallinities and not regular.

Conclusion

The conclusion of this research are MFA and degree of crystallinity were increased, when specific gravity was decreased and Stiffness properties were influenced MFA, degree of crystallinity and cell wall density than specific gravity.

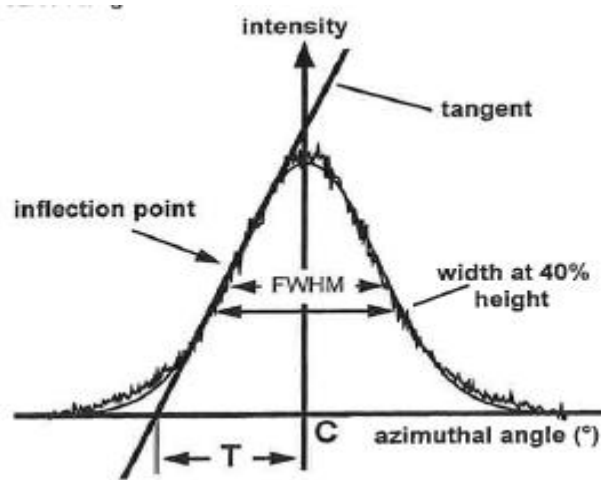
Acknowledgement

I would like to thank to Ratih Damayanti, S.Hut on her wood sample. All species were taken from wood collected the Wood Anatomy Laboratory, Research and Development Wood Products, Ministry of Forestry, Bogor.

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Suplement :



.Figure 1. Measurement T Value

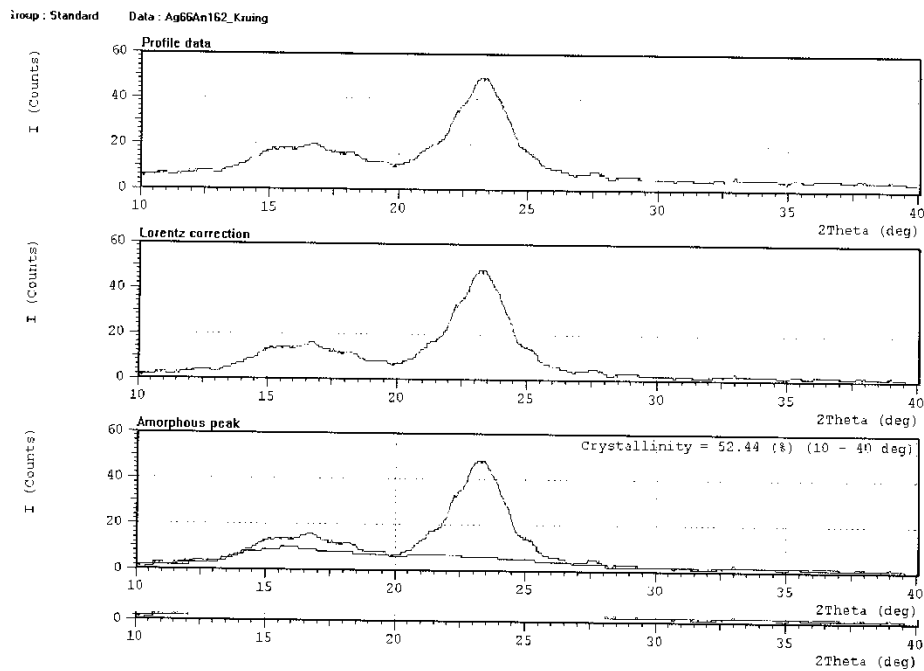


Figure 2. Degree of Crystallinity Calculation Result Screen

Table 1. MFA and Degree of Crystallinity of Keruing Wood, Teak Wood, Sungkai Wood and Sengon Wood

Species	SG	MFA (Derajat)	Degree of Crystallinity (Derajat)	MOE *	Cell Wall Density** kgm ⁻³
Keruing	0.7	10.38	52.44	132,000-209,000	1,331.42
Jati	0.6	11.71	59.32	127,700	1,375.89
Sungkai	0.6	18.44	41.63	84,000	1,383.98
Sengon	0.3	18.00	64.62	44,000	1,413.98

Keterangan :

* = Data cited Martawijaya et al. 1989

** = Simulation several research before

Chemical Component and Anatomical Features of Three Species of Bamboo

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Abstract

As a versatile plant, the basic properties of bamboo are vary depend on species, site, and position inside the stem. This study was conducted at three sites (Buria, Morekao, Tala), on three species (*Dendrocalamus asper*, *Schizostachyum brachycladum*, *Schyzotachium lima*), and three position of the stem (base, middle, top). Objective of the study is to measure chemical component and anatomical features of three species of bamboos (*Dendrocalamus asper*, *Schizostachyum brachycladum*, *Schyzotachium lima*) of West Ceram's sub-district (Taniwel, Piru, Kairatu), and three part of stem (base, middle, top). Factorial experiment in split plot design was applied in the study with 3 replications.

Result of the study indicated that there was significant effect of location to the lignin content, diameter of fiber and fiber cell lumen, and proportion of parenchyma cell; species of bamboos to the length and diameter of fiber cell; and portion of stem to the extractive soluble in hot water, soluble in alcohol benzene, length and diameter of fiber cell, and diameter of fiber lumen. Extractive soluble in cold water was 3.10%-3.79%; hot water was 5.43%-6.23%; alcohol benzene was 3.37%-4.10%; alpha cellulose was 44.22%-46.94%; holo cellulose was 71.97%-75.57%; lignin was 26.00%-27.37%; length of fiber cell was 3.40mm-3.96mm; diameter of fiber cell was 4.34micron-4.91micron; diameter of fiber cell lumen was 2.74micron-3.23micron; cell wall thickness of fiber cell was 0.76micron-0.91micron; proportion of parenchyma cell was 51.95%-56.85%; proportion of fiber cell was 27.81%-62.66%; and proportion of pore was 12.39%-14.60%.

Key words : bamboos, chemical component, extractive, cellulose, lignin, anatomical features.

Introduction

At Ceram island , people can find naturally wild bamboo especially several at sub district Taniwel, Piru and Kairatu. At Taniwel, chopstick company was used wild bamboo as raw material unfortunately it had been closed because of mismanagement even though there is big potential of bamboo.

There is several furniture and handicraft producer made of bamboo as a household business at Piru. Traditionally, local people was used wild bamboo for daily life based on their experiences such as Petung (*Dendrocalamus asper*), Sero (*Schizostachyum brachycladum*), and Tui (*Schizostachyum lima*). The value and suitable of bamboo to form one product was not depend only the experiences but also basic properties of bamboo which is not common recognize by people and industry. One of basic properties are chemical component and anatomical features of bamboo. Based on the basic properties, the use bamboo as raw material in such product might be encourage that the kind of product is common practice traditionally by local people. In the other hand, such product might be developed with reliable technology and processes that promoted in the future. Together with the study is to collect data and information about the relationship between basic properties of bamboo with location, species and portion of the cane.

Objective of the study was to determine chemical component and anatomical features of 3 (three) species of bamboo such as petung (*Dendrocalamus asper*), sero (*Schizostachyum brachycladum*), and tui (*Schizostachyum lima*) at 3 (three) sub districts such as Taniwel, Piru and Kairatu, and 3 (three) portion of the cane (bottom, middle, top).

Materials and Methods

Bamboo cane was collected from 3 (three) village (Buria, Morekao and Tala) of West Seram District, Mollucas. Chemical component analyses was conducted at Laboratorium Kimia Dasar Unpatti, mechanical properties at Politeknik Unpatti, Ambon, and anatomical features at Faculty of Forestry, UGM Jogya. 3 (three) bamboo cane was cut from the clump, then it was cut into 3 (three) portions (bottom, middle, top). 3 (three) specimen of bamboo as

replication was cut from each portion of the cane to determine chemical component and anatomical features. Kinds of the specimen comply the standard requirement such as,

- a. Samples for chemical component of bamboo was made in form of sawdust. Solvent and reagent was used such as alcohol benzene, H₂O; glacial acetic acid, NaCl₂, ice, acetate acid 1% and 10%, acetone, NaOH 17,5%, water, H₂SO₄ 72%, hot water and filter.
- b. Samples for anatomical features was made in form of thin slice of bamboo which is cut by microtome and small pieces of bamboo for maceration. Solvent and reagent was used such C₂H₅OH, H₂O₂, safranin, xylol (C₅H₁₀), H₂O, canada balsam and acetate acid glacial.

Methods

Determination of chemical component such as soluble cold water and hot water extractives based on ASTM D1110-56 (1985) procedures, soluble alcohol benzene extractives based on ASTM D1105-96 (1985) procedures; holo cellulose based on ASTM D 1104-56 (1985) procedures; alpha cellulose based on ASTM D1103-60 (1985) procedures; and lignin based on ASTM D110-84 (1985) procedures.

$$\text{Extractives (\%)} = 1 - \frac{\text{BKO}_e (1 + K_a)}{B_b} \times 100\% \quad (1)$$

$$\text{Holo cellulose (\%)} = \frac{\text{BKO}_h}{\text{BKO}_{\text{SBE}}} \times 100\% \quad (2)$$

$$\text{Alpha cellulose (\%)} = \frac{\text{BKO}_a}{\text{BKO}_{\text{SBE}}} \times 100\% \quad (3)$$

$$\text{Lignin (\%)} = \frac{\text{BKO}_{\text{Lignin}}}{\text{BKO}_{\text{SBE}}} \times 100\% \quad (4)$$

Note :

- BKO_e = oven dry weight of sawdust after extraction (gram)
- K_a = moisture content of sawdust (%)
- B_b = early weight of sawdust (gram)
- BKO_{SBE} = oven dry weight of sawdust without extractives (gram)
- BKO_h = oven dry weight of holo cellulose (gram)
- BKO_a = oven dry weight of alpha cellulose (gram)
- BKO_{Lignin} = oven dry weight of lignin (gram)

Determination of anatomical features based on procedures by LPHH (Silitonga dkk, 1972) and Kaakinen methods (2004), and Nugroho dkk (2005) such as fiber dimension and cell proportion. Formula to measure one hundred of fiber based on Kasmudjo (1998) as follow,

$$N = \frac{4S^2}{L^2} \quad \text{and} \quad S^2 = \frac{\sum f_i X_i^2}{n} - \left(\frac{\sum f_i X_i}{n} \right)^2 \quad \text{and} \quad L = \frac{\sum f_i X_i}{n} \times 0,05 \quad (5)$$

- N = number of fiber to be measure
- S = standard of deviation
- L = fiber length's average multiply by 0,05 (5 percent error is adequate)
- X_i = fiber length
- F_i = fiber frequency which possess the same dimension.
- N = number of fiber which had been measure at the beginning of one hundred fiber

Determination of fiber diameter and lumen had been measure directly using *Image Pro Plus V 4.5* program. Cell proportion measurement based on *Image Pro Plus V 4.5* program with *spacing* horizontal and vertical for one hundred cell and photo of cell anatomy at cross section plate (x). Based on the photo, number of dot grid have to be measure by using manual tag. Result of the measurement had to be transfer to Microsoft Excel program (Nugroho dkk, 2005).

Data was analyzed using factorial experiment in split plot design with 3 (three) replication. Kinds of chemical component of bamboo was analyzed such as extractives soluble in cold water, soluble in hot water, soluble in alcohol benzene, alpha cellulose, holo cellulose and lignin. Anatomical feature such as fiber dimensions (length of fiber, diameter of fiber, diameter of fiber lumen, cell wall thickness of fiber), proportions of fiber cell, parenchyma cell and pores.

Linier model of equation was made based on effect of 3 (three) factors such as location, species and portion of the cane, such as

$$Y_{ijk} = \mu + A_i + B_j + C_k + (AB)_{ij} + (AC)_{jk} + (BC)_{jk} + (ABC)_{ijk} + \sum_{ijk} \dots \dots \dots (6)$$

A, comprised of (3) three location such as Buria (Kecamatan Taniwel. Morekao (Kecamatan Piru) dan Tala (Kecamatan Kairatu).

B, comprised of (3) three species of bamboo such as petung (*Dendrocalamus asper*), sero (*Schizostachyum brachycladum*) dan tui (*Schizostachyum lima*).

C, comprised of (3) three portion of the cane such as bottom, middle and top portion

Result and Discussion

Chemical Component and Anatomical Features According to Location, Species and Portion of the Cane

Table 1 was listed down chemical component, anatomical features and whether or not there was significant effect of 3 (three) factors.

Chemical component and anatomy features	Significance	Location			Species			Portion of the cane		
		B	M	TL	P	S	T	bottom	middle	top
CHEMICAL COMPONENT (%)										
Soluble cold water	n - n - n	3.70	3.61	3.32	3.59	3.46	3.59	3.59	3.65	3.30
Soluble hot water	n - n - **	6.23	5.77	5.50	5.92	5.88	5.70	6.52	5.44	5.43
Sol. Alcohol benzene	n - n - **	3.74	3.79	3.49	4.10	3.43	3.49	3.89	3.82	3.37
Alpha cellulose	n - n - n	44.22	44.91	45.76	44.94	44.30	45.65	46.04	44.98	43.89
Holo- cellulose	n - n - n	75.57	73.31	72.48	73.63	71.96	72.77	72.54	73.14	72.67
Lignin	* - n - n	27.17	26.42	26.00	27.37	26.18	26.05	26.67	26.57	26.36
ANATOMICAL FEATURES										
CELL DIMENSION (mm, micron)										
Fiber length	n - * - **	3.79	3.56	3.70	3.90	3.55	3.57	3.96	3.67	3.40
Fiber diameter	** - ** - **	4.91	4.44	4.59	4.91	4.60	4.44	4.97	4.72	4.34
Lumen diameter	** - tn - **	3.10	2.92	2.98	3.10	3.00	2.90	3.23	3.02	2.74
Fiber wall thickness	n - n - n	0.91	0.76	0.80	0.90	0.80	0.77	0.91	0.80	0.77
CELL PROPORTION (%)										
Parenchyma	* - n - *	55.44	53.10	56.71	54.79	56.85	53.61	56.83	55.67	51.95
Fiber	n - n - **	32.31	62.66	29.99	32.64	29.03	33.30	27.81	31.84	35.31
Pore	n - n - n	12.39	14.33	14.05	12.58	14.96	13.23	14.60	13.43	13.13

Note ** = highly significant * = significant , n = no significant; B = Buria; M = Morekao TL = Tala

P = Petong (*Dendrocalamus asper*); S = Sero (*Schizostachyum brachycladum*), T = Tui (*Schizostachyum lima*).

Lignin component of bamboo from Buria was 27,17% which is bigger than bamboo from Morekao (26.42%) and Tala (26,0%). Alpha cellulose, holo cellulose and extractives component of bamboo from Buria, are similar to the Morekao and Tala. Content of alpha cellulose, holo cellulose and extractive content of bamboo's Buria was equal to Morekao and Tala. Holoselulosa content (75,57%), lignin (27,43%), soluble cold water extractives (3,70%) and soluble hot water extractives (6,23%) of bamboo from Buria was higher than Morekao (72,31%; 26,42%; 3,61%; 5,77%) and Tala (72,48%; 26,0%; 3,32%; 5,50%). Lignin and holocellulose content of bamboo from Buria was higher than Morekao and Tala. The reason of this caused by cell wall thickness (0,91 micron) and fiber length (3,79 mm) of bamboo's Buria higher than Morekao (0,76 micron; 3,56 mm) and Tala (0,76 micron; 3,70 mm) although there was no significant different between those features (Figure 1).

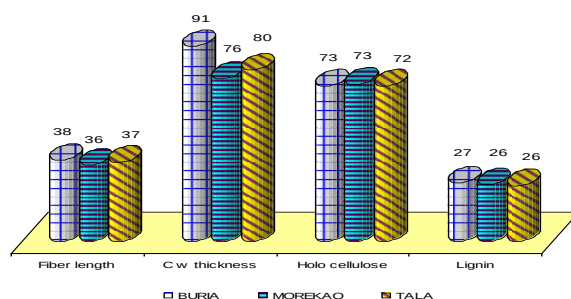


Figure 1. Comparison of bamboo based on location in term of fiber length (mm), cell wall thickness (micron), holocellulose (%) and lignin (%).

Note : fiber length multiply by 0.1

cell wall thickness multiply by 0.01

The more thick of the cell wall may cause increase of alpha, holo cellulose and lignin content which is mayor component of cell wall. In the other hand, higher lignin content of bamboo from Buria may cause increasing of chemical solution to separate lignin from pulp which is raw material in paper making.

Soluble hot water (6,23%) and cold water extractives (3,70%) of bamboo's Buria was higher than Morekao (5,77%; 3,61%) and Tala (5,50%; 3,32%). The reason of this caused by diameter lumen of fiber (0,91 micron) from bamboo's Buria that it was higher than Morekao (0,76 micron) and Tala (0,80 micron). Almost all of the extractives fill up cell lumen of pores and fiber. Although proportion of pores (12,39%) from Buria's bamboo was lower than Morekao (14,33%) and Tala (14,05%) (Figure 2).

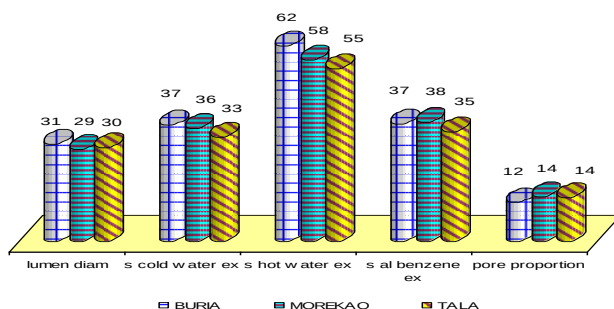


Figure 2. Comparison of bamboo based on location in term of cell lumen (micron), soluble cold water extractives (%), soluble hot water extractives (%), soluble alcohol benzene extractives (%), and pore proportion (%).

Note : lumen diameter and extractives content multiply by 1/10

Extractive content may increase fill up the pore cell although it's proportion was low. Generally, sugar and starch fill up pore cell of bamboo's cane. It is important to study bamboo preservation in relation to the diameter of pore cell and its content which is affect the right time to cut bamboo's cane. Traditionally, people cut bamboo's cane at dry season because sugar and starch content is minimum that it may prevent powder post beetle's attack.

Soluble alcohol benzene extractives of bamboo's Morekao (3,79%) was higher than Buria (3,74%) and Tala (3,45%) caused by pore cell proportion of bamboo's Morekao (14,33%) was higher than Buria (12,39%) and Tala (14,05%). Bamboo's Morekao may resist termite's attack but it can not be powder post beetle if its sugar and starch content higher than Buria and Tala. To verify this findings, it is important to study soluble NaOH extractives, diameter of pore cell, sugar and starch content of bamboo and buried test of bamboo against powder post beetle, termite, fungus.

Chemical Component and Anatomical Features According to Species

Table 1 was listed down chemical component, anatomical features and whether or not there was significant effect of 3 (three) factors. Amount of pore cell affect the resistance of bamboo against powder post beetle. Sugar and starch are mainly fill up the pore cell, that it is the principle food substance of powder post beetle. According to Kusumaningsih (1997), starch content of *Bambusa vulgaris* was the highest that make it more damage by powder

post beetle. In other word, not only amount and diameter of pore cell but also starch content is signify the resistance of bamboo.

It is easy to note that size of pore's bamboo is larger than wood by using of loupe or naked eye. Because of this reality, heat conductivity of bamboo is lower than wood, therefore furniture, mat, screen and wall paper made of bamboo feel cooler than wood. Generally, bamboo was brand as cool and nature substance compare to other construction material.

Alpha cellulose content (45,85%) of *Schyzotachium lima* was higher than *Dendrocalamus asper* (44,94%), and *Schizostachyium brachycladum* (44,30%), therefore its resistance against termite have to verify in laboratory and buried test. According to Munawar (2001), alpha cellulose content of *Gigantochloa apus* (46,36%) was higher than *Gigantochloa robusta* (44,23%). *Gigantochloa atroviolacea* (41,08%) *Bambusa vulgaris* (40,39%). *Gigantochloa apus* damage by termite was higher because of its alpa cellulose content. Termite is social insect that break down cellulose into simple compound in their intestinal tracts which it is absorb by body. It is possibly *Schyzotachium lima* might be more damage by termite compare to *Dendrocalamus asper*, and *Schizostachyium brachycladum*. Lignin content of *Schyzotachium lima* (26,05%) was lower than *Dendrocalamus asper* (27,37%), and *Schizostachyium brachycladum* (26,18%). Lignin is component of cell wall that difficult to break down by termite (Figure 3).

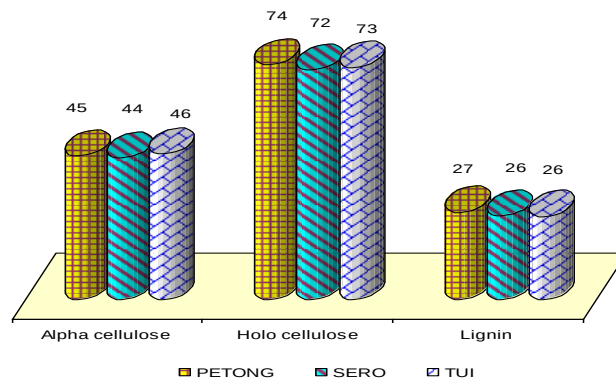


Figure 3. Comparison of bamboo based on species in term of alpha cellulose (%), holo cellulose (%), and Lignin (%).

Soluble cold water (3.59%), hot water (5.92%), and alcohol benzene extractives (4.10%) of *Dendrocalamus asper* was higher than *Schizostachyium brachycladum* (3.46%; 5.88%; 3.43%) because fiber lumen diameter (3.10 micron) of *Dendrocalamus asper* was higher than *Schizostachyium brachycladum* (0.80 micron) (Figure 4).

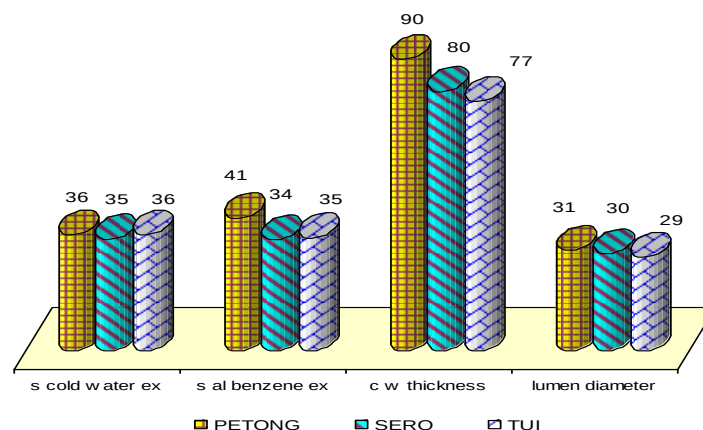


Figure 4. Comparison of bamboo based on species in term of soluble cold water (%), soluble alcohol benzene extractives (%), cell wall thickness (micron), and lumen diameter of fiber (micron).

Notes: extractives content and fiber lumen multiply by 1/10
cell wall thickness multiply by 1/100

Extractives materials fill up lumen and cell wall of pore and fiber. Soluble alcohol benzene extractives of *Dendrocalamus asper* was higher than *Schizostachyum brachycladum* that makes *Dendrocalamus asper* might resist against termite attack. According to Munawar (2001), soluble alcohol benzene extractives of *Gigantochloa apus* was lower (3.05%) than *Bambusa vulgaris* (3.20%), *Gigantochloa atrovioacea* (3.14%) and *Gigantochloa robusta* (3.10%) that termite more prefer to attract *Gigantochloa apus*. In other word, the lower soluble alcohol benzene extractives reside in bamboo the more damage of bamboo by termite. It is possibly *Dendrocalamus asper* resist against termite than *Schizostachyum brachycladum*. According to Supriana (1983) cited by Munawar (2001), termite will look for other part of materials if it contain non toxic substance. Resistance of wood against termite depend on toxic substance within the extractives. Generally, extractives of bamboo contain non toxic substances, therefore it has to treat with preservatives to resist termite, fungus and powder post beetle.

Holo cellulose (73.63%), lignin (27.37%) content and cell wall thickness (0.90 micron) of *Dendrocalamus asper* higher than *Schizostachyum brachycladum* (71.96%; 26.18%; 0.80 micron) and than *Schizostachyum lima* (72.77%; 26.05%; 0.77 micron) (Figure 5). This findings indicate that *Dendrocalamus asper* could be transform into higher pulp than other species but its lignin is higher. The more higher lignin content of *Dendrocalamus asper* may cause increasing of chemical solution to separate lignin from pulp.

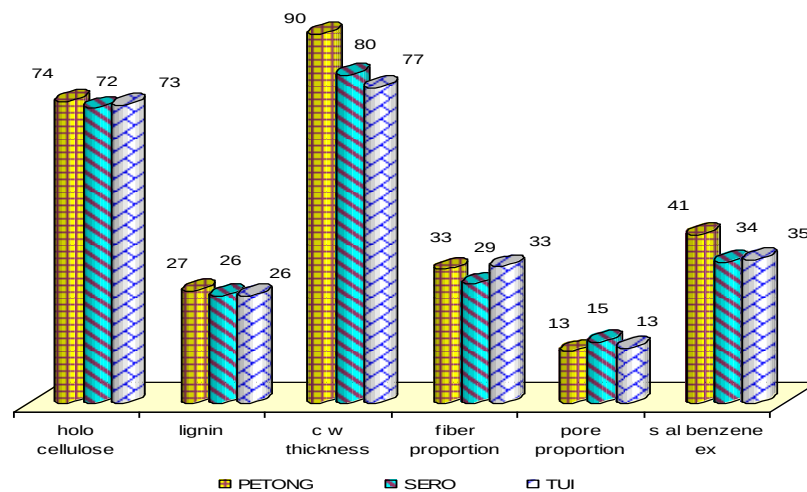


Figure 5. Comparison of bamboo based on species in term of holo cellulose (%), lignin (%), cell wall thickness (micron), fiber proportion (%), and soluble alcohol benzene extractives (%).

Notes: cell wall thickness multiply by 1/100

soluble alcohol benzene extractives multiply by 1/10

Alpha cellulose content, holo cellulose and lignin content depend on cell wall thickness and fiber proportion. The more lignin content of bamboo, the more resist bamboo against termite because lignin is difficult to break down. Holo cellulose (73.63%) and lignin (27.37%) content of *Dendrocalamus asper* higher than *Schizostachyum brachycladum* (71.96%; 26.18%) and *Schizostachyum lima* (72.77%; 26.05%). Cell wall thickness of *Dendrocalamus asper* (0.90 micron) higher than *Schizostachyum brachycladum* (0.80 micron) and *Schizostachyum lima* (0.77 micron), although fiber proportion of *Dendrocalamus asper* (32.64%) was lower than *Schizostachyum lima* (33.30%). It can be said that chemical component of cell wall not only depend on fiber proportion but also thickness of the cell wall. Chemical component of cell wall might be higher because of proportion of fiber is higher than the other species, although its thickness is lower.

Pore proportion of *Schizostachyum brachycladum* (14.96%) was higher than *Dendrocalamus asper* (12.58%) and *Schizostachyum lima* (13.23%) (Figure 5) indicate that *Schizostachyum brachycladum* easily attack by powder post beetle because sugar and starch are main substance of pore cell. Soluble alcohol benzene extractives (3.43%) of *Schizostachyum brachycladum* was lower than *Dendrocalamus asper* (4.10%) and *Schizostachyum lima* (3.49%) that it easily attack by termite. Traditionally, local people prefer *Schizostachyum brachycladum* to make fences, rafting, and fish traps, although its extractives content lower than other species. This contradiction have to clarify by a study to determine sugar and starch content of *Schizostachyum brachycladum*. It is important to determine soluble NaOH extractives content of *Schizostachyum brachycladum* that resist fungus attack, and soluble alcohol benzene extractives against termite.

Lack of information about chemical component of bamboo have to resolve with study of mayor and minor species of bamboo that important to develop bamboo for local people and industry. Study about location in relation with thickness of bamboo to clarify presumption of local people that bamboo grown at wet condition generate thicker bamboo.

Chemical Component and Anatomical Features According to Portion of Bamboo Cane.

There is significant effect of cane's portion to the soluble hot water extractives, soluble alcohol benzene extractives, fiber length, fiber diameter and lumen, proportion of parenchyma and fiber. Alpha cellulose (46,04%) and lignin (26,67%) was higher at the bottom part than middle portion (44,98%; 26,57%) and top portion (43,89%; 26,36%) of the cane (Figure 6).

Alpha cellulose content at the bottom of the cane was higher than middle and top portion, This findings indicate that bottom portion could be transform into higher pulp than other part of the cane. Result of study by Ulfah (1999) on three species of bamboo indicated that bottom portion of the cane contain higher alpha cellulose (45,38%) than middle (44,48%) and top portion (43,68%), but lignin content (25,64%) at the bottom was lower than middle (25,99%) and top portion (26,22%).

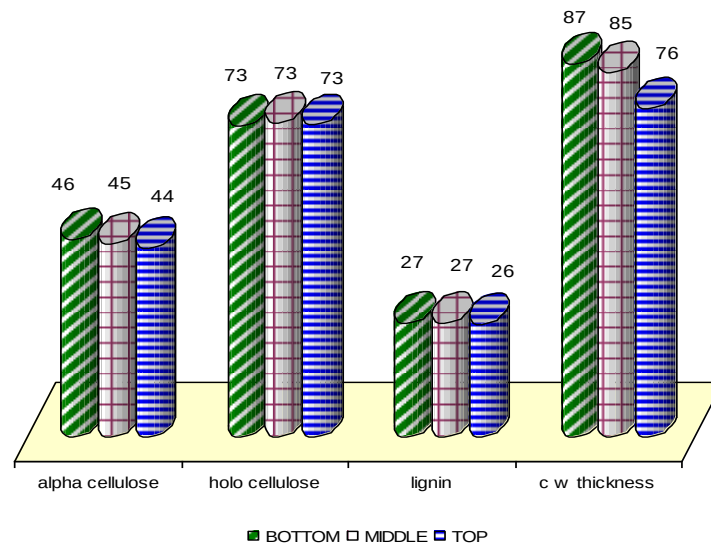


Figure 6. Comparison of bamboo based on portion of the cane in term of alpha cellulose (%), holocellulose (%), lignin (%) and cell wall thickness (micron).

Notes: cell wall thickness multiply by 1/100

Cell wall thickness of bottom portion (0,91 micron) was higher than middle (0,80 micron) and top portion (0,77 micron), that makes alpha cellulose content of bottom portion was higher than middle and top portion. Holo cellulose content (72.54%) of bottom portion was lower than middle (73.14%) and top portion (72.67%). Main component of cell wall is cellulose and lignin which is to bind cell that makes bamboo and wood became rigid. Lignin is thermo plastics substance that makes bamboo ease to shape by heat treatment. Heat treatment have been carried out by people to make furniture and handicraft from bamboo and rattan.

Soluble hot water (6,52%) and soluble alcohol benzene (3,89%) extractives of bottom portion was higher than middle (5,44%; 3,82%) and top portion 5,43%; 3,37%). This is correlate with pore proportion (14,60%), lumen's fiber diameter (3,23 micron), and cell wall thickness 0,91 micron) of bottom portion was higher than middle (13,43%; 3,02 micron; 0,80 micron) and top portion (13,13%; 0,27 micron; 0,77 micron) (Figure 7).

Amount of extractives content of bamboo depend on pore proportion, pore diameter, lumen's fiber diameter and cell wall thickness that it is hold in lumen and cell wall. Although extractives content of bottom portion was higher but it can protect the portion from termite and fungus. The most important is toxicity of the extractives. According to Ulfah (1999), soluble hot water extractives (6,58%) of bottom portion was higher than middle (6,36%) and top portion (5,64%). Soluble alcohol benzene extractives (3,70%) of bottom portion was lower than middle (3,74%) but it was higher than top portion (3,16%).

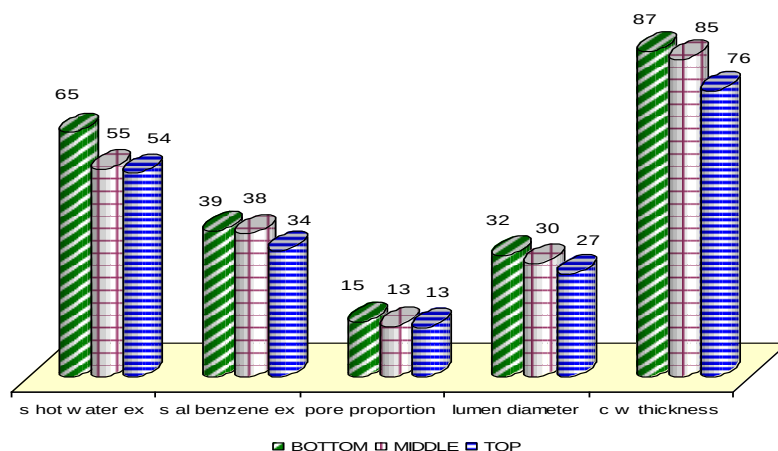


Figure 7. Comparison of bamboo based on portion of the cane in term of soluble hot water extractives (%), soluble alcohol benzene extractives (%), pore proportion (%), lumen's fiber diameter (micron) and cell wall thickness (micron).

Notes: soluble hot water and alcohol benzene extractives, and lumen's fiber diameter multiply by 1/10; cell wall thickness multiply by 1/100

Conclusions and Suggestions

Conclusions

1. There was significant effect of location to the chemical component and anatomical features of bamboo such as lignin content, diameter of fiber, diameter of lumen fiber and proportion of parenchyma cell.
2. There was significant effect of species to the anatomical features of bamboo such as length and diameter of fiber.
3. There was significant effect of portion of the cane to the chemical component and anatomical features of such as location to the chemical component and anatomical features of bamboo such as soluble hot water extractives, soluble alcohol benzene extractives, fiber length and diameter, and lumen's fiber diameter.
4. Chemical component and anatomical features of three species of bamboo such as *Dendrocalamus asper*, *Schizostachyium brachycladum*, *Schyzostachyium lima* from three locations such as Buria, Morekao and Tala, and three portion of the cane was soluble cold water (3.10%-3.79%) ; soluble hot water (5.43%-6.23%) , soluble alcohol benzene (3.37%-4.10%), alpha cellulose (3.37%-4.10%); holo cellulose (71.97%-75.57%); lignin (26.00%-27.37%); fiber length (3.40mm-3.96mm); fiber diameter (4.34micron-4.91micron); lumen's fiber diameter (2.74micron-3.23micron); cell wall thickness (0.76micron-0.91micron); parenchyma proportion (51.95%-56.85%); fiber proportion (27.81%-62.66%); pore proportion (12.39%-14.60%).

Suggestions

1. Following study have to be make is chemical component of bamboo such as starch and sugar content, soluble NaOH extractives of commercial and less known bamboo species, anatomical features such as pore diameter and vascular bundle which is not accomplish in this study.
2. There is correlation between starch and sugar content with powder post beetle attraction to the bamboo. It is important to determine what the best time to cut bamboo that may reduce powder post beetle attraction.
3. Traditionally, local people submerge bamboo in water (river) to reduce powder post beetle attraction. It is important to know how long submerge affect chemical component, physic and mechanical properties of bamboo.

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The Hardness of Indonesian Hardwood Species

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Abstract

The hardness relationship to the specific gravity and moisture content was derived from the experimental investigation of small clear specimens of 20 Indonesian hardwood species. The specific gravity range was 0.25 – 0.90 and the moisture content during the test was in between (12-18) %. Both hardness parallel to the grain and perpendicular to the grain were tested based on the ASTM D143-94 standard method. The total number of specimens amounted to 240.

The equations of hardness parallel and perpendicular to the grain correlated to the specific gravity and moisture content was $HD_{\parallel} = 14450 G^{1.38} mc^{0.063}$ and $HD_{\perp} = 19500 G^{1.92} mc^{0.172}$, respectively. The increase of moisture content from 12% to 18 % increase the hardness of wood approximately (5-10) %. The hardness perpendicular to the grain in the radial direction was 5% higher than in the tangential direction.

Key words : hardness parallel and perpendicular to the grain, specific gravity, moisture content

Introduction

Hardness properties were important for workability of wood, and also may predict the other properties of wood. The purpose of this experimental study was:

- to find the correlation between hardness, specific gravity and moisture content of the Indonesian hardwood species,
- to compare with the hardness equations in Wood Handbook, 1999,
- to evaluate the difference between hardness in the three directions of longitudinal, tangential and radial axis,
- to evaluate the effect of moisture content

Side hardness for hardwood in Wood Handbook was $HD = 16550 G^{2.31} [N]$ (green wood) and $HD = 15300 G^{2.09} [N]$ at 12% moisture content

Method and Materials

This research based on the experimental study. The hardness of Indonesian hardwood species was investigated through 24 hardwood species namely, *Akasia*, *Meranti* (red, white and yellow), *Sengon*, *Albasia*, *Kruing*, *Durian*, *Mersawa*, *Nyato*, *Bangkirai*, *Afrika*, *Kulim*, *Pete*, *Puspa*, *Johar*, *Rengas*, *Mahoni*, *Nangka*, *Bakil*, *Kulim*, *Merbau*, *Balam*, and *Kempas*. The specific gravity range was 0.20 – 0.90 and the moisture content during the test were in between (12-25)%.

The specimen dimension 50 mm x 50 mm x 150 mm was made based on the ASTM D-143-94. The total number of specimen was 288. The half ball diameter of 11.3 mm was used in the test. The direction of the load to the grain was described as Figure 1 below. The force in Newton unit to get the 5.65 mm penetration of the half steel ball was defined as the hardness of the specimen. Universal Testing Machine Hung-Ta was used and the setting of the test was shown in Figure 2 and 3. The test under 0.6 mm/ minute displacement control. The test was stopped at approximately after 6 mm penetration of the half steel ball.

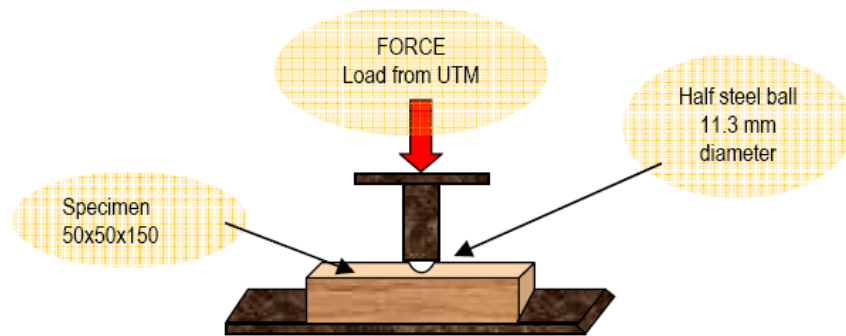


Figure 1. Schematic setting of the test.



Figure 2. Hardness specimen under perpendicular to the grain test.

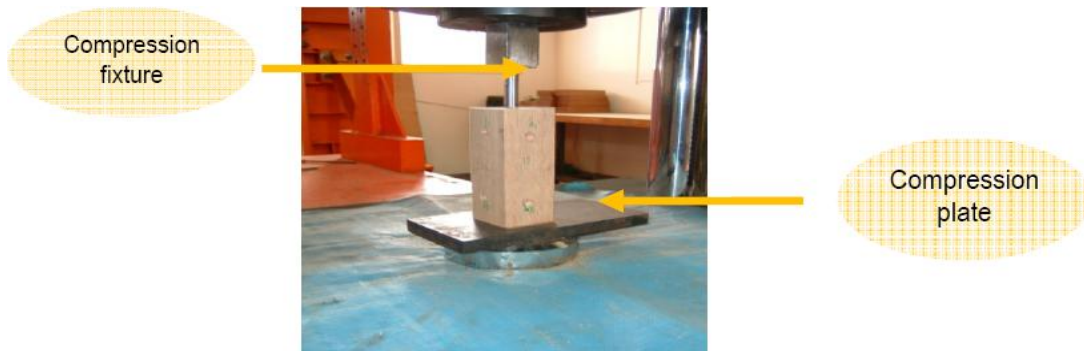


Figure 3. Hardness specimen under parallel to the grain test.

Results and Discussion

The equations of hardness parallel and perpendicular to the grain correlated to the specific gravity or and moisture content was shown as in Table 1.

Table 1. Hardness (HD)

Axis	Variable	Hardness (N)	R ²	Eq. no
T, R	G	$HD_{\perp} = 13548 G^{1.868}$	0,92	(1)
T, R	G, mc	$HD_{\perp} = 17783 G^{1.89} \cdot mc^{0.123}$	0.92	(2)*
L	G	$HD_{\parallel} = 12311 G^{1.332}$	0.86	(3)
L	G, mc	$HD_{\parallel} = 10715 G^{1.31} \cdot mc^{0.067}$	0.86	(4)

* $\alpha^{0.0114}$ for $0.01^{\circ} < \alpha < 90^{\circ}$,

T = tangential, R = radial, L = longitudinal, G = specific gravity, mc = moisture content

The hardness perpendicular to the grain was 50% higher than hardness parallel to the grain at specific gravity greater than 0.7. The hardness perpendicular to the grain in the radial direction was higher than hardness in the tangential direction. The difference of radial and tangential directions on the hardness perpendicular to the grain was not significant, approximately multiply by $\alpha 0.0114$ for $0.01^\circ < \alpha < 90^\circ$ or maximum only 5% for $\alpha = 90^\circ$.

The test data and the equations found from the test presented in the graph at Figure 4 to 7. The R2 value showed the strong correlation between all the variables.

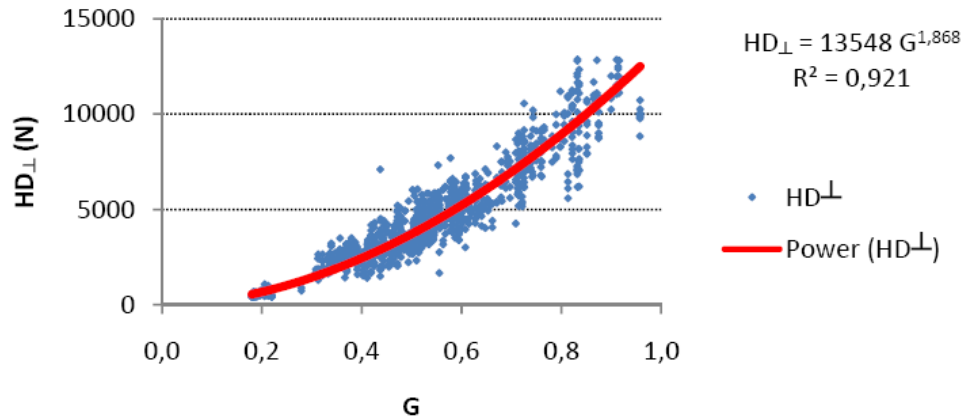


Figure 4. Correlation of hardness perpendicular to the grain and specific gravity

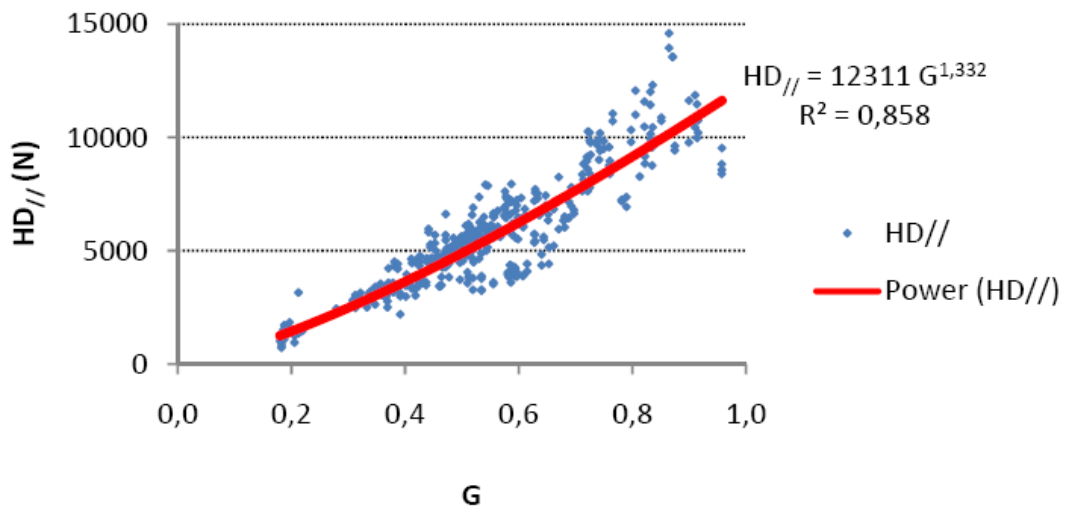


Figure 5. Correlation of hardness parallel to the grain and specific gravity

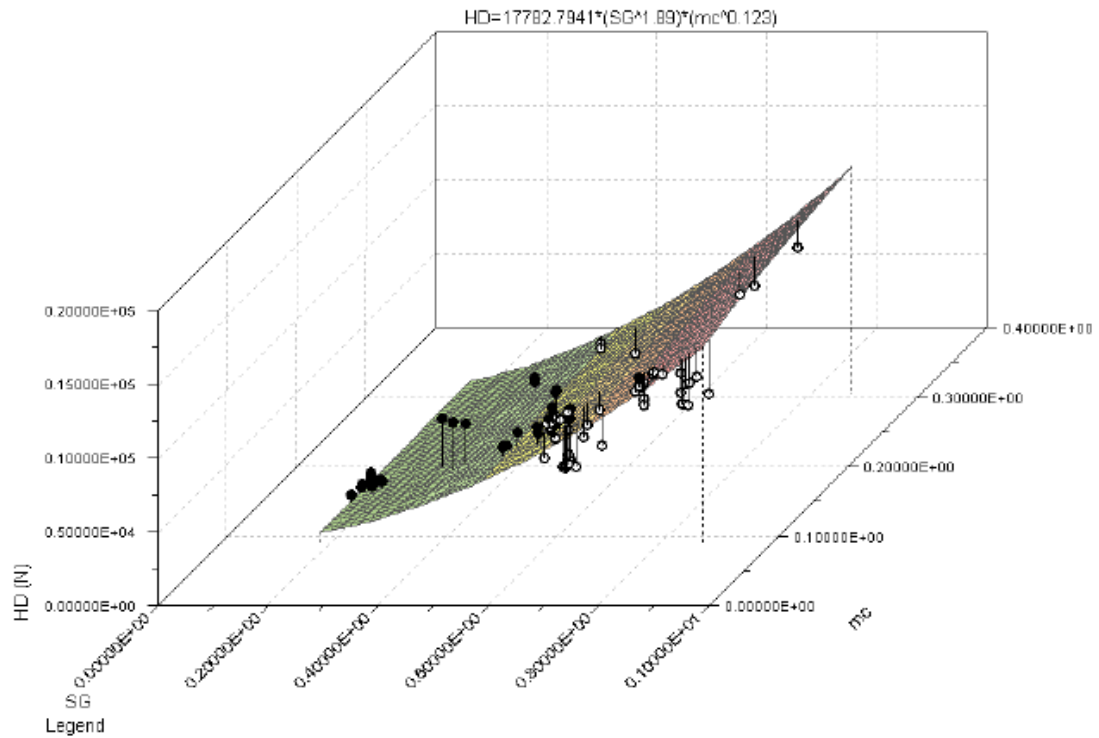


Figure 6. Correlation of hardness perpendicular to the grain vs. specific gravity and moisture content

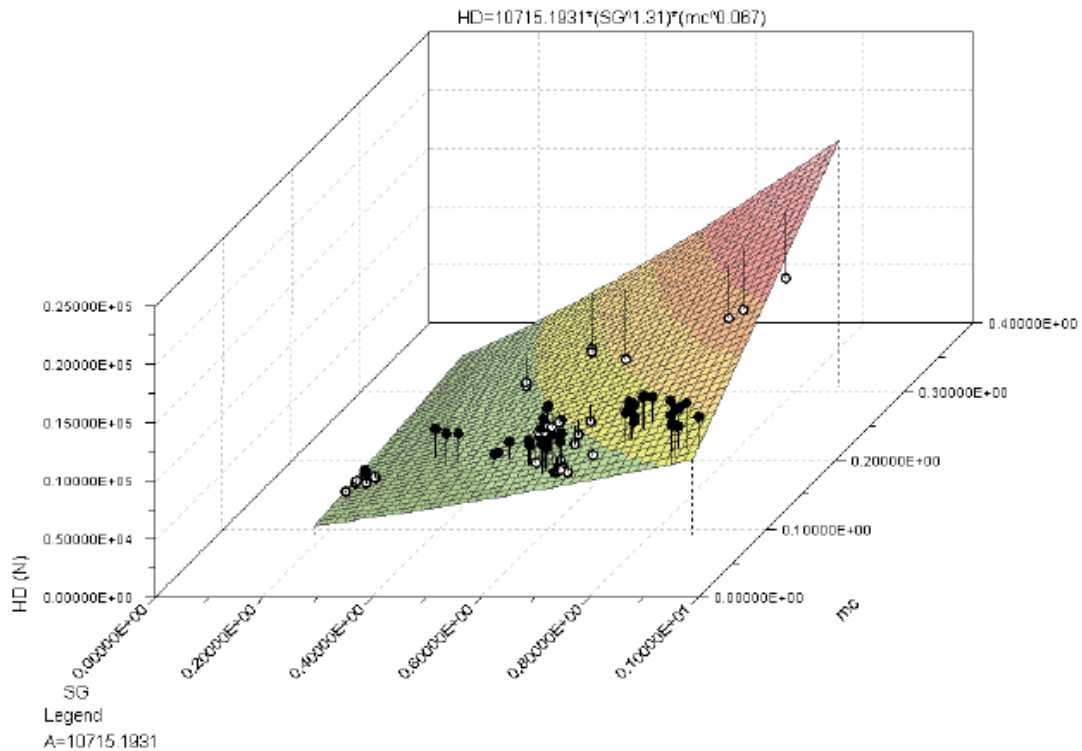


Figure 7. Correlation of hardness parallel to the grain vs. specific gravity and moisture content

The increase of moisture content as shown in Figure 8 increase the hardness of wood approximately 0.5 – 1.0 % per 1% increase of moisture content.

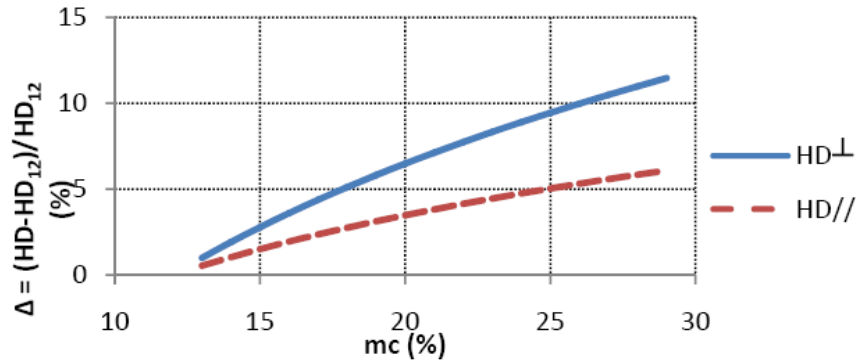


Figure 8. Percentage of hardness increase due to the effect of moisture content (mc=12% as a reference)

The hardness of Indonesian hardwood species compare to the Wood Handbook, 1999 was higher than the value from the equations in the Wood Handbook, 1999 as shown in Figure 9. Wood Handbook, 1999 was not specified the axis directions of the hardness and not include the moisture content as a variable that can affect the hardness.

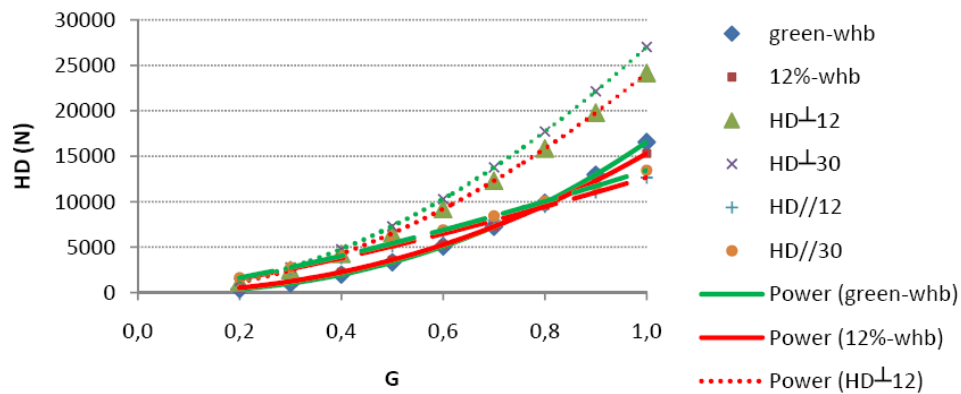


Figure 9. Comparison between the test result and Wood Handbook.

Conclusions

- There was a strong correlation between hardness and specific gravity.
- The hardness of Indonesian hardwood species was higher compare to the value from equation in the Wood Handbook.
- The influence of the increasing of the moisture content increase the hardness approximately 0.5 – 1.0 % per 1% increase of moisture content, especially in the high specific gravity.
- The hardness perpendicular to the grain was higher than in the parallel direction. The higher the specific gravity the higher the difference.
- The difference of radial and tangential directions on the hardness perpendicular to the grain was not significant.
- The hardness for future research may be correlated to the other properties through the specific gravity.

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The Bending Strength and Modulus of Elasticity of Indonesian Hardwood Species

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Abstract

Wood as a natural material has physical and mechanical properties. In determining wood properties both non-destructive and destructive test can be conducted. In this experimental study, a non-destructive test was carried out using PUNDIT and a destructive test using Universal Testing Machine - Hung Ta. The bending test was applied to 7 of Indonesian hardwood species namely: *Sengon*, *Acacia*, *Durian*, *Meranti*, *Mersawa*, *Nyatoh* and *Kempas* with a specific gravity range of 0.30 – 0.80. The specimens were tested based on the ASTM D143-94 standard method. The total number of specimens amounted to 28. The moisture content during the test was in between (12-18)%.

The non-destructive test result regarding the correlation of specific gravity and modulus of elasticity to the dynamic modulus of elasticity was: $G = 0.0039 E_d^{0.5105}$ with $R^2 = 75\%$ and $E_{sb} = 2,1081 E_d^{0.8974}$ with $R^2 = 88\%$. The correlation between bending strength and dynamic modulus of elasticity was: $F_{bp} = 0.0008 E_d^{1.1272}$ with $R^2 = 73\%$ and $F_{bu} = 0,0055 E_d^{0.9825}$ with $R^2 = 74\%$. The destructive test resulted the correlation between modulus of elasticity and specific gravity, $E_{sb} = 29060 G^{1.403}$ with $R^2 = 75\%$. The correlation between bending strength and specific gravity was $F_{bp} = 131.8 G^{1.8378}$ with $R^2 = 68\%$ and $F_{bu} = 209,3 G^{1.7026}$ with $R^2 = 78\%$. The correlation between modulus of elasticity and the ultimate bending strength was $F_{bu} = 0,0023 E_{sb}^{1.1014}$ with $R^2 = 85\%$.

The Indonesian Timber Code basic bending strength is lower than the bending strength at proportional limit (F_{bp}) especially the value more conservative for high specific gravity. The ultimate bending strength (F_{bu}) at low specific gravity is lower than the MOR (modulus of rupture) in Wood Handbook. The modulus of elasticity was found to be higher than the modulus of elasticity in Wood Handbook especially for high specific gravity.

Key words : specific gravity, modulus of elasticity, dynamic modulus of elasticity, bending strength.

Introduction

In this experimental study the value of the modulus of elasticity was obtained with two testing methods. Firstly, the non-destructive test using ultrasonic with PUNDIT and secondly, the destructive bending test using the universal testing machine Hung-Ta. Seven wood species were used in this experimental study, namely: *Sengon* (*Paraserianthes falcata*), *Acasia Mangium* (*Acacia Miller-Leguminosae*), *Durian* (*Durio Adans*), *Meranti* (*Shorea Roxb – Dipterocarpaceae*), *Mersawa* (*Anisoptera Korth – Dipterocarpaceae*), *Nyatoh* (*Palaquium Watsurifolium*) and *Kempas* (*Koompassia malaccensis*). The range of the specific gravity was in between 0.30-0.80 and the moisture content during the test was in between (12-18)%. The specimen dimension 50 mm x 50 mm x 760 mm based on the ASTM D143-94. The number of specimen amounted to four for each species and randomly there are three types of the cross section: RL, θ L, and TL. The types of cross section and loading direction were shown as in figure 1.

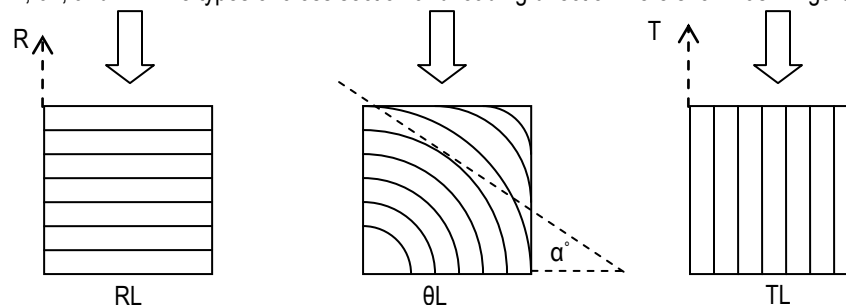


Figure 1. Wood cross section and the loading direction.

The Ultrasonic Test

In this experimental study, the ultrasonic non-destructive tester PUNDIT (Portable Ultrasonic Non-destructive Digital Indicating Tester) was used. The transmitter generates low frequency ultrasonic pulses and the transit time to the receiver can be measured. The distance between transmitter and receiver was 760 mm. Medical ultrasonic gel was used to avoid air bubbles between the surface of wood and transmitter or receiver, in order to guarantee that the ultrasonic pulse can propagate perfectly. See Figure 2.



Figure 2. The ultrasonic non-destructive tester PUNDIT.

PUNDIT recorded the transit time, so the pulse velocity may be obtained by dividing the distance between transmitter and receiver by transit time as in equation (1). The dynamic modulus of elasticity (E_d) was calculated with its correlation to the density as in equation (2)

$$V = \frac{d}{t} \quad (1)$$

$$E_d = \frac{\rho \cdot V^2}{g} \quad (2)$$

where : V = ultrasonic pulse velocity (mm/s)
 d = distance between transmitter and receiver (mm)
 t = transit time transmitter - receiver (s)
 E_d = dynamic modulus of elasticity (MPa)
 ρ = density (N/mm³)
 g = gravity = 9810 mm/s²

Destructive Bending Test

The same specimen as non-destructive test was used. The static center point loading applied to the specimen with 760 mm span. The elastic midspan deflection and the modulus of elasticity from the static bending test was:

$$\Delta_{sb} = \frac{P_e \cdot L^3}{48 \cdot E_{sb} \cdot I} \quad (3)$$

$$E_{sb} = \frac{P_e \cdot L^3}{4 \cdot \Delta_{sb} \cdot b \cdot h^3} \quad (4)$$

where : Δ_{sb} = midspan elastic deflection (mm)
 P_e = elastic load (N)
 L = span (mm)
 E_{sb} = modulus of elasticity (MPa)
 I = moment of inertia (mm⁴)
 b = cross section width (mm)
 h = cross section height (mm)

From the static bending test using UTM the bending strength F_b may also be obtain, using equation (5):

$$F_b = \frac{M \cdot y}{I} \quad (5)$$

From the center point loading test as shown in Figure 3, the maximum bending moment at midspan may be calculated as $\frac{1}{4} PL$. And by substituting the moment of inertia to the equation (5) with $y = \frac{1}{2} h$ and $M = \frac{1}{4} PL$, we can establish the bending strength as:

$$F_b = \frac{3 \cdot P \cdot L}{2 \cdot b \cdot h^2} \quad (6)$$

where : F_b = bending strength (MPa)
 M = moment (N.mm)
 y = distance from the neutral axis to the top fibres (mm)
 P = load (N)

The equation (6) may be used to calculate the elastic bending strength F_{bp} with $P = P_{bp}$ and also be used as the approach to calculate the ultimate bending strength F_{bu} (the same as modulus of rupture) based on the ultimate load $P = P_{bu}$.

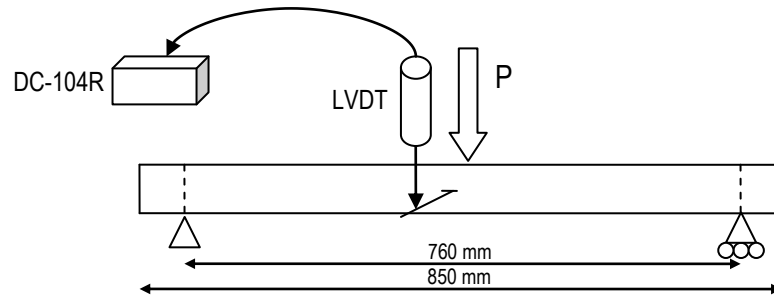
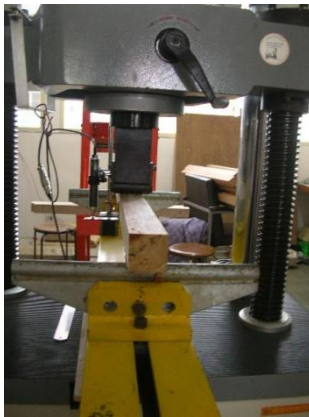
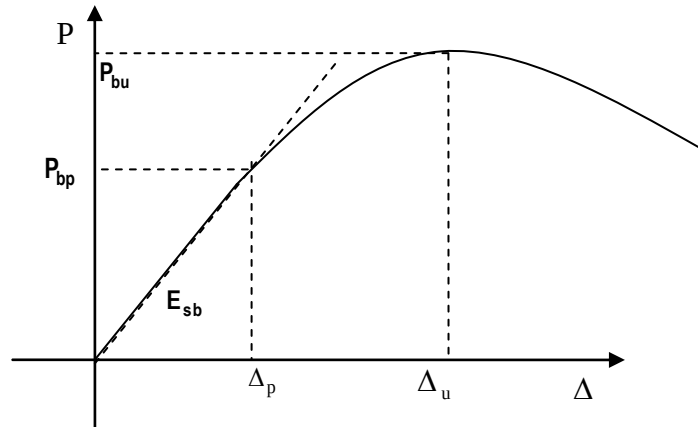


Figure 3. Schematic of loading and deflection measurement on the specimen



(a)



(b)

Figure 4. (a) The specimen under bending test, (b) Typical load vs deformation curve

Test results data were collected from the test using the Universal Testing Machine (UTM) such as time, load and displacement. The value of the displacement from UTM must be corrected by the displacement of the wood surface because of load compression at the surface contact. To accurately measure the displacement, the LVDT (Linier Variable Differential Transformer) was used to record the displacement and time. The load-displacement curve was created based on the load from UTM and displacement from the LVDT. From the load-displacement curve we can find the value of proportional and ultimate load as shown in Figure 4b.

Test Data Analysis

The analysis results either from non-destructive or destructive test may be correlated through the regression analysis. The correlations made between ultrasonic pulse velocity, elastic dynamic modulus, specific gravity, modulus of elasticity, bending strength at proportional limit and ultimate bending strength (MOR). The regression equation analysis tools employed MS-Excel by power equation. The correlation equation was used as shown in Tables 1, 2 and 3.

Correlation of Specific Gravity (G) and Modulus of Elasticity (E_{sb}), with Elastic Dynamic Modulus (E_d) and Ultrasonic Pulse Velocity (V).

Table 1. Correlation of G and E_{sb} , with V and E_d

Variable	G		E_{sb}	
	-	$R^2(\%)$	(MPa)	$R^2(\%)$
V (m/det)	$G = 0,0002 V^{0,9485}$	24	$E_{sb} = 5.E-5 V^{2,2586}$	52
E_d (MPa)	$G = 0,0039 E_d^{0,5105}$	75	$E_{sb} = 2,1081 E_d^{0,8974}$	88

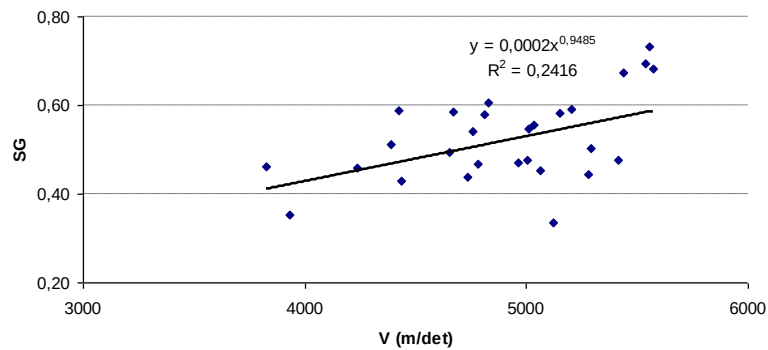


Figure 5. Correlation between G and V

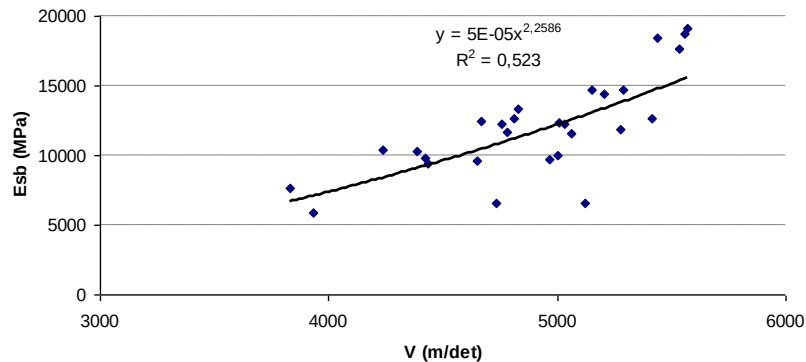


Figure 6. Correlation between E_{sb} and V

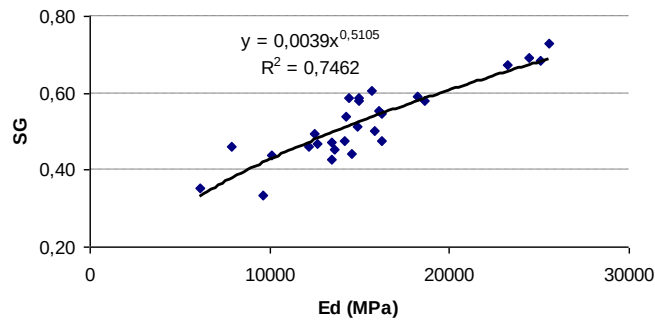


Figure 7. Correlation between G and E_d

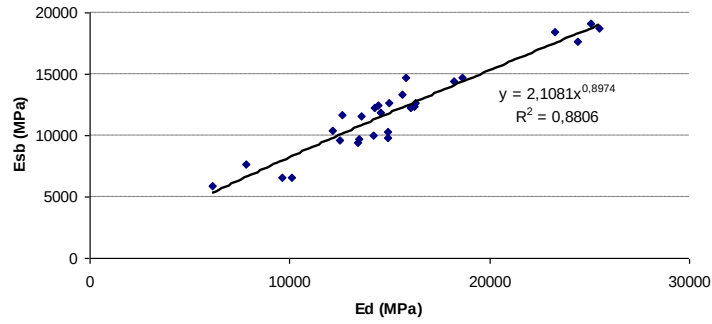


Figure 8. Correlation between E_{sb} and E_d

Correlation of Bending Strength at Proportional Limit (F_{bp}) and Modulus of Rupture (F_{bu}), with Dynamic Modulus (E_d) and Ultrasonic Pulse Velocity (V).

Table 2. Correlation of F_{bp} and F_{bu} , with V and E_d

Variable	F_{bp}		F_{bu}	
	(MPa)	$R^2(\%)$	(MPa)	$R^2(\%)$
V (m/det)	$F_{bp} = 2.E-8 V^{2,4937}$	34	$F_{bu} = 2.E-6 V^{2,0329}$	30
E_d (MPa)	$F_{bp} = 0,0008 E_d^{1.1272}$	73	$F_{bu} = 0,0055 E_d^{0.9825}$	74

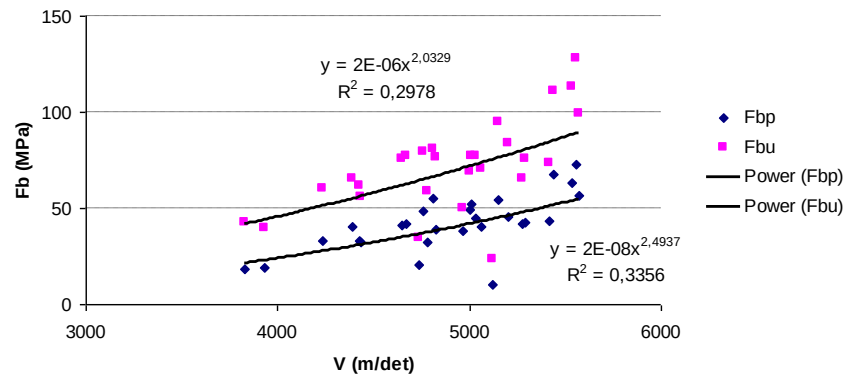


Figure 9. Correlation between F_{bp} , F_{bu} and V

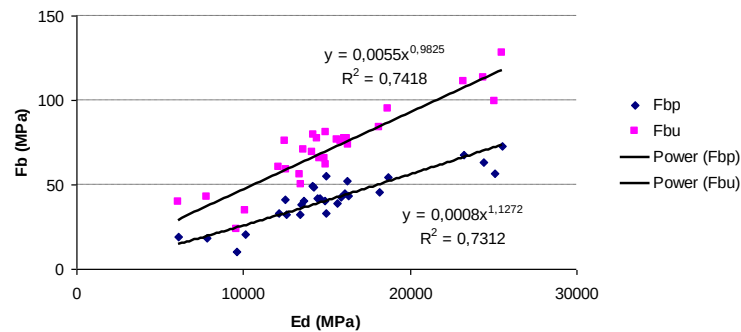


Figure 10. Correlation between F_{bp} , F_{bu} and E_d

Correlation of Modulus of Elasticity (E_{sb}), Bending Strength at Proportional Limit (F_{bp}) and Modulus of Rupture (F_{bu}) with Specific Gravity (G).

Table 3. Correlation of E_{sb} , F_{sb} and F_{bu} , with G

Variable	E_{sb}		F_{bp}		F_{bu}	
	(MPa)	R^2 (%)	(MPa)	R^2 (%)	(MPa)	R^2 (%)
G	$E_{sb} = 29060 G^{1.403}$	75	$F_{bp} = 131,8 G^{1.8378}$	68	$F_{bu} = 209,3 G^{1.7026}$	78
E_{sb}	-	-	$F_{bp} = 0,0005 E_{sb}^{1.2122}$	77	$F_{bu} = 0.0023 E_{sb}^{1.1014}$	85

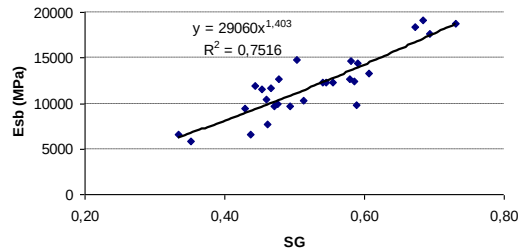


Figure 11. Correlation between E_{sb} and G

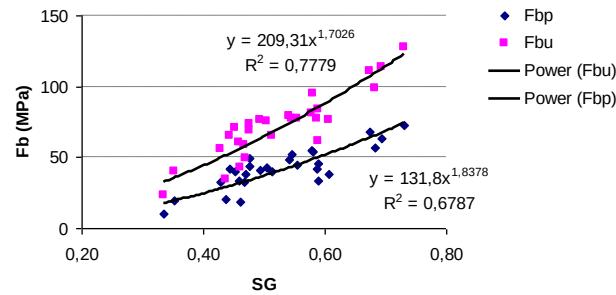


Figure 12. Correlation between F_{sb} , F_{bu} , and G

Correlation of Bending Strength at Proportional Limit (F_{bp}) and Modulus of Rupture (F_{bu}) with Modulus of Elasticity (E_{sb}).

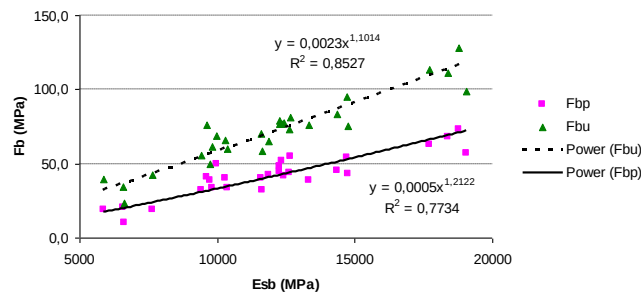


Figure 13. Correlation of E_{sb} , F_{bp} and F_{bu}

Comparison of Bending Strength from the Test to the MOR of Wood Handbook and SNI-03-xxxx-2002 Basic Bending Strength

Comparison of Bending Strength and Modulus of Elasticity to the MOR of Wood Handbook

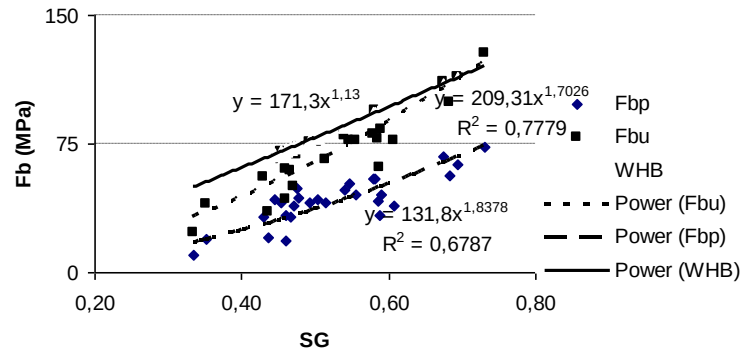


Figure 14. Comparisson of bending strength F_{bp} and F_{bu} to the MOR of Wood Handbook.

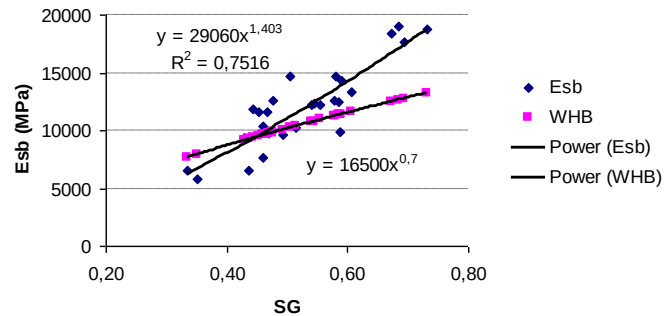


Figure 15. Comparisson of modulus of elasticity to Wood Handbook

Comparisson of Bending Strength to the SNI-03-xxxx-2002 Basic Bending Strength

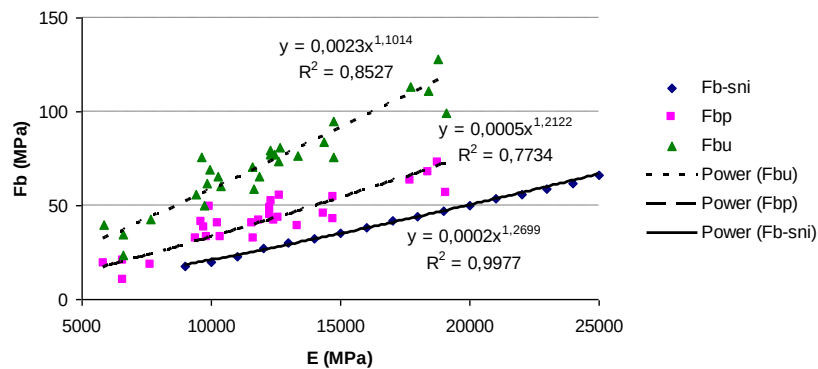


Figure 16. Comparisson of bending strength to SNI-03-xxxx-2002 basic bending strength

Conclusions

1. The elastic dynamic modulus obtained from the ultrasonic test may be used to predict the specific gravity, modulus of elasticity and bending strength with sufficient accuracy.
2. The correlation of the specific gravity and the modulus of elasticity to the bending strength is very strong and may accurately predict the bending strength.

3. The ultimate bending strength (F_{bu}) at low specific gravity is lower than MOR of Wood Handbook, but the modulus of elasticity was greater than Wood Handbook at high specific gravity.
4. SNI-03-xxxx-2002 basic bending strength was lower than bending strength at the proportional limit, and especially at high specific gravity.

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Drying Behaviors of Two Papuan Wood Species (*Alstonia scholaris* R. Br. and *Syzigium versteegii* M. et P.) in a Solar-Wood Waste Fired Kiln

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Abstract

The aim of this research is to evaluate drying behaviors of two Papuan Woods in a combining solar and wood waste powered kiln. Drying rate and wood defections of Papuan woods resulted in the kiln were presented to show the kiln performance on drying two Papuan wood species.

Result indicated that the drying schedule used in the experiment had contributed to the effectiveness of drying rate of the two Papuan woods. Drying rate of pulai wood was about 1.13 % moisture content per hour at first stage and then declined to 0.59 % per hour at the final period during an approximately 5 days-continued drying process. On the other hand, watergum wood dried in the kiln released its moisture content 0.79 % per hour at the beginning and just under 0.5 % of moisture content per hour during the last stage to reach the desired moisture content in an approximately 7 days of continue drying process. Finally, attention should be paid on the second stage of drying schedule in order to improve wood quality by reducing appearance of wood checks and discolouration.

Key words : Papuan woods, drying behavior, drying rate, wood checks and wood discolouration.

Introduction

As a primary forest product in Papua, wood consists of over 1,200 species belonging to more than 80 genera (Womersley, 1978 in Petocz, 1987). Although traditionally some of the species have been widely utilized as various wood products by local people, only less than 30 species have been studied to uncover their wood characteristics (Tokede *et.al*, 2005). *Alstonia* wood, locally known as Pulai wood, distributes mostly in northern part of Papua Island and grows in low and high land forest at an altitude of not more than 500m above sea level, whereas, *Syzigium* wood, as it locally called Watergum wood, also spreads in the same area as *alstonia* wood does but it is mainly found at an altitude of 3 to 80m above sea level (Dinas Kehutanan Irian Jaya, 1976).

In Papua, several villagers have long been using both pulai and watergum woods as their tools such as musical instrument and furniture, but watergum wood is more preferable to house constructions and weapon tools (Gandhi *et. al.*, 2006). In addition, these two papuan woods are incredibly available in the forest. It is reported that 15 trees and 12 trees per hectare for pulai and watergum wood respectively counted as standing stocks in Seremuk, Werianggi and Kaimana, West Papua Province (Tokede, *et al.*, 2006). However, the two papuan woods are considered as lesser known species. Although they have good appearance and easily workable properties, as a low specific gravity wood (less than 0.5) they are rarely important in wood market. Therefore, several researches have been conducted to initialize their wood properties and enhance wood characteristics in order to promote fast growing and low density wood species in international market.

Wood drying is a general manufacturing process in wood production. Its moisture content should be preferable to the atmospheric conditions prevailing in the intended place of use (Yusuf, 1984). Most of small and medium size of wood industries, especially furniture industries in Papua, lack facility to dry their raw materials (Tolanda, 2003). The furniture makers are confronted with inadequate knowledge of wood drying although there were two conventional methods of drying employed: sun drying and air drying. Sun drying occurs when the wood are left in the open area. Direct sun drying normally causes checks. In air drying, the woods are usually left standing against trees to prevent direct exposure to the sun but it usually takes several weeks. The mentioned constraints cause a significant reduction of quality of the wood products in their competitiveness in the export market. To deal with the problems a kiln drying should be constructed but it requires some expensive tools that hardly achieve by small and medium size wood industries in remote areas therefore a simple kiln dryer should be considered (Muslih *et. al.*, 1998).

A solar - wood waste fired kiln is appropriate for small scale wood industry since it is cheap and easy to operate (Basri and Rahmad, 2000 and Rahawarin *et al.* 2004). But the drying behavior of wood in the kiln and

anatomical effect on drying wood in relation to certain uses of the finished product should be considered in order to improve the quality of the product. Therefore, it is important to conduct a study on the drying behavior of two papuan wood species (*Alstonia scholaris* R. Br. And *Syzigium versteegii* M. et P.) in a solar-wood waste fired kiln.

Methodology

Materials and Specimen Preparation

Three logs of 210cm in length representing top, middle and bottom were cut each from about 50cm in diameter at breast high of healthy pulai wood (*Alstonia scholaris* R. Br.) and watergum wood (*Syzigium versteegii* M. et P.) in Asai Village, Manokwari, West Papua. The logs were then divided into three sample sizes, 3 x 20 x 200 cm, 5 x 5 x 200 cm and 5 x 10 x 200 cm with three replications. The specimens were numbered according to their position in trunk and end-coated with paint to prevent evaporation from longitudinal directions during drying process.

Drying Preparation

First, kiln drying specimens were arranged in three levels (according to number of replications) which is separated by stickers so air could freely circulate over all of the samples. After that, dry bulb and wet bulb thermometers were provided in the room and kiln dryer in order to be able to monitor relative humidity during the drying process.

In the night time, wood wastes were placed in the furnace and lit to run the dryer at a temperature range of 40 to 60°C. If the atmospheric temperature went up to reach the desired temperature in the day time because of an increase in solar energy coming in to the kiln, the power from the furnace was turned off. It was turned on again if the temperature was lower than the desired temperature. During the drying process, the fan motor was turned on to circulate the air in the kiln. The dry and wet bulb thermometers were set to monitor the desired temperatures and sometime water was sprayed manually to maintain the desired relative humidity inside the chamber.

Drying Schedule

The drying schedule was designed to attain moisture content range of 10% to 15% because this condition is the average range of wood Equilibrium Moisture Content in Manokwari. The drying schedule of the experiment is presented in Table 1.

Table 1. Drying Schedule used for drying pulai wood (*Alstonia scholaris* R. Br.) and watergum wood (*Syzigium versteegii* M. et P.) in a solar-wood waste fired kiln.

No.	Moisture Content (%)	Temperature (°C)		RH (%)	EMC (%)
		Dry Bulb	Wet Bulb		
1	Green - 60	36	30	64	11.2
3	60 – 30	45	37	60	9.8
4	30 – 20	49	40	57	9.2
5	20 – Final	54	41	44	7.0
6	Equalization	44	40	78	13.5

Seasoning and Monitoring

The air drying samples were left inside a room with natural air circulation and the kiln drying samples were dried in the solar-wood waste fired kiln according to the drying schedule. Variables measured during both drying process were current moisture content and wood defect.

The oven dry weight (ODW) of each drying sample was calculated in order to determine the green and current condition of the samples at any time during the drying process. Test samples were taken from every drying sample and weighted to obtain the initial weight before they were dried at 102°C (±2°C) and regularly checked until there was no further change in weight. The constant weight was then called ODW of the test sample. The moisture content of the sample then calculated using the conventional formula as follows:

$$MC\% = [(Initial\ Weight\ of\ test\ sample / Oven\ Dry\ Weight\ of\ test\ sample) - 1] \times 100$$

The calculated ODW of each drying sample was then determined from their initial moisture content and initial weight using the same formula for drying sample.

The drying samples were weighted regularly from green to dried condition to initialize the current moisture content as indicated in drying schedule. The current moisture content was the difference between current weight and calculated ODW of the drying sample. Then, it was presented in percent of oven dry weight, as follows:

$$MC\% = [(Current\ Weight / Calculated\ Oven\ Dry\ Weight) - 1] \times 100$$

Results and Discussion

Moisture Content and Drying Rate

The 54 timbers of pulai and watergum woods were dried separately using the same drying schedule in a solar-wood waste fired kiln and the other 54 of them were dried in an air drying room for comparison. Starting at a low temperature of 36°C and desired Equilibrium Moisture Content (EMC) of 11.8, the moisture of the samples were extracted from green condition to attain average moisture content of 60%. After that, the temperature was increased to 45°C and EMC of 9.8% to reach moisture content of 30%. Moreover, the temperature was further increased to be 49°C with an EMC of 9.2% and then rose to 54°C with an EMC of 7.0% to achieve the final moisture content of 10 – 15%. Finally, an equalization temperature of 44°C and EMC of 13.5 was applied. The actual drying schedule together with average moisture contents of pulai and watergum woods and drying time at every stage are presented in Table 2 and 3.

Table 2. Drying schedule, moisture reduction and drying time of pulai wood in a solar-wood waste fired kiln.

Moisture Content (%)	Temperature (°C)		RH (%)	EMC (%)	Drying Time (Hours)
	Dry Bulb	Wet Bulb			
86.36 – 63.76	36	30	64	11.2	20
63.76 - 30.02	45	37	60	9.8	46
30.02 - 19.80	49	40	57	9.2	21
19.80 - 9.26	54	41	44	7.0	18
9.26 - 10.45	44	40	78	13.5	10

Table 3. Drying schedule, moisture reduction and drying time of watergum wood in a solar-wood waste fired kiln.

Moisture Content (%)	Temperature (°C)		RH (%)	EMC (%)	Drying Time (Hours)
	Dry Bulb	Wet Bulb			
82.18 – 66.43	36	30	64	11.2	20
66.43 - 29.55	45	37	60	9.8	70
29.55 - 17.44	49	40	57	9.2	26
17.44 - 8.50	54	41	44	7.0	28
8.50- 11.62	44	40	78	13.5	15

The number of water decreased during drying process of the timbers was monitored every stage for pulai and watergum woods as presented in Figure 1 and 2.

The graphs show times spent to evaporate water from pulai and watergum wood in a solar-wood waste fired kiln. Overall, the quantity of water declined moderately to about 25% and went down slowly to reach the final moisture content. Pulai wood needed slightly over 5 days while watergum wood took just below 7 days to released water to the desired moisture content of about 11%. Commencing with the different initial moisture content, the three samples, sized 3x20x200, 5x5x200 and 5x10x200 from both pulai and watergum wood had relatively the same reduction of water in first 20 hours. After that water in sample sized 5x5x200 from the two Papuan woods evaporated faster than the others and took over sample sized 5x10x200 at moisture content of roughly about 45% until they attained the final moisture content. Drying rate of the samples sized as represented in Table 2 could elaborate more detail about the speed of the water released form the timbers.

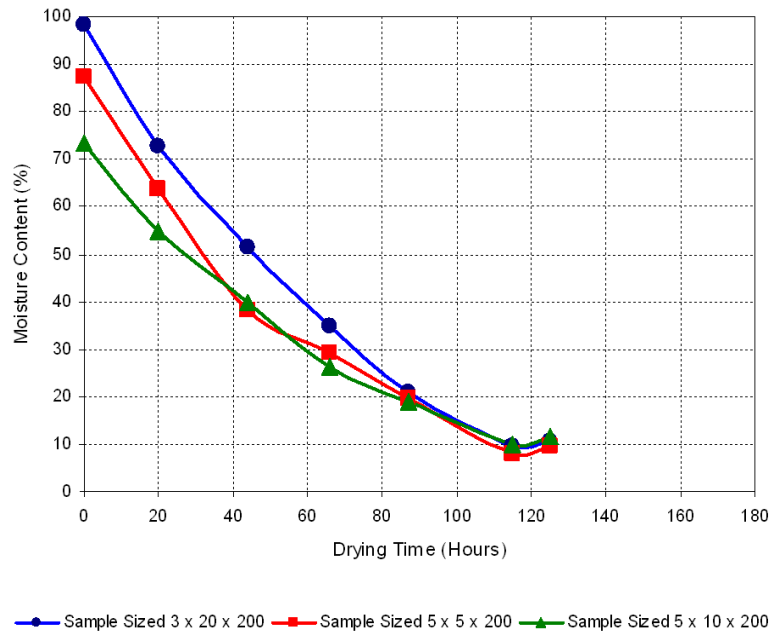


Figure 1. Comparative kiln drying rates of different sample sized of watergum pulai (*Alstonia scholaris* R. Br.) in the solar-wood waste fired kiln.

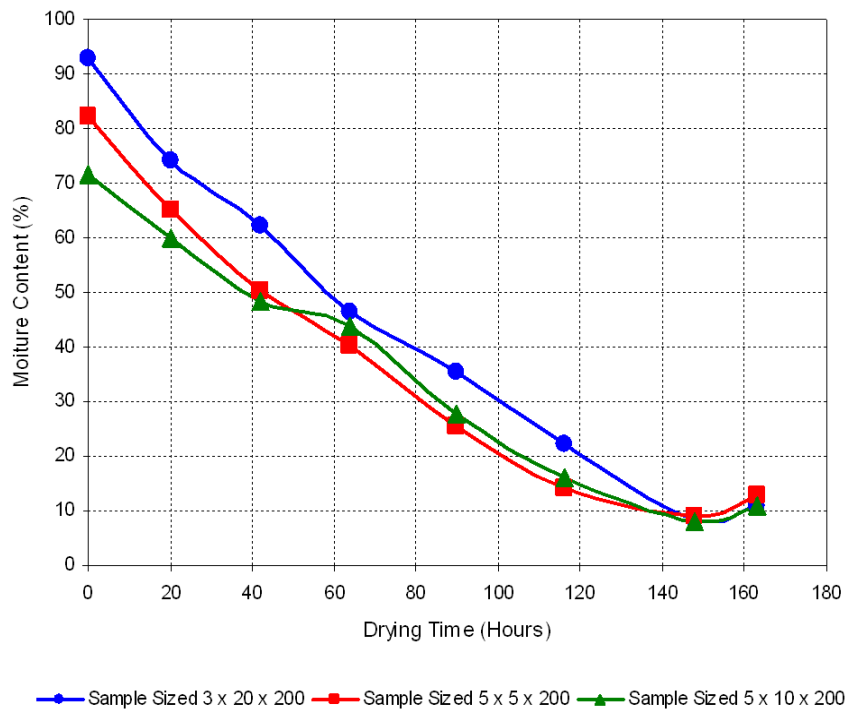


Figure 2. Comparative kiln drying rates of different sample sized of watergum wood (*Sysigium versteegii* M. et P.) in the solar-wood waste fired kiln.

Table 4. Drying rate (Percent moisture content per hour) of watergum wood in a solar-wood waste fired kiln.

Temperature (°C)		Timber Sized			Average Drying Time
Dry Bulb	Wet Bulb	3x20x200	5x5200	5x10x200	
Pulai					
36	30	1.277	1.183	0.930	1.130
45	37	0.825	0.757	0.619	0.733
49	40	0.663	0.447	0.350	0.487
54	41	0.623	0.643	0.491	0.586
Watergum					
36	30	0.933	0.854	0.576	0.787
45	37	0.842	0.862	0.702	0.802
49	40	0.633	0.540	0.557	0.577
54	41	0.763	0.276	0.452	0.497

Moisture released from woods is mostly influenced by wood specific gravity (Soenardi, 1976 and Siau, 1995) and timber dimension such as thickness and width (Casin, *et. al.*, 1979 and Budianto, 1996). As can be seen from Table 4, drying rate of both pulai and watergum woods decreased as temperature was increased. However, the drying speed of smaller sample sized of pulai wood increased again at third stage and then went up to the final stage but different sample sized of watergum wood showed the same trend of reduction moisture content. It is because pulai wood has lower specific gravity of 0.25 – 0.40 (Dinas Kehutanan Irian Jaya, 1976) than watergum wood has of 0.66 – 0.85 (Lahidu, 2007).

Defection

Wood defections occurred in the drying process were surface checks, distorsion (bowing) and discolouration. Percentage of number of timbers defected in each sample sized from pulai and watergum woods are presented in Table 5.

Table 5. Percentage of pulai dan watergum wood Defections during drying in the solar-wood waste fired kiln

Species	Timber Sized (Cm)	Percentage of Defections (%) ^{*)}		
		Surface checks	Bowing	Discolouration
Pulai	3 x 20 x 200	67	0	33
	5 x 5 x 200	44	22	11
	5 x 10 x 200	22	0	11
Watergum	3 x 20 x 200	67	0	33
	5 x 5 x 200	33	0	33
	5 x 10 x 200	33	0	33

^{*)} = Number of wood defected from 9 replicates

The most defection found in this drying process was surface check followed by discolouration and bowing. Surface checks happened because of the increase of surface tension (Budianto, 1996). It had been encountered since second stage of drying schedule. In the stage, the temperature of 54°C and RH of 60% applied in a long period caused the surface of timbers dried faster when inner part of timbers remain contained more moisture. The different moisture content had lead to cell wall tension difference. Comparing the size of the timber, the wider tangential area got more checks than others. It can be explained that orientation of wood cells in the area makes them less stable than those in radial and longitudinal surfaces (Siau, 1995). Wood discolouration occurred in drying process is because of tannin oxidation in temperature about 50°C – 60°C. Therefore, watergum with high tannin content showed higher percentage of colour change than pulai wood did.

Conclusion

Generally, solar-wood waste fired kiln has shown an effective performance in drying the two papuan wood species. It has been proved that using the applied drying schedule, it only took about 5 days to release water from pulai wood until the desired moisture content of about 11% whereas watergum wood needed slightly over 7 days to reach its final moisture content of just bellow 12 %. In addition, the different drying rate of the timbers was greatly affected by wood specific gravity and timber dimension, therefore smaller sized pulai wood with lower specific gravity had the

highest drying speed. However, second stage of the drying schedule that has led to wood checks and discolouration should be taken into consideration in order to minimize the number of wood defections in drying process.

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Fixation of *Agathis* and *Gmelina* Densified Woods at Radial Direction and Observation of their Anatomical Structure

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Abstract

Compression of wood is a method to improve wood quality. However, its product namely densified wood, tends to return to the initial shape and size (spring back) if the fixation had not completed. This compression process will also result in the changes on wood anatomy structure. The aim of this research was to assess effect of various compression degrees at radial direction on recovery of set (RS) and anatomical structure of wood of *Agathis* and *Gmelina*. The result showed that heating up to 180 °C resulted in the decreasing of RS and the increasing of wood stabilization. Cell woods namely fiber and ray parenchyma on the surface became more collapse and buckle compared to theirs at the center. Collapse and buckle produced an S-shape in wood structure. The fixation after heating up to 180°C during 20 hours either on *Agathis* or *Gmelina* densified woods was not completed.

Key words: *Agathis*, *Gmelina*, densified wood, recovery of set, wood anatomical structure

Introduction

The opportunity Of using farm-forestry wood or wood in the group of lesser known species mostly coming from fast growing species is increasing lately due to limited qualified wood in the market. These woods generally have low quality so their use is limited. In order to optimize their benefits so that capable of replacing the role of wood species often used, it needs modification of the wood properties.

Wood modification, either physically, mechanically, chemically or all combined are methods to increase wood properties. One of them is wood densification. Densification can be done by impregnation, compression and compregnation (Kollman et al., 1975). Some products of wood densification already existed are lignostone, stay pack, compreg, impreg, lignofol, kunstharzschichtholz, and Australian improved wood (Blomberg, 2006).

Some researches show that specific gravity (SG) and mechanical property of densified wood significantly increase. SG increase to 1.25 – 1.40 times, while the compression parallel to grain and tensile strength proportionally increase along with increasing SG. Compression perpendicular to grain is also higher (FPL, 1999). According to Rilatupa (2001) and Sulystiono (2001), SG of densified *Agathis loranthifolia* with the densifying level of 50% increase up to 90% from previous SG, MOE and the compression parallel to grain increase up to more than 100% while MOR is up to more than 200%. According to Wardhani et al. (2002), density and the strength of densified coconut wood also increase up to 80%.

All this time, densified wood tends to spring back due to heat and moisture. This means the fixation process is not yet permanent. One of the efforts to increase stabilization dimension of densified wood is by heating treatment. According to Inoue and Norimoto (1991) in Dwianto (1999) using Sugi wood as research material, it takes 20 hours at the temperature of 180 °C, 5 hours at 200 °C, and 3 hours at 220 °C to achieve the perfect fixation.

Densification will bring effect on wood element cells. Densified wood cells will be flat and collapse, either in elastic buckling, plastic yielding or brittle crushing (Wolcott, 1989). It is assumed that the change of densified wood anatomy structure on hardwood and softwood species will be different because the anatomy structure of wood element cells is different. Softwood tends to homogeneous (mostly dominated by tracheid cell), as for hardwood is more heterogeneous and has vessels.

Based on explanation above, this research is meant to find out the difference of wood densification level or percentage at radial direction on recovery of set (RS) and the change of anatomy structure of *Agathis loranthifolia* and *Gmelina arborea*.

Materials and Methods

The main materials are *Agathis lornanthifolia* from Hutan Pendidikan Gunung Walat Sukabumi, west java and *Gmelina arborea* from Sumedang, west Java, Indonesia. The size of sample is 2 cm (longitudinal) x 2 cm (tangential) x 4 cm (radial). Before being densified, samples were soaked in water until saturated using vacuum desiccator. Saturated wood were then densified with hot press with the temperature of 100 °C with drying set; 12.5%, 25%, and 37.5%. After achieving drying set, wood were put in an oven with the temperature of 103 ± 2 °C for 24 hours. Densified wood was reheated in an oven with the temperature of 180 °C for 5, 10, 15, 20 hours.

Dimension stabilization was determined from RS. The determination of RS referred to formula $[(T_i - T_s)/(T_o - T_s)] \times 100\%$, where T_i was the thick of densified wood sample after heated in 180 °C and soaked for 24 hours, and T_s was thick of wood after densification and heating in an oven in 180 °C, while T_o was the early oven dry thick of wood before densification.

Controlled, densified and soaked samples were then observed their anatomy structure using SEM (Scanning Electron Microscope) JEOL JSM-6360 LA, Japan. Observed samples were taken their surface and middle part by cutting them using slide microtome. The samples were then vacuumed to dry and coated in gold with the thickness of 800 Å and ready to observe. Camera picture were then analyzed with Scion Image. Picture analysis was used to determine the roundness of cell lumen. The roundness was determined by referring to formula $P^2/(4\pi A)$ where P was the perimetri and A was the area (Russ, 1995 in Bloomberg et al., 2006).

Data were then analyzed in completely randomized design factorial to find out the effect of wood variation factor (A1: *Agathis lornanthifolia*, A2: *Gmelina arborea*), variation of densification level (B1: 12.5 %, B2: 25 %, B3: 37.5 %), and variation of heating duration (C1: 0 hours (Control), C2: 5 hours, C3: 10 hours, C4: 15 hours, and C5: 20 hours). Replication used in this research was 3 times. Common model of linier statistics of research was as followed:

$$Y_{ijkl} = \mu + A_i + B_j + C_k + (AB)_{ij} + (AC)_{ik} + (BC)_{jk} + (ABC)_{ijk} + \epsilon_{ijkl}$$

Result and Discussion

Correlation of Stress and Strain

The test result of stress and strain, either for *Agathis lornanthifolia* and *Gmelina arborea* in water saturation condition was displayed on Figure 1.

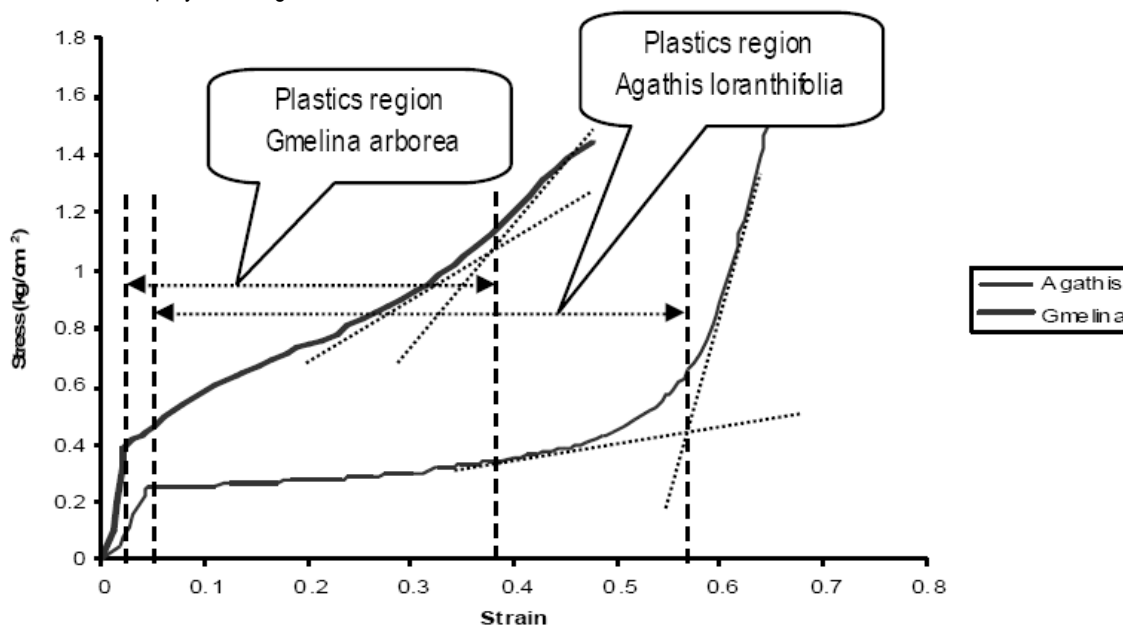


Figure 1. The correlation of Stress-Strain of *Agathis lornanthifolia* and *Gmelina arborea* in water saturation condition

The research showed that in water saturation condition, *Agathis lornanthifolia* was softer than *Gmelina arborea*: at the same strain it required lower stress. Plastic region of *Agathis lornanthifolia* was wider (0.05 – 0.57), as of

Gmelina arborea was between 0.03 – 0.38. The difference was related to the difference of element cell type and chemical component composition of wall cell between *Agathis lornanthifolia* and *Gmelina arborea*.

Recovery of Set (RS)

RS of densified *Agathis lornanthifolia* and *Gmelina arborea* showed increase along with the rise of densification level. On the contrary, the longer the heating was done with the temperature of 180 °C, the lesser the RS was. The result also showed that RS on *Agathis lornanthifolia* tended to have lower value than on *Gmelina arborea* at the same densification level. The heating treatment duration also showed that RS of both species were different, where *Agathis lornanthifolia* was lower than *Gmelina arborea* at the same heating duration (Figure 2)

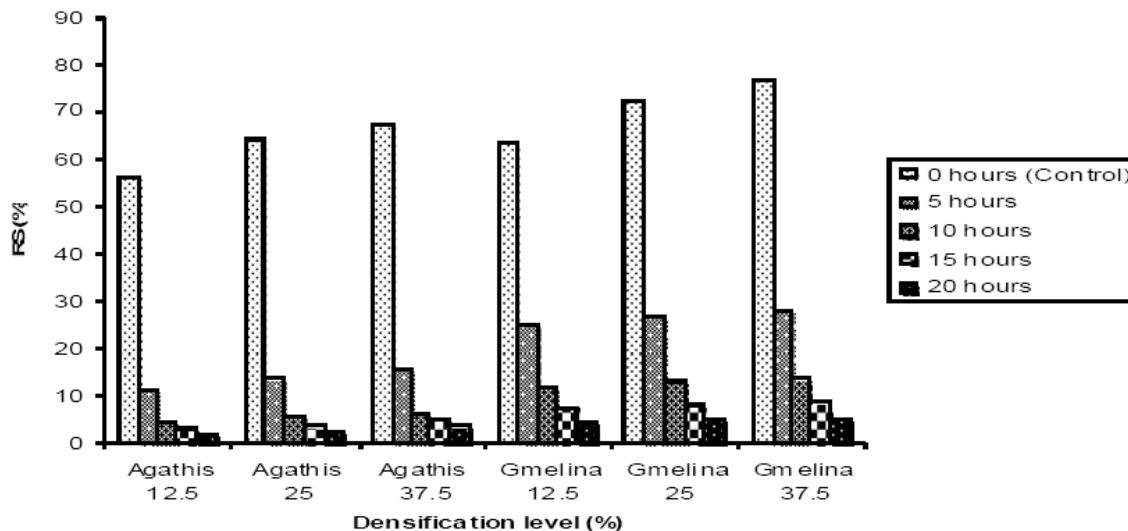


Figure 2. The correlation between densification level and heating duration at the temperature of 180 °C on RS of *Agathis lornanthifolia* and *Gmelina arborea*

The increase of RS value was in accordance with the increase of wood densification level, especially on heating less treatment. High densification level caused more densified cells and it took greater energy to reform. The change of cell dimension on the surface is different from that on deeper part. The cells on the surface tended to flat and collapse due to densification. While the cells on deeper part did not have significant change or damage. While being soaked, the collapse cells would return to their previous form.

Wood heating would affect the chemical component of wood. Stamm (1956) on Sundqvist (2004) said that there would be a great change on chemical component of wood if it was heated with the temperature of 150 – 250 °C.. It samed that hemicellulose degradation reached four times bigger than cellulose at 150 °C, while the speed of lignin degradation was half the cellulose. Hemicellulose degradation would be dominant on heating temperature below 200 °C. According to Dwianto et al. (1998) compression with the temperature above 180 °C caused degradation of hemicellulose and lignin component and as a result, the tension saved at microfibril would be released (relaxation). During compression process, lignin which was cross-link polymer would soften and flow because of hot steam pressure effect, so that it was capable to fill in matrix chamber with in the wood. The damage of water molecule due to high temperature treatment caused damage on H-bonding among molecules inside hemicellulose-lignin matrix (Amin and Dwianto, 2006).

According to Mitsui et al. (2007), heating treatment at 140 °C on Sitka spruce (*Picea sitchensis*) would degrade cellulose hydroxyl groups started from amorphous area continued to semicrystalline and ended at crystalline area. The change from amorphous into crystalline would cause decrease of water absorption ability so wood would be more stabilized. This would increase wood dimension stability.

The densification level effect, heating duration, and wood species on RS of densified wood were described at Table 1. At Table 1 shown that factor A (wood species), factor B (densification level), and factor C (heating duration at 180 °C) had effects on RS value of densified wood. Interaction between factor A and C and interaction between factor B and C showed real effect on RS which occurred.

Table 1. Analysis of Varian RS of Densified *Agathis loranthifolia* and *Gmelina arborea*

Sumber Keragaman	db	JK	RJK	Fhit	F05	F01
Factor A	1	1.140,047	4,362	719,438	4,000	7,080**
Factor B	2	262,070	131,035	82,691	3,150	4,980**
Interacts AB	2	0,168	0,084	0,053	3,150 ^{tn}	4,980
Factor C	4	49.253,309	12.313,327	7.770,448	2,530	3,650**
Interacts AC	4	326,516	81,629	51,513	2,530	3,650**
Interacts BC	8	293,711	36,714	23,169	2,100	2,820**
Interacts ABC	8	5,504	0,688	0,434	2,100 ^{tn}	2,820
Galat	60	95,078	1,585			
Total	89	51.376,402				

Anatomy of Densified *Agathis loranthifolia*

The appearance of *Agathis loranthifolia* microscopic structure on cross section control (without densification), densified, or densified wood which had been re-soaked in water for 24 hours was described on Figure 3. On Figure 3, here was a change of cell form especially lumen cell and wood rays. Cell form change (especially tracheid lumen cell) could be seen from its roundness value: the bigger the roundness value was (> 1), the more flat the tracheid cell would be (Table 2).

Table 3. The roundness of *Agathis loranthifolia* tracheid cell lumen before and after being densified and after densified wood was soaked

Treatment	Densified	Recovery
Control	1,20 ± 0,09	
12,5% S	2,74 ± 0,81	2,14 ± 0,55
12,5% C	1,24 ± 0,10	1,24 ± 0,05
25,0% S	2,96 ± 0,54	1,63 ± 0,51
25,0% C	1,34 ± 0,16	1,28 ± 0,09
37,5% S	3,78 ± 1,37	1,62 ± 0,28
37,5% C	1,37 ± 0,22	1,35 ± 0,23

Note : S (Surface), C (Central)

On Figure 3 and Table 3, it was clearly shown that wood densification would affect its cell lumen form. The cell densification was started at the surface which continued to deeper area. The roundness of cell lumen was affected by densification level: the higher the level was then the more flat the wood cell would be. This was indicated by the roundness value which was getting higher. At soaked densified wood. The cells tended to return to its previous form. This was signified by roundness value which was getting lower compared to the same value at densified wood.

Wood densification also gave effect to wood rays appearance on cross section. It seemed that the rays, especially those on the surface, buckled due to compression. It happened because pressure direction was parallel to its rays direction. On the other hand, rays in the middle area of the sample tended not to change because the pressure in deeper area was relatively lower.

The research result also showed that tracheid cells of *Agathis loranthifolia* caused collapse after being densified. The tracheid cell wall also caused buckling. Figure 4 displayed the letter S-like form on buckled tracheid cell wall; due to densification. At the Figure 4 above, it was shown that the buckling occurred on tracheid cell wall did not cause a crack. This type of change was classified as elastic buckling. It was presumed because the sample of densified wood was in water saturation condition (elastic) so it would not cause damage during densification.

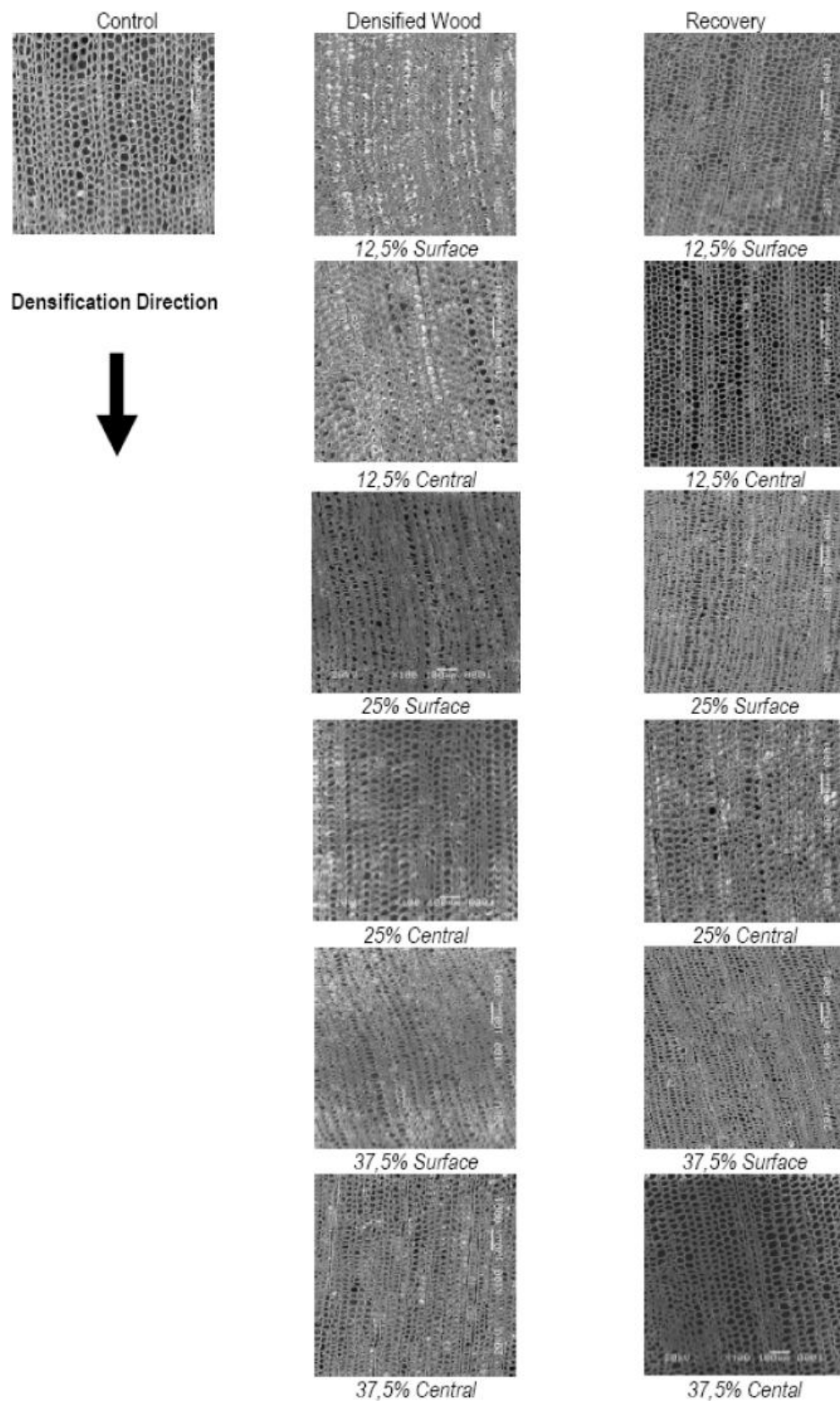


Figure 3. Micrograph of *Agathis loranthifolia* before and after being densified and after densified wood was soaked (Figure size 960 x 970 μm^2)

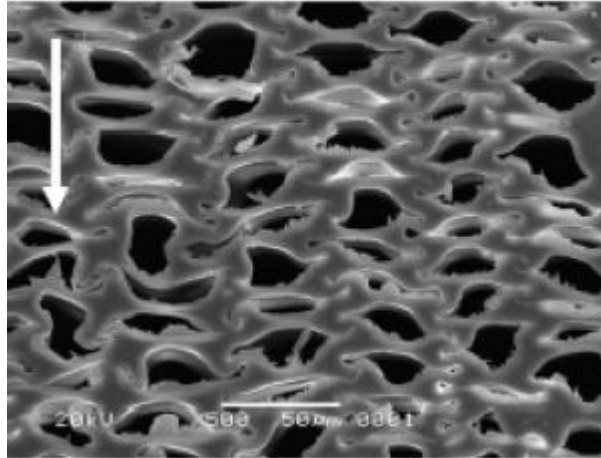


Figure 4. Micrograph of densified *Agathis loranthifolia* cell wall form having elastic buckling (Figure size 190 x 255 μm^2)

Anatomy of Densified *Gmelina arborea*

The appearance of *Gmelina arborea* microscopic structure on cross section, control (without densification), densified, or densified wood after being re-soaked in water for 24 hours was displayed on Figure 5. It appeared there had been a change on cell form (cell lumen) and wood rays. The lumen form change of *Gmelina arborea* fiber as well as *Agathis loranthifolia* tracheid cell lumen was seen from the roundness value. The higher the value was (>1), then the more flat the fiber would be (Table 4).

Table 4. The roundness of *Gmelina arborea* tracheid cell lumen before and after being densified and after densified wood was soaked

Treatment		Densified	Recovery
Control	$1,24 \pm 0,06$		
12,5% S		$2,24 \pm 0,81$	$1,35 \pm 0,17$
12,5% C		$1,31 \pm 0,06$	$1,25 \pm 0,09$
25,0% S		$3,77 \pm 1,38$	$1,76 \pm 0,26$
25,0% C		$1,36 \pm 0,17$	$1,29 \pm 0,10$
37,5% S		$4,90 \pm 2,17$	$1,40 \pm 0,17$
37,5% C		$1,41 \pm 0,18$	$1,32 \pm 0,15$

Note : S (Surface), C (Central)

At Figure 5 and Table 4 were also seen there was level change of cell roundness on before and after densified samples also after densified wood were re-soaked in water for 24 hours. The higher the densification level was, the more flat the fiber would be.

As well as on *Agathis loranthifolia* tracheid, *Gmelina arborea* fiber also caused the hardest collapse on the surface. Similar thing also happened to its vessel cells. The cells having deformation were not yet experienced perfect fixation when they were heated at 180 °C for 5 hours. This could be seen from the form change of cell lumen happening after densified wood was re-soaked in water for 24 hours. The roundness value after being soaked was lower than was on densified wood (Table 4). This was confirmed by SEM observation where roundness value of densified wood cell lumen which was re-soaked tended to return to its previous form.

Densified wood also turned out to give different effect on earlywood and latewood section (Figure 5). When being densified, earlywood section tended to have bigger deformation than latewood did. This related to cell wall thickness. Latewood element cells were generally thicker than those in earlywood so that they could hold pressure force longer.

Cell wall, either fiber or vessels also caused buckling due to densification process. This was obviously seen especially on the surface where greater deformation occurred. Cell wall buckling did not cause a crack because densified wood was first in saturation condition so it was elastic. Due to the densification, cell wall of *Gmelina arborea* fiber also had letter S-like shape (Figure 6)

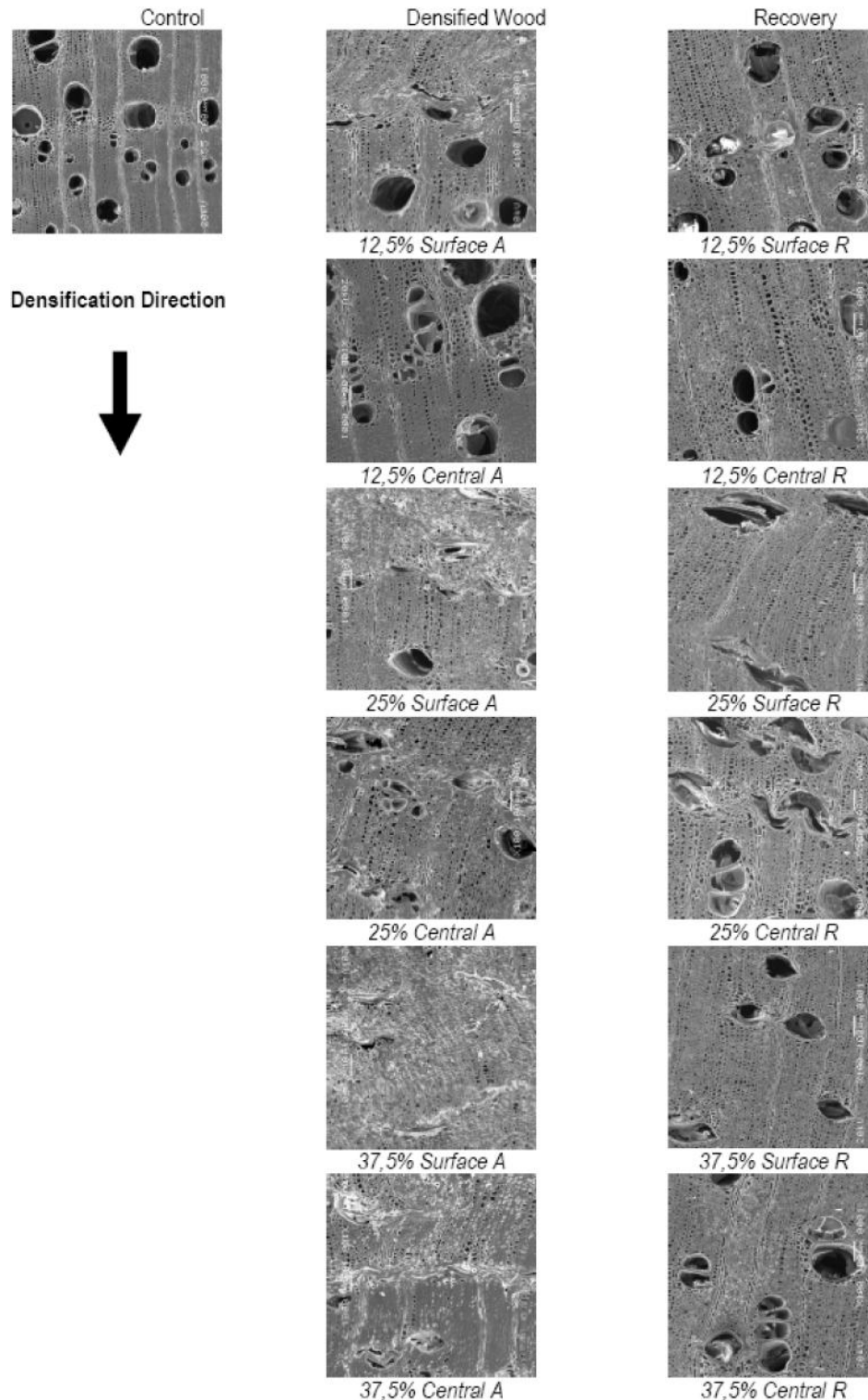


Figure 5. Micrograph of *Agathis loranthifolia* before and after being densified and after densified wood was soaked (Figure size 960 x 970 μm^2)

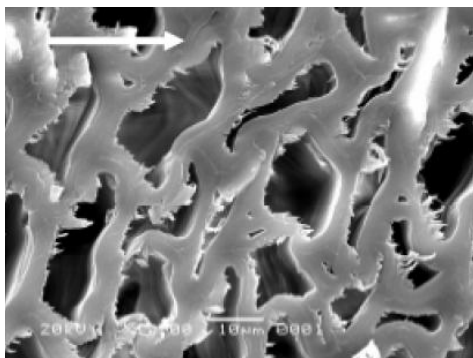


Figure 6. Micrograph of *Gmelina arborea* cell wall form after densification (level 25%) (Figure size 60 x 84 μm^2)

Conclusions

Based on the research result, there were some conclusions as followed:

1. Heating at 180 °C at any densification wood, either on *Agathis loranthifolia* or *Gmelina arborea* could decrease the RS and increase the dimension stabilization of densified wood: the longer the heating was, the lower the RS and more stable the dimension would be. °C
2. Densified wood which was heated at 180 °C until 20 hours, both *Agathis loranthifolia* and *Gmelina arborea* still did not make perfect fixation.
3. Element cells of wood, especially on the surface, were more collapsed and buckled; the higher the densification level was, the more collapsed and buckled the cells would be.

Suggestions

The heating at 180 °C for 20 hours as mentioned above still did not make perfect fixation. Therefore, it would require similar research by giving more time of heating (>20 hours), or increase the temperature which is save for wood. The effect of heating on the change of amorphous region into crystalline was also interesting to observe, considering it related to dimension stabilization.

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Physical and Mechanical Properties of Randu and Angsana Impregnated with Polystyrene

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Abstract

The aim of this research was to know the physical and mechanical properties of Randu (*Ceiba pentandra* Gaertn) and Angsana (*Pterocarpus indicus*) polystyrene. Clear specimens were used with dimension 2 x 2 x 30 cm with MC 7 %. Replication of wood sample was three. Samples were divided into 3 treatments; there were control, soaked and vacuum-pressured. Three of each species were soaked by styrene monomer liquid for 3 days. The others were put in tank and given treatment by vacuum at 600 mm Hg for 30 minutes, then Pressured at 10 kg/cm² for 30 minutes. After that, woods were wrapped by aluminum foil and dried with temperature 60°C for 24 hours to make polymerize, then conditioned in the room for 2 weeks.

The result showed that average of polymer loading by soaking on Randu wood and vacuum-pressure were 32.20% and 92.43%, respectively. While by soaked on Angsana wood and vacuum-pressure were 22.20% and 68.71%, respectively. There were increasing in density, stability of dimension, hardness, modulus of elasticity (MOE), modulus of rupture (MOR) and compression parallel to grain.

Key words : Polystyrene, Randu, Angsana, physical and mechanical properties.

Introduction

Industrial Plantation Forest has being developed for additional supply of log in Indonesia, and fast growing species were dominantly planted. . These species have a great contribution, not only improvement of damage forest productivity, but also to balance of supply and demand for wood industry. The disadvantage of fast growing species has inferior physical and mechanical properties and more susceptible attacked by biodeterioration than the ordinary structural wood.

Many methods that can use to improve wood qualities. One method is modifying wood properties with impregnation particular chemical agents into the wood, such as polystyrene. Some researchers mentioned that polystyrene can improve the physical, mechanical properties and also the wood durability.

Lawniczak (1993) mentioned that polystyrene impregnated wood produced by a thermal polymerization process has been used on an industrial scale in Poland. Lawniczak and Kozlowski (1993) stated that polystyrene bamboo with 20 % weight gain increased MOR 60 % in dry condition and 300 % in wet condition, decreased two third water adsorption, and more resistant to fungal attack. Furthermore Lawniczak (1995) studied another research, the inner part of coconut wood was impregnated with polystyrene using heat as catalyst, and the products had equal properties with outer part of coconut wood and more resistant to fungal attack.

Bakraji et.al (2000) mentioned that wood polymer composite with styrene that is gamma-radiation-induced can increase polymer loading 18-54 % and the compression strength with compression strength factor (Cf) between 1.04 – 1.15 on poplar, cypress, white willow, swamp mahogany and walnut. Furthermore Baysal et.al (2006) mentioned that styrene can weight gain 203.7 ± 18.1 %, increase anti swelling efficiency (ASE) 72.6 ± 7.4 % and wood density from 0.52 to 0.94, decrease water absorption from 250.4 ± 15.3 % to 35.7 ± 3.5 %, and also increase MOE and MOR properties.

Impregnation of polystyrene is possible to improve wood of fast growing species, such as to Randu and Angsana Wood. The purpose of this research was to know the physical and mechanical properties of the polystyrene wood.

Methods

Wood Preparation

The wood species were used for physical and mechanical test were Randu (*Ceiba pentandra Gaertn*) and Angsana (*Pterocarpus indicus*). The small clear specimens sized 2 cm x 2 cm x 30 cm were used for the test.

Samples were divided into three treatments; there were control, soaked and vacuum-pressure. Three of each species were soaked by styrene monomer liquid for 3 days. The others were put in tank and given treatment by vacuum at 600 mm Hg for 30 minutes, then Pressure at 10 kg/cm² for 30 minutes. After that, woods were wrapped by aluminum foil and dried with temperature 60°C for 24 hours to make polymerize, then conditioned in the room for 2 weeks.

Physical Properties Test

Some physical properties test were moisture content, density and polymer loading. The formula of physical properties test were

a. Polymer loading

$$\text{Polymer loading} = \{(B_P - B_K) / B_K\} \times 100 \%$$

B_K : weight of control wood; and B_P : weight of treatment wood

1. Moisture Content = $\{(B_A - B_{KT}) / B_{KT}\} \times 100\%$,

B_A : weight prior to the test; and B_{KT} : weight oven dry

2. Density = B_{KU} / V_{KU} (g/cm³)

B_{KU} : weight to the air dry condition; and V_{KU} : volume to the air dry

Mechanical Properties Test

Some mechanical properties test were modulus of rupture (MOR) and modulus of elasticity (MOE), hardness and compression parallel to grain. The formula of mechanical properties test :

$$1. \text{ Modulus of Rupture (MOR) } = (3 PL) / (2 bh^2) \text{ kg/cm}^2$$

$$2. \text{ Modulus of Elasticity (MOE) } = (PL^3) / (4 ybh^3) \text{ kg/cm}^2$$

$$3. \text{ Compression parallel to grain } = P/A \text{ kg/cm}^2$$

$$4. \text{ Hardness } = P/A \text{ kg/cm}^2$$

Where

P = max load/force (kg),

L = span length,

b = wide (cm)

h = height (cm)

y = deflection (cm),

A = area (cm²),

Results and Discussions

Physical Properties Polystyrene Wood

After polymerization process with heat, the average of polymer loading of Randu woods could be described as follows, soaking and vacuum-pressure were 32.20 % and 92.43 %, respectively. While average of polymer loading of Angsana woods, soaking and vacuum-pressure were 22.20 % and 68.71 %, respectively.

The moisture content of wood polymer decreased with treatments, both on randu and angšana. The other hand, density increased with treatments, as shown in Table 1.

Table 1. Average of physical properties of Randu and Angsana.

Variable	Polymer Loading (%)	Moisture Content (%)	Density (g/cm ³)
Randu			
Control	-	13,86	0,24
Soaking	31,20	12,59	0,31
Vacuum-pressure	92,43	11,72	0,45
Angsana			
Control	-	11,63	0,47
Soaking	22,20	10,20	0,61
Vacuum-pressure	68,71	9,90	0,81

Impregnation of polystyrene into woods, such as lumen, vessel, void spaces inside cell walls, decreased hydrophobic properties. Therefore, the moisture content in the wood decreased due to increasing polystyrene in wood. Furthermore, impregnation of polystyrene caused increasing of density, both on randu and angsana woods.

Impregnated Polystyrene into Randu was higher than Angsana, because density of randu is lower (0.2 g/cm³) then Angsana (0.4 g/cm³). Generally wood with low density has big pore, thin cell walls, big lumen, and also low extractive content. They could make more permeable (Pandit, 1996)

Mechanical Properties Polystyrene Wood

Average of mechanical properties of this research i.e. MOE, MOR, hardness, MOR, MOE and compression parallel to grain shown in Table 2.

Table 2. Average of mechanical properties of Randu and Angsana

Variable	Compression parallel to grain (kg/cm ²)	MOR (kg/cm ²)	MOE (kg/cm ²)	Hardness (kg/cm ²)
Randu				
Control	124,69	225,48	16336,71	108,67
Soaking	128,42	227,37	16416,81	113,33
Vacuum-pressure	138,26	271,59	18825,22	133,33
Angsana				
Control	431,69	944,95	67865,66	331,33
Soaking	441,86	951,71	68217,67	341,00
Vacuum-pressure	444,81	969,29	69925,48	352,33

Table 2 shown that vacuum-pressure treatment has the highest value for all parameter respond, after that soaking treatment Vacuum-pressure treatment has the high value, because high pressure in tank can force polystyrene enter into wood, then made bonding with wood structure. Therefore, wood strength will increase.

Conclusions

From discussions above, it could be concluded that:

1. Wood with low density is easier to be entered polystyrene than high density.
2. Impregnation polystyrene could increase physical and mechanical properties.
3. Vacuum-pressure treatment force polystyrene enters to woods, those cause vacuum-pressure treatment is better than soaking treatment.

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***Acacia mangium* Shear Modulus Based on ASTM D198-05a (2008) and Modulus of Elasticity Curve**

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Abstract

Shear modulus (G) is required to obtain the value modulus of elasticity (MOE) that includes the effect of shear distortion of beam cross section. The objectives of this research were to determine shear modulus based on ASTM, and developed method, curve of $MOE_{normal/short-span}$; comparison between the two mentioned values. This research used *Acacia mangium*, family Leguminosae, as a medium density wood. The first method, the procedure of investigation in the laboratory was tested in accordance with ASTM D198-05a(2008), "Standard Test Methods of Static Tests of Lumber in Structural Sizes". By plotting $1/E_f$ versus $(h/L)^2$, where E_f is the apparent modulus of elasticity calculated under center point loading, h is depth of beam, and L is length of beam, the shear modulus can be found. The second method, shear modulus determination had been developed using the apparent modulus of elasticity curve of normal and short span ratio versus $G/MOE_{normal-span}$, where normal span is 14 h, and short span is $< 14 h$. The result of this research can be obtained that based on ASTM, the *A.mangium* shear modulus was $1/19,02$ multiply MOE_{app} , and $1/18.40$ multiply $MOE_{h/L=14}$ based on curve of $MOE_{normal/short-span}$; the value based on two methods were not significantly different.

Key words : *shear modulus, modulus of elasticity, apparent, medium density wood*

Introduction

In the development of design methods of wood component like beam, the deformation caused by shear force is an important parameter in a design process. Wood shear modulus as a parameter of wood shear nature is required in designing beam structure.

With bending laboratory test, the measurement of deflection was obtained. Followed by a simple calculation, the modulus of elasticity of wood (MOE) can then be obtained. In the calculation, it is basically only considering on the deflection caused by bending, and seldom consider the deflection caused by shear force. In calculating the effect of deflection caused by shear force, the data of wood shear modulus is required. Unfortunately, the information or research on wood shear modulus is very limited. As the result, the calculation using the wood shear modulus was often ignored. It was proven by former researchers that by ignoring the deflection caused by shear force of wood, the exact value of MOE cannot be obtained, i.e. it is smaller. Bodig, in 2003 stated that more mistakes were done by ignoring the deflection caused by shear force, depends on the type of beam, loading condition, MOE/G ratio and span-height ratio.

For high beam of wood, it is required to consider the effect of deflection caused by shear force not only the effect of bending. With adequate information on the result of researches, done on the wood shear modulus, designers can then calculate the wood modulus of elasticity affected by shear force. Yoshihara, in 1998 stated that the effect of shear stress depends on the beam height-span ratio, if the height-span ratio is big, this should be put into consideration. Sulistyawati, in 2006 in her research indicated that high beam with short span or the double degree value of the high beam towards span length ratio is quite big; deflection caused by shear force should be put into consideration. It was also indicated that by considering the deflection caused by shear force with value of shear modulus for beam, the flexural stiffness (EI) of beam would have a greater value. Based on the fact, that modulus of elasticity will be greater for a certain height and span of beam, thus in calculating the stiffness value; the effect of deflection caused by shear force should be put into consideration. This means that the beam capacity to bear the

flexure will be greater. By considering a greater *MOE*, a more economical design of beam would be obtained. In calculating deflection caused by shear force it is required to obtain the value shear modulus of wood.

One of the regulations used to obtain the shear modulus of wood is ASTM D198-5a (2008). This regulation was the latest revision after several reviews. This research has also developed a method of obtaining the value by conducting a faster and simpler analysis. By reading the correlation curve of $MOE_{normal/short\ span} - G/MOE_{normal-span}$ by conducting bending test for wood's dimension with $L/h = 14$ as the normal span and $L/h < 14$ as the short span, and quickly afterwards obtaining the value shear modulus.

The objectives of this research were to determine shear modulus based on ASTM, and developed method curve of $MOE_{normal/short-span}$; comparison between the two mentioned above.

Material and Methods

Material and Equipment

The wood used in this research was *Acacia mangium*, family Leguminosae obtained from the products of Plantation Forest Perhutani III in Legok, Bogor, West Java. The wood is about 8 years old with log diameter between 22 – 28 cm. The drying process was done by nature, the wood beams with cross-section dimension of 6,50 cm x 6,50 cm arranged in orderly pile, placed in a room with roof. When the moisture content reached about 15%, the wood beams were planed to obtain beam cross-section dimension of 6 cm x 6 cm.

The equipment used in this research were: wood cutter, wood planer, caliper, moisture meter, Universal Testing Machine Instron 330 Type with loading capacity of 50 KN, and computer with supporting soft and hard ware.

Research Method

The tests were conducted in the Wood Technical Laboratory, Faculty of Forestry, Department of Forest Products, Bogor Agricultural University, Dramaga, Bogor, West Java. To obtain the wood shear modulus, the tests were conducted by using two methods: (1) Based on *ASTM D198-5a (2008)* about “*Standard Test Methods of Static Test of Lumber in Structural Sizes*” Section 44-51, Shear Modulus, (2) based on the method developed by the writer by reading the corelation curve $MOE_{normal/short\ span} - G/MOE_{normal\ span}$.

1. ASTM D198-05a (2008) Method

The beam was placed on top of two placements which was given load in the centre of the span and the resulted deflection was measured. This procedure was conducted with minimum four different span on one tested beam. Each span was defined at double degree value of the beam height span or $(h/L)^2$ i.e between 0.035 up to 0.0025, or

$$L = \sqrt{\frac{h^2}{0.035}} \quad \text{to} \quad \sqrt{\frac{h^2}{0.0025}} \dots\dots\dots (1)$$

As the beam cross-section tested was defined at 6 cm x 6 cm, the span tested are to be between 32 up to 120 cm. The number of the tested was 3 (three). A number of tests were conducted on each beam arranging different span of 110 cm, 75 cm, 60 cm, dan 46 cm respectively, for all beams.

Additional load was given with prediction of bending stress within elastic limits. On every additional load, reading of the deflection measurement in the middle of the span was done. The speed of loading is 3 mm/minute. To estimate that the tests were still within the elasticity limits, it can be done by defining the largest loading by calculating the bending stress that might emerge. Based on the data, the correlation curve of force and deflection was illustrated, the slope angle of the curve was used to calculate the wood modulus of elasticity.

Before the tests were conducted for each beam, measurement of the beam cross section dimension were done, i.e. the beam width and height on three tested spots, which were to be used further in the calculation of modulus of elasticity.



Figure 1 The examination of bending test by Universal Testing Machine

Shear modulus was gained from the correlation curve material $(h/l)^2$ towards axis x and $1/E_f$ value, towards axis y. The material shear modulus is proportional towards the straight line point of intersection of several coordinate point resulted from the tests conducted towards the axis y calculated from the coordinate point 0(0,0), the material towards $1/MOE$ was shown, where E_f is $MOE_{apparent}$ and E is MOE_{true} . The examination of bending test can be seen in Figure 1.

2. Hypothesis Method of the Correlation Curve $MOE_{normal/short span} - G/MOE_{normal span}$

This method is descended from the strain energy theory used as the base to gain the shear modulus of wood as well as the base of ASTM regulation arrangement. The writer developed this simpler method to obtain wood shear modulus by reading the correlation curve of $MOE_{normal/short span} - G/MOE_{normal span}$, where normal-span, is the span where $L = 14 h$ and short-span, is the span where $L < 14 h$. The modulus of elasticity data used in this research was obtained simultaneously from the bending tests results based on ASTM D198-05a (2008). The curve indicates the correlation of $MOE_{L/h=14}/MOE_{L/h<14}$ ratio towards value a, which is shear modulus G and $MOE_{L/h=14}$ ratio.

Based on the energy theory discussed in several text book (Tauchert 1974, Timoshenko 1976, Gere and Timoshenko 1997, Oden and Ripperger 1981, as well as Beer and Johnston 1992), with Castigliano theory, the deflection equation caused by bending moment and shear force can then be obtained.

The equation for deflection caused by elasticity moment is:

$$\Delta_b = \int_0^L \frac{M}{EI} \bigg|_{x=0} \frac{\partial M}{\partial X} dx \dots\dots\dots (2)$$

Where $M|_{x=0}$ is bending moment caused by external loading and can be written as M , whereas $\frac{\partial M}{\partial X}$ is bending moment caused by loading of one unit at the point where the deflection is to be defined, and deflection caused by shear force is:

$$\Delta_s = k \int_0^L \frac{V}{GA} \bigg|_{x=0} \frac{\partial V}{\partial X} dx \dots\dots\dots (3)$$

where $V|_{x=0}$ is shear force caused by external load and can be written as V , whereas $\frac{\partial V}{\partial X}$ is shear force caused by load of one unit at the point where the deflection is to be defined. E or normally called MOE is modulus of elasticity, I is inertia moment, G is shear modulus, A is the cross-section area, and k is beam cross-section form factor.

Assuming the tested material is isotropic, the elastic deflection caused by bending shear force of prismatic beam under a single-centre point load is,

$$\Delta_{total} = \frac{PL^3}{48EI} + \frac{kPL}{4GA} \dots\dots\dots (4)$$

Where:

P = load (N)
 L = length of span (mm)
 I = Inertia moment (mm⁴)
 k = shape factor (prismatic cross section $k = 1,20$)
 A = cross section area (mm²)

or,

$$\Delta_{total} = \frac{PL^3}{48EI} + \frac{0.30PL}{GA} \dots\dots\dots (5)$$

From the Equation 5, a formula is developed to gain the value of $MOE_{L/h=14}/MOE_{L/h<14}$ as follows,

$$\frac{MOE_{L/h=14}}{MOE_{L/h<14}} = \left[1 + \frac{0.00612}{(G / MOE_{L/h=14})} \right] \dots\dots\dots (6)$$

From Equation 6, both material of each counter and divisor is the modulus of elasticity, which counts the deflection caused by bending moment only. Figure 2 is the curve obtained from the calculation of Equation 6, where value a , is the ratio of G towards $MOE_{L/h=14}$.

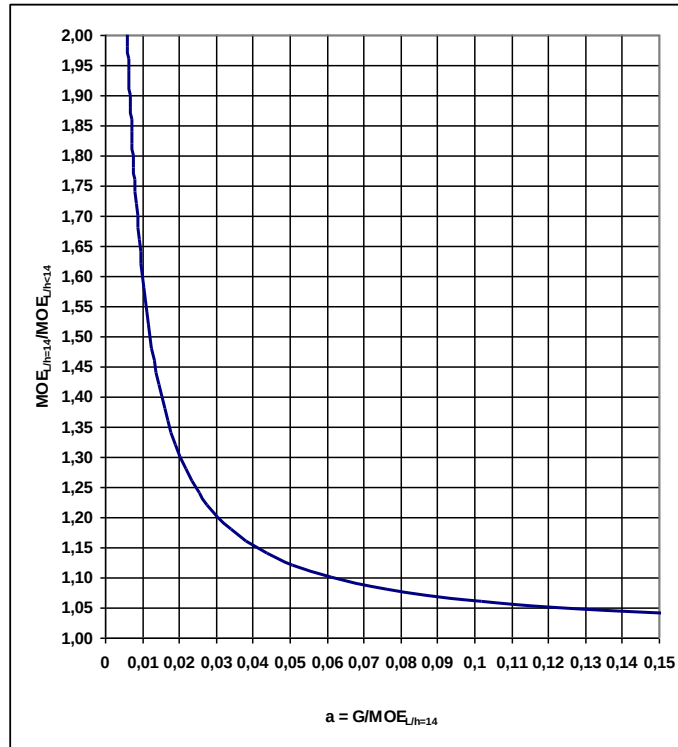


Figure 2 The Curve obtained of shear modulus value G

Result and Discussion

The tests result of beam placed on top of two placement with different spans, each MOE_{app} value i.e. modulus of elasticity which concern only on deflection caused by bending, can be calculated. The value in detail elaborated in Figure 3. From the graphic it can be seen that with bigger span beam the value of MOE_{app} is bigger if compared to the smaller span. Even though sometimes occurred in beam 1 that MOE_{app} with 60 cm span is bigger compared to the 75 cm span. Also for the tested beam 2, MOE_{app} with 75 cm span is bigger if compared to the 110 cm span. But if the above data made into a graphic and the regression equation is completed, it is definite that the shorter the span the smaller the MOE_{app} value.

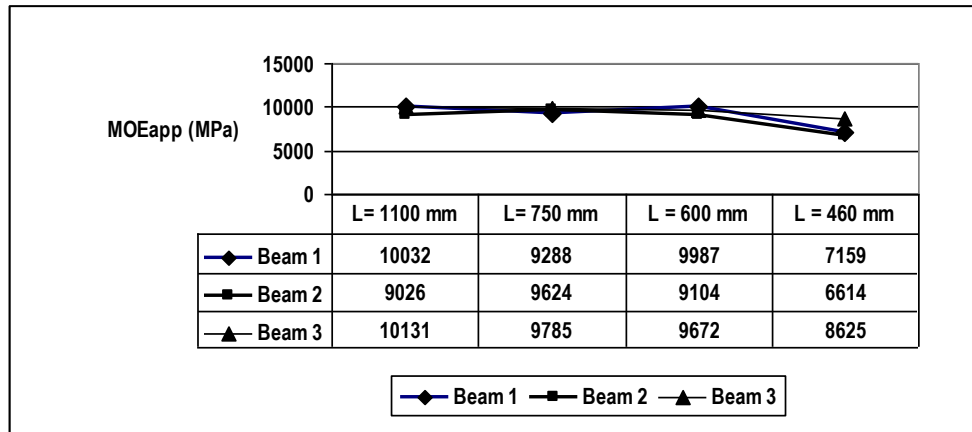


Figure 3 Modulus of elasticity apparent based on length of span

The $(h/L)^2$ value of each tested beam are between 0.003 up to 0.017, the value fulfilled the requirement as arranged based on the ASTM 198-05a (2008) regulation, i.e. between 0.0025 up to 0.035. Each $1/MOE_{app}$ value can be calculated for each beam and further be plotted into a curve as illustrated in Figure 4. Regression equation was made based on the four value of each beam. The former definition i.e. the smaller span the smaller the MOE value, vice versa in Figure 4 can be seen that the smaller span the bigger $1/E$ value. From the three diagram, at x value = 0, $1/MOE_{true}$ value is obtained, and further the MOE_{true} value of each beam can be calculated.

The shear modulus G is $1/2/K1$, where $K1$ is the slope of linear line formed from the diagram of correlation $(h/L)^2$ and $(1/MOE_{app})$. From the analysis result further performed, it can be seen that the value of G are $(1/2,87)$, $(1/22,84)$ and $(1/10,35) \times MOE_{app}$ for beam 1, 2, and 3 respectively, or an average of $(1/19,02) \times MOE_{app}$.

To obtain the shear modulus by using the second method, i.e. by reading the correlation curve $MOE_{normal/short-span} - G/MOE_{normal span}$, see again Figure 2. First calculate MOE which calculate only the deflection caused by bending, whereas $L/h = 14$ and $L/h = 10$ based on the regression equation already obtained from the correlation curve of $(h/L)^2$ and the $(1/MOE)$ value, as illustrated in Figure 4. MOE_{normal} of the second method was defined at the $L/h = 14$ ratio, since at that position the biggest MOE was obtained, Figure 5. This was the reason why MOE at the position of $L/h = 14$ is defined as MOE_{normal} . Based on the curve reading, it was obtained that value a for beam 1, 2, and 3 respectively are 0,0444, 0,0436, and 0,1022, or the value of shear modulus G for beam 1,2, and 3 respectively are $(1/22,51)$, $(1/22,91)$, and $(1/9,78) \times MOE_{L/h=14}$ or an average of $(1/18,40) \times MOE_{L/h=14}$. The differences value of G between beam 1, and 2 toward beam 3 happened because of in homogeneity of wood, even though same species. In homogeneity wood such as knots, grain inclination, and variation of annual ring width are contained, influences the result of test method (Yoshihara, and Kubojima, 2002). The shear test data dispersion decreased quickly as the grain slope increased (Liu, 2005).

Divisor value from the factor towards MOE_{app} for the first method based on ASTM and $MOE_{L/h=14}$ for the second method by reading the curve as illustrated in the stem diagram as can be seen from Figure 6. The value of $1/a$ for both methods is almost at the same level. For the first and the third tested beam at the first method based on ASTM each has the value of 6,0% and 3,1% higher compared to the second method by reading the curve. Whereas for the second tested beam, the first method has a smaller value of 0,3% if compared to the second method. Based on the statistical analysis, the shear modulus value of both methods is not different.

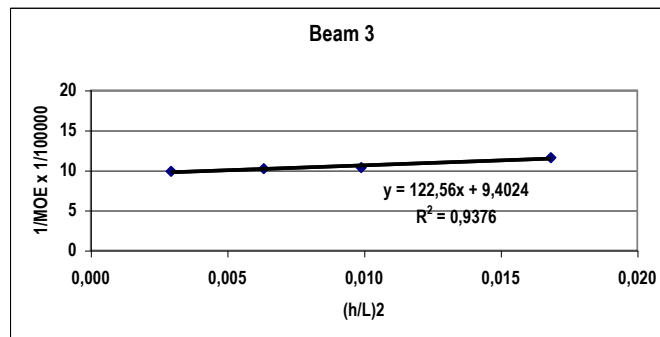
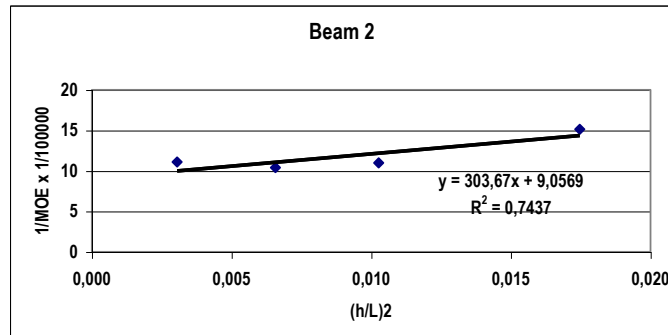
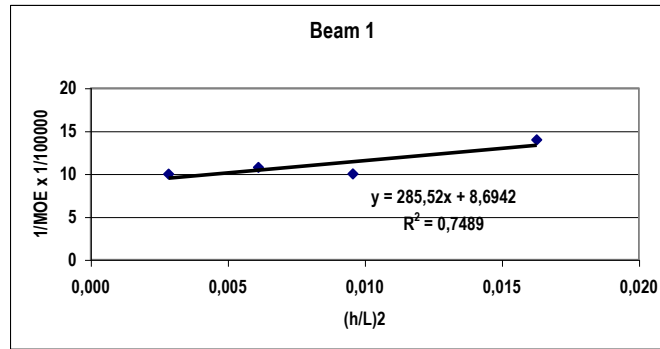


Figure 4 The relation of $(h/L)^2$ and $(1/MOE)$ value

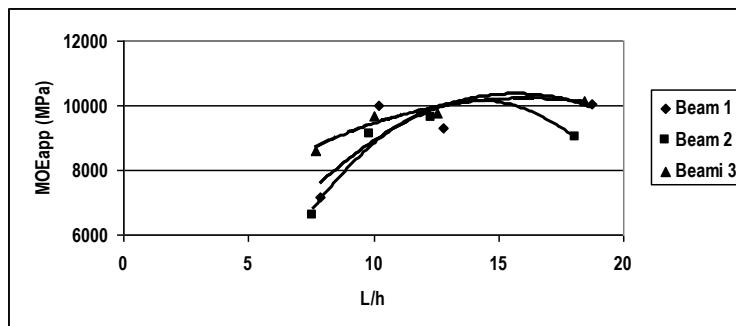


Figure 5 The curve of apparent modulus of elasticity toward span-height beam ratio

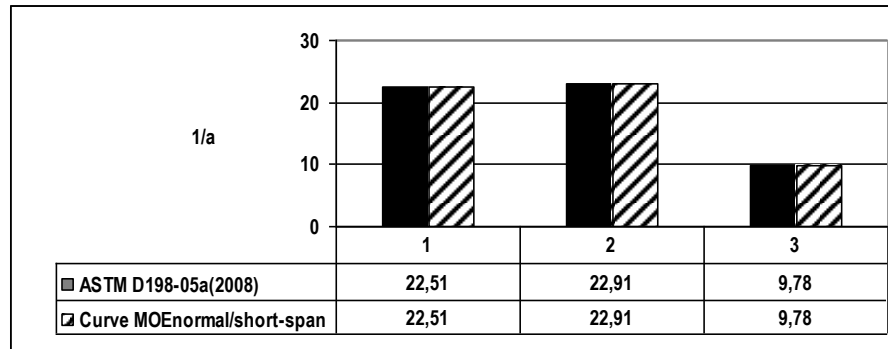


Figure 5 The divisor value shear modulus G toward modulus of elasticity

Conclusion

From the analysis of the 2 (two) methods based on ASTM D198-05a (2008), and by reading the correlation curve of $MOE_{normal/short-span}$ towards $G/MOE_{normal-span}$ it can take into conclusion as follows: for the first and second methods each has obtained the value shear modulus of wood (G) at $(1/19,02) \times MOE_{app}$ and $(1/18,40) \times MOE_{L/h=14}$; the value shear modulus of wood based on ASTM can easily and quickly be obtained by reading the $MOE_{normal/short-span}$ curve which needs only 2 (two) MOE_{app} data; the value shear modulus of wood gained from both methods are the same; the second method is to be used to gain the exact value of the shear modulus in the correct manner.

Recommendation

The wood as natural material which is grown and developed, ready to be used as a beneficial product, with different mechanical and physical characteristic, so that test is a necessity in order to obtain the value of shear modulus (G) of different kind of species. Furthermore, the wood species is grouped based on the value of the shear modulus, which is almost at the same level.

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The Reliability of LVL-CFB Shearwall Structure Due to Pseudo Dynamic Cyclic Load

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Abstract

Utilization of wood raw material as the structure component of modern houses in Indonesia, more and more abandoned by the community. On the other hand the trend of residential building environmentally friendly and energy saving has been encouraged to be realized and timber Planted Forest products as building materials which are realistic for this purpose.

Experimental study of shearwall as a structural element has been done in order to determine the capacity of strength. This is necessary for utilization by practitioners in construction of the house or residential buildings earthquake resistant structures. This shearwall frame structure made of engineered wood Laminated Veneer Lumber (LVL) with nailed sheathing of Cement Fiber Board (CFB) with size 1800 X 2700 X 18 mm. Specimen tested against pseudo dynamic cyclic load with in plane horizontal direction which was simulating earthquake load.

The study found that the Non-Engineered earthquake resistant T.36 house is required to install two shearwall panels in one wall without opening, as a structural element to anticipate the earthquake force at the zone with the highest risk of earthquake in Indonesia.

The structural system which combination of wood and cement based building materials shows the well enough behavior, so that the shearwall panel can be used as structural elements in house and residential building earthquake resistant.

Key words: Non-Engineered earthquake resistant T.36 house, Shearwall, LVL engineered wood, Cement Fiber Board (CFB).

Introduction

Utilization of wood as components of the Engineered and Non-engineered building structure has become a cultural history of humankind since the construction of houses began to grow. In Indonesia, timber as structural and non-structural material has been used since a long time, particularly natural tropical forest wood that is bountiful, but the development of natural forest timber utilization is not well regulated, resulting in the presence of natural forest wood to deteriorate drastically. On the other hand, when the global warming issue surfaced, the consequence is a demand to realize the environment-friendly residential, energy saving and sustainable settlements. This condition puts the wood materials produced by Planted Forest, as one of building materials that realistic to be able to meet these demands.

The use of shearwall elements in Non-Engineered structures as one solution in anticipation of the earthquake load that has a horizontal direction. In residential construction that includes types of Non-Engineered structures, information about the capacity of shearwall element is necessary, because in designing was not carried out specific calculations on the structure of the house to be constructed.

In this experimental study was conducted structural testing of shearwall element in which the frame made by engineered wood Laminated Veneer Lumber (LVL) and sheathing of nailed Cement Fiber Board (CFB). The purpose of this test is to determine shear strength capacity of the shearwall due to horizontal pseudo-dynamic cyclic load which was simulated as an earthquake force.

Design

Standard design house for low-income people in Indonesia is T.36 it means 36 m² areas, where the floor plan of the house is 6 X 6 m (*Figure. 1*). Because most of the areas in Indonesia are earthquake prones, then the house must withstand earthquakes. One of the structural elements that can be used to anticipate the earthquake forces are

shear walls. Installation of shear walls on the building is applied with a uniform stiffness distribution in order to avoid excessive concentration of force on a structural component or components connection which can cause damage when an earthquake comes.

Based on the calculation of earthquake forces that will be received by the T.36 house in which a house construction of LVL wood walls and roof frames and wall sheathing by CFB board, corrugated metal roof tile at the highest earthquake risk zone (zone 6) is equal to 68.37 kN, so that for every wall of the house carrying force about 34,19 kN. With the design of shear wall panels examined, on a high wall with a length of 2700 mm and 6000 mm, at least one panel and a maximum of three panels can be installed. Thus, shear walls capacity needed range from 9 kN to 27 kN.

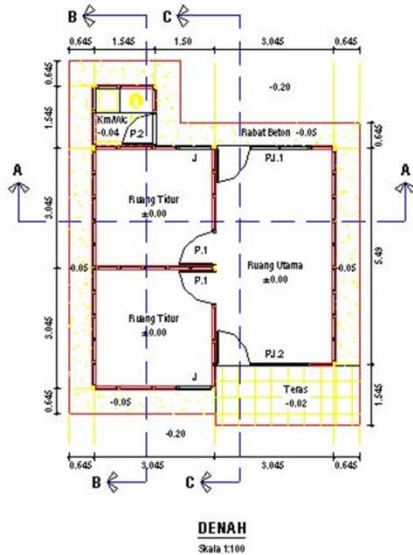


Figure 1. Floor plan of T.36 Earthquake resistant house

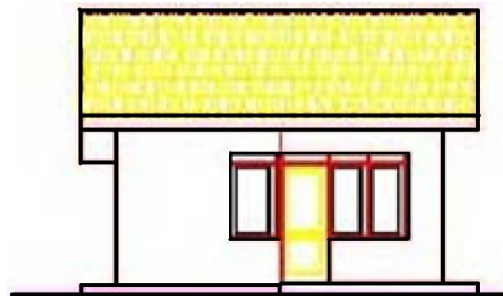


Figure 2. Facade of T.36 Earthquake resistant house

Table 1. Earthquake load design

No.	Object	Weight (N)
1.	Full Wall	7390.04
2.	Opening Wall	2586.53
3.	Roof, Roof frame, ceiling	82461.12
	House Weight	112452.74
	Seismic Design Load	68371.26

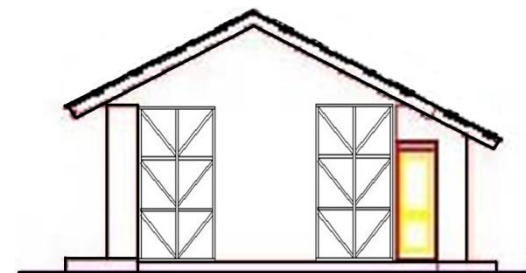


Figure 3. Side view of T.36 Earthquake resistant house with design and position of shearwall

Experimental Methods

To investigate the behavior and capacity of LVL engineered wood shear wall structure with CFB panels, the full-scale structural testing carried out with in plane horizontal load on the top of shear wall specimen as an earthquake load simulations.

Material

This Shear wall uses two relatively new materials in the construction in Indonesia. LVL engineered-wood made of material based produced by Planted Forest, were Sengon wood (*Paraserianthes falcataria*) and Rubber wood (*Hevea brasiliensis*) in the same way with the manufacture of plywood making. The material properties of LVL are list in Table 1 below.

Table 2. Mechanical and physical properties of engineered wood LVL

Property	Value	Unit
Moisture	10.74	(%)
Density	0.54	(gr/cm ³)
Modulus of Elasticity Parallel to the grain; MOE	7511,45	(MPa)
Modulus of Rupture, Parallel to the grain; MOR	62.20	(MPa)
Modulus of Elasticity Perpendicular to the grain; MOE	6174,12	(MPa)
Modulus of Rupture, Perpendicular to the grain; MOR	51,36	(MPa)
Tension parallel to the grain	40,82	(MPa)
Tension Perpendicular to the grain	1,82	(MPa)
Shear	5,38	(MPa)
Adhesive	0,52	(MPa)
Nail withdrawal	908,46	(N)
Delamination	0	(mm)

The other material is CFB that made of cement mortar with bamboo fibers produced with the size of 1800 x 900 x 18 mm. The material properties of CFB are list in *Table 3* below.

Table 3. Mechanical and physical properties of Cement Fiber Board

Property	Value	Unit
Density	1.22	(gr/cm ³)
Modulus of Elasticity ; MOE	31670	(MPa)
Modulus of Rupture ; MOR	94.808	(MPa)

Specimen

Shearwalls specimen that was examined sized 2700 X 1800 X 18 mm made of two kinds of different building materials, LVL as a frame materials and CFB as sheathing materials.

Cross section dimension of LVL was 50 x 90 mm for the outer frame and cross section dimension LVL 30 X 70 mm rod composed of horizontal, vertical and diagonal 45° (*Figure 3.*) as a frame within.

CFB board sheathed on LVL frame fastened by nails with 70 mm steel nails spaced 100 mm on each side and before the installation of nails, drilling done on the CFB with a diameter of 60% of the diameter of the nail. After the panel is installed, do the painting for identification purposes to describe the plot cracks breakdown.

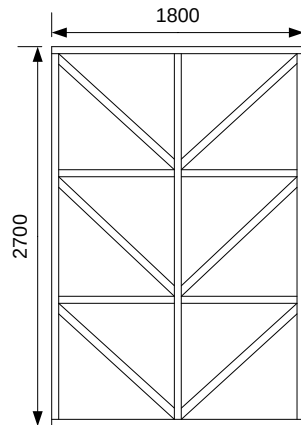


Figure 4. Design of shearwall frame and made by LVL



Figure 5. Making the wooden frame LVL shearwall specimens



Picture 6. Wood frame shear walls cement board panels

Specimens tested at the rigid steel frame apparatus, where the bottom of the specimen was fix it with no horizontal, vertical, and rotation movement, in plane and perpendicular direction. While the top of the wall there is only

in plane horizontal movement, giving load can be performed (*Figure 4.*). At the top of the specimen mounted horizontal high strength steel rod so that the specimen claimant did not experience excessive horizontal torsion.

Structural Testing

Testing was done by providing the structure of cyclic horizontal load in both directions with a certain increment on low speed, so the test is categorized as a pseudo-dynamic. Loading until the specimen is no longer given the weight and strength have been degraded by more than 20%.



Figure 7. shear wall specimens during testing

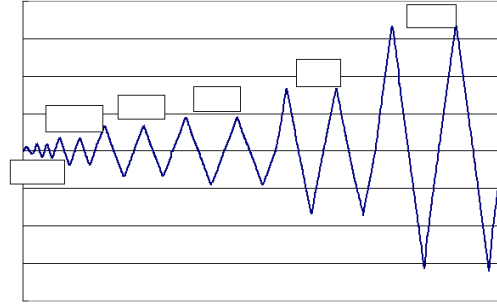


Figure 8. Shear wall specimens were tested

The damage begins with the shift between the panel occurs (*Figure 9.*); this is because the deformation of the frame shear wall panel member elements.

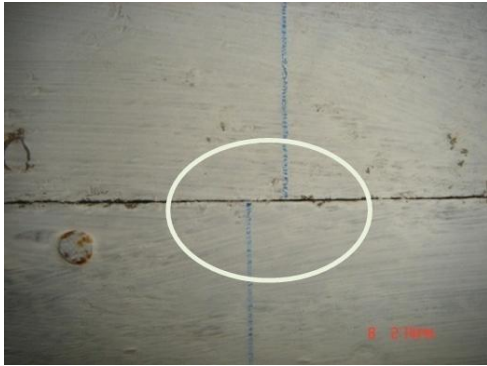


Figure 9. The shift between the CFB panels visible from the reference line



Figure 10. Nail withdrawal between LVL structural members

When specimen started received cyclic load, showing a CFB panels corner torn by the nail that is not deforms in accordance with the displacement occurred. In extreme conditions, damaged happen during the release of CFB panel which bound by a nail (*Figure 11.*), and loosen the connection between the frame members has occurred (*Figure 12.*).



Figure 11. Part of the CFB panels were broken because of the deformation order sliding wall panels

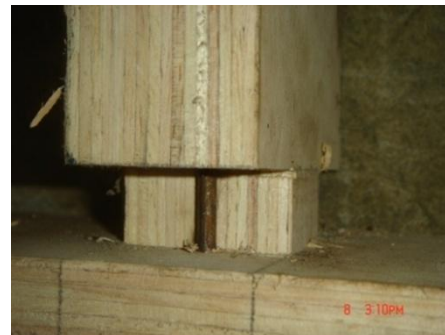


Figure 12. Components in order to stem sliding wall panels ripped the framework of deformation due to sliding wall panels

Generally, weakening occurs on all outer edge of CFB panels that nailed to the LVL frame member, the other is the weakening of the connection between LVL members. While in the middle of CFB panel and the LVL member were no damage has occurred, so if the fastener used in every connection have sufficient strength, the shear strength of this shearwall panel will be increase.

Test results provide hysteretic curve as in *Figure 9* and envelop curve in *Figure 10*.

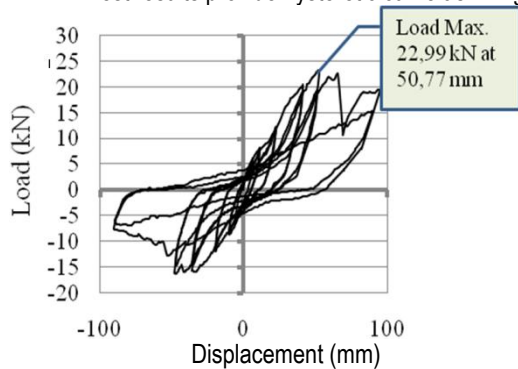


Figure 13. Hysteretic curve with measurements at the top specimen

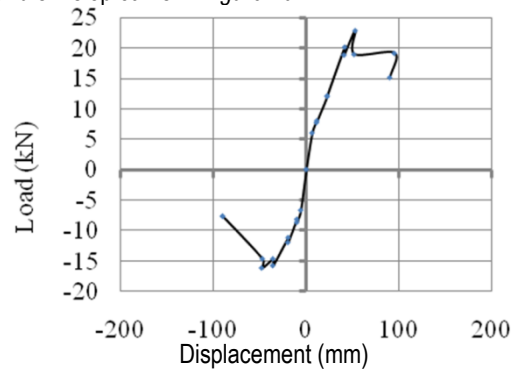


Figure 14. Envelop curve with measurements at the top of the specimen

Result and Discussion

Visual observation of physical deformation and damage were done, also conducted the recording of data provided by measuring the load, displacement, and strain. The test results shows, that the behavior of the load structure in the pushed of specimen direction move linear in the elastic regime to more or less at load 6.1 kN with a displacement was 6.31 mm. Having reached this point shows the structure behavior growing in linear conditions again to reach a maximum load of 22.99 kN at 52.77 mm displacement, which occurred after the load reduction due to damaged components on the load of 20.20 kN at displacement 41.47 mm. In the opposite direction of the load means on pulled of specimen, symmetrical situation occurs in the condition of elastic limit with the load 6.05 kN at 20.20 mm displacement. Furthermore, the movement of the structure is somewhat different in the extreme values, but the pattern of structure behavior seen relatively similar. Structure behavior described by the envelop curve (*Figure 10*.) In a qualitative form showed the ductile behavior, where this behavior is required in an earthquake-resistant building structures.

Nails withdrawal at the wood frame connection damage cause losing rigidity resulting loss of connection, although the connection is not loosen. While damage to the CFB panel's corner due to large deformation in the frame of LVL timber.

Shearwall panel's strength is produced simultaneously by the stiffness and strength of LVL frame and CFB panels mounted on the frame. To overcome the damage and increase the capacity of shearwalls can be fastening the frame connections using screws, steel plate with a screw or bolt fastener.

Analytic calculations earthquake design load was based on the weight of the house and earthquake acceleration that will be occurred in the highest risk zone of earthquake in Indonesia. The calculation gives the result of the earthquake force about 68.37 kN for T.36 house that constructs of LVL and CFB structure.

To meet the shear strength at the one wall without opening of T.36 house, that the load demand were 34.19 kN load, it can be installed two shearwall panels that have been studied, which that have a total shear strength about 46 kN.

Installation of cement board panels on both sides of the framework would be better for reliability and aesthetics, so the house will look as masonry houses earthquake-resistant, the demand by society in Indonesia.

Conclusion

Shearwall panels made by LVL frame and CFB sheathing can be used as structural elements in Non-engineered earthquake resistant T.36 house. The combination of wood materials with a panel of cement based board works well when viewed from the factors and forces necessary to ductility earthquake-resistant homes.

Acknowledgements

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Bamboo Connection Design (An advanced Research)

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Abstract

In the previous research a joint was designed by filling a tapered rounded wooden plug into each end of the culms and a tapered steel ring was used to push the end of the bamboo tapered. To keep on attaching the wood to inner bamboo, epoxy was used. The weakness in this joint was on tension which could resist about 1200 kg. This research is an advanced study of using bamboo as space truss members. This study focuses on developing bamboo joint, that stronger than previous design; especially in tension. To increase the tension, additional epoxy was applied between outer bamboo and steel ring. The sample made of 80 cm bamboo culm with diameter 4 cm. The experiment showed resistance force of 1500 kg in tensile and 2800 kg in compression.

Key words : space truss, members, tension, compression

Introduction

Bamboo as building materials have several advantages; such as: low density, high strength, aesthetics, large moment of inertia. According to Nuryatin research(2000) about basic physical and mechanical bamboo properties show that *Gigantochloa apus* Kurz have compression strength 307 kg/cm², tension strength 1400 kg/cm² and density of 0,6. These value is similar with value in Purwito research (1995) in Morisco (2006) for more than three years old bamboo which the result was 250 to 1,000 kg/cm² in compression and 1,000 to 4000 kg/cm² in tension. A research refers to ISO 22157-2004 about physical and mechanical bamboo properties shows density, tensions strength and compression strength repeatedly 0,71 gr/cm³, 57 MPa and 12MPa (Bachtiar,2008).

Another advantage, bamboo could be harvested in relatively short time. If wood for building construction can be harvested after more than ten years planted, bamboo for building construction could be picked just after 3 years old. As member of grass family, cut of bamboo culms couldn't make the clump died. The clump could continuously produce and growth new culms.

Bamboo strength in tension is similarly with tension strength of steel, whereas its shears strength is low, which makes bamboo easily cracks. So, bamboo culm is suitable to use as space truss members, which get only tension and compression force without bending. The constrain in using bamboo as building materials is in designing connection of bamboo culm that could strong enough for tension as well as compression. On the contrary, using natural bamboo culm could give higher value in aesthetic.

Connection is the most critical part in a structure, because of its function to deliver working loads. In truss, there are only two kinds of working loads; tension and compression. Therefore, to develop a connection design, we have to pay more attention for tension and compression strength of the connection.

In the research before, a model of bamboo connection for using bamboo culm as space truss member has been developed. Its showed that the connection made of bamboo with 4 cm diameter could receive about 1000 kg in tension and 2300 kg in compression. To improve the connection strength especially in tension, the connection would be developed.

Material dan Methods

Materials used in the study are 3-5 years old *Gigantochloa apus* Kurz bamboo 4- 4.5 cm in diameter as main material, with wood , steel pipes, steel rings, bolts and nuts and also epoxy as additional materials.

Preparation of samples starts by sorting bamboo culms, which must be old (> 3 years), suitable in diameter (40R45 mm) and also straight at least at the lowest to the middle part of the culm. Flow chart of sample preparation could be seen in Figure 1. and the detail of connection design could be seen in figure 2

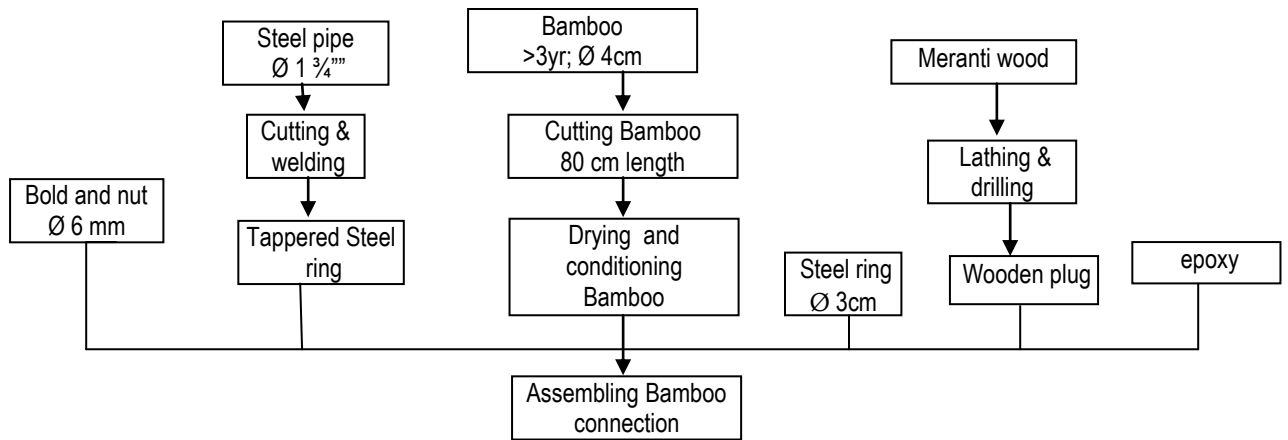


Figure 1. flow chart of Sample preparation

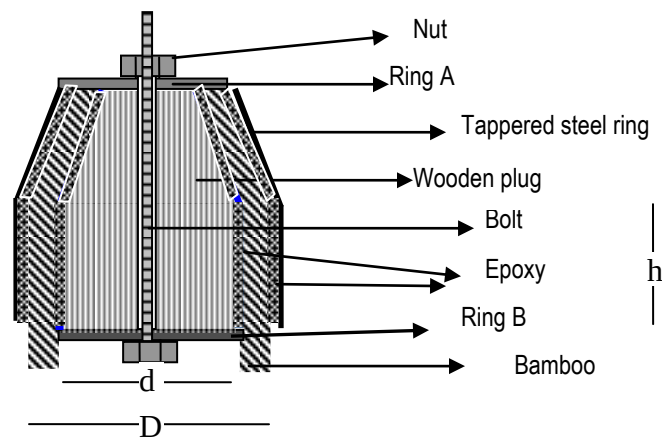


Figure 2. Joint designed

After assembling process to make connection, samples will split to two kinds of test; one part (10 samples) will perform to tension force and other parts (10 samples) to compression force.

In previous study, epoxy applied only between wooden plug and inner bamboo wall. Therefore, the strength which hold tension force, is only on its shear strength. On the other hand, bamboo shear strength is the weakest strength.

In this study more adhesive is applied. Adhesive that applied between outer wall of bamboo and tapered steel ring will make connection more solid, especially in supporting tension force. In this case, bamboo outer wall will take part to hold tension.

Force Distribution in the Connection

a. compression

Compression force firstly works onto bolt, which then the force sent to the nut. From nut force delivered to ring A. Then the nut will distribute the compression to the culm.

b. tension

the force firstly works onto the bolt, which then sent to ring B. From ring B force delivered to wooden plug; afterwards the tension distribute to inner wall of the culm.

Result and Discussion

Calculation of Connection Strength

Connection strength, tension as well as compression could be analyse according to physical and mechanical properties of bamboo, especially *Gigantochloa apus* bamboo and also according to dimension of the connection

details made. In calculating compression strength of connection all bamboo wall is assumed to support the compression, but in tension only shears of bamboo wall accept the tension. The prediction of the maximum connection strength calculated could be seen in Table 1, below.

Table 1. Analytical maximum strength

Dimension	D=4cm, L= 80 cm	Unit
Compression strength (σ_{tk})	127,00	kg/cm ²
Buckling factor (ω)	1,97	
Compression (P_{tkn})	501,43	kg
Compression stress (σ_{trk})	600	kg/cm ²
Culm tension ($P_{tarik\ buluh}$)	3297,00	kg
Shear stress (τ)	25,00	kg/cm ²
Shear high (h)	5	cm
Shear Tension ($P_{tarik\ geser}$)	1175	kg

Sample Connection Strength

According to the testing conducted to the samples, the average tension strength of the connection is 1.500 kg and average compression strength is 2.800 kg as shown in Table 2.

Table 2. Samples strength

Laboratory testing	average	minimum	maximum	n
Tension (kg)	1.500	1.300	1.996	10
Compression (kg)	2.800	2.400	3.660	10

Comparing the sample strength, both tension and compression strength, are higher than the results of previous study as shown in Figure 3.

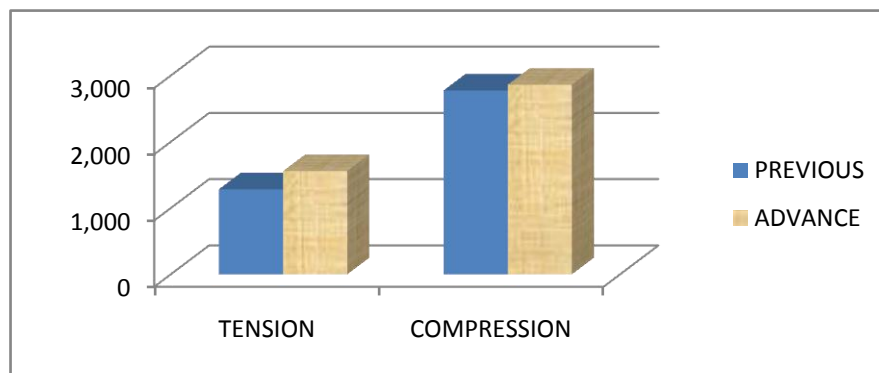


Figure 3. Comparison of connection strength

Even though, strength of the connection is higher than the results of previous design, but that is not optimum. Observing the damage of tested samples, all destructions happen on adhesive part. Epoxy doesn't work well. It's maybe because of the epoxy quality. If better quality epoxy applied, higher strength could be reached.

Conclusion

1. Adhesive that applied between outer wall of bamboo and tapered steel ring produce a stronger connection. It will make connection more solid, especially in supporting tension force.
2. Applying adhesive between outer wall of bamboo and tapered steel ring, improve +/- 20% of tension strength.

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Possibility of Javanese Traditional House Reconstruction Using Laminated Veneer Lumber (LVL)

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Abstract

Many historic and traditional buildings damaged by Yogyakarta earthquake on May 2006 included wooden construction. There are three type of traditional wooden house damage and it has each solution. First is heavy damage, the traditional wooden house is collapse. It is need to rebuild or reconstruction with new material. Second is medium damage, non-structure of the house is damage but the structure is stable. It is need strengthening on construction. Third is light damage, non-structure of the house is damage without serious impact. It is need kind of refinishing.

Now, the first type of damage is not good solving. One of problem is procurement new material as solid wood with big dimension. It is difficult to procure solid wood as mass, big dimension and quick. It is need material alternatives to substitute the solid wood but it is meet character of traditional wooden house. Characters of traditional wooden house are type of join, behavior of join, and system of construction.

This paper is result of preliminary research towards using LVL as a part of Javanese traditional house preservation. This contribution gives an overview of a going comprehensive research project. Comparisons between of characteristics of Joglo construction and properties of LVL showed fairly good agreements. In the symposium, the author would like to show the possibility and problems of reconstruction of Javanese traditional house using LVL.

Key words : Javanese traditional house, LVL, reconstruction, join construction.

The May Earthquake and Sustainability of Javanese Traditional House

The 27th May 2006 earthquake inflicted massive damage to many buildings in Yogyakarta, included traditional houses. This fact shows that, aside from the age factor, the old building technology was insufficient to withstand the 5.9 Richter scale earthquakes. Understanding earthquake resistant construction is very important for repairing and building post-earthquake houses, as well as to anticipate future earthquakes (JHS, 2007).



Figure 1. Some Joglos are damage and collapse by Yogyakarta earthquake
Source: Prihatmaji, 2006.

The earthquake has severely damaged or even demolished many traditional houses, especially *Joglo* type, rendering them in need of immediate repair or rebuilding. Rehabilitation or reconstruction using new materials and technique – which are easier and cheaper compared to traditional techniques – leads to the concern about the changing character of Javanese traditional House.

Safeguarding and conserving Javanese traditional house and its wooden construction mean safeguarding and conserving the rich historic and cultural values of Javanese cultures, including the detail and construction techniques of Javanese traditional houses.

The Type of Javanese Traditional Houses

The Javanese traditional houses are a dwelling house that has the composition and proportion specific to the Javanese architectural style. There are four types of Javanese traditional houses based on roof shape. They are *Joglo*, *Limasan*, *Kampung* and *Panggung Pe*. Each type has several variants amounting to a total of 26 variants. *Joglo* is the most complicated and sophisticated roof type in terms of the construction and techniques, whereas *panggung pe* is the simplest type (Tjahyono, 1989 in JHS, 2007). So, in the paper will discuss how to reconstruction of *Joglo*.

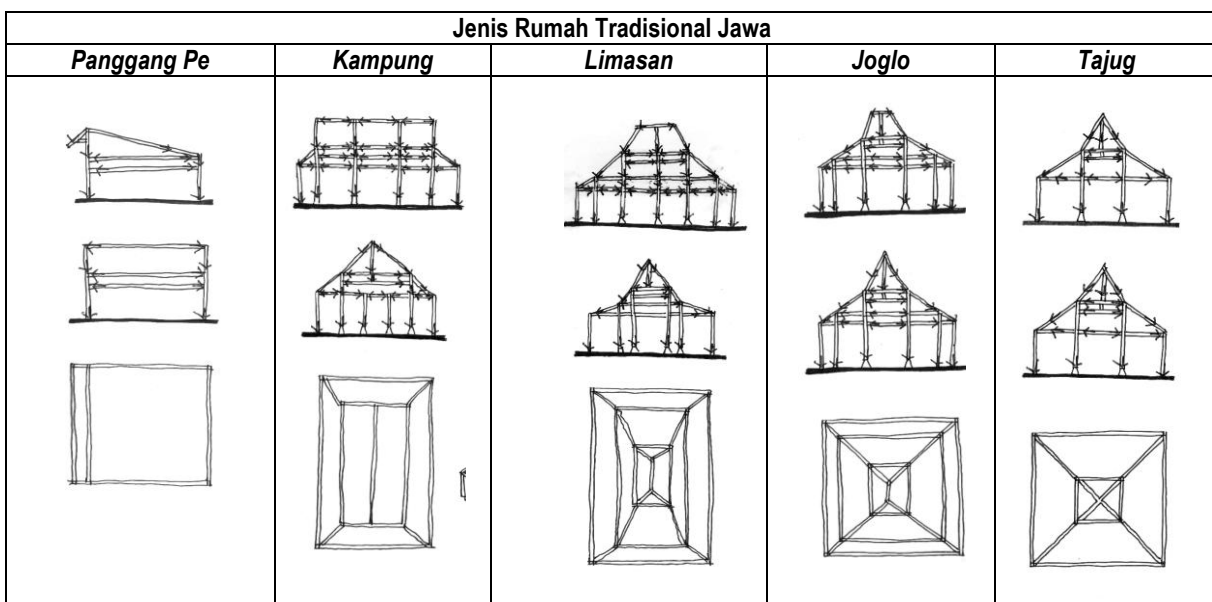


Figure 2. Types of Javanese Traditional House
Source: Prihatmaji, 2004

Joglo has been designed by *kalang adeg* (Javanese traditional architect) and tested over time to withstand earthquake forces. *Joglo* has been tested by experimentally to resistance from earthquake in third zone area in Indonesia (Prihatmaji, 2003, 2006). For instance, the *Joglo* structure is a type of traditional open frame structure that is quite seismically resistance. The structural stability of this building against earthquakes is primarily attributed to the main frames structure consisting of *saka guru* and beams. The structure supposedly behaves adequately during light to medium earthquake owing to its ductility. The building is mainly a wooden structure that significantly contributes to its ductile characteristic. The collapse of several *Joglo* building in Yogyakarta is primarily due to the deteriorated wood and improper construction joint detail. For better structural quality of *Joglo* buildings in the future, better wood quality and joint construction are mandatory.

Joglo : Tradition of Timber

The *Joglo* use timber as the primary construction material, both as the building structural component and architectural elements. *Joglo* uses a 'knock down' construction method using tendons and mortise (*purus-pasak*) joints without nails so that the elements of the building can be easily dismantled and moved. The best and most commonly used type of timber is teakwood (*Tectona grandis*). Replacement for teakwood may be timber from jackfruit trees (*Arthocarpus heterophyllus*), timber from coconut trees (*Cocos nucifera*), or yearly timber such as johar (*Cassia siamea lamk*), akasia (*Acacia mangium*), and laban (*Vitex pubescens vahl*).

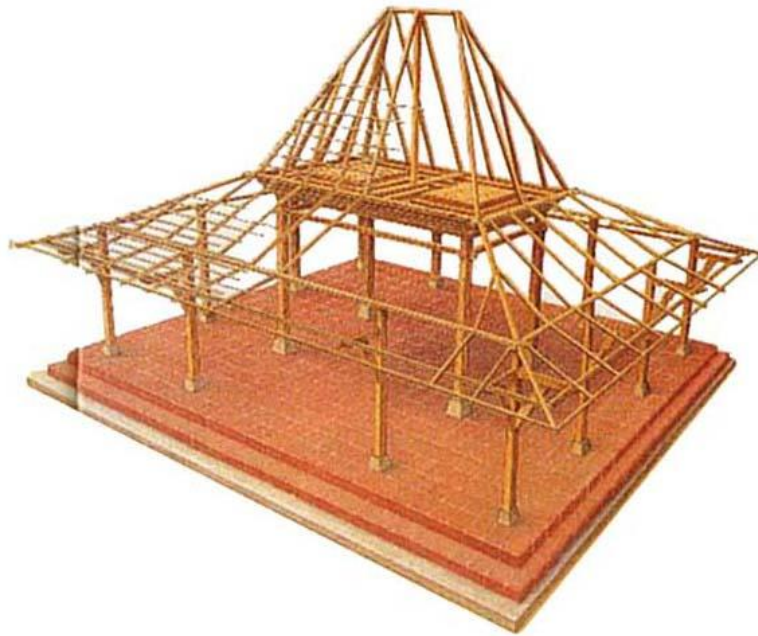


Figure 2. Wooden Construction of Joglo
Source: Indonesian Heritage: Architecture, 1998 : 35

Reconstruction process for rebuild *Joglo* is not fairly working because lack of timber as primarily material. Timber for build of *Joglo* has several requirements as mention *kawruh griya* (Priyotomo, 2007) as local genius for choosing good material. In general timber to construct of *Joglo* has require equal as teakwood, aside consider mass procurement and easy to manage. Laminated veneer lumber (LVL) materials represent a design alternative for structural timber building. The study of processing options for producing LVL in plywood manufacturing and glued-laminating facilities is of interest as this would allow existing production equipment to be used (Youngquist, 1984).

Characteristics of Joglo Construction and Properties of LVL

The structure consist of wooden beams and columns. The basic principle of this structure is a solid wooden framework formed by joining four columns (*saka guru*) and double beams, i.e. *blandar* (*pamidhangan panyelak* and *blandar pamidhangan pamanjang*) and *sunduk* (*sunduk panyelak* and *sunduk pamanjang*). The joints are the key to its structural stability. For instance, the main structure of the *Joglo* is an open framework of *sakas*/columns and *blandars*/beams (Prihatmaji, 2006).

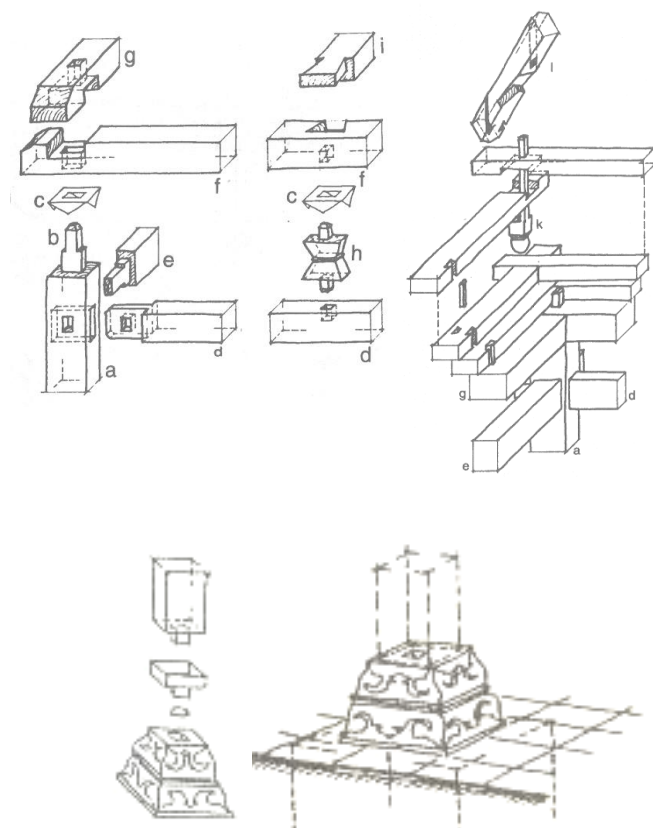


Figure 3. Cathokan System (above) and Purus System (below). Source: Frick, 1997.

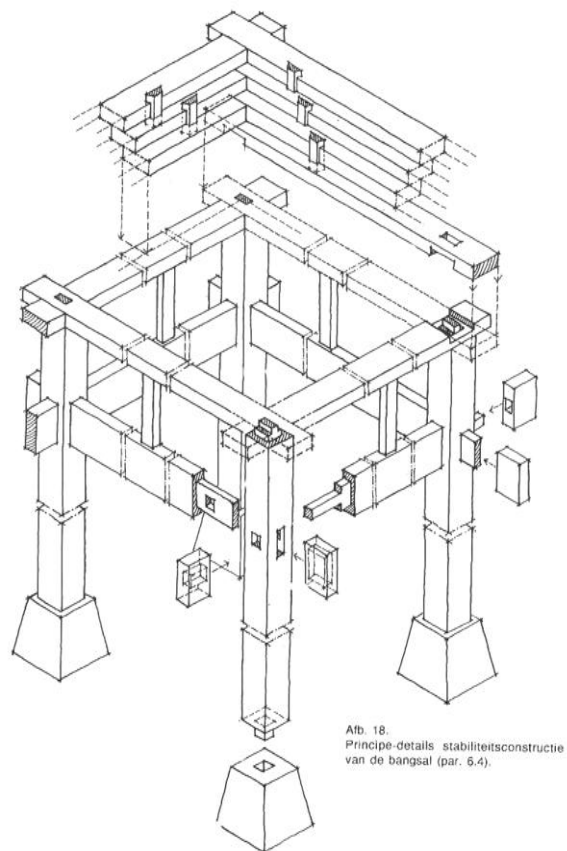


Figure 4. Joints Details and Construction System of Joglo. Source: Leedam, 1969

Building elements of the Javanese traditional house are divided into three parts: (i). Understructure (foot): consists of the foundation, floor, and base foot (*umpak*). (ii). Intermediate structure (body): consists of the *saka guru* (columns), walls, doors, windows, and ventilation openings. (iii). Superstructure (head): consists of the roof frame, roof cover, and ceiling.

Table 1. The Joint and Construction System of Joglo.

Building elements	Type of joint	Generic Application (Configuration)
Understructure	<i>Purus</i> system: the <i>purus</i> which functions as a lock is inserted into the hole of the <i>purus umpak</i> .	Compression member Joints
Intermediate structure	<i>Cathokan</i> system: beam at the center of the building, such as the <i>sunduk kili</i> , <i>blandar pamanjang</i> use the <i>cathokan</i> system. This system may or may not utilize a locking mechanism. The lock is made to protrude upward to prevent the beam from moving.	Tension member Compression member Flexure member Joints Beam columns (flexure plus axial tension or compression)
Superstructure		Tension member Flexure member Joints

Table 2 has to show a relation between structural applications with LVL performance. Relation between joint and construction system of Joglo and LVL performance is identified as below.

Table 2. Laminated Veneer Lumber Identification

Generic application (configurations)	Purpose of reinforcement	Desired characteristics of reinforcement	Specific products
Tension members	Reduce member's high sensitivity to growth defects; increase effective area, tensile capacity, and the reliability of the member	High, predictable tensile strength	Diagonal bracing
		Ease of placement parallel to tensile stress direction	Chord members of trusses
	Localized reinforcement at connectors leads to smaller cross-sections	High modulus	Tension webs in trusses
		Versatility of physical properties	Perimeter members in dome structures
Compression members	Increase compression capacity and stiffness	High strength and modulus	Truss components
		Placement of reinforcement uniformly around the perimeter of member	Interior columns in buildings, frames
	Increase buckling load about either axis		Compression members in plates and shell structures
			Box columns
Flexural members	Use reinforcement to increase beam stiffness — decrease deflection	High strength and stiffness	Continuous span beams
		Predictable fracture stress at ultimate load	Floor joists
	Reduce variability, hence allowable stress values will be increased or ultimate strength may be used	Desirable ductility at ultimate load	Headers
		Placement of reinforcement at or "ear both tensile and compressive faces of beam for deflection control	Rigid frame members
	Increase shear and torsional capacity		Bridge stringers
	Increase impact resistance		Electrical or street pole cross-arms
	Improve fatigue and creep performance	Reinforcement on vertical side faces for shear and torsion purposes	Crane runway girders
		Localized reinforcement for "pact purposes	Box beams
			Ladders
			Scaffolding
Joints	Reinforcement of finger and butt joints increases the strength of the joint and provides material continuity	High strength	May be applied to any member with internal joints or splices
		Resistance to environmental effects	Bolted connections
	Increase bearing strength and net cross-sectional strength of mechanically fastened assemblies		Nailed or stapled components
			Continuous tension members
Beam-columns (flexure plus axial tension or compression)	Reinforcement increases resistance to axial and bending forces	High strength and stiffness	Bracket-loaded columns
		For axial load purposes, place reinforcement uniformly around member's perimeter	Columns of frames where moments of girders are partly resisted by abutting columns
	Generally increase strength and stiffness as with columns and flexural members	Large bending moments require concentration of reinforcement at face or largest compressive or tensile force	Transversely loaded columns (utility poles)
			Inclined rigid frame members
			Arch ribs
Other assemblies	Increase bending, tension, pressure and impact capacities where forces are applied in quick, repeatable succession	High strength and modulus	Windmill blades
		Relatively low specific gravity	Ski construction
	Provide light weight-to-strength ratio, with increased tensile capacity	Resistance to environmental effects	Containment silos
		Resistance to chemical attack	Wood pallets
	Improve nail-holding system	Dimensional stability	Chemical plant structural members
	Increase strength at stress concentration (corners)		

Source: Laufenberg, et al, 1984.

Characteristics of LVL were suitable for material construction of Joglo, as a structural product, laminated veneer lumber (LVL) was considered a likely appropriate use of the material substitute. Mention both of table above to show how properties of LVL meet characteristic of *Joglo* construction.

General Conclusions

This study opens the possibility to use LVL for Javanese traditional houses (Joglos type). Comparison

between characteristic of details and construction system of Joglos and characteristic of LVL is showed fairly good agreements. LVL could use for structural material and construct a joints for Joglos reconstruction. Characteristic of joints construction (tongue and gull) is fulfilled by LVL properties. For further research is need to create full scale experiment method.

Acknowledgement

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Biocomposites of Polypropylene or Polylactic Acid Reinforced with Sisal or Bamboo Micro Fibers

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Abstract

Development of biocomposites of polypropylene (PP) or polylactic acid (PLA) reinforced with sisal (*Agave sisalana*) or betung bamboo (*Dendrocalamus asper*) micro fibers were tried in this experiment. Dry pulp was mixed with granular PP and Maleic anhydride modified PP (MAPP) in a Laboplastomill to make a compound. The compound was hot pressed and cold pressed. PLA was dissolved in dichloromethane, and wet pulp and triacetin were added. The mixture was dried and processed further in a Laboplastomill. Further processing condition was similar to that of fibers – PP composites. The ratios of sisal or bamboo fiber / PP or PLA were 30/70, 40/60, and 50/50. MAPP at the amount of 5% of board weight was added to PP composites, while 7% triacetin (as plasticizer) was added to PLA composites. The board size was 150 mm by 50 mm by 3 mm, with target density of 1.0 g/cm³ for PP composites and 1.3 g/cm³ for PLA composites. The boards were subjected to bending test using Universal Testing Machine (UTM). Results shown that fibers/PLA composites have higher mechanical properties than that of fiber/PP composites. Composites made from bamboo fibers have similar mechanical properties with those of sisal fibers. The optimum ratio of fibers / PP or PLA obtained was 40 / 60.

Key words: biocomposites, polypropylene, polylactic acid, sisal, bamboo, micro fibers

Introduction

Bio composites or green composites have been subjected to extensive research in the last decade (Mohanty et al. 2002, Natraveli and Chabb 2003, Berglund 2004, Mathew et al. 2005, Bogoeva-Gaceva et al. 2007, John and Thomas 2008). The composites are utilized for materials of automotive components, buildings, and electronics (Marsh 2003, Nakagaito et al. 2005, Iwamoto et al. 2005, Bledzki et al. 2006). Composites originated from natural fibers are environmentally friendly and renewable. Among some advantages of using natural fibers compare with synthetic fibers such as fiber glass are non toxic, light, better specific mechanical properties, non abrasive to tools, and cheaper (Zimmermann et al. 2004, Oksman et al. 2003, Wambua et al. 2003, Mohanty et al. 2002, Leao et al. 1998). Research on composites from sisal fibers has been done a lot especially using raw fibers (Li et al. 2000). As well as some research on composite of bamboo fibers-thermoplastic polymers using raw bamboo fibers have been conducted (Shibata et al. 2008, Okubo et al. 2004, Lee et al. 2004). Thermoplastic polymers that widely used are polypropylene (PP), and poly lactic acid (PLA). However researches of composites using sisal or bamboo fibers with diameter of micro size have not been done. Zimmermann et al. (2004) stated that there is a high correlation between size of fibers and the strength. The smaller the diameter of fiber the higher its mechanical properties. As an example, wood pulp fibers have modulus of elasticity of 10 GPa, but when in the form of crystal cellulose become 250 GPa. The small fibers are more homogenous and micro crack that usually occurs in bundle of fibers can be avoided in the single fiber.

The purpose of this research is to develop bio composites from sisal and bamboo fibers using polymer matrices of conventional polymer (polypropylene) or natural polymer (poly lactic acid). In particular, effect of ratio of micro size fibers and polymer on the mechanical properties of composites is evaluated.

Materials and Methods

Polypropylene (PP) homopolymer obtained from Grand Siam Composites Co., Thailand (melt flow index 13.3 g/10 min., melting point 165.5 °C); polylactic acid (PLA) Lacea H400 from Mitsui Co., Japan, and MAPP Umex 1001 from Sanyo Chemical Industries, Japan. Fibers of sisal (*Agave sisalana*) were obtained from Blitar area, East Java and betung bamboo (*Dendrocalamus asper*) was collected from Bogor area, West Java. Fibers of sisal and

bamboo were processed into pulp as follows. Sisal fibers were cleaned and cut into 2cm length. Fresh cut betung bamboo were cut into 1 m length, debarked and split into two parts. Bamboo parts were processed with bamboo crusher for 10 times, and then cut into about 5 cm length. Fibers of sisal or bamboo at amount of 250 g (oven dried weight) cooked in NaOH 2.5% (1 part of fiber soaked in 10 part of solution) for 2 hours. Soft materials were separated from the cooker liquid and washed until clean. The materials then processed using beater Hollander for 90 minutes. The grinding was continued using stone grinder for 5 times. The pulp was stored in a freezer before use. Observation by Scanning Electron Microscope (SEM) was done to the pulp before and after stone grinder process to make sure that the fiber diameter size was smaller than 10 μm that called micro fiber.

Composite fiber/PP was prepared by mixing dry pulp with polymer. Dry pulp was prepared by filtering and drying wet pulp in an oven at temperature of 60 °C for 24 hours. Dry pulp was tear into small pieces about 1 cm by 1 cm and mixed with PP in a Laboplastomill at temperature of 175 °C, 60 rpm for 20 minutes. Compound then hot pressed at temperature of 180 °C, pressure of 1 MPa for 30 seconds. Immediately compound was taken and cold pressed at pressure of 1 MPa for 5 minutes, and sample was taken. Composite of fiber/PLA was prepared by soaking PLA in dichloromethane, wet pulp and triacetin were added, and mixed until homogenous. Compound was dried in an oven at temperature of 60 °C for 6 hours. Dry compound was processed in a Laboplastomill at temperature of 170 °C, 60 rpm for 20 minutes. Further process was similar to that of fiber/PP composite (hot pressing and cold pressing). Ratios of sisal or bamboo fibers / PP or PLA were 30/70, 40/60, and 50/50. Maleic anhydride modified PP (MAPP) at the amount of 5% was added when mixing fiber/PP, while triacetin as plasticizer at the amount of 7% was added when mixing fiber/PLA. The composite size made was 150 mm by 50 mm by 3 mm, with target density of 1.0 g/cm³ for fiber/PP composite and 1.3 g/cm³ for fiber/ PLA composite. Composites were conditioned at room temperature for 3 days and tested for mechanical properties using Universal Testing Machine (UTM). The span was 100 mm and crosshead speed of test was 50 mm/min.

Results and Discussion

SEM Observation of Fibers

SEM observation was done for sisal and bamboo fibers at condition before and after stone grinding process, this is to make sure if the diameter size of fiber is less than 10 μm ("micro fiber"). The results are presented in Figure 1 for sisal fiber and Figure 2 for bamboo fiber. It can be seen that both for sisal and bamboo fibers the diameter size of fibers after stone grinder processing is smaller than before the process. The average diameter size of fibers is less than 10 μm , here we called micro fiber. Similar process has been done by Nakagaito and Yano (2004) to obtained nano size diameter of cellulose fibers. Zimmermann et al (2004) stated that the smaller the diameter of fiber the higher its mechanical properties. Hopefully in this experiment by using micro diameter size of fibers to reinforce polymers will result in high strength composite.

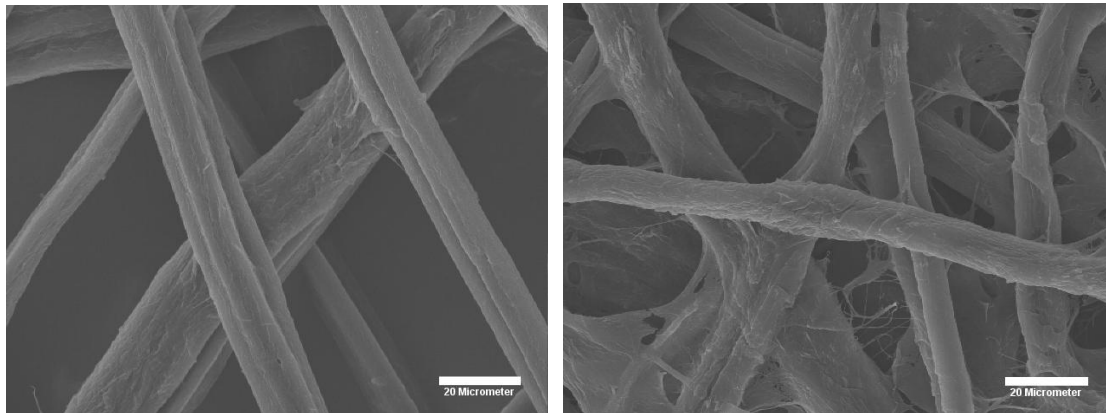


Figure 1. Sisal fiber before stone refiner (left), and after 7 times stone refiner (right).

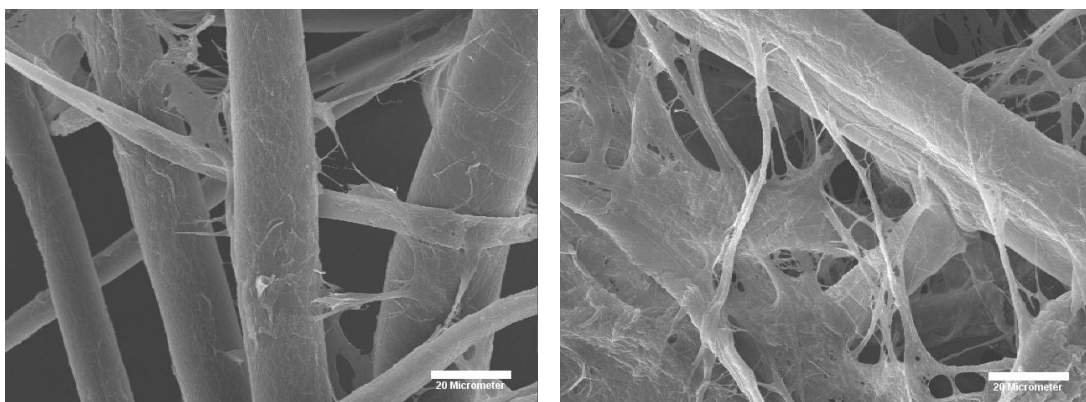


Figure 2. Bamboo fiber before stone refiner (left), and after 8 times stone refiner (right).

Mechanical Properties of Composites

Results of mechanical properties of fiber/PP composite and pure PP is presented in Table 1, while that of fiber/PLA composite and pure PLA is presented in Table 2.

Micro fibers of sisal and bamboo as reinforcement of PP and PLA composites yielded in higher mechanical properties compare to those of pure PP or PLA (Tables 1 and 2). In the fiber/PP composite, ratio of sisal fiber/PP of 40/60 has the highest percentage increase (107%) of MOR compare to pure PP. Similarly the highest percentage increase (185%) of MOE was exhibited by ratio of sisal fiber/PP of 40/60. In the fiber/PLA composite the same trend was observed. The highest percentage increase is from fiber/PLA with ratio of 40/60 that is bamboo fiber/PLA (50%) for MOR and sisal fiber/PLA (155%) for MOE. This result is slightly different with that of Mohanty et al. (2004b), they obtained that ratio of sisal fiber to PP of 30/70 gave optimum mechanical properties. At higher ratios of fiber/PP (45/55) the mechanical properties of composites decreased. For bamboo fiber/PP composites, Okubo et al. (2004) found that the optimum ratio of bamboo fiber/PP is 50/50. In this research they used 5% MAPP.

Table 1. Mechanical properties of composites fiber / polypropylene (PP).

Composites (ratios)	Modulus of Rupture (MPa)	Modulus of Elasticity (GPa)
Sisal/PP:		
30/70	50.47	2.59
40/60	57.05	3.36
50/50	52.10	3.34
Bamboo/PP:		
30/70	52.36	2.80
40/60	47.52	2.78
50/50	47.71	3.25
PP (pure)	27.52	1.18

Table 2. Mechanical properties of composites fiber / polylactic acid (PLA).

Composites (ratios)	Modulus of Rupture (MPa)	Modulus of Elasticity (GPa)
Sisal/PLA:		
30/70	98.12	5.77
40/60	100.42	8.07
50/50	61.54	6.22
Bamboo/PLA:		
30/70	100.83	6.15
40/60	105.23	7.06
50/50	73.31	6.11
PLA (pure)	70.36	3.17

Composites of fibers/PLA have higher mechanical properties compare to those of fibers/PP. This may due to the difference in density, composite of fibers/PLA have higher density (1.3 g/cm^3) compare to those of fibers/PP (1.0 g/cm^3). SEM images of fracture surfaces of composites (Figures 3 and 4) showed that both composites of fibers/PP and fibers/PLA were mixed homogenously. When source of fibers was considered, the composite using PP or PLA reinforced with sisal or bamboo fibers have similar mechanical properties. Sisal and bamboo fibers have almost the same mechanical properties. Sisal fiber has density of $1.33 - 1.50 \text{ g/cm}^3$, tensile strength of 400-700 MPa, and Young's modulus of 9.0-38.0 GPa (Munawar 2008), while bamboo fiber has density of 1.31 g/cm^3 , tensile strength of 450 MPa, and Young's modulus of 18.5 GPa (Shibata et al. 2008).

Composites of sisal fiber/PP in this experiment have flexural strength of MOR at range of 50.47 – 57.05 MPa and MOE at range of 2.59 – 3.36 GPa. These results are higher compare with those obtained by Mohanty et al. (2004a) using lower ratio of sisal fiber. They found that composites of sisal fiber/PP with ratio of 21/79 have flexural strength (MOR) of 48.96 MPa and flexural modulus (MOE) of 2.188 GPa. In this experiment it was found that addition of 1% MAPP gave optimum mechanical properties. In the present experiment MAPP was added at higher percentage (5%). Composites sisal fiber/PLA has flexural strength of MOR at range of 61.54 – 100.42 MPa and MOE at range of 5.77 – 8.07 GPa. Researches on sisal fiber with PLA as matrix have not been found before. As a comparison, Oksman et al. (2003) conducted research on composites of flax (*Linum usitatissimum*) fiber and PLA. At ratio of flax fiber/PLA of 30/70 they obtained tensile strength of 53 MPa and tensile modulus of 8.3 GPa. When the ratio of fiber was increased to 40/60 the mechanical properties were decreased (tensile strength of 44 MPa and tensile modulus of 7.3 GPa). Other research on development of composite from micro fibrillated cellulose of wood with PLA as polymer matrix has been conducted by Suryanegara et al. (2009).

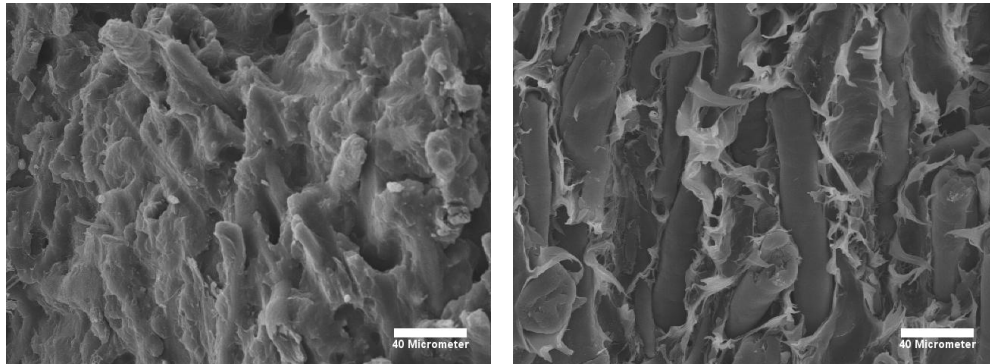


Figure 3. SEM images of fracture surface of fibers / PP composites (50/50), sisal (left), bamboo (right).

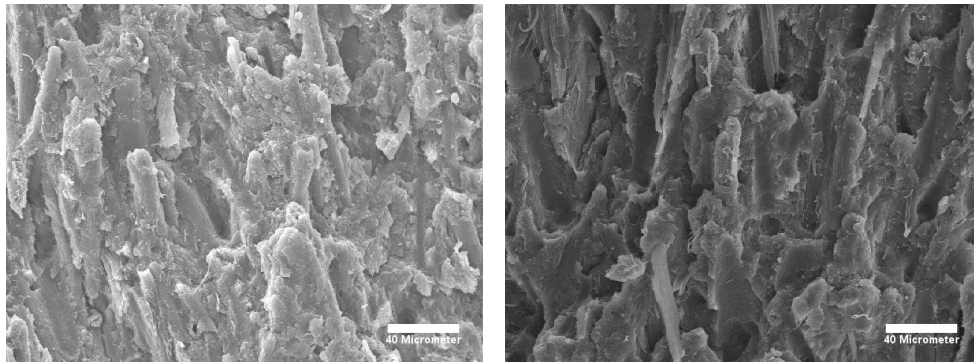


Figure 4. SEM images of fracture surface of bamboo fibers / PLA composites (50/50), sisal (left), bamboo (right).

Composites of bamboo fiber/PP in this experiment have flexural strength of MOR at range of 47.71 – 52.36 MPa and MOE at range of 2.8 – 3.25 GPa. Even though direct comparison could not be made, these mechanical properties are close to that obtained by Okubo et al (2004). In this research they obtained that composites of bamboo fiber/PP with ratio of 40/60 have tensile strength value of 30.3 MPa and Young's modulus of 3.66 GPa. On the other hand composites of bamboo fiber/PLA in the present experiment have higher flexural strength compare to those of bamboo fiber/PP composites that are for MOR at range of 73.31 – 105.23 MPa and MOE at range of 6.11 – 7.05 GPa. Lee et al. (2004) found that composites bamboo fiber/PLA with ratio of 30/70 and added 5% MAPP have tensile

strength of 35 MPa and Young's modulus of 2,72 GPa. They observed that increases of fiber ratio decreases tensile strength but increases Young's modulus of composites.

Conclusions

The mechanical properties of composites were affected by polymer matrices used. Composites of fibers/PLA have higher mechanical properties compared to those of fibers/PP composites. Sisal or bamboo fibers as reinforcement of PP or PLA composites yielded in similar mechanical properties. Optimum ratio of fiber/polymer obtained in this experiment is 40/60.

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Static Bending Strength of Meranti Merah (*Shorea spp*) LVL Bonded by PVAc

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Abstract

The purpose of this study is to determine the static bending strength: stiffness (MOE) and modulus of rupture (MOR) of red meranti laminated veneer lumber (LVL) consist of 5, 7 and 9 layers. LVL had bonded by Polyvinyl Acetate (trade name is Lem *Rajawali*) and compressed by cold press for 24 hours. The samples of static bending strength are test according to Indonesian National Standard SNI 01 5008.2.1999.

The results of this study illustrate that the average of MOE is 125230 kg/cm² and MOR was 371 kg/cm². Based on the veneer number, MOE of five, seven and nine layers was 115600 kg/cm², 124192 kg/cm² and 135900 kg/cm², whereas MOR value is 432 kg/cm², 397 kg/cm² and 285 kg/cm², respectively. The average of MOE of nine layers red meranti LVL is greater than the average of MOE of red meranti solid wood. It is indicated that red meranti LVL is possible be light structural material to substitute red meranti solid wood because these are included to III-IV strength class.

Key words : static bending strength, LVL, red meranti, layer number,

Introduction

Red meranti (*Shorea spp*) is economically the most important timber genus in Indonesia and it is consist of two groups, namely light red meranti and dark red meranti. Light red meranti less heavy than dark meranti. General use of this timber is for light constructional work, light-duty flooring, panelling, ceiling, interior partitions and especially for plywood and veneer. Veneer and plywood industries need some requests to log before processing at rotary peeling: cylindrical, big diameter, straight. Normally, red meranti is the first choice as veneer and plywood industry raw material. Unfortunately, at this time, the amount of red meranti forest in Kalimantan is decreasing and some of veneer and plywood industries are closed. Some of exist veneer and plywood industries in Samarinda are produce red meranti plywood with red meranti or sengon veneer as core.

The alternate of structural material beside plywood is structural composite lumber (SCL). According to Berglund and Rowell (2005), structural composite lumber is manufactured by laminating strips of veneers or strands of wood glued parallel to the length. Three types of SCL products are oriented strand lumber (OSL), parallel strand lumber (PSL) and laminated veneer lumber (LVL). LVL produced from veneers that are approximately 2.5 to 3.2 mm thick and varying lengths. The major adhesives used to produce LVL products are exterior type adhesives such as phenol-formaldehyde or isocyanides.

Laminated veneer lumber is closely related to plywood and it produced in larger quantities than PSL and LSL. Veneers 3 mm in thickness are adhesively bonded together parallel to the length under pressure into thick boards. Similar to the lay-up strategy in glued-laminated timber (glulam), veneer with higher grades is placed on the faces while the lower grade veneers are in core. This specific lay-up configuration of veneers effectively utilizes materials' strength and improves the strength and stiffness of products in a desired way (Bao, 2002). In contrast with sawn lumber, the strength-reducing characteristics of LVL are dispersed within the veneer and have much less of an effect on strength properties. Thus, relatively high design values can be assigning to strength properties for LVL. It can be substitute for sawn lumber products in many applications (Moody, Hernandez and Liu, 1999). Laminated veneer lumber is used extensively for scaffold planks and in the flanges of prefabricated I-joists, roof and floor joists, lintels, framework studs, etc which takes advantage of the relatively high design properties and it is also used in a number of non structural applications, such as the manufacture of windows and doors.

The purpose of this study is to determine the static bending strength (MOE and MOR) of red meranti LVL consist of five, seven and nine layers with 2.2mm of veneer thickness. Its possibility as structural member to substitute either plywood or solid wood is one of this study desire.

Material and Method

Materials

The material investigated was laminated veneer lumber of red meranti (*Shorea spp*) consist of five, seven and nine layers. Red meranti dried veneers (2.2 mm of thickness) were taken from PT. Kayu Lapis Murni Samarinda and Polyvinyl Acetate glue (trade name is *Lem Rajawali*) was purchased at local material store. The equipments are Universal Testing Machine WOLPERT, cold press machine, balance, oven and calliper.

Methods

1. LVL Production and Specimen

Veneers conditioned at constant room until reached to 12% of moisture content and cut into less than cold press surface dimension. Glue spread at both surfaces of veneer at a spread rate of 0.02 g /cm², pressed for a day at room temperature at 10 MPa, and conditioned for 7 days. LVL converted into density, shear strength and static bending test specimens.

The dimension of static bending specimen is 23 times of specimen thickness (L) x 5.0 cm (W) x specimen thickness (T) cm. Three types of static bending specimen and its dimension are available at Figure 1.



Figure 1. Shape and dimension (cm) of red meranti LVL static bending specimens (a = 9 layer; b = 7 layers; c = 5 layers)

2. Testing Procedure

LVL density and shear strength specimens were test based on DIN standard; density is DIN 52182-88 and shear strength is DIN 52187-88, whereas static bending specimens were test by two load points according to SNI 01-5008.2-1999 standard as figure follow.

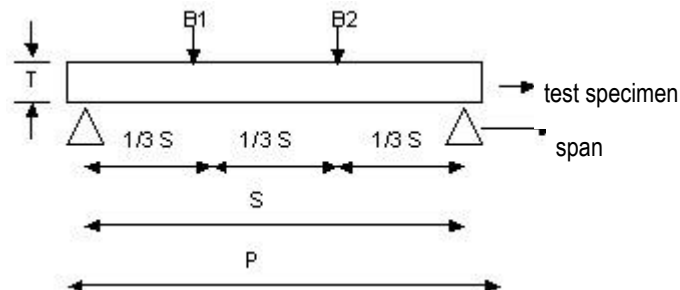


Figure 2. Static Bending Test according to SNI 01-6240-2000 Standard
Remarks : B = load; S = span; P = length of specimen; T = thickness of specimen

Result and Discussion

Generally, red meranti that use as raw material in plywood industry is light red meranti, commonly it is called "red meranti", because it can rotary peel easier than dark red meranti. Red meranti veneers (2.2 of thickness) were lay-up into five, seven and nine layers of LVL. The LVL target thickness of each treatment is 1.10 cm, 1.54 cm and 1.98 cm. The average of LVL thickness determination of each treatment is 1.14 cm, 1.59 cm and 2.04 cm. This result indicated that LVL thickness is greater than the target, because of the glue line, more layers means more glue lines. According to SNI 01-5008.2-1999, LVL divided into 2 classes, structure and non-structural. Structural LVL requests at least 2.5 cm of thickness, so all of red meranti LVL in this study categorized to non-structural LVL.

The average of density, stiffness (MOE), modulus of rupture (MOR), shear strength and wood failure are show at Table 1 below.

Table 1. Average of density, MOE, MOR and shear strength of red meranti (*Shorea* spp) LVL

Layer number	Replication	Density (g/cm ³)	MOE (kg/cm ²)	MOR (kg/cm ²)	Shear strength (N/mm ²)	Wood Failure (%)
Five	10	0.51	115600 (12.28)	432 (32.82)	3.28 (23.52)	41.50
Seven	10	0.49	124192 (14.46)	397 (23.70)	1.99 (17.42)	28.60
Nine	10	0.52	135900 (14.76)	285 (19.93)	1.76 (17.71)	27.80

Remark: value at parentheses is coefficient of variance

1. Density

The range of red meranti LVL density is 0.47 – 0.55 g/cm³, whereas the average of density of 5, 7 and 9 layers LVL is 0.51 g/cm³, 0.49 g/cm³ and 0.52 g/cm³ respectively as displayed at Table 1. The number of layer did not influence to LVL density, the seven layers one is lower than other one, because meranti is belong to a group has widely divergent of density. Soerianegara and Lemmens (1994) explained that density of light red meranti (*Shorea* spp) is 300 – 600 kg/m³, so the irregular trend of LVL density based on its layer number is reasonable. Veneer lay-up randomly depend on its colour and neglected the veneer density, the darker veneers placed at the outer. Based on its density, red meranti LVL could be substitute solid wood, either LVL or solid wood of red meranti are include to III – IV class in accordance with Strength Classification of Indonesian Wood by Dumanauw (1990), 0.30 – 0.60 g/cm³ categorized to III – IV class.

2. Static bending strength

Flatwise bending strength with two load points (SNI 01-5008.2-1999 standard) carried out in this study to determine the stiffness (MOE) and strength (MOR) of red meranti LVL. The average of MOE and MOR of red meranti LVL are 125,230 kg/cm² and 371 kg/cm² respectively, however the average of each treatment shows at Table 1. The detail information of its average as well as the range of MOE and MOR are illustrate at Figure 3.

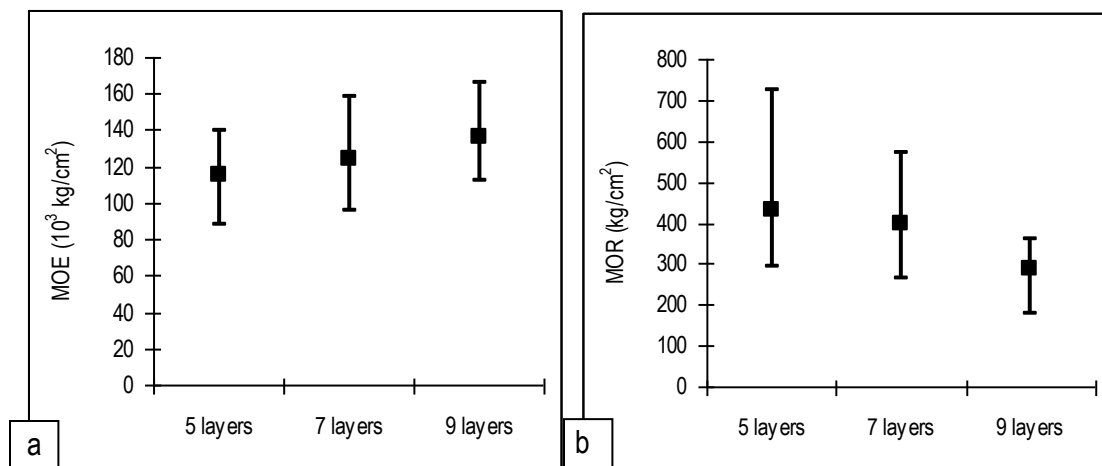


Figure 3. MOE (a) and MOR (b) of red meranti LVL

Figure 3 (a) above shows that the average of MOE of each treatment higher than MOE of red meranti solid wood. According to Martawijaya, *et.al.* (1981), MOE of red meranti is 114,000 kg/cm². It happened because LVL consist of dried veneers that had selected and removed its defects before laying-up. Solid wood may contain the defect, natural or processing defect.

MOE of nine layers of LVL (135,900 kg/cm²) is higher than either seven layers (124,192 kg/cm²) or five layers (115,600 kg/cm²). Along with SNI 01-5008.2-1999 standard, structural LVL divides into six stress classes and MOE of LVL of all treatments include to 120 E (105 – 120 x 10³ kg/m³) to 140 E (120 – 140 x 10³ kg/m³) class. However, number of layer of LVL has insignificant effect to the average of MOE statistically. Related to this, MOE of LVL is similar each other and could be utilize likely red meranti solid wood such as flooring, panelling, ceiling.

Strength (MOR) of red meranti LVL has contrast behaviour with MOE as illustrated at Figure 3 (b), MOR of five layers LVL (432 kg/cm²) higher than either seven (397 kg/cm²) or nine layers (285 kg/cm²). Many factors affect the strength of LVL, such us veneer quality, lay-up, adhesive type and the processing. In this study, the quality as well as the strength of veneer did not determine before laying-up. Veneer lay-up derived from the colour of veneer, usually the darker veneer was placed on the surface and the lighter veneer was put on the inner part. The reason is darker veneer may has higher density than lighter one, so the strength of darker veneer will be high too.

Statistically, the same as MOE, number of layer has insignificant effect to MOR of LVL. Therefore, utilization of red meranti as light structural member is not necessary to give more attention for the number of layer especially 5 to 9 layers of red meranti veneer. Notification for the grade quality only before it applies in the building structure. According to SNI 01-5008.2-1999 standard, MOR of LVL include to Quality 1 of structural LVL in low categorize, 80 E to 120 E.

Comparing to red meranti solid wood, MOR of LVL is lower than red meranti solid wood. Martawijaya, *et.al.* (1981) described that light red meranti group has MOR value about 618 kg/cm². This is occurred due to PVAc glue did not bond with the wood properly. Reasonable thing to hold up is the failure after testing, some of specimens failed at shear area, neither specimen crack at the tension nor compression area due to its toughness is quite high. Figure 4 below explain more about shear failure of bending strength specimens after testing with two loads points.



Figure 4. Shear failure after testing

Table 1 declares that shear strength of red meranti LVL bonded with PVAc is very low as well as the wood failure after shear testing, 27.80% to 41.50%. Polyvinyl Acetate is one of thermoplastic glue, white colour emulsion, its water resistance is low and use as interior adhesive. Its bonding strength is lower than exterior adhesive. Take note to the thickness of LVL, its bending and shear strength, this product should be use as interior member that does not hold back the load or furniture.

Conclusion

By this study, some conclusions were taken: Firstly, red meranti LVL has medium density and include low to medium categorize of stiffness and strength based on SNI 01-5008.2-1999 standard. Secondly, red meranti veneer was bonded with PVAc have low shear strength and it is appropriate be interior non structural member only, Thirdly, shear failure occurred after bending strength test mainly, and finally, statistically the number of layer insignificant effect to neither MOE nor MOR.

Red meranti LVL (5, 7 or 9 layers) ought to utilize interior partitions, panelling, ceiling or furniture that place at dry area enough to protect from delaminating process.

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Termite Resistance of Oriented Strands Board (OSB) Made of Small Diameter Fast Growing Species

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Abstract

Small diameter fast growing species, namely akasia (*Acacia mangium* Willd.), ekaliptus (*Eucalyptus* sp.), and gmelina (*Gmelina arborea* Roxb.) were used as raw material of OSB. There were 5 models of OSB produced, bonded by several types of resin, namely Phenol Formaldehyde (PF) powder type, liquid PF, isocyanate (IC), the face and back layers bonded by powder or liquid PF and the core layer bonded by IC. OSB was made of three plies, with 9 mm target thickness and ratio of strands weight in face:core:back was 1:1:1. Mat forming methods in face was lengthwise and the core was widthwise. The board was pressed at 25 kg/ cm² for 15 minutes at 160°C. Level of resin was 7% based on oven dry strands weight. The boards were tested for resistance to termites after a year later. Both laboratory test and field test were conducted. Laboratory test was conducted at Centre for Forest Products Research and Development, Gunung Batu, Bogor. *Cryptotermes cyanocephalus* Light mortality was determined. Weight loss after termite attack was determined based on the difference between initial and final dry weights of specimen after debris of the termite attack had been removed. Field test (grave yard test) was conducted at "Hutan Tridharma Kampus USU" in Medan, North Sumatera. The board were stacked in for 12 weeks and weight loss was determined and criteria of attack was evaluated by scoring. Five replications were made for each board model. The results showed that range of weight loss were 3.88-8.22% for laboratory test and 3.46-24.97% for grave yard test. Degree of attack and mortality of *C. cyanocephalus*, respectively were 5-21% and 71-100% for akasia, 7-28% and 78-88% for ekaliptus, and 4-20% and 82-94% for gmelina. Based on scoring, criteria of attack were classified at B-C class, that mean there were 1-40% termite attack. *Macrotermes gilvus* Hagen was found in the grave yard test.

Key words : Oriented Strands Board (OSB), termite resistance, fast growing species, laboratory test, grave yard test

Introduction

Oriented strand board (OSB) is one of the primary structural composites that are gaining increased utilization in both residential and commercial applications, such as sheeting, flooring, and I-joist material in construction (Han *et.al*, 2005). OSB can be successfully produced from low density wood from fast-grown trees (Wolcott *et.al*, 1997). In Indonesia fast growing species are usually consist of high portion of juvenile wood, nondurable, and low density (Rachman *et.al*, 2005).

OSB as structural material and one of panel products is designed for plywood substitution (Nishimura *et.al*, 2004). Unfortunately, in the future, plywood producers can no longer rely on the high quality and large diameter wood for their raw material. Based on the above condition, one of the solving this problem is production of OSB made of small diameter wood from fast growing species. Because of exterior using, so the OSB bonded by waterproof adhesive, such as Phenol Formaldehyde or Isocyanate. Previous work (Nuryawan *et.al*, 2007, 2008a, 2008b) showed the physical and mechanical properties of OSB which were bonded by several resin types met the JIS A 5908 (2003) standard. Unfortunately, the termite resistance test hasn't been conducted. This researches are intended to investigate the termite resistance of OSB both subterranean termite and dry termite.

Materials and Methods

In this research, the OSB are determined as board made of three layers strands, on face and back were lengthwise and on core was widthwise. Strands made from logs of akasia (*Acacia mangium* Willd.), ekaliptus (*Eucalyptus* sp.), and gmelina (*Gmelina arborea* Roxb.). Disc flaker was used to produce strands. The target of the board thickness was 9 mm and the density was 0.75 g/cm³. Ratio of strands weight in face: core : back was 1:1:1, pressed at 25 kg/cm² for 15 minutes at 160°C. The resin content was 7% based on oven dry strand weight, and there were five models of the produced OSB, which were bonded by several types of resin, namely Phenol Formaldehyde (PF) powder type, liquid PF, isocyanate (IC), the face and back layers bonded by powder or liquid PF and the core layer bonded by IC. Each model was produced in five replications, so totally there were 75 board samples. The board cut into specimens after 1 year later.

For subterranean termite (grave yard test), the board was trimmed to a final size of 10 mm by 20 mm by 250 mm. Before be evaluated, all of the specimens were dried into oven dry (103±2)°C and weight to determine the initial weight. Thus, in the final testing, all of the debris on specimens had been removed to determine the final weight and weight loss (Nuryatin *et.al*, 2003) Field test (grave yard test) was conducted at "Hutan Tridharma Kampus USU" in Medan, North Sumatera. The board were stacked in for 12 weeks and weight loss was determined according to Indonesian National Standard (SNI) 01-7207 (2006) that be shown at Table 1. The criteria of attack was evaluated by scoring (Table 2). Five replications were made for each board model.

Table 1. Weight loss classification to subterranean termite

Grade	Resistance Class	Weight loss (%)
I	Very strong	< 2
II	Strong	2-4.4
III	Moderately strong	4.4-8.2
IV	Poor	8.2-28.1
V	Very poor	>28.1

Source : SNI 01-7207 (2006)

Table 2. Scoring assessment to criteria of subterranean termite attack

Grade	Specimen condition	Range value
A	No attack	0
B	There are termite bite	1-20
C	Mild attack	21-40
D	Severe attack	41-60
E	More than 50%	61-80

Source : Febrianto, *et.al* (2000)

For dry termite (laboratory test), the board was trimmed to a final size of 25 mm by 50 mm by 10 mm. Similar with grave yard test, all of the specimens were dried into oven dry (103±2)°C and weight to determine the initial weight before be evaluated. Thus, in the final testing, all of the debris on specimens had been removed to determine the final weight and weight loss (Ayrilmis *et.al*, 2005) Laboratory test was conducted at Centre for Forest Products Research and Development, Gunung Batu, Bogor. *C.cyanocephalus* Light mortality was determined. Five replications were made for each board model. The grade of weight loss was evaluated by Indonesian National Standard (SNI) 01-7207 (2006) (Table 3). Five replications were made for each board model.

Table 3. Class of wood resistance to dry termite attack

Grade	Resistance Class	Weight loss (%)
I	Very strong	< 2
II	Strong	2-4.4
III	Moderately strong	4.4-8.2
IV	Poor	8.2-28.1
V	Very poor	>28.1

Source : SNI 01-7207 (2006)

Results and Discussion

Figure 1 showed the grave yard test results, ranged of weight loss were II-IV grade based on SNI 01-7207 (2006) with the ranged were 3.46-24.97% (strong ~ poor). The worse damage caused by *Macrotermes gilvus* Hagen are presented by OSB which bonded with Powder Phenol Formaldehyde or OSB bonded by PF type powder on face and back layer and the core by IC.

Its well known that adhesive type powder, include PF powder will difficult to penetrating into wood strands. Because the pattern of the wetting was dots form. Different than liquid form adhesive, there are five steps in bonding. Flowing first, transferring, penetrating, wetting, and the last is solidifying (Marra, 1992). In this case, penetrating of adhesive type powder worse than liquid type, because there a little interlocking action between adhesive and the strands. The best OSB, which be bonded by IC.

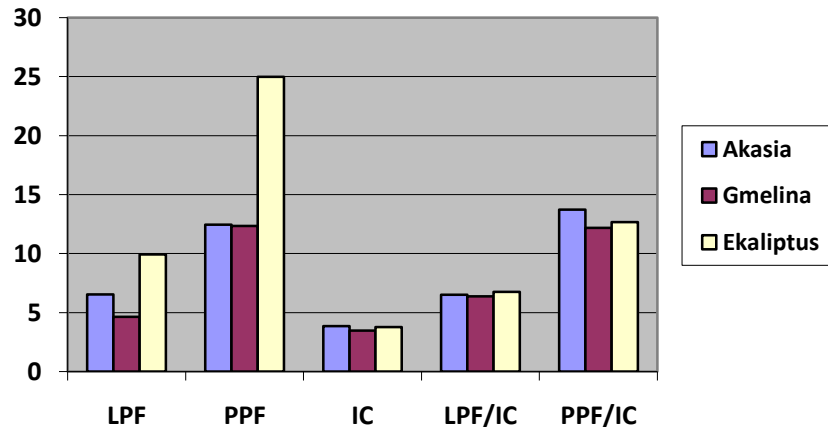


Figure 1. Weight loss after 12 weeks of exposed at *Macrotermes gilvus* Hagen

Remarks : LPF : OSB bonded by PF type liquid, PPF : OSB bonded by PF type powder, IC : OSB bonded by IC, LPF/IC : OSB bonded by PF type liquid on face and back layer and the core by IC, PPF/IC : OSB bonded by PF type powder on face and back layer and the core by IC.

Based on scoring assessment according to Febrianto, *et.al* (2000), the criteria of attack were classified at B-C class, that mean there were 1-40% termite attack. *Macrotermes gilvus* Hagen was found in the grave yard test.

The laboratory test results showed in Figure 2, 3, and 4. All of the parameters, consist of weight loss, mortality, and degree of attack after exposed by *C.cyanocephalus* Light, didn't show specific tendency. Figure 2 explained that weight loss after 12 weeks of exposed at *Cryptotermes cyanocephalus* Light was as same as grave yard test class, ranged of weight loss were II-IV grade based on SNI 01-7207 (2006) with the ranged were 3.88-8.22% (strong ~ poor). From this case, if we conclude that resistance of OSB made from small diameter fast growing species to termite, both subterranean and dry termite, was strong ~ poor classification.

Figure 3 presented the mortality of dry termite. Unfortunately, there were no specific tendency if we observed both of the wood species and used of resin type. 100% mortality occurred at akasia's OSB bonded by powder type PF and the lowest mortality occurred at akasia's OSB bonded by PF type powder on face and back layer and the core by IC.

Figure 4 presented the degree of attack of dry termite. Similar with Figure 3, there were no specific tendency if we observed both of wood species and the used of resin type.

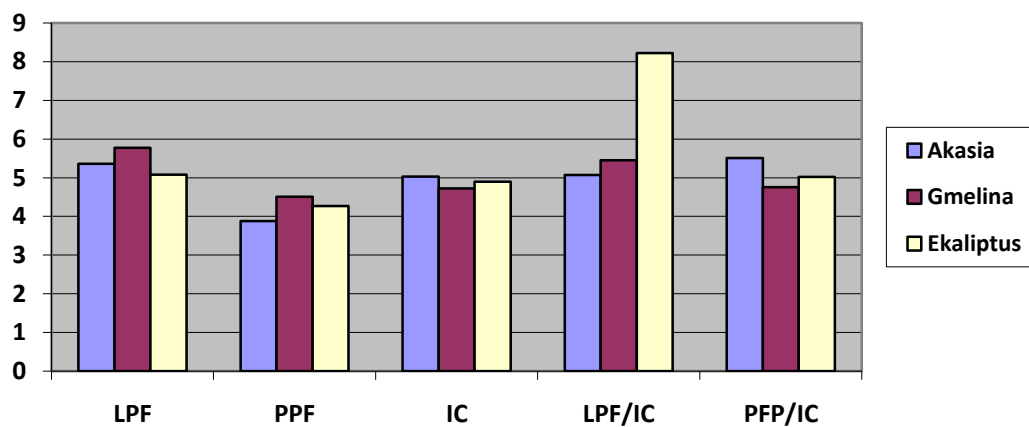


Figure 2. Weight loss after 12 weeks of exposed at *C. cyanocephalus* Light
Remarks : see Figure 1

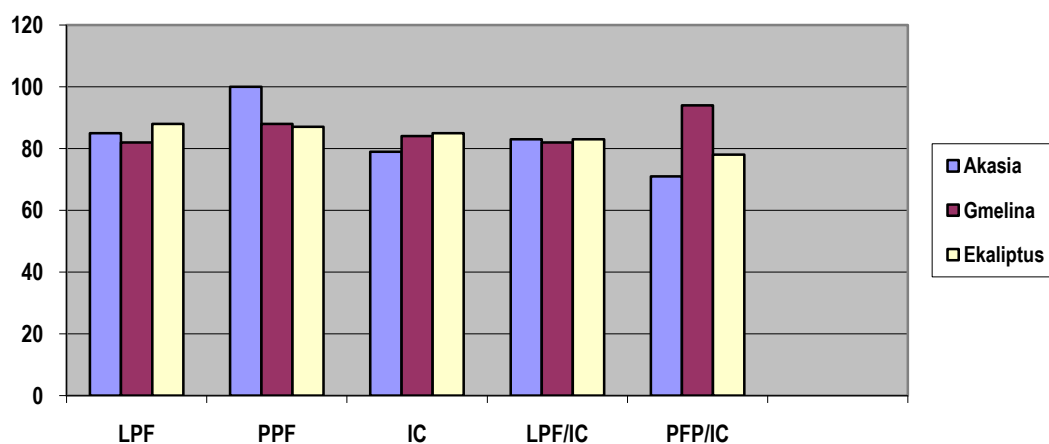


Figure 3. The mortality (%) of *Cryptotermes cyanocephalus* Light
Remarks : see Figure 1

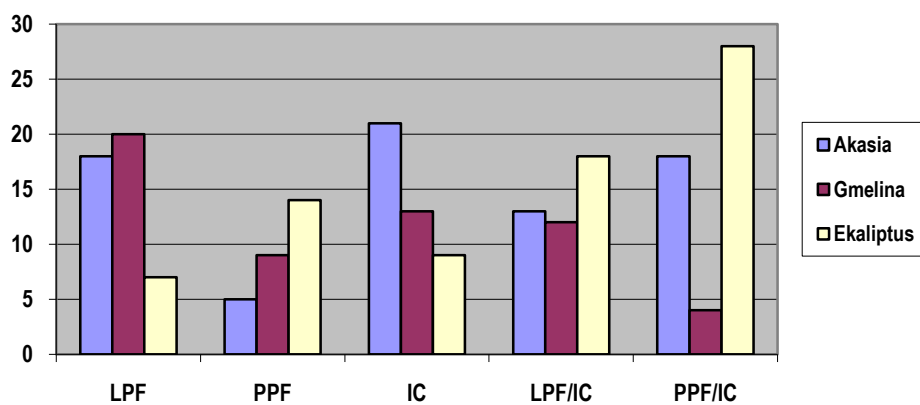


Figure 4. Degree of attack by *C. cyanocephalus* Light
Remarks : see Figure 1

Conslussion

The resistance of OSB made from small diameter fast growing species to termite, both subterranean and dry termite, was strong ~ poor classification according to weight loss criteria by SNI 01-7207 (2006).

Both parameters of mortality and degree of attack by dry termite (*C.cyanocephalus*), there were no specific tendency if we observed both of the wood species and used of resin type.

Acknowledment

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The Properties of Oil Palm Fronds Cement-Bonded Board

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Abstract

This study deals with the manufacturing technology of cement-bonded board using fronds of oil palm. For the purpose of this study, basic analyses of cement hydration and the compatibility of fronds with cement were conducted. The mechanical and dimensional properties of oil palm cement-bonded board manufactured by a conventional cold-pressing method were then investigated under various conditions.

The results show that the addition of magnesium chloride improved the compatibility of oil palm fronds with cement. The compatibility factor increased by more than 90% with the addition of 5% magnesium chloride. The addition of magnesium chloride also enhanced the cement hydration and ultimate board strength properties. However, the addition of 5% magnesium chloride did not improve the properties of board sufficiently, at the cement/wood ratio of 2.2:1.0.

Key words : oil palm fronds, cement-bonded board, magnesium chloride

Introduction

During the cultivation and production of oil palm, the industry generates a number of by-products and residues, which are neither recycled nor converted to value-added products at present. Studies have shown the possibilities of the effective utilization of oil palm vascular bundles from empty fruit bunch (EFB) and fronds as cellulosic raw materials in the production of cement-bonded board. Additional research, however, is necessary to improve the compatibility of such materials with cement because of the highly species-sensitivity of the wood-cement-water system.

Hydration characteristics of cement have been commonly used to assess the compatibility of potential lingo-cellulosic materials with cement. It is known that in the presence of water, the cement compound (i.e. silicates and aluminates) form products of hydration, which in time produce a firm and hard mass – hardened cement paste. This hydration process is an exothermic reaction. When using portland cement as a binder, the exothermic behavior depends on the species being tested. Therefore, such compatibility can be expressed in terms of cement hydration data when mixed with a given wood species.

The objectives of this study were to establish a manufacturing technology of cement-bonded board using fronds of oil palm. For the purpose of this study, basic analysis of cement hydration and compatibility of fronds with cement were conducted. The mechanical and dimensional properties of oil palm frond cement-bonded board manufactured by a conventional cold-pressing method were then investigated under various conditions.

Materials and Methods

Materials

The materials used were fronds of oil palm (*Elaeis guineensis* Jacq), ordinary portland cement and magnesium chloride ($MgCl_2$).

Methods

a. Hydration Measurement

The hydration temperature was measured in an insulated box. The cement/wood ratio of 13.3 : 1.0 and powder size of 80 pass/100 on mesh were chosen based on the formula that resulted in the preliminary study. $MgCl_2$ was added to each mixture in the range of 0% - 15% based on cement weight.

The compatibility of oil palm fronds with cement was evaluated using the C_A -factor calculation method.

b. Manufacturing Cement-bonded Board

Boards with a target density of 1.2 g/cm³ were manufactured at cement/oven-dried particle/water weight ratios of 2.2:1.0:1.32 and 2.7:1.0:1.62, respectively. The 300x300 mm hand formed mats were cold-pressed to a target thickness of 12 mm and kept in an oven for 24 h at 60°C followed by 2 weeks curing at room temperature.

Results and Discussion

a. Compatibility of Oil Palm Fronds with Cement

The hydration temperature of the cement-fronds mixtures with addition of MgCl₂ is shown in Figure 1.

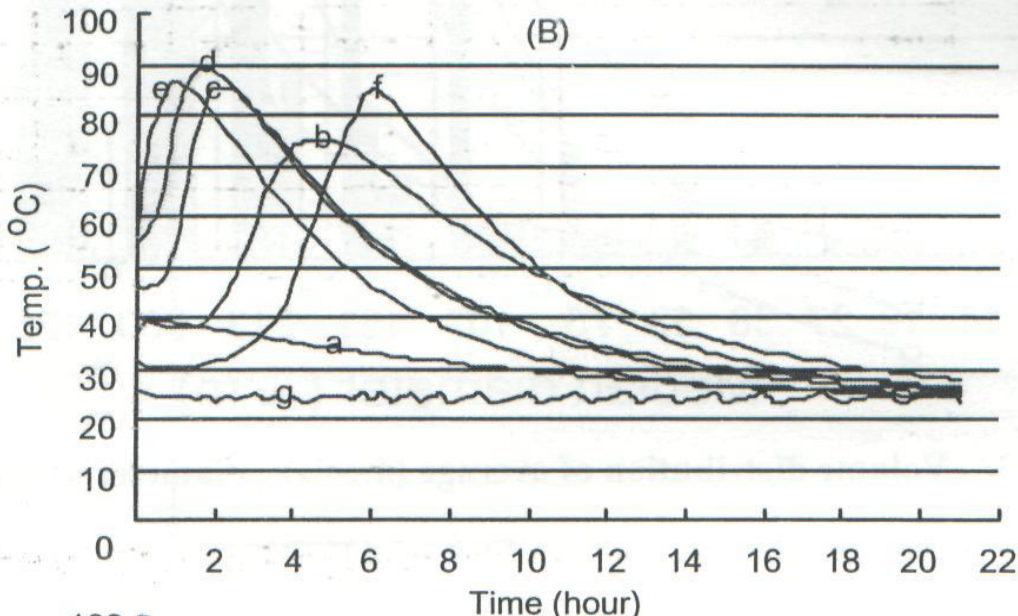


Figure 1. Hydration temperature of cement mixed with fronds using MgCl₂.
a. 0%; b. 5%; c. 7.5%; d. 10%; e. 15%; f. neat cement; g. room temp

The hydration temperature curve for cement without MgCl₂ indicates that cement hydration is retarded when the fronds are present. This showed that the oil palm fronds could not be used solely as the raw material for cement-bonded board owing to its inhibitory effect on cement hydration due to the inherent extractives of the materials. It is known that chloride react with tri calcium aluminate in cement, forming calcium hydrochloroaluminate (3CaO.Al₂O₃.CaCl₂.10H₂O). The suitability of hydrochloroaluminate in water is greater than that of ettringite (3CaO.Al₂O₃.3CaSO₄.32H₂O). Moreover, the grains of minerals in cement are surrounded by a more permeable layer than that in neat cement, and the reactions at the beginning are intensified. These reactions liberate a large amount of heat.

b. Properties of Cement-bonded Board from Oil Palm Fronds

The results showed that the bending properties of board improved significantly after adding MgCl₂. The moduli of rupture (MOR) and elasticity (MOE) increased with increasing amount of MgCl₂ to a maximum, followed by a decline, as shown in Figure 2.

The improvement effect of MgCl₂ was more prominent at a cement/wood ratio of 2.2:1.0 than at 2.7:1.0, especially when the MgCl₂ addition was increased from 5.0% to 7.5%. This improvement effect on the strength properties of board might be due to the suitable alkalinity of MgCl₂. The alkalinity of MgCl₂ could not be expected to trigger dissolution of the inhibitory extractives but, rather, to enhance the hydration reaction of cement and the substantial strength development of board.

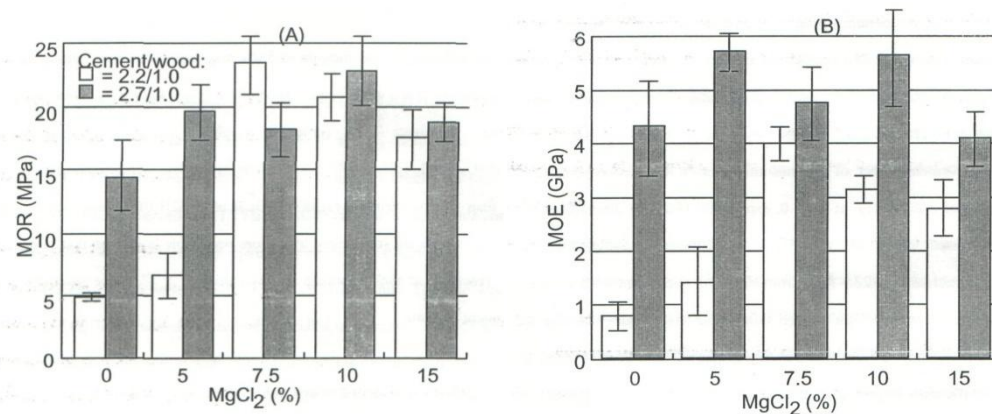


Figure 2. Effect of MgCl₂ on bending properties at different cement/wood ratios

A similar trend was observed for internal bond (IB) strength, where the MgCl₂ had a favorable effect on the board. The acceleration effect of MgCl₂ could also produce high bondability of cement, as reflected in the high IB strength shown in Figure 3.

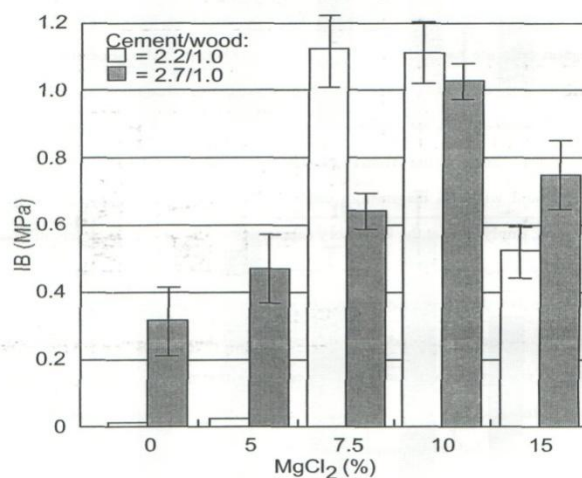


Figure 3. Effect of MgCl₂ on IB strength at different cement/wood ratios

Conclusion

The addition of magnesium chloride improved the compatibility of oil palm fronds with cement. The compatibility increased by more than 90% with the addition of 5% MgCl₂. This additive also enhanced the cement hydration and ultimate board strength properties.

Effects of Some Factors on Veneer Volume Recovery

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Abstract

The ratio of veneer volume production (input) by rotary to log volume (output) is stated as the veneer volume recovery. The veneer volume recovery is affected by log diameter, moisture content, specific gravity and stem form quotient. The research uses 100 pcs of log from four wood species of *Anisoptera spp*, *Palaquium spp*, *Canarium spp* and *Octomeles sumatrana* at PT. Tunggal Agathis Indah Wood Industries, Sidangoli, Maluku Utara. They are prepared to rotary for peeling.

The veneer volume recovery is stated as dependent variable, but log diameter, moisture content, specific gravity, stem form quotient and their interactions are stated as independent variable. The research uses multiple linear regression analysis.

The purpose of this research is to investigate the effect of diameter of log, moisture content, specific gravity, stem form quotient and their interaction on veneer volume recovery. The multiple linear regression model for effect of log diameter, moisture content, specific gravity, stem form quotient and their interaction on veneer recovery by stepwise analysis was $Y = -18.89 - 0.007 X_1 X_2 + 1.149 X_1 + 1.21 X_2 X_3 X_4$, With $R^2 = 82.32 \%$

Key words: Log diameter, moisture content, spesific gravity, stem form quotient and veneer recovery.

Introduction

There were 4000 wood species in Indones, 400 number of them will have an important role in Indonesia in the future (Memed et al. 1981 and Kliwon et al. 1984) . This is based on the fact that those wood species are utilized. From those 400 species, 259 species have been known in wood trade and are classified into 120 wood trade names (Martawijaya, et al. 1981).

According to Kliwon et al. (1984), one of the efforts to improve wood utilized was through veneer and plywood making, where plywood processing was started in 1970's (Apkindo, 1986). In that time, wood product contributed to export value was the second larger after petroleum (Astana et al. 1991). Until 1985 the contribution of wood product to non petroleum export value was the greatest is recording 20%. The export contribution was dominated by plywood (61.60%) and followed by sawn timber (26.40%) and the others 12.20% (Sarsito, 1988 in Astana, et al. 1991). At that time plywood export increased. The export increase can weaken the position of the industry when the logging rate is higher than the annual allowable cut that can be harvested. Mean while, the determination of material supply not yet concern to real capacity as indicated by peeler material quantity that can be supplied (Purnama, et al. 1993 in Astana, et al. 1991).

Therefore, efforts to increase the efficiency of forest resource utilization especially plywood has become crucial, and such efforts involve production techniques. Researches on the aspect of production techniques ought to be developed to determine veneer volume recovery. Assauri (1980) stated that all production factors, such as machines, equipments, labours and raw materials had to be used efficiently. In production process to convert raw materials into any product by the equipment must be reduced the waste and cost.

Prana (2002) stated that the future task was to complete the information provided by the various among species by research. The variation among species was among others: specific gravity, moisture content, log diameter and tree form quotient. These factors influence veneer volume recovery: 1). Specific gravity: Wood species which have a specific gravity of 0.4-0.7 are suitable for plywood and veneer making (FAO, 1966). Wood species with lower specific gravity are easier to peel than those with higher specific gravity (Kamil, 1970). Rieuwpassa (2004) stated that veneer volume recovery of meranti was 60,39 % with a specific gravity of 0.37 and veneer volume recovery of 59.17 with a specific gravity of 0.39. 2). Moisture content: Water contents in wood are classified as free water and bound water. Haygreen and Bowyer, (1982) stated that several wood characteristics, except weight, were not influenced by water quantity inside cells. For example, if a quarter of lumen is filled with water, the wood strength was the same as

those woods with half of its lumen filled with water. According to FAO (1966), wood species with very low specific gravity were very difficult to peel except when the moisture content was high. This statement was supported by Kamil (1970), who stated that wood with low specific gravity were easier to peel when wet. 3). Log diameter: Nagaraju (1974) in Kliwon et al. (1984) and Kainama (1997) revealed that the higher log diameter the higher veneer volume recovery and the lower the percentage of waste. 4). Tree form quotient: Suharlan and Sudiono (1973) stated that tree form quotient was a certain number that was trick volume ratio and cylinder volume that had the same height and base area. Avery (1975) stated that a form quotient is the ratio of some upper stem diameter to dbh. The higher form quotients indicated lower rate of stem taper and correspondingly greater tree volume. According to Prodan (1965) in Anonymous (1992), the tree form quotient can be calculated with formula: $F = b_0 + b_1h + b_2(h/d)$, where F = tree form quotient, b_0 = a constant, b_1 and b_2 = regression coefficient, h = height of tree or length of log and d = diameter of log. Tree form quotient determines the log volume (input) as one element to determine veneer volume recovery.

Rachman et al. (1988) and Anonymous (1998) revealed that recovery was the percentage of processing product to the raw material used or the percentage of ratio of output to input in used. Wooldfin (1973) in Rachman and Karnasudirdja (1978) stated that 65.05 % waste was produced from peeling of Bolth Douglas fir, Apkindo (2000) stated that log reduce in plywood industry, the veneer volume recovery around 45-50%. FAO (1966) suggest that to select wood species which were suitable for veneer and plywood making, since this would produce good quality of veneer and high recovery percentage.

From the above literature review that veneer volume recovery is influenced by various factors, ie: wood specific gravity, moisture content, log diameter and tree form quotient. The objective of this research was to study the effects of log diameter, moisture content, specific gravity, tree form quotient and their interactions to the veneer volume recovery and to determine the multiple linear regression model as an estimator of veneer volume recovery.

The used of this research is to determine veneer production target based on the quantity of raw materials being planned, and also to determine the quantity of plywood produced based on the model.

Materials and Methods

1. Materials

The material used in this research were 100 pieces log, which were ready for peeling from wood species of mersawa, nyatoh, kenari and binuang, at PT. Tunggal Agathis Indah Wood Industry in Sidangoli, North Maluku.

2. Data Collection

Veneer volume recovery yield was affected by log diameter, moisture content, specific gravity, stem form quotient and their interaction. The detailed steps of processing to collect data were:

- a. To measure log base diameter and top diameter with scale stick, to fix stem form quotient, where :

$$\text{Stem form quotient} = \frac{\text{Top diameter}}{\text{Base diameter}}$$

- b. To measure moisture content with moisture meter.
- c. To measure the length of log and average diameter to fix the volume of log as input factor, by formula: $V_{\log} = 0.7854 \times l \times d^2$, where: V = log volume; l = length, d = diameter
- d. To peel the log at rotary lathe: the logs are brought to rotary lathe for peeling process. The yield of peeling process was face and back veneer. $V_{\text{vnr}} = Q \times L \times W \times T$, where: V = veneer volume; Q = veneer quantity; L = veneer length; T = veneer thickness. Their volumes were stated as volume output. The veneer volume recovery can be calculate by formula:

$$\text{Recovery} = \frac{\text{Output}}{\text{Input}} \times 100\%$$

- e. To prepare samples for drying at laboratory to find their dry weigths and volumes to fix their specific gravities. Specific gravity was calculated by formula:

$$\text{Specific gravity} = \frac{\text{Wood density (g/cm}^3\text{)}}{\text{Water density (g/cm}^3\text{)}}$$

3. Data Analysis

Veneer volume recovery were determined as the dependent variable, and log diameter, moisture content, specific gravity, stem form quotient and their variation interactions were the independent variables. This research used stepwise analysis in order to find multiple linear regression model (Steel and Torrie, 1981) ie:

$$Y = b_0 + b_i X_i, 1 \leq i \leq 15$$

Where:

Y = veneer volume recovery,

b_0 = constant,

b_i = regression coefficient,

X_i = independent variables, with $1 \leq i \leq 15$.

To calculate the regression coefficient, a matrix processing is used.

Where:

$$\begin{pmatrix} n & x_1 & x_2 & \dots & x_{15} & b_0 \\ x_1 & x_1^2 & x_1 x_2 & \dots & x_1 x_{15} & x_1 x_{15} \\ x_2 & x_1 x_2 & x_2^2 & \dots & x_2 x_{15} & x_2 x_{15} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ x_{15} & x_1 x_{15} & x_2 x_{15} & \dots & x_{15}^2 & x_{15}^2 \end{pmatrix} \mathbf{A} \begin{pmatrix} b_1 \\ b_2 \\ \vdots \\ b_{15} \end{pmatrix} \mathbf{\beta} = \begin{pmatrix} \Sigma y \\ \Sigma x_1 y \\ \Sigma x_2 y \\ \vdots \\ \Sigma x_{15} y \\ Y \end{pmatrix} \mathbf{\Sigma y}$$

$$\mathbf{\beta} = \mathbf{A}^{-1} \mathbf{Y}$$

$$S_{bi} = \sqrt{\frac{c_{ii} (SSE)}{n - k - 1}} \quad SSR = \hat{\beta}' x' y - \frac{(\Sigma y)^2}{n}; \quad SSE = \Sigma y^2 - SSR$$

To determine where the model could be used as the best estimator, t-test was done, where

$$t_{cal} = \frac{b_i}{S_{bi}} \begin{cases} < t_{0.05}, \text{receive } H_0 : \beta_i = 0 \\ > t_{0.05}, \text{riject } H_0 : \beta_i \neq 0 \end{cases}$$

Result and Discussion

Results

Observation data from 100 pieces of logs ready for peeling in rotary lathe showed that the average log diameter was 65.55 cm, moisture content was 60.90 %, specific gravity was 0.446, stem form quotient was 0.977 and average veneer volume recovery was 46.48 % (Appendix 3).

Stepwise analysis show that the first X variable to enter the regression equation is X_{13} , the second is X_5 , the third is X_1 and the fourth is X_{14} . So that the multiple linear regression model: is: $Y = -18.89 - 0.5416 X_{13} - 0.007 X_5 + 1.149 X_1 + 1.21 X_{14}$,

The result of stepwise analysis (Table 1) for t-test showed that only coefficient of constant, coefficient of log diameter (X_1), coefficient of interaction between log diameter and moisture content (X_5) and coefficient of interaction among moisture content, specific gravity and stem form quotient (X_{14}) give significant to high significant effect on veneer volume recovery but interaction among log diameter, moisture content and specific gravity do not give significant effect to veneer volume recovery, because t-test shows that t_{cal} smaller than t_{table} for X_{13} .

Table 1. Result of stepwise regression analysis of X_{13} , X_5 , X_1 and X_{14} on Y (veneer Volume recovery)

Predictor	Coefficient	SE coefficient	T	P
Constant	-18.890	7.735	-2.44	0.016
X_{13}	-0.5416	0.2932	-1.85	0.068
X_5	-0.007	0.0020	-3.23	0.0022
X_1	1.149	0.2471	4.65	0.000
X_{14}	1.2126	0.2949	4.11	0.000

So that the multiple linear regression model that can be used as the best predictor on the veneer volume recovery was:

$$Y = -18.89 - 0.007 X_5 + 1.149 X_1 + 1.21 X_{14},$$

with coefficient of determination $R^2 = 82.32 \%$.

The analysis variance the effect of the independent variables X_{13} , X_5 , X_1 and X_{14} , to veneer volume recovery (Y) is shown in Table 2.

Table 2. Analysis of variance for Y regressed on X_{13} , X_5 , X_1 and X_{14} .

Source of variance	Df	SS	MS	F	P
Regression	4	8162.4	2040.6	100.50	0.000
X13	1	6921.7	6921.7	374.15**	
X5	1	792.8	792.8	42.85**	
X1	1	135.8	135.8	7.34**	
X14	1	312.1	312.1	16.87**	
Residual	95	1752.9	18.5		
Total	99	9915.			

$$F_{Table} 0.05 (1.95) = 3.953$$

$$0.01 (1.95) = 6.846$$

The result of analysis variance in Table 2 shows that log diameter (X_1), the interaction between log diameter and moisture content (X_5), interaction among log diameter, moisture content and stem form quotient (X_{13}) and interaction among moisture content, specific gravity and stem form quotient (X_{14}) give highly significant effect to veneer volume recovery. But null hypothesis for b_{13} is receive using a t-test,

Discussion

1. Wood Species in Used

- 1.1. Mersawa. The botanical name of mersawa is *Anisoptera spp* belonging to Dipterocarpaceae family. The observation data at Appendix (Table 3) shows that its specific gravity ranges from 0.43 to 0.582. According to Martawijaya et al. (1981), Dumanauw and Virsarany (1981) and Anonymous (1992), the specific gravity of mersawa ranges from 0.49 to 0.85. This species is suitable for veneer and plywood making without pretreatment (Dumanauw and Virsarany, 1981; and Martawijaya et al. (1981).
- 1.2. Kenari. The botanical name of kenari is *canarium spp* belonging to Burceraceae family (Anonymous (1992). The observation data at Appendix (Table 3) shows that its specific gravity ranges from 0.426 to 0.610. According to Dumanauw and Virsarany (1981), the specific gravity of mersawa ranges from 0.48 to 0.68. This species is suitable for veneer and plywood making (Samingan, 1974; Dumanauw and Virsarany, 1981; and Anonymous, 1992).
- 1.3. Nyatoh. Nyatoh is a trade name for *genua spp*, *payena spp* and *palaquium spp* of the family Sapotaceae. Research data at Appendix (Table 3) shows that its specific gravity ranges from 0.413 to 0.552. According to Martawijaya, et al. (1981), the specific gravity of mersawa ranges from 0.45 to 0.76. In Maluku this species is known as siki (Anonymous (1975). This species is suitable for veneer making without pretreatment ((Samingan, 1974, and Martawijaya et al. 1981).
- 1.4. Binuang. The botanical name of binuang is *octomeles sumatrana* of the Ditiaceae family, in Maluku is known as polaka. The research data at Appendix (Table 3) shows that its specific gravity ranges from 0.227 to 0.428. According to Martawijaya et al. (1981), and Dumanauw and Virsarany (1981), its specific gravity ranges from 0.16 to 0.48. Martawijaya et al. (1989) and Mandang and Pandit (1997) suggested that this species be used as the core veneer of plywood.

2. Effect of Log Diameter on Veneer Volume Recovery

Based on the statistical analysis, the coefficient of independent variable of log diameter (b_1) has a positive value. T-test shows that t_{cal} is significantly different with t_{table} , which means that the bigger log diameter, the higher the veneer volume recovery. This research result agrees with the statement of Rinne (1952) in Kainama (1997), Nagaraju (1974) in Kliwon et al. (1984) and Kewilaa (2007) that the bigger log diameter the higher veneer volume recovery.

3. The Interaction Affect between Log Diameter and Moisture Content on Veneer Volume Recovery

The result of statistical analysis shows that the bigger value of interaction between log diameter and moisture content (X_5), the lower veneer volume recovery. It is shown by its regression coefficient. This Result was supported by hypothesis test, t_{cal} bigger than t_{table} , then reject hypothesis $H_0: \beta_5 = 0$. Therefore, the regression coefficient $b_5 = -0.007$, illustrates that every one unit increase in the interaction value of log diameter and moisture content, the veneer volume recovery will decrease 0.007 percent.

4. The Interaction Affect among Log Diameter, Moisture Content and Specific Gravity on Veneer Volume Recovery

The analysis result of the interaction affect among log diameter, moisture content and specific gravity on veneer volume recovery shows a negative effect on veneer volume recovery. The regression coefficient shows every unit increase in interaction value of log diameter, moisture content and specific gravity (X_{13}) will decrease 0.5416 percent of veneer volume recovery. But this is not supported by the hypothesis test because test hypothesis of $H_0 : \beta_{13} = 0$, is true. Therefore, b_{13} can be rejected from regression model.

5. The Interaction Affect among Moisture Content, Specific Gravity and Stem Form Quotient on Veneer Volume Recovery.

The analysis result of the interaction affect among moisture content, specific gravity and stem form quotient on veneer volume recovery shows a positive effect on veneer volume recovery. The regression coefficient shows that every unit increase in interaction value of moisture content, specific gravity and stem form quotient (X_{14}) will increase the veneer volume recovery of 1.21 percent. This is supported by the hypothesis test of $H_0 : \beta_{14} \neq 0$. It means that b_{14} can be received in regression model.

This analysis result determines the multiple linear regression model by X_{13} , X_5 , X_1 and X_{14} as the predictor on veneer volume recovery:

$$Y = -18.89 - 0.5416 X_{13} - 0.007 X_5 + 1.149 X_1 + 1.21 X_{14},$$

but t-test for X_{13} (Table 1) shows that t_{cal} smaller than t_{table} . It means that hypothesis $H_0 : \beta_{13} = 0$ is true or reject b_{13} in the regression model.

Therefore, this analysis result determines the multiple linear regression model as the best predictor on veneer volume recovery is:

$$Y = -18.89 - 0.007 X_5 + 1.149 X_1 + 1.21 X_{14}, \text{ or}$$

$$Y = -18.89 - 0.05 X_1 X_2 + 1.149 X_1 + 1.21 X_2 X_3 X_4,$$

With a determination coefficient $R^2 = 82.32\%$.

Result of veneer volume recovery estimation based on the model is presented in Appendix (Table 5).

The result at Appendix (Table 5) show that average veneer volume recovery based on model nothing t-test is 1.961% smaller than the average veneer volume recovery data, but with t-test is 13.588% higher than the average veneer volume recovery data.

Conclusions and Suggestions

A. Conclusions

Based on this research and its analysis, it can be concluded that:

1. Log diameter (X_1), interaction between log diameter and moisture content (X_5), and the interaction among moisture content, specific gravity and stem form quotient (X_{14}) give contribute to determine the veneer volume recovery.
2. The multiple linear regression model as the best predictor for veneer volume recovery is: $Y = -18.89 - 0.05 X_1 X_2 + 1.149 X_1 + 1.21 X_2 X_3 X_4$. With a determination coefficient $R^2 = 82.32\%$.
3. The estimation of the average veneer volume recovery value by model is higher 13.588% than the veneer volume recovery research data.

B. Suggestions

This research that has been conducted concern to face and back veneer volume recovery. It is suggested that:

1. Following research need to be conducted to determine veneer volume recovery of core veneer in combination with prior research to fix the number of the plywood in the plywood process.
2. The above multiple linear model regression can be used to estimate the veneer volume recovery of face and back veneer especially for mersawa, nyatoh, kenari and binuang.

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Appendix

Table 3. Research data of the effect of some factors on veneer volume recovery

No	Diameter range	Wood species	Base diameter (cm)	Top diameter (cm)	Average diameter (m)	Moisture content (%)	Specific gravity	Core diameter (cm)	Input (m ³)	Output (m ³)	Recovery (%)
1	80-UP	MRSW	84	82	0.83	80	0.437	20	1.4073	0.8773	62.339
2			82	82	0.82	80	0.528	24	1.3736	0.8312	60.513
3			90	87	0.89	80	0.558	28	1.6000	0.9529	59.557
4			87	87	0.87	70	0.521	18	1.5462	0.9795	63.348
5			85	83	0.84	80	0.497	18	1.4414	0.9101	63.139
6		KNR	82	80	0.81	60	0.437	27	1.3403	0.7812	58.286
7			86	84	0.85	55	0.512	24	1.4759	0.8906	60.341
8			81	80	0.81	40	0.493	21	1.3238	0.8080	61.036
9			88	87	0.88	50	0.541	17	1.5640	0.9868	63.093
10			83	82	0.83	50	0.521	35	1.3904	0.7476	53.769
11		BNANG	90	87	0.89	70	0.316	28	1.6000	0.8010	50.063
12			84	83	0.84	70	0.281	21	1.4243	0.7423	52.117
13			81	80	0.81	70	0.279	24	1.3238	0.6710	50.687
14			88	87	0.88	65	0.320	35	1.5640	0.7309	46.732
15			83	83	0.83	70	0.323	27	1.4073	0.7001	49.748
16		NYATOH	85	84	0.85	50	0.418	18	1.4586	0.8439	57.856
17			82	80	0.81	45	0.526	26	1.3403	0.7286	54.361
18			89	87	0.88	45	0.495	32	1.5820	0.8320	52.593
19			92	90	0.91	45	0.465	23	1.6917	0.9598	56.737
20			100	96	0.98	50	0.506	26	1.9619	1.1054	56.343
21	70-79	MRSW	73	71	0.72	70	0.535	23	1.0590	0.6054	57.167
22			76	76	0.76	70	0.504	24	1.1799	0.6763	57.317
23			75	73	0.74	65	0.511	30	1.1186	0.5951	53.198
24			73	71	0.72	70	0.526	21	1.0590	0.6168	58.244
25			79	77	0.78	80	0.539	18	1.2429	0.7491	60.273
26		KNR	79	78	0.79	45	0.610	27	1.2588	0.6940	55.130
27		KNR	76	73	0.75	45	0.488	34	1.1338	0.5613	49.505
28			78	76	0.77	45	0.512	21	1.2112	0.7010	57.877
29			72	70	0.71	40	0.426	17	1.0298	0.6070	58.944
30			74	73	0.74	50	0.502	26	1.1036	0.6037	54.704
31		NYATOH	71	70	0.71	50	0.483	18	1.0153	0.5665	55.795
32			77	75	0.76	50	0.552	26	1.1799	0.6217	52.689
33			78	76	0.77	40	0.495	21	1.2112	0.6691	55.243
34			73	72	0.73	50	0.511	32	1.0738	0.5160	48.056
35			74	73	0.74	45	0.472	18	1.1036	0.6191	56.099
36		BNANG	76	74	0.75	80	0.284	28	1.1491	0.5253	45.715
37			75	74	0.75	70	0.291	21	1.1338	0.5544	48.897
38			73	72	0.73	70	0.316	24	1.0738	0.5078	47.292
39			74	72	0.73	65	0.277	35	1.0886	0.4453	40.905
40			78	76	0.77	70	0.247	20	1.2112	0.5999	49.530
41	60-UP	MRSW	70	68	0.69	80	0.533	21	0.9726	0.5327	54.771
42			62	60	0.61	70	0.555	20	0.7601	0.4095	53.872
43			64	63	0.64	70	0.463	16	0.8237	0.4656	56.524
44			68	66	0.67	75	0.552	18	0.9170	0.5136	56.007
45			62	61	0.62	70	0.582	25	0.7726	0.3893	50.385
46		KNR	70	68	0.69	65	0.537	18	0.9726	0.4829	49.651
47			62	60	0.61	60	0.504	25	0.7601	0.3439	45.242
48			63	61	0.62	60	0.537	18	0.7853	0.3910	49.792
49			64	63	0.64	55	0.426	24	0.8237	0.3839	46.606
50			67	66	0.67	50	0.502	23	0.9034	0.4325	47.875
51		NYATOH	68	68	0.68	55	0.495	27	0.9446	0.4221	44.686
52			65	64	0.65	50	0.413	21	0.8499	0.4030	47.419
53			62	61	0.62	50	0.485	18	0.7726	0.3748	48.509
54			69	68	0.69	55	0.514	20	0.9585	0.4431	46.226
55			66	64	0.65	50	0.506	18	0.8631	0.4227	48.975

Continuing table 3.. Research data of the effect of some factors on veneer volume recovery

No	Diameter range	Wood species	Base diameter (cm)	Top diameter (cm)	Average diameter (m)	Moisture content (%)	Specific gravity	Core diameter (cm)	Input (m3)	Output (m3)	Recovery (%)
56		BNANG	65	63	0.64	80	0.294	25	0.8367	0.3253	38.877
57			68	66	0.67	70	0.291	23	0.9170	0.3711	40.468
58			64	63	0.64	70	0.316	24	0.8237	0.3239	39.322
59			68	67	0.68	60	0.277	23	0.9308	0.3774	40.548
60			62	62	0.62	70	0.273	20	0.7853	0.3228	41.107
61	50-Up	MRSW	52	50	0.51	80	0.498	18	0.5313	0.2500	47.051
62			55	53	0.54	80	0.505	16	0.5957	0.2921	49.036
63			54	52	0.53	80	0.452	23	0.5738	0.2503	43.619
64			58	58	0.58	80	0.479	18	0.6872	0.3338	48.574
65			56	55	0.56	80	0.440	17	0.6292	0.3065	48.710
66		KNR	52	50	0.51	50	0.519	23	0.5313	0.2117	39.843
67			55	53	0.54	50	0.515	20	0.5957	0.2571	43.160
68			54	52	0.53	45	0.489	18	0.5738	0.2539	44.247
69			58	58	0.58	55	0.429	18	0.6872	0.3107	45.212
70			56	55	0.56	50	0.573	25	0.6292	0.2509	39.874
71		NYATOH	58	57	0.58	40	0.465	21	0.6754	0.2837	42.004
72			59	59	0.59	40	0.495	21	0.7111	0.3010	42.328
73			53	51	0.52	45	0.495	23	0.5524	0.2154	38.995
74			57	56	0.57	40	0.413	21	0.6521	0.2724	41.772
75			52	51	0.52	45	0.485	21	0.5418	0.2189	40.402
76		BNANG	54	52	0.53	70	0.293	25	0.5738	0.1849	32.222
77			57	56	0.57	75	0.428	21	0.6521	0.2330	35.730
78			59	57	0.58	70	0.326	25	0.6872	0.2319	33.745
79			53	52	0.53	80	0.257	23	0.5631	0.1886	33.496
80			59	58	0.59	70	0.297	24	0.6991	0.2410	34.473
81	40-UP	MRSW	45	44	0.45	65	0.603	18	0.4045	0.1847	45.658
82			48	45	0.47	65	0.426	20	0.4417	0.1965	44.486
83			49	47	0.48	65	0.413	18	0.4707	0.2208	46.912
84			46	44	0.45	70	0.374	18	0.4137	0.1877	45.374
85			43	42	0.43	65	0.404	21	0.3690	0.1512	40.977
86		KNR	46	45	0.46	50	0.522	23	0.4229	0.1363	32.229
87			47	45	0.46	50	0.519	18	0.4323	0.1584	36.645
88			42	42	0.42	50	0.51	17	0.3604	0.1304	36.187
89			47	45	0.46	55	0.508	23	0.4323	0.1474	34.100
90			47	46	0.47	40	0.537	18	0.4417	0.1707	38.645
91		NYATOH	41	40	0.41	50	0.482	23	0.3351	0.0970	28.949
92			48	47	0.48	55	0.495	23	0.4609	0.1508	32.718
93			44	43	0.44	55	0.413	18	0.3866	0.1369	35.416
94			42	41	0.42	60	0.506	25	0.3518	0.0958	27.229
95			42	40	0.41	55	0.477	20	0.3434	0.0987	28.742
96		BNANG	48	47	0.48	75	0.284	23	0.4609	0.1283	27.836
97			49	47	0.48	70	0.227	25	0.4707	0.1247	26.49
98			43	41	0.42	70	0.296	23	0.3604	0.0917	25.447
99			45	43	0.44	70	0.257	32	0.3955	0.0724	18.306
100			47	45	0.46	70	0.408	23	0.4323	0.1261	29.172

Table 4.. The effect of log diameter, moisture content, specific gravity, tree form quotient and their interaction on veneer volume recovery

No	Base diameter (X ₁)	Moisture content (%) (X ₂)	Specific gravity (X ₃)	Form quotient (X ₄)	X ₅ (X ₁ X ₂)	X ₆ (X ₁ X ₃)	X ₇ (X ₁ X ₄)	X ₈ (X ₂ X ₃)	X ₉ (X ₂ X ₄)	X ₁₀ (X ₃ X ₄)	X ₁₁ (X ₁ X ₂ X ₃)	X ₁₂ (X ₁ X ₂ X ₄)	X ₁₃ (X ₁ X ₃ X ₄)	X ₁₄ (X ₂ X ₃ X ₄)	X ₁₅ (X ₁ X ₂ X ₃ X ₄)	Recovery Y
1	84	80	0.437	0.976	6,720	36.708	82	34.960	78.095	0.427	2,936.640	6,560	35.834	34.128	2,866.720	62.339
2	82	80	0.528	1.000	6,560	43.296	82	42.240	80.000	0.528	3,463.680	6,560	43.296	42.240	3,463.680	60.513
3	90	80	0.558	0.967	7,200	50.220	87	44.640	77.333	0.539	4,017.600	6,960	48.546	43.152	3,883.680	59.557
4	87	70	0.521	1.000	6,090	45.327	87	36.470	70.000	0.521	3,172.890	6,090	45.327	36.470	3,172.890	63.348
5	85	80	0.497	0.976	6,800	42.245	83	39.760	78.118	0.485	3,379.600	6,640	41.251	38.824	3,300.080	63.139
6	82	60	0.437	0.976	4,920	35.834	80	26.220	58.537	0.426	2,150.040	4,800	34.960	25.580	2,097.600	58.286
7	86	55	0.512	0.977	4,730	44.032	84	28.160	53.721	0.500	2,421.760	4,620	43.008	27.505	2,365.440	60.341
8	81	40	0.493	0.988	3,240	39.933	80	19.720	39.506	0.487	1,597.320	3,200	39.440	19.477	1,577.600	61.036
9	88	50	0.541	0.989	4,400	47.608	87	27.050	49.432	0.535	2,380.400	4,350	47.067	26.743	2,353.350	63.093
10	83	50	0.521	0.988	4,150	43.243	82	26.050	49.398	0.515	2,162.150	4,100	42.722	25.736	2,136.100	53.769
11	90	70	0.316	0.967	6,300	28.440	87	22.120	67.667	0.305	1,990.800	6,090	27.492	21.383	1,924.440	50.063
12	84	70	0.281	0.988	5,880	23.604	83	19.670	69.167	0.278	1,652.280	5,810	23.323	19.436	1,632.610	52.117
13	81	70	0.279	0.988	5,670	22.599	80	19.530	69.136	0.276	1,581.930	5,600	22.320	19.289	1,562.400	50.687
14	88	65	0.320	0.989	5,720	28.160	87	20.800	64.261	0.316	1,830.400	5,655	27.840	20.564	1,809.600	46.732
15	83	70	0.323	1.000	5,810	26.809	83	22.610	70.000	0.323	1,876.630	5,810	26.809	22.610	1,876.630	49.748
16	85	50	0.418	0.988	4,250	35.530	84	20.900	49.412	0.413	1,776.500	4,200	35.112	20.654	1,755.600	57.856
17	82	45	0.526	0.976	3,690	43.132	80	23.670	43.902	0.513	1,940.940	3,600	42.080	23.093	1,893.600	54.361
18	89	45	0.495	0.978	4,005	44.055	87	22.275	43.989	0.484	1,982.475	3,915	43.065	21.774	1,937.925	52.593
19	92	45	0.465	0.978	4,140	42.780	90	20.925	44.022	0.455	1,925.100	4,050	41.850	20.470	1,883.250	56.737
20	100	50	0.506	0.960	5,000	50.600	96	25.300	48.000	0.486	2,530.000	4,800	48.576	24.288	2,428.800	56.343
21	73	70	0.535	0.973	5,110	39.055	71	37.450	68.082	0.520	2,733.850	4,970	37.985	36.424	2,658.950	57.167
22	76	70	0.504	1.000	5,320	38.304	76	35.280	70.000	0.504	2,681.280	5,320	38.304	35.280	2,681.280	57.317
23	75	65	0.511	0.973	4,875	38.325	73	33.215	63.267	0.497	2,491.125	4,745	37.303	32.329	2,424.695	53.198
24	73	70	0.526	0.973	5,110	38.398	71	36.820	68.082	0.512	2,687.860	4,970	37.346	35.811	2,614.220	58.244
25	79	80	0.539	0.975	6,320	42.581	77	43.120	77.975	0.525	3,406.480	6,160	41.503	42.028	3,320.240	60.273
26	79	45	0.610	0.987	3,555	48.190	78	27.450	44.430	0.602	2,168.550	3,510	47.580	27.103	2,141.100	55.130
27	76	45	0.488	0.961	3,420	37.088	73	21.960	43.224	0.469	1,668.960	3,285	35.624	21.093	1,603.080	49.505

Continuing Table 4. The effect of log diameter, moisture content, specific gravity, tree form quotient and their interaction on veneer volume recovery

No	Base diameter (cm) (X ₁)	Moisture content (%) (X ₂)	Specific gravity (X ₃)	Form quotient (X ₄)	X ₅ (X ₁ X ₂)	X ₆ (X ₁ X ₃)	X ₇ (X ₁ X ₄)	X ₈ (X ₂ X ₃)	X ₉ (X ₂ X ₄)	X ₁₀ (X ₃ X ₄)	X ₁₁ (X ₁ X ₂ X ₃)	X ₁₂ (X ₁ X ₂ X ₄)	X ₁₃ (X ₁ X ₃ X ₄)	X ₁₄ (X ₂ X ₃ X ₄)	X ₁₅ (X ₁ X ₂ X ₃ X ₄)	Recovery Y
28	78	45	0.512	0.974	3,510	39.936	76	23.040	43.846	0.499	1,797.120	3,420	38.912	22.449	1,751.040	57.877
29	72	40	0.426	0.972	2,880	30.672	70	17.040	38.889	0.414	1,226.880	2,800	29.820	16.567	1,192.800	58.944
30	74	50	0.502	0.986	3,700	37.148	73	25.100	49.324	0.495	1,857.400	3,650	36.646	24.761	1,832.300	54.704
31	71	50	0.483	0.986	3,550	34.293	70	24.150	49.296	0.476	1,714.650	3,500	33.810	23.810	1,690.500	55.795
32	77	50	0.552	0.974	3,850	42.504	75	27.600	48.701	0.538	2,125.200	3,750	41.400	26.883	2,070.000	52.689
33	78	40	0.495	0.974	3,120	38.610	76	19.800	38.974	0.482	1,544.400	3,040	37.620	19.292	1,504.800	55.243
34	73	50	0.511	0.986	3,650	37.303	72	25.550	49.315	0.504	1,865.150	3,600	36.792	25.200	1,839.600	48.056
35	74	45	0.472	0.986	3,330	34.928	73	21.240	44.392	0.466	1,571.760	3,285	34.456	20.953	1,550.520	56.099
36	76	80	0.284	0.974	6,080	21.584	74	22.720	77.895	0.277	1,726.720	5,920	21.016	22.122	1,681.280	45.715
37	75	70	0.291	0.987	5,250	21.825	74	20.370	69.067	0.287	1,527.750	5,180	21.534	20.098	1,507.380	48.897
38	73	70	0.316	0.986	5,110	23.068	72	22.120	69.041	0.312	1,614.760	5,040	22.752	21.817	1,592.640	47.292
39	74	65	0.277	0.973	4,810	20.498	72	18.005	63.243	0.270	1,332.370	4,680	19.944	17.518	1,296.360	40.905
40	78	70	0.247	0.974	5,460	19.266	76	17.290	68.205	0.241	1,348.620	5,320	18.772	16.847	1,314.040	49.530
41	70	80	0.533	0.971	5,600	37.310	68	42.640	77.714	0.518	2,984.800	5,440	36.244	41.422	2,899.520	54.771
42	62	70	0.555	0.968	4,340	34.410	60	38.850	67.742	0.537	2,408.700	4,200	33.300	37.597	2,331.000	53.872
43	64	70	0.463	0.984	4,480	29.632	63	32.410	68.906	0.456	2,074.240	4,410	29.169	31.904	2,041.830	56.524
44	68	75	0.552	0.971	5,100	37.536	66	41.400	72.794	0.536	2,815.200	4,950	36.432	40.182	2,732.400	56.007
45	62	70	0.582	0.984	4,340	36.084	61	40.740	68.871	0.573	2,525.880	4,270	35.502	40.083	2,485.140	50.385
46	70	65	0.537	0.971	4,550	37.590	68	34.905	63.143	0.522	2,443.350	4,420	36.516	33.908	2,373.540	49.651
47	62	60	0.504	0.968	3,720	31.248	60	30.240	58.065	0.488	1,874.880	3,600	30.240	29.265	1,814.400	45.242
48	63	60	0.537	0.968	3,780	33.831	61	32.220	58.095	0.520	2,029.860	3,660	32.757	31.197	1,965.420	49.792
49	64	55	0.426	0.984	3,520	27.264	63	23.430	54.141	0.419	1,499.520	3,465	26.838	23.064	1,476.090	46.606
50	67	50	0.502	0.985	3,350	33.634	66	25.100	49.254	0.495	1,681.700	3,300	33.132	24.725	1,656.600	47.875
51	68	55	0.495	1.000	3,740	33.660	68	27.225	55.000	0.495	1,851.300	3,740	33.660	27.225	1,851.300	44.686
52	65	50	0.413	0.985	3,250	26.845	64	20.650	49.231	0.407	1,342.250	3,200	26.432	20.332	1,321.600	47.419
53	62	50	0.485	0.984	3,100	30.070	61	24.250	49.194	0.477	1,503.500	3,050	29.585	23.859	1,479.250	48.509
54	69	55	0.514	0.986	3,795	35.466	68	28.270	54.203	0.507	1,950.630	3,740	34.952	27.860	1,922.360	46.226
55	66	50	0.506	0.970	3,300	33.396	64	25.300	48.485	0.491	1,669.800	3,200	32.384	24.533	1,619.200	48.975

Continuing table 4. The effect of log diameter, moisture content, spesific gravity, tree form quotient and their interaction on veneer volume recovery

No	Base diameter (cm) (X ₁)	Moisture ontent (%) (X ₂)	Specific gravity (X ₃)	Form quotient (X ₄)	X ₅ (x ₁ x ₂)	X ₆ (x ₁ x ₃)	X ₇ (x ₁ x ₄)	X ₈ (x ₂ x ₃)	X ₉ (x ₂ x ₄)	X ₁₀ (x ₃ x ₄)	X ₁₁ (x ₁ x ₂ x ₃)	X ₁₂ (x ₁ x ₂ x ₄)	X ₁₃ (x ₁ x ₃ x ₄)	X ₁₄ (x ₂ x ₃ x ₄)	X ₁₅ (x ₁ x ₂ x ₃ x ₄)	Recovery Y
56	65	80	0.294	0.969	5,200	19.110	63	23.520	77.538	0.285	1,528.800	5,040	18.522	22.796	1,481.760	38.877
57	68	70	0.291	0.971	4,760	19.788	66	20.370	67.941	0.282	1,385.160	4,620	19.206	19.771	1,344.420	40.468
58	64	70	0.316	0.984	4,480	20.224	63	22.120	68.906	0.311	1,415.680	4,410	19.908	21.774	1,393.560	39.322
59	68	60	0.277	0.985	4,080	18.836	67	16.620	59.118	0.273	1,130.160	4,020	18.559	16.376	1,113.540	40.548
60	62	70	0.273	1.000	4,340	16.926	62	19.110	70.000	0.273	1,184.820	4,340	16.926	19.110	1,184.820	41.107
61	52	80	0.498	0.962	4,160	25.896	50	39.840	76.923	0.479	2,071.680	4,000	24.900	38.308	1,992.000	47.051
62	55	80	0.505	0.964	4,400	27.775	53	40.400	77.091	0.487	2,222.000	4,240	26.765	38.931	2,141.200	49.036
63	54	80	0.452	0.963	4,320	24.408	52	36.160	77.037	0.435	1,952.640	4,160	23.504	34.821	1,880.320	43.619
64	58	80	0.479	1.000	4,640	27.782	58	38.320	80.000	0.479	2,222.560	4,640	27.782	38.320	2,222.560	48.574
65	56	80	0.440	0.982	4,480	24.640	55	35.200	78.571	0.432	1,971.200	4,400	24.200	34.571	1,936.000	48.710
66	52	50	0.519	0.962	2,600	26.988	50	25.950	48.077	0.499	1,349.400	2,500	25.950	24.952	1,297.500	39.843
67	55	50	0.515	0.964	2,750	28.325	53	25.750	48.182	0.496	1,416.250	2,650	27.295	24.814	1,364.750	43.160
68	54	45	0.489	0.963	2,430	26.406	52	22.005	43.333	0.471	1,188.270	2,340	25.428	21.190	1,144.260	44.247
69	58	55	0.429	1.000	3,190	24.882	58	23.595	55.000	0.429	1,368.510	3,190	24.882	23.595	1,368.510	45.212
70	56	50	0.573	0.982	2,800	32.088	55	28.650	49.107	0.563	1,604.400	2,750	31.515	28.138	1,575.750	39.874
71	58	40	0.465	0.983	2,320	26.970	57	18.600	39.310	0.457	1,078.800	2,280	26.505	18.279	1,060.200	42.004
72	59	40	0.495	1.000	2,360	29.205	59	19.800	40.000	0.495	1,168.200	2,360	29.205	19.800	1,168.200	42.328
73	53	45	0.495	0.962	2,385	26.235	51	22.275	43.302	0.476	1,180.575	2,295	25.245	21.434	1,136.025	38.995
74	57	40	0.413	0.982	2,280	23.541	56	16.520	39.298	0.406	941.640	2,240	23.128	16.230	925.120	41.772
75	52	45	0.485	0.981	2,340	25.220	51	21.825	44.135	0.476	1,134.900	2,295	24.735	21.405	1,113.075	40.402
76	54	70	0.293	0.963	3,780	15.822	52	20.510	67.407	0.282	1,107.540	3,640	15.236	19.750	1,066.520	32.222
77	57	75	0.428	0.982	4,275	24.396	56	32.100	73.684	0.420	1,829.700	4,200	23.968	31.537	1,797.600	35.730
78	59	70	0.326	0.966	4,130	19.234	57	22.820	67.627	0.315	1,346.380	3,990	18.582	22.046	1,300.740	33.745
79	53	80	0.257	0.981	4,240	13.621	52	20.560	78.491	0.252	1,089.680	4,160	13.364	20.172	1,069.120	33.496
80	59	70	0.297	0.983	4,130	17.523	58	20.790	68.814	0.292	1,226.610	4,060	17.226	20.438	1,205.820	34.473

Continuing Table 4. The effect of log diameter, moisture content, specific gravity, tree form quotient and their interaction on veneer volume recovery

No	Base diameter (cm) (X ₁)	Moisture content (%) (X ₂)	Specific gravity (X ₃)	Form quotient (X ₄)	X ₅ (x ₁ x ₂)	X ₆ (x ₁ x ₃)	X ₇ (x ₁ x ₄)	X ₈ (x ₂ x ₃)	X ₉ (x ₂ x ₄)	X ₁₀ (x ₃ x ₄)	X ₁₁ (x ₁ x ₂ x ₃)	X ₁₂ (x ₁ x ₂ x ₄)	X ₁₃ (x ₁ x ₃ x ₄)	X ₁₄ (x ₂ x ₃ x ₄)	X ₁₅ (x ₁ x ₂ x ₃ x ₄)	Recovery Y
81	45	65	0.603	0.978	2,925	27.135	44	39.195	63.556	0.590	1,763.775	2,860	26.532	38.324	1,724.580	45.658
82	48	65	0.426	0.938	3,120	20.448	45	27.690	60.938	0.399	1,329.120	2,925	19.170	25.959	1,246.050	44.486
83	49	65	0.413	0.959	3,185	20.237	47	26.845	62.347	0.396	1,315.405	3,055	19.411	25.749	1,261.715	46.912
84	46	70	0.374	0.957	3,220	17.204	44	26.180	66.957	0.358	1,204.280	3,080	16.456	25.042	1,151.920	45.374
85	43	65	0.404	0.977	2,795	17.372	42	26.260	63.488	0.395	1,129.180	2,730	16.968	25.649	1,102.920	40.977
86	46	50	0.522	0.978	2,300	24.012	45	26.100	48.913	0.511	1,200.600	2,250	23.490	25.533	1,174.500	32.229
87	47	50	0.519	0.957	2,350	24.393	45	25.950	47.872	0.497	1,219.650	2,250	23.355	24.846	1,167.750	36.645
88	42	50	0.510	1.000	2,100	21.420	42	25.500	50.000	0.510	1,071.000	2,100	21.420	25.500	1,071.000	36.187
89	47	55	0.508	0.957	2,585	23.876	45	27.940	52.660	0.486	1,313.180	2,475	22.860	26.751	1,257.300	34.100
90	47	40	0.537	0.979	1,880	25.239	46	21.480	39.149	0.526	1,009.560	1,840	24.702	21.023	988.080	38.645
91	41	50	0.482	0.976	2,050	19.762	40	24.100	48.780	0.470	988.100	2,000	19.280	23.512	964.000	28.949
92	48	55	0.495	0.979	2,640	23.760	47	27.225	53.854	0.485	1,306.800	2,585	23.265	26.658	1,279.575	32.718
93	44	55	0.413	0.977	2,420	18.172	43	22.715	53.750	0.404	999.460	2,365	17.759	22.199	976.745	35.416
94	42	60	0.506	0.976	2,520	21.252	41	30.360	58.571	0.494	1,275.120	2,460	20.746	29.637	1,244.760	27.229
95	42	55	0.477	0.952	2,310	20.034	40	26.235	52.381	0.454	1,101.870	2,200	19.080	24.986	1,049.400	28.742
96	48	75	0.284	0.979	3,600	13.632	47	21.300	73.438	0.278	1,022.400	3,525	13.348	20.856	1,001.100	27.836
97	49	70	0.227	0.959	3,430	11.123	47	15.890	67.143	0.218	778.610	3,290	10.669	15.241	746.830	26.494
98	43	70	0.296	0.953	3,010	12.728	41	20.720	66.744	0.282	890.960	2,870	12.136	19.756	849.520	25.447
99	45	70	0.257	0.956	3,150	11.565	43	17.990	66.889	0.246	809.550	3,010	11.051	17.190	773.570	18.306
100	47	70	0.408	0.957	3,290	19.176	45	28.560	67.021	0.391	1,342.320	3,150	18.360	27.345	1,285.200	29.172
Jml	6,555	6,090	44.624	97.679	399,000	2,934	6,409	2,672	5,947	43.593	175,702	390,040	2,869	2,609	171,758	4,648
Aver	66	60.900	0.446	0.977	3,990	29.341	64.090	26.717	59.471	0.436	1,757	3,900	28.688	26.093	1,717.584	46.481

Table 5. Estimation effect of log diameter, moisture content, specific gravity, tree form quotient and their interaction on veneer volume recovery (y estimation)

No	Base Diameter (cm) (X ₁)	Moisture Content (%) (X ₂)	Specific Gravity (X ₃)	Form Quotient (X ₄)	Recovery Y	Stepwise Nothing t-test $\hat{Y}_1$	Stepwise by t-test $\hat{Y}_2$
1	84	80	0.437	0.976	62.339	52.458	71.880
2	82	80	0.528	1.000	60.513	57.052	80.518
3	90	80	0.558	0.967	59.557	60.022	86.334
4	87	70	0.521	1.000	63.348	58.004	82.572
5	85	80	0.497	0.976	63.139	55.795	78.153
6	82	60	0.437	0.976	58.286	52.892	71.840
7	86	55	0.512	0.977	60.341	56.785	80.095
8	81	40	0.493	0.988	61.036	53.689	75.066
9	88	50	0.541	0.989	63.093	58.270	83.781
10	83	50	0.521	0.988	53.769	55.412	78.568
11	90	70	0.316	0.967	50.063	51.392	66.293
12	84	70	0.281	0.988	52.117	47.342	59.983
13	81	70	0.279	0.988	50.687	45.731	57.829
14	88	65	0.320	0.989	46.732	51.975	67.064
15	83	70	0.323	1.000	49.748	48.635	63.165
16	85	50	0.418	0.988	57.856	54.986	74.016
17	82	45	0.526	0.976	54.361	54.633	77.440
18	89	45	0.495	0.978	52.593	58.342	81.683
19	92	45	0.465	0.978	56.737	59.924	82.607
20	100	50	0.506	0.960	56.343	64.070	90.398
21	73	70	0.535	0.973	57.167	52.702	73.290
22	76	70	0.504	1.000	57.317	53.122	73.883
23	75	65	0.511	0.973	53.198	52.060	72.278
24	73	70	0.526	0.973	58.244	52.307	72.549
25	79	80	0.539	0.975	60.273	56.001	78.495
26	79	45	0.610	0.987	55.130	54.002	79.790
27	76	45	0.488	0.961	49.505	50.709	70.017
28	78	45	0.512	0.974	57.877	52.235	73.326
29	72	40	0.426	0.972	58.944	47.561	63.724
30	74	50	0.502	0.986	54.704	50.334	70.197
31	71	50	0.483	0.986	55.795	48.324	66.649
32	77	50	0.552	0.974	52.689	52.723	75.162
33	78	40	0.495	0.974	55.243	51.846	72.236

Continuing Table 5. Estimation effect of log diameter, moisture content, specific gravity, tree form quotient and their interaction on veneer volume recovery (y estimation)

No	Base Diameter (cm) (X ₁)	Moisture Content (%) (X ₂)	Specific Gravity (X ₃)	Form Quotient (X ₄)	Recovery Y	Stepwise Nothing t-test Ŷ ₁	Stepwise by t-test Ŷ ₂
34	73	50	0.511	0.986	48.056	49.988	69.929
35	74	45	0.472	0.986	56.099	49.504	68.179
36	76	80	0.284	0.974	45.715	41.251	52.642
37	75	70	0.291	0.987	48.897	43.183	54.854
38	73	70	0.316	0.986	47.292	43.284	55.616
39	74	65	0.277	0.973	40.905	42.854	53.663
40	78	70	0.247	0.974	49.530	42.722	52.896
41	70	80	0.533	0.971	54.771	52.816	72.460
42	62	70	0.555	0.968	53.872	49.411	67.460
43	64	70	0.463	0.984	56.524	46.080	61.889
44	68	75	0.552	0.971	56.007	52.417	72.163
45	62	70	0.582	0.984	50.385	51.226	70.468
46	70	65	0.537	0.971	49.651	50.927	70.718
47	62	60	0.504	0.968	45.242	45.328	61.718
48	63	60	0.537	0.968	49.792	47.031	64.786
49	64	55	0.426	0.984	46.606	43.367	57.913
50	67	50	0.502	0.985	47.875	46.603	64.561
51	68	55	0.495	1.000	44.686	47.761	66.004
52	65	50	0.413	0.985	47.419	43.321	57.647
53	62	50	0.485	0.984	48.509	43.482	59.517
54	69	55	0.514	0.986	46.226	48.593	67.537
55	66	50	0.506	0.970	48.975	45.977	63.529
56	65	80	0.294	0.969	38.877	36.940	46.979
57	68	70	0.291	0.971	40.468	39.435	49.845
58	64	70	0.316	0.984	39.322	38.843	49.633
59	68	60	0.277	0.985	40.548	40.437	50.496
60	62	70	0.273	1.000	41.107	35.917	45.091
61	52	80	0.498	0.962	47.051	44.595	58.090
62	55	80	0.505	0.964	49.036	46.105	60.611
63	54	80	0.452	0.963	43.619	42.310	55.049
64	58	80	0.479	1.000	48.574	46.581	61.639
65	56	80	0.440	0.982	48.710	42.809	55.925
66	52	50	0.519	0.962	39.843	38.785	52.850
67	55	50	0.515	0.964	43.160	40.286	55.080
68	54	45	0.489	0.963	44.247	38.004	51.786
69	58	55	0.429	1.000	45.212	40.486	53.972

Continuing Table 5. Estimation effect of log diameter, moisture content, specific gravity, tree form quotient and their interaction on veneer volume recovery (y estimation)

No	Base Diameter (cm) (X ₁)	Moisture Content (%) (X ₂)	Specific Gravity (X ₃)	Form Quotient (X ₄)	Recovery Y	Stepwise Nothing t-test Ŷ ₁	Stepwise by t-test Ŷ ₂
70	56	50	0.573	0.982	39.874	42.820	59.901
71	58	40	0.465	0.983	42.004	39.264	53.630
72	59	40	0.495	1.000	42.328	40.510	56.339
73	53	45	0.495	0.962	38.995	37.565	51.248
74	57	40	0.413	0.982	41.772	37.746	50.282
75	52	45	0.485	0.981	40.402	36.972	50.378
76	54	70	0.293	0.963	32.222	32.336	40.594
77	57	75	0.428	0.982	35.730	41.847	54.838
78	59	70	0.326	0.966	33.745	36.596	46.667
79	53	80	0.257	0.981	33.496	29.492	36.735
80	59	70	0.297	0.983	34.473	35.384	44.721
81	45	65	0.603	0.978	45.658	44.332	58.712
82	48	65	0.426	0.938	44.486	35.443	45.833
83	49	65	0.413	0.959	46.912	35.752	46.273
84	46	70	0.374	0.957	45.374	32.805	41.725
85	43	65	0.404	0.977	40.977	32.791	41.988
86	46	50	0.522	0.978	32.229	36.027	48.758
87	47	50	0.519	0.957	36.645	36.068	48.726
88	42	50	0.510	1.000	36.187	33.913	45.523
89	47	55	0.508	0.957	34.100	36.997	49.387
90	47	40	0.537	0.979	38.645	34.002	47.391
91	41	50	0.482	0.976	28.949	31.869	42.319
92	48	55	0.495	0.979	32.718	37.428	50.038
93	44	55	0.413	0.977	35.416	31.961	41.586
94	42	60	0.506	0.976	27.229	36.345	47.589
95	42	55	0.477	0.952	28.742	33.089	43.431
96	48	75	0.284	0.979	27.836	29.063	36.298
97	49	70	0.227	0.959	26.494	26.061	31.843
98	43	70	0.296	0.953	25.447	26.774	33.352
99	45	70	0.257	0.956	18.306	25.576	31.565
100	47	70	0.408	0.957	29.172	35.219	45.170
Jlh	6,555	6,090	44.624	97.679	4,648	4,452	6,007
Aver	65.550	60.900	0.446	0.977	46.481	44.520	60.069

Distribution and Identification of Subterranean Termites of *Macrotermes gilvus* Hagen in Dungus Iwul Sanctuary, Bogor, Indonesia

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Abstract

The study on distribution and population ecology subterranean termites of *Macrotermes gilvus* Hagen in natural forestry was conducted from December 2006 to April 2007. The result of distribution aspect based on global positioning system (GPS). Nest classification is according to Meyer *et al.* (2003). The nest mapping is based on the elevations of their natural habitat in Yanlappa sanctuary (190-211 asl). The result of analysis morphology showed that subterranean termite *Macrotermes* in the natural forest community are belong to one group *Macrotermes gilvus* Hagen. Based on nest size, the colony of *Macrotermes* can be classified into three different sizes: large, medium, and small nest. Large nest consists of 15 colonies, medium nest 23 colonies and small nest 5 colonies can be found in Yanlappa sanctuary. Temperature and humidity are the most environmental factors that may affect termites and the other factors are rain fall, soil structure, and plant vegetation.

Key words: distribution, identification, *Macrotermes gilvus* Hagen, sanctuary

Introduction

Termites are an important group of insect pests to Indonesia and neighboring Southeast Asian countries. This group contributed approximately 50% of business turnover of the pest control industry in Indonesia in 2000 (Nandika *et al.* 2003). Termites are among the most economically important insects in the world. While also ecologically important in nutrient recycling, they're best known as structural and plant pests that compete with people for shelter and food.

More than 300 species of termites have been described from Indonesia (Tarumingkeng 2000). *Macrotermes gilvus* Hagen (ordo Blattodea, family termitidae, subfamily macrotermitinae) is common mound-building termite species in the whole of southest Asia, from Indo-China and Malaya to Indonesia (Sumatera, Java, Borneo) and Philippines. The familie termitidae is known as the higher termites (Ngee & Lee 2002). One main distinct characteristic of this species is the bright yellow-colored abdomen of the soldier termite, which has a salivary gland that extends to the abdomen (Krishna & Weesner 1969). In Thailand, Malaysia and Indonesia this species are also a serious pest of living plants, in natural ecosystems, they forage more regularly on dead plants (Lee *et al.* 2007). With the rapid urbanization in Indonesia and the neighboring Southeast Asian countries, many plantations have been cleared and developed to become residential premises and complexes. This species is now readily found along the perimeters of buildings and structures in Indonesia (Nandika *et al.* 2003), for instances, infests doors and window frames of dwelling houses.

Despite the potential of *M. gilvus* (Hagen) as a structural pest in the Indo- Malayan region. However, the information on these pest species is very limited. Thus, information on its distribution and identification are essential for better management strategies against this species have to be developed.

The objective of the research was to distribution and identification of colonies of *M. gilvus* on Dungus Iwul Sanctuary.

Materials and Methods

Research was conducted between March 2007 and April 2007 in Dungus Iwul Sanctuary, Bogor, West Java, Indonesia. Insect samplings were conducted by using colony classification (Meyer 2001) i.e. small nest (0 – 0,99 m), middle nest (1 – 1,99 m) and large nest (≥ 2 m).

The collected insects were kept in 70% ethanol, and brought back to the laboratory for identification. They were identified under a dissecting scope using soldier termite keys by Tho (1992) and Thapa (1981). The specimen also was identified in Natural History Museum, London. The soldier identification features included (1) shape and

characteristics of the head and mandibles, (2) antenna, (3) post-mentum, (4) pro-, meso- and meta-notum, (5) Size and colouration of termites, and (6) other individual characteristics.

Distribution of colony termite was done using absent present method (Clark *et al.*, 1971; Clark & Turton, 1973). Data processing and analysis were conducted using ArcView 3.2 software.

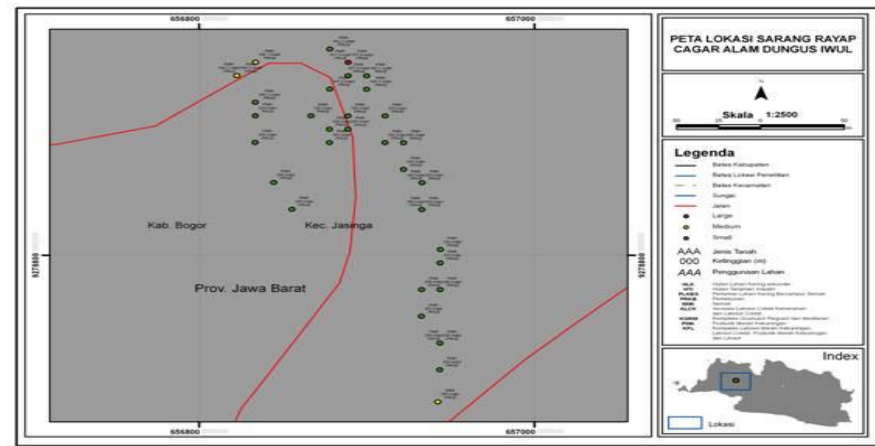
Result and Discussion

Dungus lwul Sanctuary is about 1 Ha and located between 6°40' S and 106°45' E., with rainfall was about 2,399 mm/year. Soil is recorded as grey alluvial association and primer sediment was clay and sand with waved physiographic. Vegetation of the area was dominated by *Dipterocarpus hasseltii*, *Hopea sangal* Korth, *Schima walichii* Korth, *Altingia excelsa* Noronhae, *Litsea* spp, *Lagerstroma* spp and *Ficus septica*.

Table 1. Morphologic caracter of *M. gilvus* Hagen in Dungus lwul Sanctuary (n = 225)

Parameter		Dungus lwul Santuary (196-211 mdpl)		
		Higher	Medium	Small
Length of head	P.Mayor	3.45-3.52	3.41-3.47	3.41-3.47
	P.Minor	1.75-1.81	1.81-1.92	1.89-1.94
Width of heat	P.Mayor	2.71-2.78	2.75-2.77	2.74-2.79
	P.Minor	1.46-1.5	1.47-1.5	1.47-1.5
Lenght of mandible	P.Mayor	1.82-1.86	1.63-1.86	1.82-1.86
	P.Minor	1.31-1.33	1.32-1.34	1.32-1.35
Segment of antenna	P.Mayor	17	17	17
	P.Minor	17	17	17
Lenght of posmentum	P.Mayor	2.43-2.46	2.43-2.45	2.43-2.45
	P.Minor	1.22-1.24	1.21-1.23	1.22-1.23
Width of posmentum	P.Mayor	0.75-0.77	0.74-0.77	0.75-0.77
	P.Minor	0.45-0.47	0.45-0.47	0.45-0.47
Width of pronotum	P.Mayor	2.36-2.38	2.35-2.38	2.35-2.38
Width of mesonotum	P.Mayor	2.24-2.27	2.25-2.27	2.25-2.27
	P.Minor	0.91-0.93	0.91-0.93	0.91-0.93
Width of metanotum	P.Mayor	2.23-2.26	2.23-2.25	2.23-2.25
	P.Minor	0.981-1.01	0.98-1.02	0.98-1.02

The result of analysis morfology showed that subterranean termite *Macrotermes* in Dungus lwul Sanctuary are belong to one group *Macrotermes gilvus* Hagen. The same this research conducted by Prof. Paul Eggleton and Dr. David T. Jones from Natural History Museum, UK.



In the study area 1 Ha there were 37 points of termite colonies found consisted of 1 spots of large nests, 3 spots of middle nests, and 33 spots of small nests.

The result calculation with Chi-Square Test indicates that subterranean termites *Macrotermes* with parameter that used C, C/N, sand, Dust, clay and temperature, N and pH indicates that pattern subterranean termites *Macrotermes* from Dungus Iwul Sanctuary are spread group model.

The mounds are constructed of soil particles (like coarse sand, fine sand, silt, clay and organic carbon), extract and saliva, these in varying proportions (Wilson 1971). The *M. gilvus* Hagen uses re-packed, orally transported soil particles, cemented with saliva into walls. It is thought that mound structure of termites is determined by three important factors: the species, the soil composition and the microclimatic conditions (like rain and temperature).

Conclusions

1. The nest distribution subterranean termites *Macrotermes gilvus* Hagen are spread group model
2. Factors affecting soil termite population *Macrotermes gilvus* Hagen are micro climate, macro climate, pH, predators, soil type, and resource food.

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Identification of Wood Destroying Beetles Attacking Log and Timber

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Abstract

Wood utilization for construction material still becomes a special choice for most Indonesian society. However, wood as construction material naturally has extract or carbohydrate components becoming food source for organisms such as insects. For that reason the research was done with an aim to identify wood destroying beetles at logs and timbers of some wood species in PT Rante Mario, Makassar. The study is expected to give the information regarding the variety of insect types attacking logs and timbers. The determination of beetle types was conducted by identifying morphology, and wood condition attacked (part of attacked wood, yielded frass, tunnel characteristic and also form and size of drilled hole). Results showed that there were 10 families of wood beetles from coleopteran found in PT. Rante Mario. There were Lyctidae (*Lyctus brunneus*), Anobiidae (*Dorcatoma dresdensis*), Bostrychidae (*Xylobiops basilaris* [Say].), Cerambycidae (*Parandra brunnea* [Fab].), Curculionidae (Species A and Species B), Scolytidae (*Ips pini* [Say].), Platypodidae (*Platypus wilsoni* Swaine, *Platypus cylindrus* dan Species C), Brentidae (*Arrhenodes minuta* [drury].), Passalidae (*Odontotaenius disjunctus* [Illiger].) and Nitidulidae (*Glischrochilus fasciatus* [Oliv].). The most destroying beetle on logs and timbers were Lyctidae, Anobiidae, Bostrychidae, and Platypodidae. The wood species mostly attacked by beetles in the form of logs were yellow meranti (*Shorea Spp*), *M fasciculata* (*Manilkara merilliana*), *I. bijuga* (*Intsia Spp*), *C. petandra* (*Ceiba Pentandra*), *M. indica* (*Mangifera Indica*) and *D. zibethinus* (*Durio zibethinus*), while those in the form of timbers were yellow meranti (*Shorea Spp*), *K. celebica* Kosterm (*Kalappia celebica kosterm*), *M. indica* (*Mangifera Indica*), *D. zibethinus* (*Durio zibethinus*), *C. petandra* (*Ceiba Pentandra*) and mixture wood.

Key words: Coleoptera, Log, Timber

Introduction

Wood utilization for construction material still becomes a special choice for most Indonesian society. Wood has a lot of excess. It is easy to find with many forms and sizes, to workmanship, and also represents the isolator for heat and electrics. However, wood as construction material naturally has extract or carbohydrate components becoming food source for organisms such as insects.

One of insect types attacking wood is beetle. Two types of beetles are dry wood powder and wet wood powder beetles. The beetle can quicken the damage of wood and make hole bored at hardwood and softwood. Damanik (2003) mentioned annual economic loss that happened as a result of wood damage due to the beetle attacks reaches billions rupiah. They can attack trees, log, dry wood, fresh log, timber, and products from wood in storage and in usage as well.

The purpose of this study is to give information regarding the varieties of insect types attacking logs and timbers, particularly in PT. Rante Mario. This information would be useful in determining methods for the wood products protection against beetle attacks.

Materials and Method

This research takes samples in PT. Rante Mario, Makassar of South arch Sulawesi. The identification of the beetles was executed in Laboratory of Base and Technology Forest Chemical, Forestry Faculty of University Hasanuddin, Makassar

Depository Model of log at PT. Rante Mario was done by heaping log, while timber has tidy hence part of log and timber identified by: as length as surface; then selected by log and timber attacked by a beetle marked with the existence of hole and excrement (frass) which has hole bored around.

Processes to identify the beetle types can be done by:

- a. Identify pursuant to morphology marking owned by beetles (Coleoptera). Morphology marking used in identifying are head, antenna, thorax, leg, wing (elytra), abdomen, size measure, form and colour. Amenity to recognize the morphology marking based on the size measure of beetle and observation can be done by using lup or microscope (Borror et al., 1996).
- b. Identify pursuant to wood type, attacked wood condition, legislate or terrace, yielded frass, tunnel characteristic, and also form and size of bored hole. (Eaton And Hale, 1993).
- c. Identifications referring to identification books - How to know The Beetles Second Edition (Arnett et al., 1980), An Introduction to The Study of Insects Sixth Edition (Borror et al., 1996), Wood Decay Pests and Protection (Eaton And Hale, 1993).

Results

Results showed that there were wood destroying beetles attacking logs and timbers in PT. Rante Mario Makassar. There were *Agathis alba*, *Manilkara fasciculata*, *Palaquium spp*, *Terrietia sp.*, *Callophyllum inophyllum* L, *Kalappia celebica* Kosterm, *Ceiba petandra*, *Durio zibethinus*, red meranti (*Shorea spp*), yellow meranti (*Shorea spp*), *Intsia bijuga*, *Mangifera indica*, *Koompassia malaccensis* Maing, tapi-tapi, pontho, and mixture woods.

Table 1. Identifying the species of wood destroying beetles by marking morphology.

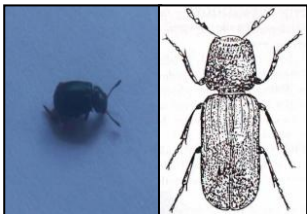
No.	Family	Size	Antenna	Morphology of Beetle			Note
				Leg	Colour	Size and form of body	
1.	Anobiidae : <i>Anobium fulvicorne</i> 	5 mm	Type kapitat consisted of 11 internodes; big last 3 internodes.	Pretarsus branch becomes sharp and diametrical and there are thorns at the end of tibia	Glossy black	Roundish and head bent to downwards.	Pronotum bigger than head and larva is fathish and bent
2.	Bostrychidae : <i>Xylobiops basilaris</i> (Say). 	8 mm	Type klavat consisted of 10 internodes; length and last big 3 internodes	Pretarsus like tortous and pointed yoke tibia and tarsus growed the Brown plume.	Glossy black	Long and rather cylindrical.	Pronotum bigger than head; larva is tortous and has bigger head.

Table 1. Continue

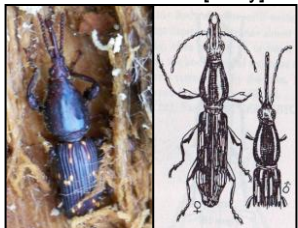
No.	Family	Size	Antenna	Morphology of Beetle			Note
				Leg	Colour	Size and form of body	
3.	Brentidae : <i>Arrhenodes minuta</i> [drury] 						
	Male	22 mm	Type klavat that is the in form of like pennant, joint mounting to more and more to back part more and more big consisted of 11 internodes which flatten and tip of big last segment and become sharp; as length as antenna; growed by reddish brown of smooth plume.	structure Tungkai consisted of [by] the koksa, trokanter, femur, tibia, tarsus, pretarsus (nail) which is there are [in] back part [of] tarsus off[is in form of tortous branch and part of tibia and tarsus growed by rather stiff thorn	Red to brown and glossy	Cylindrical, long and slender.	There are blot yellow at elytra, male beetle own the snout as a means of to suck.
	Female	25 mm	Type of like klavat, and also as length as antenna; growed by smooth plume. of brown to red	Pretarsus (nail) which there are in back part of tarsus in form of tortous branch and part of tibia and tarsus growed by rather stiff thorn.	Red to brown and glossy	Cylindrical, length and slender.	Female beetle own the mouth appliance (mandible) like scissors used to drill the female size measure and wood bigger than male.

Table 1. Continue

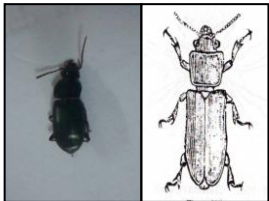
No.	Family	Size	Antenna	Morphology of Beetle			Note
				Leg	Colour	Size and form of body	
4.	Cerambycidae : <i>Parandra brunnea</i> (Fab.) 	20,2 cm	Type filiform like marjan, consisted of 8 internodes which flatten and ellipse.	Part back part of tibia, there are very uppermost thorn and tarsus growed by rather stiff plume.	dark black and glossy	Length and rather cylindrical.	Pronotum like square and bigger than head, eye very uppermost and thorny tungkai.
5.	Curculionidae : Species A 	8 mm,	type kapitat consisted of 11 internodes which flatten and big last three internodes and growed by smooth plume of black	back part of tarsus is form of tortous branch and part of tibia and tarsus growed by rather stiff and harsh plume	white with black blot	oval	length of antenna 6 mm and arise in snout mid with the very uppermost eye
	Curculionidae : Species B 	13 mm,	type kapitat consisted of 11 internodes which flatten and tip of big last internodes, and also as long as antenna; growed by smooth plume of yellow to brown	pretarsus (nail) which there are back part of tarsus form of tortous branch and part of tibia and tarsus growed by rather smooth plume	red brown to	rather length and cylindrical	length of antenna 6 mm; pronotum bigger than head; length of larva 6 mm

Table 1. Continue

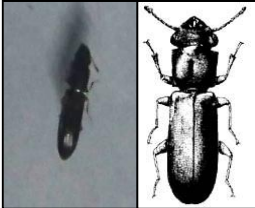
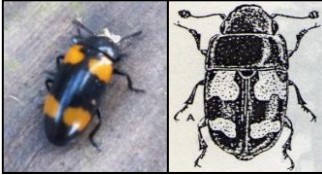
No.	Family	Size	Antenna	Morphology of Beetle			Note
				Leg	Colour	Size and form of body	
6.	Lyctidae : <i>Lyctus brunneus</i> 	3 mm	Type kapitak consisted of 11 internodes and big last 2 internodes.	Pretarsus branch to become sharp and tortous.	glossy black	Slim and length (flat)	pronotum bigger than head and pupa tortous in form of letter C
7.	Nitidulidae : <i>Glischrochilus fasciatus</i> (Oliv.). 	15 mm	type kapitak consisted of 11 internodes, whereabouts three internodes most big back part, antenna; grew by smooth plume of black	Back part of tarsus is in form of tortous branch while shares tip of tibia, there are very uppermost thorn and tarsus grew by rather stiff plume.	glossy black and pattern yellow at elytra	Length or oval	there are 2 blot tide yellow at elytra
8.	Passalidae : <i>Odontotaenius disjunctus</i> (Illiger) 	14 mm	type lamellate that is long first internodes and next internodes minimize and third the joint [in] back part extend to lateral form the separate oval dewlap, antenna; consisted of 10 internodes and growing by longish refinement plume	Pretarsus in form of branch like fishing tortuous and pointed while shares of femur and tibia, there are stiff and pointed thorn and also part of tarsus grew by the smooth plume.	Glossy black	wide and flat	pronotum bigger than head and in form of parallelogram, and surface elytra scraggly

Table 1. Continue

No.	Family	Size	Antenna	Morphology of Beetle			Note
				Leg	Colour	Size and form of body	
9.	Platypodidae : <i>Platypus wilsoni</i> Swaine 	5-7 mm	Type genikulat in form of elbow, consisted of 5 pennant whereabouts big last pennant and do] not segment but growed by longish refinement plume.	pretarsus in form of branch like fishing tortuous and pointed while big femur shares and there are thorn of tibia	black to brown	Length, slender. and cylindrical,	Head more wide from pronotum, foot/feet, elytra, and tip of antenna; growed by the fur, convex eye.
	<i>Platypus cylindrus</i> 						
	Species C 						

Table 1. Continue

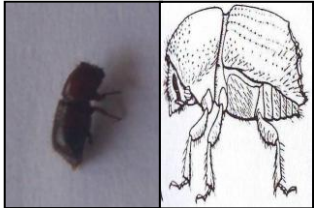
No.	Family	Size	Antenna	Morphology of Beetle			Note
				Leg	Colour	Size and form of body	
10.	Scolytidae : <i>Ips pini</i> 	2-4 mm	Type genikulat in form of elbow, with the length first internodes and next internodes minimize and luff at shares pedicel and consisted of 7 internodes whereabouts apart and big last internodes and also growed by brown smooth plume.	Pretarsus in form of tortuous and pointed yoke while shares tip of tibia, there are very stiff and pointed thorns.	brown to black	Rather small and fat.	shares elytra, abdomen, and head in growing by bur and stiff, eye is not convex (flatten)

Table 2. Identifying the species of wood destroying beetles by material attacked.

No	Family	Wood Type		Attacked Wood Condition		Environmental Condition	Frass (Excrement)	Form and size of bored hole	Tunnel characteristic
		Log	Timber	Log	Timber				
1.	Lyctidae	<i>M. fasciculata</i> , <i>D. zibethinus</i> , red and yellow meranti, <i>Terrietia sp</i>	red and yellow meranti, <i>Terrietia sp</i> , and <i>M. indica</i>	Surface of dry log	have been dried	rain, cloudy	mealy smooth like powder, white and yellow	0,5 - 1,5 mm, circle like needle hole.	circle and parallel random but with the fibre direction
2.	Anobiidae	tapi-tapi, <i>M. indica</i> , <i>C. inophyllum L</i> , <i>Intsia Spp</i> , pontho	pontho, <i>I. bijuga</i> , <i>C. inophyllum L</i> , mixture wood	Surface of log rather mouldy and dry.	have been dried	clear weather	Smooth powder but rather circle and lump.	1 – 3,5 mm, circle or ellipse	circle, random And branch, and also cut the fibre direction.
3.	Bostricidae	<i>Palaquium spp</i> , <i>M. fasciculata</i> , <i>K. celebica</i> Kosterm, pontho, yellow meranti	Yellow meranti, <i>M. fasciculata</i> and <i>K. celebica</i> Kosterm	Log still owns the husk, not dried.	not yet been dried	rain, cloudy	dust which lump and rather harsh	2- 6 mm, circle and jagged.	circle but a lot are random
4.	Cerambycidae	yellow meranti, <i>D. zibethinus</i> , <i>M. fasciculata</i>	<i>D. zibethinus</i> , <i>K. malaccensis</i> Maing, <i>M. fasciculata</i> , and mixture wood	log in a state of wet (fresh)	not dried	rain, drizzle	not lump, longish and harsh fibrous.	3 - 12 mm, oval and rather circle	oval, zigzag and random
5.	Curculionidae (a)	<i>C. inophyllum L</i> , <i>M. fasciculata</i> , yellow meranti	Not found.	Dry log and have mouldered.	not found	rain, drizzle	like lump circle and smooth	1 - 3 mm, oval until circle	Oval and step aside the hole rather jagged.
	Curculionidae (b)	<i>Ceiba petandra</i> , <i>M. fasciculata</i> , yellow meranti	yellow meranti, <i>Palaquium spp</i>	Wet log which medium decay.	not found	rain season but clear weather	item circle but refine and lump	1,5 – 4 mm, oval until circle	not found
6.	Scolitydae	<i>Agathis alba</i> , yellow meranti	not found	log which still own the husk and wet	fresh timber/not yet been dried	clear weather	Smooth circle of granule which lump and wet.	0,5 - 2 mm, circle, and around tunnel growed by the blue fungi	circle, cutting fibre direction and there are black pock or stain at tunnel;

Table 2. Continue

No	Family	Wood Type		Attacked Wood Condition		Environmental Condition	Frass (Excrement)	Form and size of bored hole	Tunnel characteristic
		Log	Timber	Log	Timber				
7.	Platipodidae (a)	<i>C. petandra</i> , <i>M. indica</i> and <i>Intsia</i> Spp	<i>C. petandra</i> , <i>M. indica</i>	Log fresh, and log surface is newly skinned.	fresh timber/not yet been dried	drizzle, cloudy	Smooth shiver until harsh, length and lump.	0,5 - 3,5 mm, circle	not found
	Platipodidae (b)	<i>D. zibethinus</i> , <i>C. petandra</i> , <i>Intsia</i> Spp	<i>C. petandra</i> and <i>M. fasciculata</i>	Log which still own the husk and wet. (fresh)	fresh timber/not yet been dried	cloudy, drizzle	harsh fibrous shiver and long	1 - 3,5 mm, circle	circle, zigzag and around tunnel growed by the blue fungi
	Platipodidae (c)	<i>D. zibethinus</i> , yellow meranti	yellow meranti and <i>D. zibethinus</i>	log which still fresh	Still fresh and whereas dried.	clear weather	harsh fibrous shiver is length and separate	0,5 – 3 mm circle	circle, zigzag, around tunnel growed [by] the blue fungi
8.	Brentidae female	red meranti , yellow meranti , <i>K. malaccensis</i> Maing	yellow meranti and <i>K. celebica</i> Kosterm	dry log surface and mouldy.	mouldy timber and damp	cloudy	harsh fibrous shiver is length and separate	3 - 12 mm, circle and not flat	Rather big circle and, its edge are jagged of parallel and instruct fibre.
	Brentidae male	red meranti, yellow meranti	not found	under rotten log husk	not found	cloudy	circle and rather smooth	3 - 12 mm, circle and not flat	not found
9.	Passalidae	<i>Palaquium</i> spp, tapi-tapi, yellow meranti	not found	new fresh log skinned	not found	cloudy	harsh granulate and separate (dry)	3-7 mm, circle until ellipse	Circle, zigzag, its edge is jagged and barrel instruct the fibre
10.	Nitidulidae	pontho, <i>M. indica</i> , red meranti	<i>M. indica</i> , red meranti , mixture wood	log still be damp (wet)	not yet been dried	clear weather	harsh fiber and length	oval until ellipse	not found

Discussions

Pursuant to type of sample wood perceived (log and timber) at Table 1. Wood destroying beetles can be classification following:

1. Wood destroying beetles attacking log

Result showed that there are 10 families of wood destroying beetles attacking log. There were Anobiidae, Bostrichidae, Brentidae, Cerambycidae, Curculionidae, Lyctidae, Nitidulidae, Passalidae, Platypodidae, and Scolytidae.

2. Wood destroying beetles attacking timber

Result showed that there are 8 families of wood destroying beetles attacking timber. There were Lyctidae, Bostrichidae, Cerambycidae, Curculionidae, Anobiidae, Platypodidae, Brentidae, and Nitidulidae.

3. Wood destroying beetles attacking log and timber

Wood destroying beetles attacking log and timber found were Lyctidae found at log and timber *Terrietia* sp, red meranti and yellow meranti; Bostrichidae found at log and timber *M. fasciculata*, *K. celebica* Kosterm, and yellow meranti; Cerambycidae found at log and timber *M. fasciculata*, and *D. zibethinus*. Curculionidae (species a) not found at log and timber while Curculionidae (species b) found at log and timber *M. fasciculata*, and yellow meranti; Anobiidae found at log and timber pontho, *I. bijuga* and *C. inophyllum* L.; Platypodidae (ambrosia beetle) divisible for 3, there are Platypodidae (*Platypus wilsoni* Swaine) found at log and timber *C. petandra*, Platypodidae (*Platypus cylindrus*) found at log and timber *C. petandra* and *M. fasciculata*, Platypodidae (species c) found at log and timber *C. petandra* and yellow meranti; Brentidae found at log and timber only at yellow meranti; Nitidulidae found at log and timber red meranti and *M. indica*.

Family Anobiidae

Anobiidae was found at log tapi-tapi, *M. indica*, *C. inophyllum* L, *Intsia* Spp, pontho with the dry log condition, log surface rather mouldy, and having been skinned. Anobiidae Beetle's was found at larva stadium, pupa stadium and adult stadium. *A. fulvicorne* was on nly found by one species. Larva and pupa were found at *M. indica*, pontho and *C. inophyllum* L with the fathish form and tortuous, white and found under rather wet log husk. Larva have activity to drill into wood so that damage generated by hole bored (Fig 1.) while marking of damage and frass yielded like Table 2. Generally, colour frass based on the wood types attacked, for example, white frass means the attacked wood type was *M. indica* or *Intsia* Spp. Detectable frass around hole bored and even most frass are still sticky at hole bored surface.

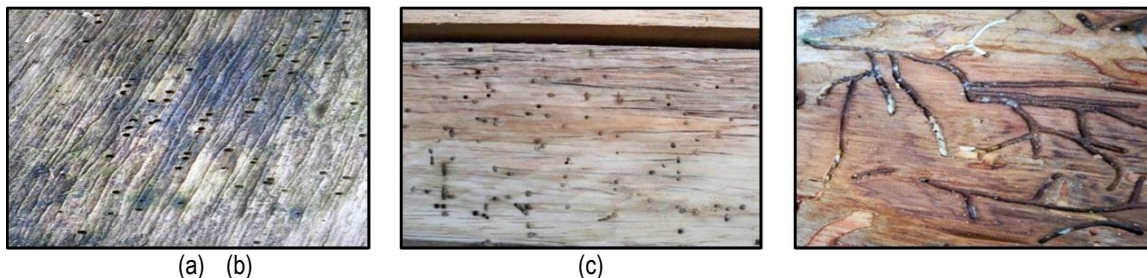


Fig 1. Hole bored and tunnel characteristic (Gallery) *A. fulvicorne*: (a) hole bored at log *C. inophyllum* L, (b) hole bored at mixture timber, and (c) tunnel characteristic (gallery) at log *Intsia* Spp

Anobiidae was found at timber pontho, *C. inophyllum* L, *I. bijuga* and mixture wood and also attacked heartwood and sapwood with the wood condition which have been dried and depository in bond. This matter is as phrased by Eaton and Hale (1993) that this family attacked heartwood and sapwood and also attaching dried wood or in a dry condition.

Family Bostrichidae

Bostrychidae was found at log *Palaquium* spp, yellow meranti, *M. fasciculata*, pontho and *K. celebica* Kosterm with the condition of log surface still own husk having not yet been dried. According Borror et al. (1996) most types of attacks from Bostrichidae were hole bored and tree attacking. Bostrychidae beetle's was found at larva stadium and adult stadium, and only found by one species that was *X. basilaris* (Say). Adult beetle was found at yellow meranti and *M. fasciculata*. Larva was found at yellow meranti. Larva fathish and tortuous and form like letter C, white, and head bigger than its back part shares. Damage marking was generated by hole bored and frass like Table 2.

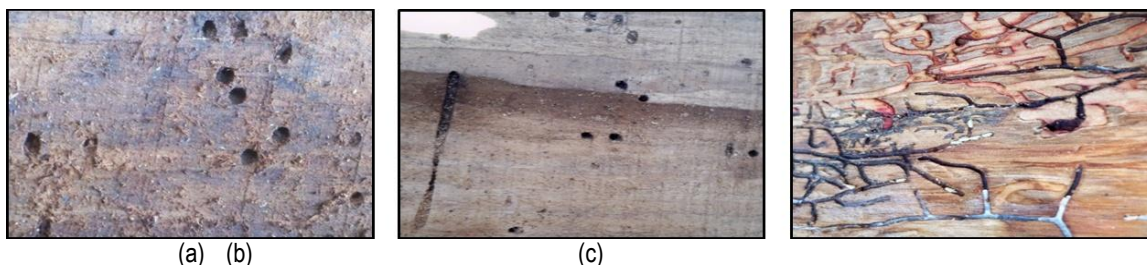


Fig 2. Hole bored and tunnel characteristic (gallery): *X. basilaris* (Say); (a) hole bored at timber of *M. fasciculata*, (b) hole bored at timber pontho, and (c), tunnel characteristic (gallery) found at log yellow meranti .

Bostrychidae was found at timber yellow meranti and attacked heartwood and sapwood, while at *K. celebica* Kosterm and *M. fasciculata* only attacked heartwood with whereas dried condition and depository in bond. This matter is according to statement of Borror et al., (1996) that Bostrychidae attacked hardwood and attaching heartwood because there were a lot of foods source in the wood. Wood was attacked in a dry condition or whereas it was dried.

Family Brentidae (The Straight-Snouted Beetles)

Brentidae was found at log red meranti, yellow meranti, *K. malaccensis* Maing with the dry log surface condition and mouldy. Brentidae beetle's was found at larva stadium and adult stadium. The species were: *A. minuta* (drury) consisted of the male and female. Larva was found at red meranti. Larva form was slender with length 12 mm, blur white and part of head were rather small and pointed and also found black blot. A larva was very slippery and soft and found under log husk which still be wet. Damage was generated with the hole bored in oval form (Fig 3a. and 3b.) and tunnel characteristic (Fig 3c.). Damage marking was generated by hole bored and frass like Table 2.

Brentidae was found at timber yellow meranti and attacking heartwood and sapwood while *K. celebica* Kosterm only was found to attack heartwood with the mouldy timber condition and damp. This matter was as phrased by Arnett et al., (1980) that this family attacking timber especially at heartwood and sapwood, and also attacked in a dry condition or whereas dried

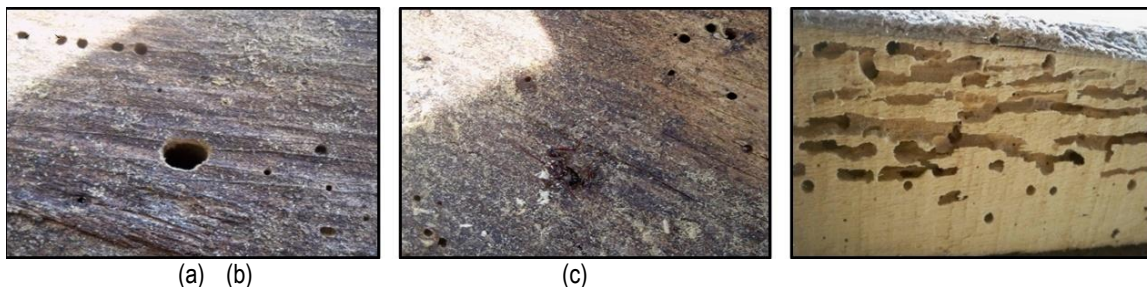


Fig 3. Hole bored *A. minuta* (drury): (a) and (b) hole bored at *K. malaccensis*

Family Cerambycidae

Cerambycidae was found at log yellow meranti, *D. zibethinus*, and *M. fasciculata* with the log condition in a state of wet or still fresh. According to Arnett et al., (1980) this family was ordinary found under bark or log and Cerambycidae was known as hole bored wood at phase of larva and a few attaching log fresh . Cerambycidae beetle's found at larva and adult stadium. Only found by one species that was: *P.brunnea* (Fab.). The beetle adult found at yellow meranti, *D. zibethinus*, and *K. malaccensis* Maing. Larva found at *K. malaccensis* Maing and *M. fasciculata*. Larva form was rather big with length 15 mm, yellow, and the end of part was big and uppermost with brown colour. Along side larva's body seen lines of poleness and every share was brown dot (spiracle) as much 9 dot. Damage was generated with the hole bored at Fig 4. Damage marking generated by hole bored and frass like Table 2.



Fig 4. Hole bored and tunnel characteristic (gallery): *P. brunnea* (Fab.): (a) hole bored at log of yellow meranti, and (b) tunnel characteristic (gallery) at log of *M. fasciculata*.

Cerambycidae was found at timber *M. fasciculata* and attacking heartwood while *D. zibethinus*, *K. malaccensis* Maing (Fig 5.) and mixture wood found to attack heartwood and sapwood with the wood condition having not dried and depository in bond. This matter was according to statement of Eaton and Hale (1993) that this family attacked heartwood and sapwood and also timber having not been dried.



Fig 5. Hole bored and tunnel characteristic (gallery) *P. brunnea* (Fab.): hole bored at timber *K. malaccensis* Maing.

Family Curculionidae

At perception in field, it was found two species from Curculionidae. The second species had not yet earned identification.

Species A

Species A was found at log *M. fasciculata*, *C. inophyllum* L and yellow meranti with the dry log condition. Curculionidae Beetle's was found at larva and adult stadium. Adult beetle of Species A was found at *C. inophyllum* L with the morphology marking at Table 1. Larva found at yellow meranti. The larva's form was rather long and length 3 mm, blur white and part of head were rather small and pointed. The larva was very slippery and soft and found under rotten log husk. Damage was generated with the hole bored (Fig 6.) while Damage marking generated by hole bored and frass like Table 2.

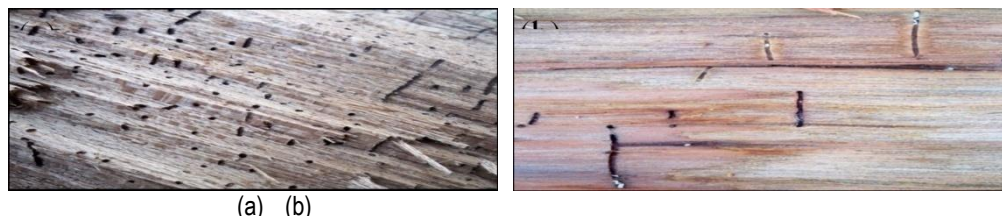


Fig 6. Hole bored and tunnel characteristic (gallery): (a) hole bored at log of *M. fasciculata*, (b) hole bored at yellow meranti .

Species B

Species B was found at log *C. petandra*, *M. Fasciculata*, and yellow meranti with the wet and decay log condition. The Beetle of species B was found at larva and adult stadium. Adult beetle of species B was found at *C. petandra*, *M. fasciculata* and yellow meranti with the morphology marking at Table 1. Larva was found at yellow meranti. The larva's form was long and length 6 mm, blur white and part of head which were rather small and pointed.

The larva was very slippery and soft and found under rotten log husk. Damage marking generated by hole bored and frass like Table 2.

This species was also found at timber found at *M. fasciculata* and attaching heartwood while *Palaquium spp* and yellow meranti found to attaching at heartwood and sapwood with the wood condition was not dried and have mouldered. This matter was according to statement of Eaton and Hale (1993) that this family attaching heartwood and sapwood and also timber of decay. Frass /ekskremen like Table 2.

Family Lyctidae

Lyctidae was found at log *M. fasciculata*, *D. zibethinus*, *Terrietia Sp*, yellow meranti and red meranti with the dry log surface condition and having been skinned. Lyctidae beetle's was found at larva, pupa and adult stadium. There was only one species from Lyctidae found - *L. brunneus*. Adult beetle was found at yellow meranti, red meranti and *Terrietia sp* with the morphology marking at Table 1. Larva was found at *M. fasciculata* by group. Larva form's was rather tortuous and like letter C, white ivory and part of head with brown blot. Pupa was found at *M. fasciculata* and *Terrietia sp*. Pupa was white colour with length 3 mm. At this phase was marked with the wing appearance from metasternum. Damage was generated with the hole bored (Fig 7.). Damage marking generated by hole bored and frass like Table 2.

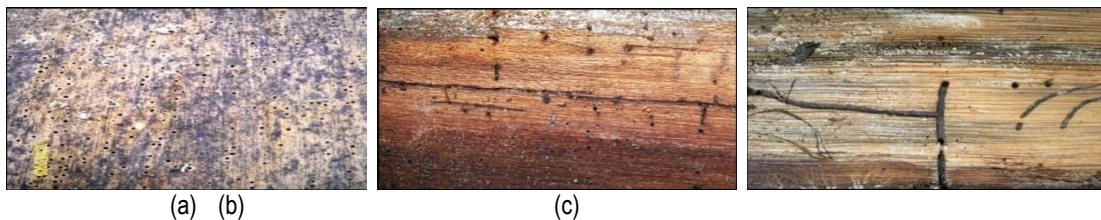


Fig 7. Hole bored and tunnel characteristic (gallery) *L. brunneus*: (a) hole bored at *D. zibethinus*, (b) hole bored and tunnel characteristic at red meranti and (c), tunnel characteristic at *M. fasciculata*.

At timber, this family was found at *Terrietia sp*, red meranti, yellow meranti, and *M. indica* and attacking heartwood with the wood condition was newly dried and depository in bond. This matter was according to statement of Eaton and Hale (1993) that this beetle only attacked heartwood because of owning high extract. Wood condition was attacked by new wood dried with the attack form like hole circle with the diameter about 0,8- 2 mm.

Family Nitidulidae (The sap-feeding beetles)

Nitidulidae was found at log pontho *M. indica* and red meranti with the condition of log surface which still be damp (wet). This matter was phrased by Arnett et al. (1980) that this family attacked the wet log wood (fresh) or having not yet been dried. Nitidulidae beetle's was found at adult stadium, and only one species found - *G. fasciatus* (Oliv.). Damage was generated with big hole in oval (Fig 8.). Damage marking was generated by hole bored and frass like Table 2.

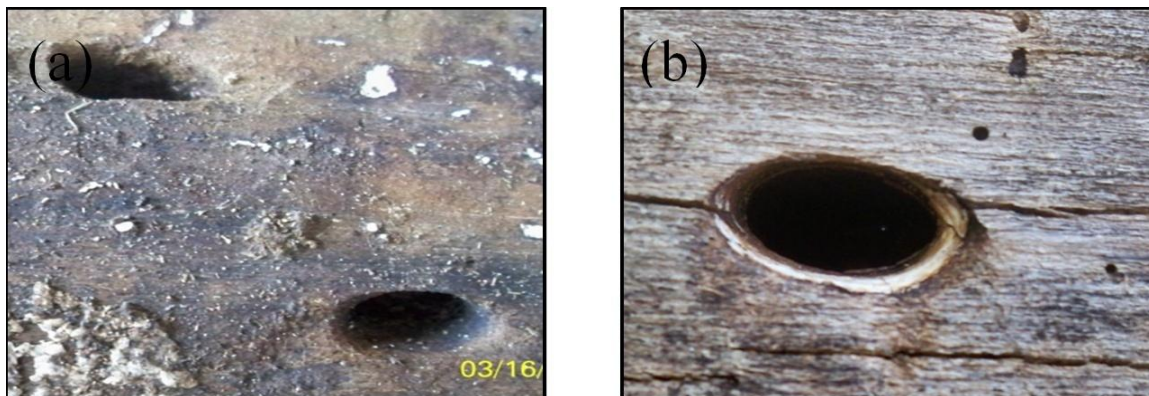


Fig 8. Hole bored *G. fasciatus* (Oliv.); (a) hole bored at timber pontho and (b) hole bored at log red meranti .

Nitidulidae was found at timber *M. indica* and mixture wood and also attacked heartwood and sapwood, while red meranti only attacked heartwood with the timber condition which had not yet been dried. This matter was phrased

by Arnett et al. (1980) that this family attacked the timber especially at heartwood and sapwood, and also wood which had not yet been dried.

Family Passalidae

Passalidae was found at log *Palaquium* spp, tapi-tapi, and yellow meranti with the new log fresh condition in skinning. Passalidae beetle's was found at larva and adult stadium. There was only one species from Passalidae found that is *O. disjunctus* (Illiger). Adult Beetle was found as much 2 tail with the morphology marking at Table 1. Larva found tapi-tapi and yellow meranti. Larva's form was the short fattish, white ivory and part of head and tip were equal size (flatten). The larva was very slippery and soft and found on the surface of log tapi-tapi and yellow meranti which was still wet. Damage was generated with the hole bored in oval until circle and tunnel characteristic (Fig 9.) Damage marking was generated by hole bored and frass like Table 2.

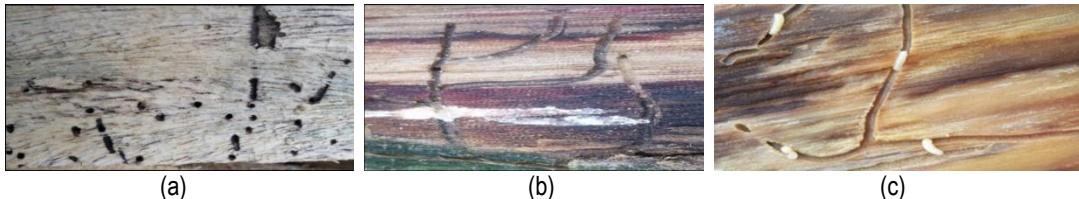


Fig 9. Hole bored from *O. disjunctus* (Illiger): (a) hole bored at log wood but, and (b) tunnel characteristic at log *Palaquium* spp. (c) tunnel characteristic at yellow meranti.

Platypodidae (Kumbang Ambrosia)

Platypodidae beetles were found at larva and adult stadium. In field, it was only found three species. They are *P. wilsoni* Swaine, *P. cylindrus*, and third species having not yet been identified (Species C).

Platypus wilsoni Swaine

Platypodidae was found at log *C. petandra*, *M. indica* and *Intsia* Spp, with the condition of log was fresh and log surface newly skinned. This matter was told by Martawijaya (1988) that this family attacked hardwood, heartwood and sapwood. Wood condition attacked was fresh log which newly skinned, timber, and tree stand up. *P. wilsoni* Swaine was only found at adult phase as much 4 tail with the morphology marking at Table 1. Damage was generated with the hole bored at Fig 10. Damage marking generated by hole bored and frass like Table 2.



Fig 10. Hole bored *P. wilsoni* Swaine: hole bored at log *M. indica*

Platypodidae was found at timber *C. petandra* and *M. indica* and attacked heartwood and sapwood with the condition of fresh timber/having not yet been dried. This matter was phrased by Eaton and Hale (1993) that this family attacked heartwood and sapwood and also attaching the fresh timber which was newly skinned. Damage was generated with the hole bored (Fig 11.). Damage marking was generated by hole bored and frass like Table 2.

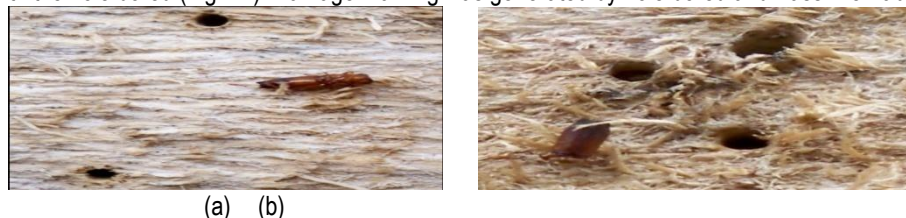


Fig 11. Hole bored *P. wilsoni* Swaine: (a) hole bored at timber *M. indica*, (b) hole bored at timber *C. petandra*.

Platypus cylindrus

Adult beetle was found at *D. zibethinus*, *I. bijuga* and *C. petandra*. Log condition which still own the husk and wet (fresh). This matter was told by Martawijaya (1988) that this family attacked hardwood and also attacked heartwood and sapwood. Wood condition attacked was fresh log which were newly skinned, timber, and tree stand up. *P. cylindrus* found at larva and adult phase with the marking of morphology at Table 1. Damage was generated with the hole bored (Fig 12.). Damage marking generated by hole bored and frass like Table 2.



Fig 12. Hole bored *P. cylindrus*: (a) hole bored and (b) tunnel characteristic at log *C. petandra*

This species was found at timber *C. petandra* and *M. fasciculata* and also attacked heartwood and sapwood with the new condition of fresh skinned timber. This matter was phrased by Eaton and Hale (1993) that this family also attacked heartwood, sapwood and fresh timber which were newly skinned.

Species C

Adult beetle of Species C was found at log *D. zibethinus* and yellow meranti. Log condition attacked is still fresh and newly skinned, and also tree standing up (strightened). This matter was told by Eaton and Hale (1993) that this family attacked hardwood, heartwood and sapwood. Beetle of species C was found at adult stadium with the morphology marking at Table 1. Damage was generated with the hole bored (Fig 13a.), and tunnel characteristic (Fig 13b.). Damage marking was generated by hole bored and frass like Table 2.



Fig 13. Hole bored from adult beetle of species C: (a) hole bored at log *D. zibethinus*, and (b) tunnel characteristic at log yellow meranti.

This species was found at timber *D. zibethinus* and yellow meranti and also attacked heartwood and sapwood with the fresh or dried timber condition This matter was phrased by Eaton and Hale (1993) that this family attacked heartwood and sapwood with the dried timber condition or in a dried condition.

Family Scolytidae (Bark Beetles)

Scolytidae was found at log agathis and yellow meranti with the log condition which husk and wet. Scolytidae beetle's was found at larva, pupa, and adult stadium. There' was only one species from this family found - *I. pini* (Say). Adult beetle was found at *A. alba* as much 5 tail and yellow meranti as much 8 tail with the morphology marking at Table 1. Larva found at yellow meranti as much 19 tail. Larva's form was fattish and short, white, and part of head were rather small and pointed. The larva was very slippery and soft and found under husk of log yellow meranti which still be wet. Damage was generated with the hole bored at Fig 14. Damage marking generated by hole bored and frass like Table 2.

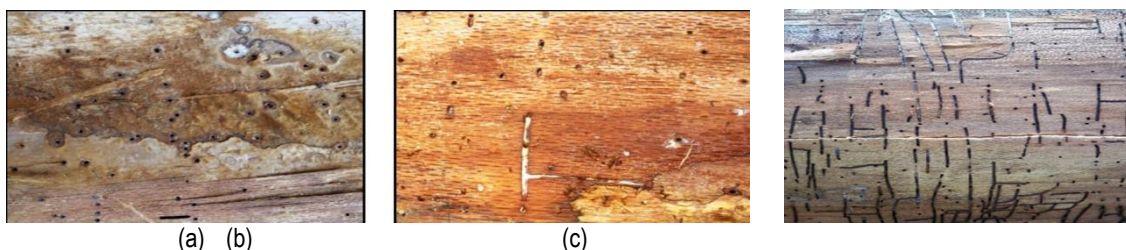


Fig 14. Hole bored and tunnel characteristic (gallery) *I. pini* (Say): (a) hole bored at log agathis, (b) hole bored at yellow meranti, and (c), tunnel characteristic (gallery) at *A. alba*

Conclusion

The research results the identification wood destroying beetles attacking at log and timber.

1. There were 10 families of wood from coleoptera found PT. Rante Mario that were
 - a. Anobiidae, species *Dorcatoma dresdensis*
 - b. Bostrychidae, species *Xylobiops basilaris* [Say]
 - c. Brentidae, species *Arrhenodes minuta* [drury]
 - d. Cerambichidae, species *Parandra brunnea* [Fab]
 - e. Curculionidae, Species A and Species B
 - f. Lyctidae, species *Lyctus brunneus*
 - g. Nitidulidae, species *Glischrochilus fasciatus* [Oliv]
 - h. Passalidae, species *Odontotaenius disjunctus* [Illiger]
 - i. Platypodidae, species *Platypus wilsoni* Swaine, *Platypus cylindrus*, and Species C
 - j. Scolytidae, species *Ips pini* [Say]
2. The most destroying beetles on log and timber were Lyctidae, Anobiidae, Bostrychidae, Platypodidae
3. The wood species mostly attacked by beetles in the form of log were yellow meranti, *M. fasciculata*, *C. petandra*, *M. indica* and *D. zibethinus* while those in the form of timber were yellow meranti, *M. indica*, *D. zibethinus* and *C. petandra*.

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Growth Inhibition of *Staphylococcus aureus* and *Escherichia coli* by Secretions derived from Soldier Defensive of Subterranean Termites *Coptotermes curvignathus* Holmgren

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Abstract

Termite soldier from genus *Coptotermes* (Blattodea: Rhinotermitidae) eject a viscous, white and sticky defensive secretion. These soldier defensive secretions used to overcome their enemy. In this research, soldier defensive secretions from *C. curvignathus* was isolated and extracted in polar and non-polar solution and used to inhibition the growth of *Staphylococcus aureus* and *Escherichia coli* bacteria. The solution used for extraction were ethyl acetate, ethanol, aquabidestilata and n-hexane. The result showed that extract from ethanol shown the highest inhibition zone to *S. aureus* growth with average value was 30.52 mm, meanwhile the inhibition zone to *E. coli* was 25.71 mm. Extract from ethyl acetate shown the average inhibition zone was 17.92 mm to *S. aureus* and 12.99 mm to *E. coli*. Minimum Inhibition Concentration of ethanol extract was 3.65% for *E. coli* and 1.84% for *S. aureus*. The compound then purified by GCMS and the result showed that mainly bioactive compound was Tetradecanal C₁₄H₂₈O.

Key words : antibacterial, soldier defensive secretions, *Coptotermes curvignathus* Holmgren, *Staphylococcus aureus*, *Escherichia coli*

Introduction

Social insects have evolved a variety of behaviour and physiological defence mechanisms, because they live in crowded, persistent, warm and resource-rich nests providing ideal conditions for the development of microorganisms. Defence mechanisms including antibiotic-producing symbionts and allogrooming (Roseangus, *et al.* 1998), antibiotic secretions (Roseangus, Lefebvre and Traniello. 2000), removal of wastes and corpses (Roseangus and Traniello. 2001) and immune defences (Traniello, Roseangus, and Savoie. 2002). Another potential mechanism of defence may be to add plant compounds with antimicrobial properties to the nest. Some research has been conducted to investigation the soldier defensive secretions, such as Prestwich (1984) on *Nasutitermes* genus, Chuah *et al.* (1989) on *Nasutitermes* genus, Chuah and Goh (1990) on *Hospitalitermes* genus, Goh *et al.* (1990) on *Lacessititermes* genus, Roseangus and Traniello (2001) on *Zootermopsis* genus, Lamberty *et al.* (2001a) on *P. spiniger*, and Da Silva *et al.* (2003) on *Pseudacanthotermes* genus. Results of the research showed that soldier defensive secretions has a bioactive compound which potential as antimicrobial for bacterial and fungus. Pearce (1997) said that soldier defensive secretions has antimicrobial function as a chemical mechanisms to overcome pathogen bacterial and fungus which live together underground with termites. Soldier termites of the subfamilies Coptotermitinae employ a chemical secretions in colony defence, applying a lipophilic mixture of electrophilic compounds which act as contact insecticides (Pasteels, and Bordereau. 1998). So far, chemical defence of *Coptotermes* soldier hasn't been investigated. This research aimed to investigation the antibacterial of soldier defensive secretions from *Coptotermes curvignathus* Holmgren, the minimum inhibition concentration and the bioactive compound of soldier defensives secretions.

Materials and Methods

Bacteria Culture

The bacteria used in this research was *Staphylococcus aureus* and *Escherichia coli* enteropatogen K_{1.1} from Biotechnology Laboratory, Center Research of Biotechnology Bogor Agricultural University (IPB) Bogor West Java Indonesia. Medium for bacteria growth was Bacto Tryptone 1%, yeast extract 0,5 %, NaCl 1% and Agar 1,5% with pH 7,0 (neutral). Then each bacteria were incubated in incubation room on 37°C for three days.

Determined Bacteria Late Log Phase

One ose bacteria from NA agar was inoculated to five millilitre NB then incubation for 24 hour. After that 10 μ l of the culture then inoculated to ten millilitre NB then incubation and watch on their growth on 0, 8, 12, 16 and 26 hour respectively with spectrophotometer on 600 nm wave to know the late log phase of each bacteria. After the late log phase determined, then we counted the cell of each bacteria with haemocytometer.

Preparation of Bacterial

Result of late log phase for *E.coli* and *S. aureus* bacteria was 16 hour, which contain 10^8 CFU/ml. The concentration of bacteria used for evaluation antibacterial was 10^6 CFU/ml.

Isolation and Extraction Soldier Defensive Secretions from *C. curvignathus*

Colonies of subterranean termites *C. curvignathus* Holmgren were obtained from dead Pine tree in Yanlappa Jasinga, Bogor, West Java Indonesia and rearing on Laboratory of Forest Biology Bogor Agricultural University (IPB) for one year (*Laboratory reared termites colony*). Soldiers were removed from the colony and the defensive secretions were isolated. Isolation soldier defensive secretions from *C. curvignathus* was conducted in referred from Prestwich *et al.* (1984) and Quintana *et al.* (2003) methods with several modification. Secretions was eject from soldier fontanel after disturbed with Pasteur pipette then the secretions put to bottle glass for extraction. Solution for extraction were aquabidestilata, ethanol, ethyl acetate and n-hexane. Total soldier used for this research was 16.000 termites, and every solution was extracted secretions from 4.000 soldier termites.

Extraction soldier defensive secretions from *C. curvignathus* was conducted in referred from Preswitch *et al.* (1980) and Chuah *et al.* (1990) methods with several modification. Secretions was diluted in 10 ml aquabidestilata, then homogenized and then put in fresh-dry machine to remove the aquabidestilata and get the filtrate. Meanwhile on other organic solution (ethanol, ethyl acetate and n-hexane), the secretions was diluted in 10 ml solution then homogenized and then put in nitrogen gas to remove the solutions and get the filtrate.

Preparation the Filtrate

Filtrate from secretions with n-hexane was diluted in aquades with Tween 80 (0,5%), meanwhile filtrate from secretions with ethanol, ethyl acetate, and aquabidestilata was diluted in aquabidestilata to made the concentration 40 % for each filtrate.

Antibacterial Bioassay

Antibacterial bioassay was conducted with Carson and Riley (1995) methods, as follows: 20 μ l bacteria culture was remove to 30 ml NA medium in one Petri dish then the medium was waited until compact. After that eight hole was made on the medium with same range in $\varnothing$ 6 mm. Then each filtrate was put in the hole and also the solution of each filtrate as a control treatment, as amount 60 μ l respectively. Petri dish then incubation on culture room for 24 hour and 37°C. Evaluation the inhibition bacteria growth was conducted with measured the transparency zone surround the hole (millimetre) and every treatment was conducted with duplo replication.

Evaluation Minimum Inhibitory Concentration (MIC)

Minimum inhibitory concentration was the lowest concentration to inhibited all bacteria growth on medium. The filtrate used was ethanol filtrate because this filtrate resulted the highest inhibition. Evaluation was conducted Carson and Riley (1995) methods with concentration 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, and 70 % respectively. MIC value was counted with Bloomfield (1991) methods.

GCMS Analysis

The ethanol filtrate were identified by gas chromatography mass spectra (GCMS) analysis. The GC was Shimadzu QP 5050 model equipped with GC 17a , column DB5 MS (30 m length x 0.25 mm diameter). The GC settings were as follows : initial column temperature set at 40°C for 5 min; temperature programmed from 40°C to 330°C with a rate 4 °C/min. Mass spectra resolution was 1000, with interval 0.5 sec; ionises energy 0.90 kv and retention time 1.6-56.0. Identified the compound were obtained according to Clement *et al* (3) and compared with data on NIST 62 (*National Institute Standard and Technology*), WILEY 229 and PESTICD.LIB

Results and Discussion

Antibacterial

Result of the research showed that filtrate ethanol has inhibited bacteria growth both on *S. aureus* and *E. coli* with average inhibition zone were 30.52 mm and 25.71 mm respectively. Filtrate ethyl acetate also inhibited bacteria growth both on *S. aureus* and *E. coli* with average inhibition zone were 17.92 mm and 12.99 mm respectively. Meanwhile other filtrate (n-hexane, aquabidestilata) and other solution as control treatment has shown no antibacterial activity. Suriawiria (1978) has classified the antibacterial activity and said that if inhibition zone was more than 20 mm, the filtrate has a very strong antibacterial activity, and if inhibition zone was 10 – 20 mm, the filtrate has a strong antibacterial activity. This research showed that filtrate ethanol was very strong and filtrate ethyl acetate was strong. The inhibition zone of bacteria *S. aureus* and *E. coli* was shown on Table 1.

Table 1. Inhibition Zone Bacteria Growth *S. aureus* and *E. coli* in Medium with Filtrate Secretions of Subterranean Termites *C. curvignathus* and Solute Extraction

Bacteria	Inhibition Zone Bacteria Growth (mm)							
	F-ethanol	F-ethyl acetate	F-n-hexane	F-aquabi destilata	ethanol	ethyl acetate	n-hexane	aquabi destilata
<i>S. aureus</i>	30.52	17.92	0	0	0	0	0	0
<i>E. coli</i>	25.71	12.99	0	0	0	0	0	0

The solution used for extraction the secretions has a different polarity. This is aim to know the activity of antibacterial under different polarity. This behaviour is very important to identified the bioactive compound of antibacterial from termites secretions (Pomeranz and Meloan. 1999). The polarity of solution from non polar to polar was n-hexane, ethyl acetate, ethanol and aquabidestilata, with polarity value 0, 38, 68, and 90 respectively. Result of the research showed that filtrate n-hexane and filtrate aquabidestilata has no inhibition zone to bacteria growth. Moshi and Mbwambo (2005) explained that filtrate n-hexane from *Terminalia sericea* root can't inhibited bacteria *S. aureus* and *E. coli* either. Meanwhile all the solution used as control treatment (n-hexane, ethyl acetate, ethanol and aquabidestilata) also shown no inhibition zone. This is shown that all the solution didn't give a contribution to antibacterial activity from filtrate secretions termites.

The highest value of inhibition zone was on filtrate ethanol (polar). Kanazawa *et al.* (1995) explained that any compound which has behaviour maximum polarity has a tendency to has maximum antibacterial activity, because for interaction between antibacterial compound and the bacteria need hydrophilic lipophilic balance. The compound polarity was the important physical behaviour. Hydrophilic was needed to assure that antibacterial compound was dissolve in water as antimicrobial medium. But the compound on membrane hydrophobic cell need lipophilic, to maintain the optimum activity (Brannen and Davidson. 1993).

Result of the research showed that *E. coli* (gram negative bacteria) was more resistant than *S. aureus* (gram positive bacteria). Lamberty *et al.* (2001b) showed the same result and explained that secretions from insect was more effective to inhibited gram positive bacteria than gram negative bacteria. Fardiaz (1992) said that gram negative and gram positive bacteria has different cell wall which made different on sensitivity, especially on physical treatment, enzyme and antibiotic. The cell wall of gram negative bacteria consist of some layer with high fatty (11-12%) which made it more resistant from antibacterial compound, meanwhile on cell wall gram positive bacteria consist of membrane with peptidoglycan and teicoat acid (Pelczar and Reid. 1977). Nuraida *et al.* (1999) explained that gram negative bacteria was more resistant to filtrate polar Picung fruit than gram positive bacteria, because of the different between cell wall bacteria. Gram positive bacteria consist of 90% peptidoglycan layer and teicoat acid, meanwhile gram negative bacteria consist of 5-10% peptidoglycan and protein, lipophilic saccharide, phospholipids and lipoprotein. The outer membrane of gram negative bacteria was stronger than gram positive bacteria. (Cano and Colome. 1986).

Minimum Inhibitory Concentration of Filtrate Ethanol

Result of the research showed that inhibition zone bacteria growth on *S. aureus* started from 10% concentration and more higher when the concentration up to 20%, meanwhile inhibition zone on *E. coli* bacteria was lowest tha *S. aureus*. This result was similar to the first result that gram negative bacteria was more resistant than gram positive bacteria. Inhibition zone bacterial growth on both *S. aureus* and *E. coli* was shown on Figure 1.

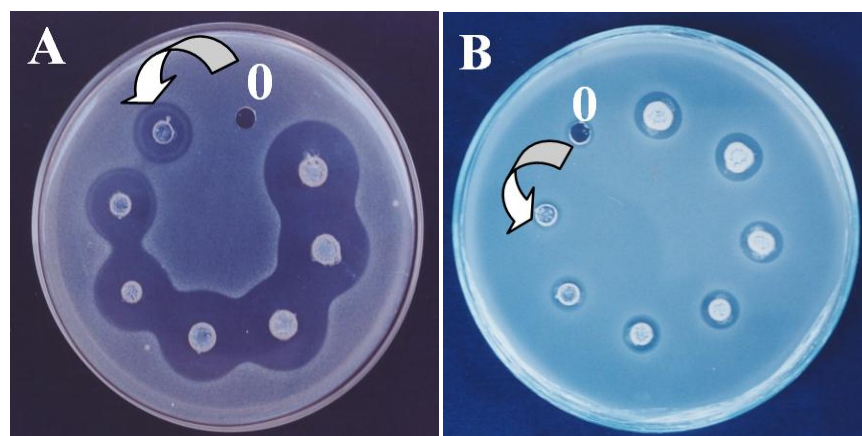


Figure 1. Inhibition Zone Bacteria Growth *S. aureus* (A) and *E. coli* (B) in Medium with Filtrate Ethanol in concentration 0-70%

MIC value of filtrate ethanol was 3,65% for *E. coli* and 1,84% for *S. aureus*. Some MIC from filtrate insects secretions and plant was shown on Table 2. Result of the research concluded that filtrate secretions from subterranean termites *C. curvignathus* has a bioactive compound as antibacterial. Some compound which has antibacterial behaviour were phenol and phenolic agents, aldehyde, halogen, alcohol and other substances (Pelczar and Chan. 1988).

Table 2. Minimum Inhibitory Concentration Filtrate Insects Secretions and Plant to *S. aureus* and *E. coli* bacteria

Extract Source	MIC		Researcher
	<i>S. aureus</i>	<i>E. coli</i>	
Filtrate ethanol termites <i>C. curvignathus</i>	1,84%	3,65%	Farah Diba 2006 ¹
Beluntas Leaf	2,94%	2,66%	Ardiansyah 2003 ²
Salam Leaf	1,91%	1,49%	Nuraida <i>et al.</i> 2001 ¹
Picung Fruit <i>Pangium edule</i> Reinw	3,46%	5,56%	Nuraida <i>et al.</i> 1999 ¹
Defensin from ant <i>Phormia terranova</i>	1,5 – 3 μ M	1,5 – 3 μ M	Lamberty <i>et al.</i> 2001a ¹
Spinigerin from termites <i>Pseudacanthotermes spiniger</i>	---- ⁴	3 – 6 μ M	Lamberty <i>et al.</i> 2001a ¹
Cecropin from mosquitoes <i>Aedes aegypti</i>	---- ⁴	0,25 – 0,5 μ M	Lamberty <i>et al.</i> 2001a ¹
Tectorigenin from herbal <i>Belamcanda chinensis</i>	50 μ g/ml	> 200 μ g/ml	Bong-Oh <i>et al.</i> 2001 ³
Gomesin from spider <i>Acanthoscurria gomesiana</i>	1,6 – 3,15 μ M	0,4 – 0,8 μ M	Silva <i>et al.</i> 2000 ¹
Androctonin from scorpion <i>Androctonus australis</i>	15 – 30 μ M	6 – 15 μ M	Silva <i>et al.</i> 2000 ¹
Poneracin from ant <i>Pachycondyla goeldii</i>	16 – 32 μ M	32 – 64 μ M	Orivel <i>et al.</i> 2001 ¹
Spinigerin from termites <i>Pseudacanthotermes spiniger</i>	8 μ M	16 μ M	Lee <i>et al.</i> 2003 ¹
Androctonin from scorpion <i>Androctonus australis</i>	15 – 30 μ M	6 – 15 μ M	Sabatier <i>et al.</i> 1996 ¹

Remarks: ¹ First bacteria population 10^6
² First bacteria population 10^4
³ First bacteria population 10^5
⁴ N.A

GCMS Analysis

The bioactive compound from filtrate ethanol of soldier defensive secretions *C. curvignathus* were determined by GCMS analysis. Chromatogram of filtrate ethanol was shown in Figure 2 and the chemical compound was shown in Table 3. The chemical compound were consisted aldehyde group, namely Tetradecanal, Pentadecanal, Undecanal, and Octadecanal and 2-methyl pentane from alcane group.

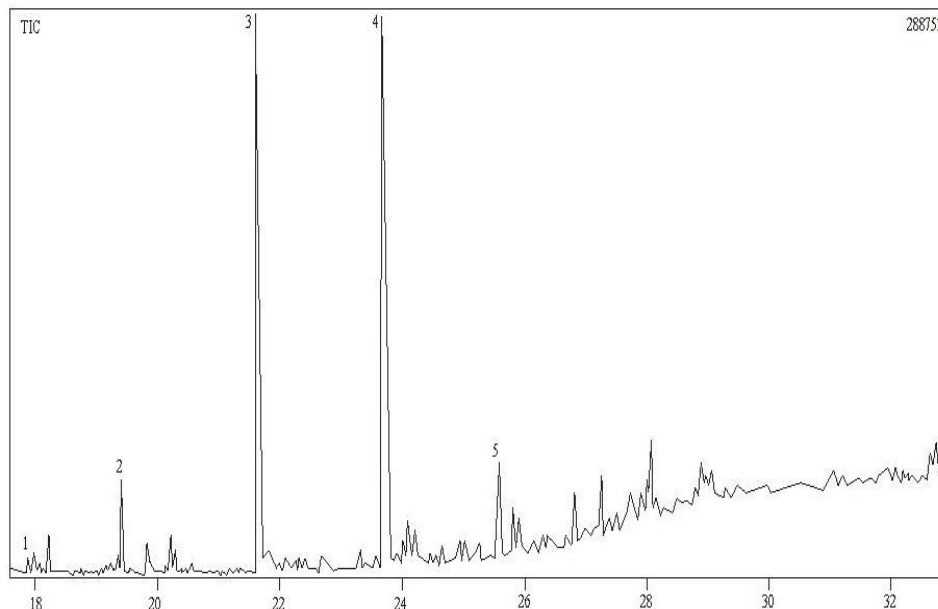


Figure 2. Chromatogram of soldier defensive secretions *C. curvignathus* Holmgren in Ethanol filtrate. Peak Number is based on Number at Table 3.

Table 3. Chemical Compound and Retention Time from Ethanol Filtrate of soldier defensive secretions *C. curvignathus*

Peak No.	Retention Time	LRIexp	LRIref	Chemical Compound	Group
1.	1.419	-	673 (a)	2-methyl-Pentane (C ₆ H ₁₄)	Alcane
2.	19.420	1027	-	Undecanal (C ₁₁ H ₂₂ O)	Aldehyde
3.	21.654	1096	1107 (b)	Tetradecanal (C ₁₄ H ₂₈ O)	Aldehyde
4.	23.706	1134	-	Pentadecanal (C ₁₅ H ₃₀ O)	Aldehyde
5.	25.573	1178	-	Octadecanal (C ₁₈ H ₃₆ O)	Aldehyde

Remarks : LRI experiment from GCMS, DB-5 Column

LRI reference (a) Larrayoz *et al.*, (7), DB-5 Column

LRI reference (b) Mondello *et al.*, (9), DB-5 Column

Conclusions

Filtrate ethanol and filtrate ethyl acetate soldier defensive secretions of subterranean termites *C. curvignathus* has antibacterial activity. The average inhibition zone bacteria growth of *S. aureus* was 30.52 mm and *E. coli* was 25.71 mm on ethanol filtrate and classified as very strong antibacterial. Meanwhile the average inhibition zone bacteria growth of *S. aureus* was 17.92 mm, and *E. coli* was 12.99 mm on ethyl acetate filtrate and classified as strong antibacterial. Gram negative bacteria more stronger than gram positive bacteria because the different between cell wall composition. Minimum inhibitory concentration of ethanol filtrate to *S. aureus* was 1.84% and to *E. coli* was 3.65%. Gas chromatography mass spectra (GCMS) analysis resulted 5 volatile compounds, mainly aldehyde compounds, including tetradecanal, pentadecanal, undecanal and octadecanal.

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Screening and Characterization of Cellulase Enzyme Producers from Indonesian Actinomycetes

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Abstract

Selulosa merupakan komponen utama pembentuk biomassa dinding sel tanaman, merupakan suatu polimer linear yang tersusun dari unit glukosa tak larut yang terikat melalui ikatan p- 1,4 glukosida dan jutaan ton selulosa diproduksi melalui fotosintesis. Aktinomisetes tersebar luas di tanah, memiliki peranan penting dalam degradasi lignoselulosa dari dinding sel tanaman. Pada umumnya degradasi lignoselulosa pada substrat alami lebih banyak dilakukan oleh fungi, sedangkan peranan aktinomisetes dalam proses ini masih belum banyak diketahui. Beberapa aktinomisetes didapatkan sebagai dekomposer selulosa yang aktif, dan selanjutnya diteliti kemampuan degradasi serta produksi enzimnya. Sembilan puluh empat isolat ID 06 koleksi BTCC diskriming kemampuannya dalam menghasilkan enzim selulolitik, sebanyak 38 isolat mempunyai kemampuan untuk menghasilkan enzim selulolitik. Dari hasil deteksi kemampuan selulolitik menggunakan metode congo red diketahui bahwa ID6-455 mempunyai kemampuan selulolitik yang tinggi dengan membentuk diameter zona bening sebesar 4,40 cm. Hasil uji optimum produksi enzim sellulase selama 10 hari, hasil produksi enzim maksimum terdapat pada hari ke-6 dengan aktivitas spesifik sebesar 0.279 U/mg. Uji kromatografi lapis tipis dilakukan terhadap perbedaan waktu fermentasi dari 0-7 hari, dengan konsentrasi substrat 1%. Berdasarkan uji KLT, isolat ID6-455 mampu memecah substrat Birchwood Xilan. Mannan dan CMC menjadi senyawa turunannya yaitu gula yang lebih sederhana pada hari ke-1. Analisis molekuler berdasarkan 16S rDNA gen menunjukkan bahwa isolat ID6-455 memiliki kesamaan dengan *Streptomyces* sp.

Cellulose, the major component of plant biomass, is a linear polymer of anhydroglucose units linked by p-1, 4-glucoside bonds and millions tons of cellulose produced through photosynthesis. Actinomycetes are widely distributed in soil, where they play an important role in the degradation of the lignocellulose of plant cell walls. However, lignocellulose degradation in natural substrates is largely attributed to fungi, and the importance of actinomycetes in this process may be underestimated. Some actinomycetes were found to be active cellulose decomposers and therefore studied for their degradation activity and protein production. Ninety-four isolate actinomycetes from Biotechnology Culture Collection (BTCC) collection were screened for their ability to produce cellulolytic enzymes. From them 38 isolates have the ability to produce cellulolytic enzymes by congo red methods. A strain, ID6-455 have high cellulolytic ability to form a clear zone with diameter of .40 cm. The optimization of cellulolytic production of the strain show that the strain ID6-455 has high enzyme production with the specific activity on 0,279 U/mg at the 6 days incubation. Thin layer chromatography (TLC) tests were conducted on difference fermentation time from 0 - 7 days, in substrate concentration 1%. Based on TLC test, ID6-455 capable of breaking the substrate (CMC) into compounds of cellulose derivatives in the 1 day. Molecular analysis of 16S rRNA are showed that the isolate ID6-455 was identified as *Streptomyces* sp.

Key words: Screening, Characterization, Cellulase, Actinomycetes

Introduction

Cellulose is the most common carbohydrate occurring in plants throughout the world. In plant, cellulose comprises almost 50% of carbohydrate, while hemi-cellulose comprises 15–34% (Das & Singh, 2004 and Reddy & Yang, 2005). Most of these compounds are difficult to decompose rapidly in the natural environment (Knauf & Moniruzzaman, 2004 and Reddy & Young, 2005). Compost is organic matter that has been biologically decomposed by microorganisms. In composting, organic matter is degraded by cellulases and ligninolytic enzymes. Along with humus-like end products, the microorganisms convert organic material into carbon dioxide, biomass and thermal energy (Tuomela et al., 2000). Compost microorganisms that have previously been identified include *Bacillus* spp., *Actinomycetales*, *Thermus* spp., *Streptomyces* spp., *Aspergillus* spp. among others (Strom, 1985; Beefa et al., 1996;

McCaig et al., 2001; Song et al., 2001). Interest in these microorganisms has increased due to potential commercial applications, which include biodegradation and the production of bioactive compounds such as antibiotics and enzymes (Malherbe and Cloete, 2002)

Various microorganisms isolated from compost have been identified (McCaig et al., 2001; Song et al., 2001 and Das & Singh, 2004). Interest in these microorganisms has increased owing to potential commercial applications, namely biodegradation and production of bioactive compounds, including antibiotics and enzymes (Malherbe & Cloete, 2002). The composting process used for decomposing plant biomass waste can be accelerated by adding cellulose-producing actinomycetes. Organic matter in soil crucially influences soil systems and increases crop productivity. The application of compost in soil provides a key source of plant nutrients, and improves soil fertility, aeration, porosity, structure and water-holding capacity (Tuomela et al., 2000). With regard to natural systems, soil organic matter management is also essential for sustainable use of agricultural system, and for enhancing soil quality (Malherbe & Cloete, 2002).

Actinomycetes are widely distributed in soil, where they play an important role in the degradation of the lignocellulose of plant cell walls (Crawford, 1986). However, lignocellulose degradation in natural substrates is largely attributed to fungi, and the importance of actinomycetes in this process may be under estimated. Thus far, well-known cellulolytic actinomycetes include members of the genera *Cellulomonas* and *Thermomonospora* (Calza, et al 1985; Dermoun, et al 1988). In the genus *Streptomyces*, cellulose-degrading activity has been found in some strains (Spear, et al. 1993). In general, actinomycetes could be divided into two groups, Streptomyces Group and Non-Streptomyces Group or so called Rare Actinomycetes. Streptomyces Group consist of the genera *Streptomyces*, *Kitasapospira*, and *Streptacidiphilus*; while Non-Streptomyces Group consist of genera

During the study on isolation and identification of actinomycetes found in several botanical gardens and other area in Indonesia, we found 3,193 isolates of actinomycetes from soil and leaf-litter samples. These isolates have not been screen for their application in bioindustry. In this paper, we screened actinomycetes collection for their capability to produce cellulolytic enzym. We also describes cell growth and cellulolytic activity of *Streptomyces* sp. strain ID6-455 which described as a strain that has a good cellulolytic activity. In the preliminary study, we also try to apply the strain to degrade agricultural waste for production of compost. The methodology used to detect cellulolytic activity of actinomycetes was using soluble cellulose derivatives (CMC-carboxymethylcellulose) as substrate.

Material and Methods

Microorganisms

A total of 94 actinomycetes collected in Kutai National Park in East Kalimantan, Gili and Kuta in Lombok Island, and Cibinong in West Java, Indonesia, were screened to their cellulolytic activity. The actinomycetes were isolated from soil samples.

Table 1. Sources of Actinomycetes/Sterptomyces Used in This Study

Isolated from	Number of Isolates used in this study
	Soil Samples
Kutai National Park, East Kalimantan	54
Gili and Kuta, Lombok Island	28
Cibinong Science Center, West Java	14

Screening for Cellulase-Producing Actinomycetes

Each isolate was cultured on the production medium containing substrate of Carboxy Methyl Cellulose (CMC) agar plate. Pure actinomycetes/Streptomyces isolates were cultured onto CMC agar plates and incubated for 4 days at 28°C. Plates were then flooded with 0.1% Congo red for 15-20 min, then washed with 1ml NaCl, and kept overnight at 5°C. Bacterial colonies exhibiting clear zones against red color of non-hydrolyzed media were considered cellulase producers; and were tested again for confirmation (Carder, 1986).

Characterization of the Most Active Actinomycetes Isolates

Actinomycetes colonies that showed the largest clear zone were characterized morphologically and physiologically according to the International Streptomyces project (ISP) (Shirling and Gottlieb, 1966) and as described by Saadoun et al. (2008).

Cellulase Activity Assay

Cellulase activity was measured following the method of Miller (1959). Briefly, a reaction mixture composed of 0.2 ml of crude enzyme solution plus 1.8 ml of 1% carboxymethyl cellulose (CMC) in 50 mM sodium phosphate buffer (pH 7.0) was incubated at 37 °C in a water bath for 30 min. The reaction was terminated by adding 3 ml of DNS reagent. The color was then developed by boiling the mixture for 5 min. Optical densities of samples were measured at 575 nm against a blank containing all the reagents minus the crude enzyme. Results were interpreted in terms of enzyme activity in which one unit (U) of enzyme activity was defined as the amount of enzyme, which liberates 1µmol of glucose per minute under the above assay conditions (Miller, 1959).

Thin layer chromatography (TLC)

TLC was done using silica gel (F254, Merck). It was developed at ambient temperature for 30 min with the solvent system of chloroform-methanol-water (90 : 65 : 15). Spots were visualized by spraying with 6% serium sulfate solution, and heating at 100°C for 10 min.

Effects of pH and Temperature on Cellulase Activity

This experiment was designed to test the effect of the combination of both temperature and pH on cellulase activity. Buffers of citrate (pH 5, and 6), phosphate (pH 7), and Tris HCl buffer (pH 8 and 9) at 50 mM were used in this study to prepare 1% (W/V) CMC solution. Culture filtrates were used as crude enzyme source. Enzyme production was assayed as described earlier at a wide range of temperatures from 30 to 90°C.

Phylogenetic tree of potential isolates

The multiple alignments were performed by the program Clustal W (ver. 1.6) (Thompson et al., 1994). The distance matrixes for the aligned sequences were calculated by the two-parameter method of Kimura (1980). The Neighbour-Joining method was used for constructing a phylogenetic tree (Saitou and Nei, 1987). The robustness for individual branches were estimated by bootstrapping with 1000 replicates (Felsenstein, 1985). The type strains of the species and the accession numbers of the nucleotide sequences were cited from databases.

Results and Discussion

Actinomycetes Isolates

A total of 94 isolates actinomycetes used in this study were isolated from soil in Kutai National Park in East Kalimantan, Gili and Kuta in Lombok Island, and Cibinong in West Java, Indonesia were defined as a Group of Streptomyces. Based on results in origin, all isolates were isolated from soil. More than 50% of tested isolates capable of degrading CMC as indicated by the formation of clear zone around the growing colonies (Fig 2.), then 8 isolates (ID6-285, ID6-297, ID6-363, ID6-378, ID6-381, ID6-455, ID6-491 and ID6-499) have strong ability to degrade CMC (Table 1). One colony was selected (ID6-455) for physiology tests performed, the profile the use of substrate CMC, pH optimum, temperature optimum and enzyme activity cellulase.

Screening for Cellulase-Producing Actinomycetes

Table 1. Actinomycetes isolates that have cellulolytic activity

No	Colony appearance		16S rDNA closest to	16S rDNA similarity (%)
	Isolate	Clear zone (cm)		
1	ID6-101	1.3	<i>Nonomuraea</i>	97
2	ID6-109	1.76	<i>Micromonosporaceae</i>	96
3	ID6-153	1.6	<i>Streptomyces</i>	97
4	ID6-238	1.38	<i>Micromonosporaceae</i>	96
5	ID6-256	3	<i>Streptomyces</i>	97
6	ID6-279	1.9	<i>Streptomyces</i>	96
7	ID6-285	3.94	<i>Streptomyces</i>	97
8	ID6-297	3.47	<i>Streptomyces</i>	97
9	ID6-293	2	<i>Streptomyces</i>	97
10	ID6-304	2.7	<i>Streptomyces</i>	96
11	ID6-320	2.2	<i>Streptomyces</i>	97
12	ID6-327	1.1	<i>Streptomyces</i>	97

No	Colony appearance		16S rDNA closest to	16S rDNA similarity (%)
	Isolate	Clear zone (cm)		
13	ID6-330	2.8	<i>Streptomyces</i>	96
14	ID6-332	2.5	<i>Streptomyces</i>	97
15	ID6-349	2.66	<i>Streptomyces</i>	97
16	ID6-363	3.46	<i>Nonomuraea</i>	97
17	ID6-364	2.65	<i>Streptomyces</i>	99
18	ID6-373	1.75	<i>Streptomyces</i>	97
19	ID6-376	2.4	<i>Streptomyces</i>	97
20	ID6-378	3.15	<i>Streptomyces</i>	97
21	ID6-381	3.18	<i>Streptomyces</i>	96
22	ID6-390	2.4	<i>Streptomyces</i>	97
23	ID6-393	3.45	<i>Streptomyces</i>	96
24	ID6-404	1.9	<i>Streptomyces</i>	97
25	ID6-407	2.1	<i>Streptomyces</i>	91
26	ID6-419	2.5	<i>Streptomyces</i>	98
27	ID6-421	1.8	<i>Streptomyces</i>	97
28	ID6-422	1.4	<i>Streptomyces</i>	97
29	ID6-425	1.8	<i>Streptomyces</i>	97
30	ID6-426	1.9	<i>Streptomyces</i>	96
31	ID6-432	3	<i>Streptomyces</i>	97
32	ID6-439	2.65	<i>Streptomyces</i>	96
33	ID6-445	2.1	<i>Streptomyces</i>	97
34	ID6-455	4.40	<i>Streptomyces</i>	97
35	ID6-472	2.1	<i>Streptomyces</i>	97
36	ID6-486	3	<i>Streptomyces</i>	96
37	ID6-491	4.35	<i>Streptomyces</i>	97
38	ID6-499	3.37	<i>Streptomyces</i>	97

From 94 isolates actinomycetes screened, 38 isolates of forming a clear zone on CMC media that have the potential activity to produce cellulase enzymes were obtained. Ten isolates of which shown high cellulose degradation activity were selected to further study. The high cellulose degradation activity of actinomycetes were chosen by the diameter of clear zone is about a 3-4 cm, as shown in Table 1. Further, reproducibility screening test from 10 isolates was conducted by re-analyzed them with the same method. One isolate, ID6-455 was used for next study because it has high activity to degrade CMC substrate.

Characteristics of cellulolytic actinomycetes ID6-455 strain.

Characteristic morphology of the one potential isolate ID6-455 strain was studied. Colony of strain ID6-455 obtained nearly round shape, flat edges, and the surface hairy. White color colony appeared in early stage of growth and became dark gray color colony during the incubation period. Colony color difference may due to differences in colony age. According Lechevalier and Lechevalier (1980) color that appears in the colony actinomycetes have resulted from pigmentation.



Fig 1. *Streptomyces* sp. Strain ID6-455

Isolate ID6-455 that obtained from isolation of soil in Lombok, using Sodium Dodecyl Sulfate-Yeast Extract medium showed branched substrate mycelia, from which aerial hyphae developed in the form of closed spirals

formation. Mycelium grown from vegetative branches form mycelia fibers. The whole-cell hydrolysate of the strain contained LL-diaminopimelic acid. Based on these characteristics, strain ID6-455 considered to the genus *Streptomyces* (Fig.1).

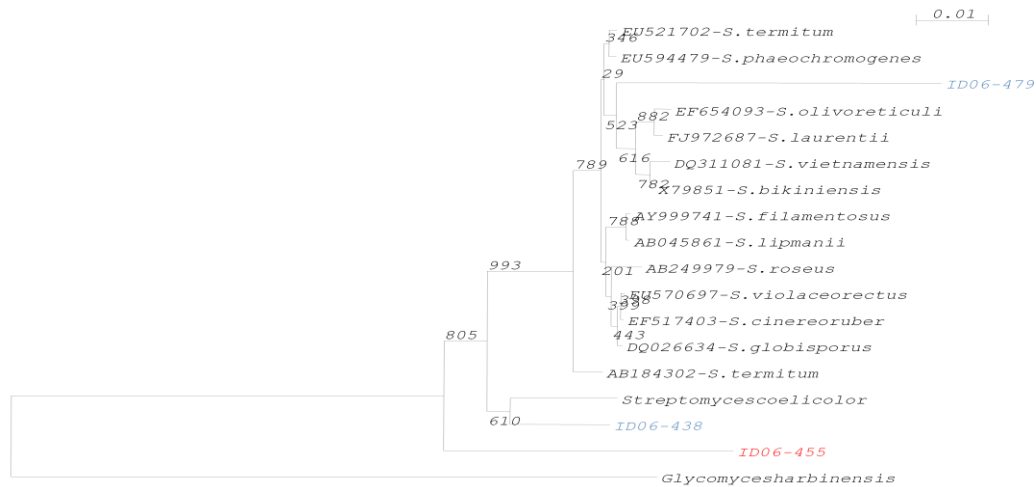


Fig.2 Phylogenetic tree of ID6-455 strain

Further analysis on phylogenetic analysis of its 16S rDNA sequence revealed that closely related species was genus *Streptomyces*, which has 97% nucleotide similarity (Fig.2). Observations on the formation of clear zones on the area around the colony indicates the existence of clear zone, which means that the active isolates obtained degrade cellulose (CMC) substrat as shown in Fig 3.

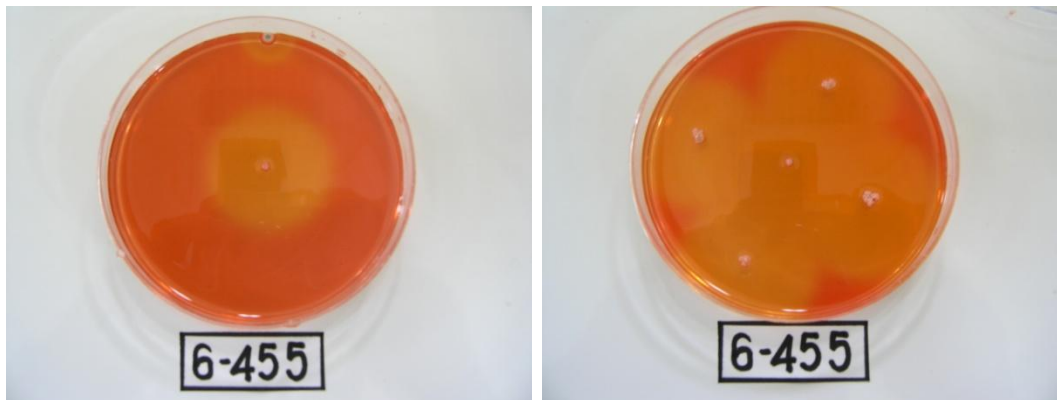
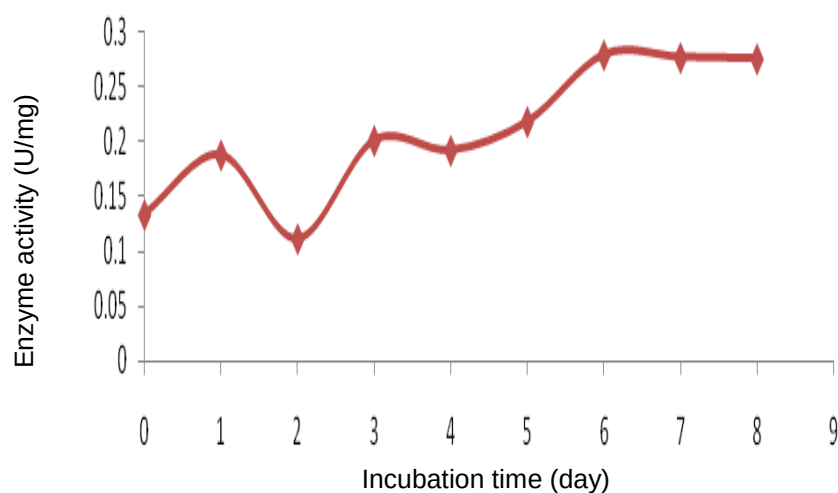


Fig. 3 Cellulolytic actinomycetes screening using the Congo red method.

Cellulase Activity Assay

Streptomyces species have been always a source of thousands of bioactive compounds. Enzymes are one of the important products of this unusual group of bacteria. Most of the *Streptomyces* isolates recovered from the different soils produced fiber hydrolytic enzymes. Cellulase, one important hydrolytic enzyme, was produced by most of the isolates (Saadoun et al, 2008).



This studies had shown that cellulase production was closely paralleled the growth curves. Specific activity of cellulase enzymes produced from *Streptomyces* sp. Strain ID6-455 increased with growth time. The highest specific activity achieved during the incubation for 6 days, in the amount of 0.279 U / mg (Fig. 4).

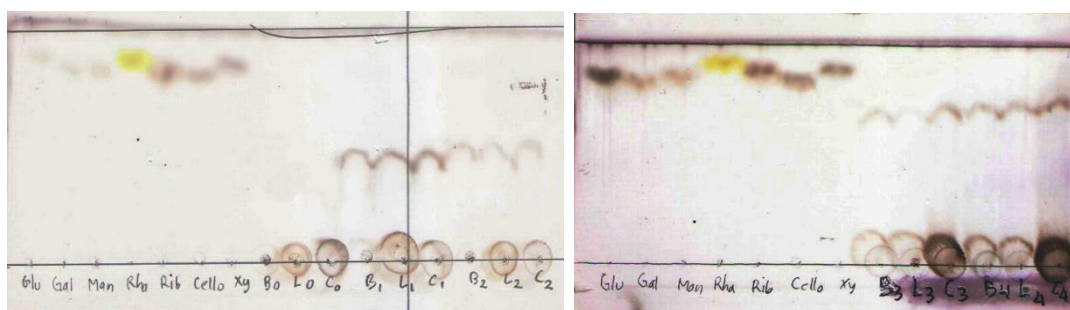


Fig 5. Thin layer chromatogram of substrat hydrolyzed by ID6-455 strain

We have tried to investigate various carbohydrates production and cellulose degrading enzyme activity in the culture broth of cellulase producing actinomycetes, strain ID6-455, by thin layer chromatogram analysis. Thin layer chromatogram of oligosaccharides produced is shown in Fig. 5. Substrat Xylan, Mannan and Carboxymethylcellulose (CMC) were degraded by cellulase enzyme strain ID6-455 produced and an oligosaccharide have already been detected after one-day culture. Chromatographic results indicate that a variety of oligosaccharide intermediates are formed by hydrolysis of Birchwood xylan, Locus bean and CMC, thus indicating internal hydrolysis of the cellulose chain.

Effects of Ph and Temperature on Cellulase Activity

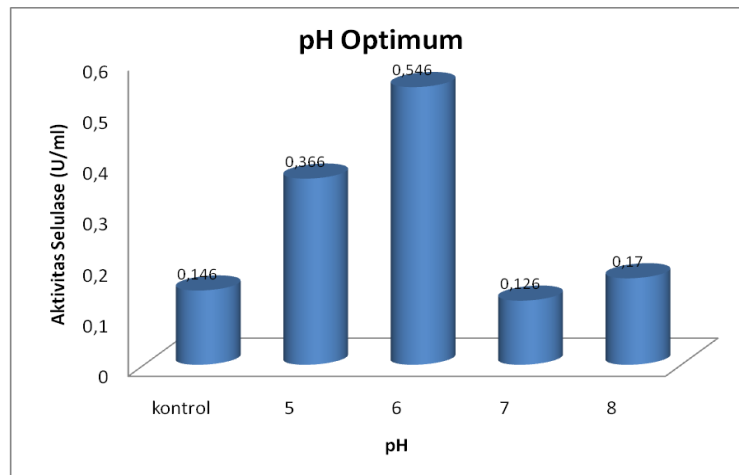


Fig 6. Effect of pH on CMCase activity

Fig 6 and Fig 7 shows the effect of pH and temperature on cellulase activity; pH and temperature ranges of 5.0 to 8.0 and 30 to 90 °C respectively were necessary for maximum enzyme activity. CMCase enzyme from the active isolate ID6-455 was found active over a pH range of 5-8 with maximum activity at pH 6. This result is considerably similar to what was reported by Theberge et.al. (1992) who showed that the optimum pH for endoglucanase from a strain of *Streptomyces lividans* was 5.5.

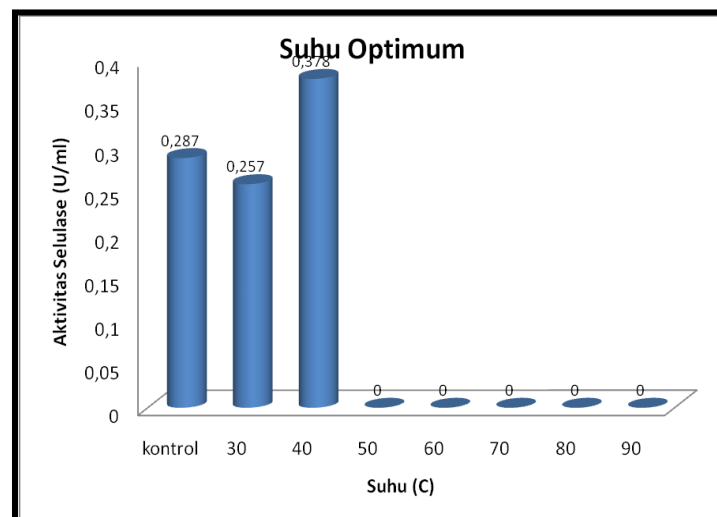


Fig 7. Effect of temperature on CMCase activities

The maximum CMCase activity of isolate ID6-455 was recorded at 40 °C, and the maximum CMCase or cellulase activity of isolate 6-455 was measured as 0.378 U/ml. These results are in agreement with results reported by McCarthy (1987), who reported an optimal temperature for cellulase activity in the range of 40-55 °C for several *Streptomyces* species including *S. lividans*, *S. flavogrisus*, and *S. nitrosporus*.

Conclusion

In conclusion, the findings of the present study showed that naturally occurring actinomycetes have a great potential to produce cellulase enzyme. Our analysis of screening for cellulolytic actinomycetes showed a high of degradation activities was produced by *Streptomyces* species. Screening cellulose enzyme producers from 94 isolates actinomycetes showed a varied clear zone of degradation CMC substrate among the isolates, between 0- 4.40 cm and about 38 isolates have potential degradation activity of CMCase. The highest degradation of CMCase was

performed from isolate ID6-455 identified as *Streptomyces* sp, with the highest specific activity achieved during the incubation for 6 days, in the amount of 0.279 U / mg. pH optimum of pH 6, with the highest activity of 0.279 U / ml and optimum temperature of 40 °C, with the highest activity of 0.378 U / ml.

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Molecular Identification of Actinomycetes Isolated from Termite Mound

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Abstract

Cellulose, the most abundant form of fixed carbon in the biosphere, is insoluble and its efficient degradation is largely restricted to those specific groups of microorganisms that are able to produce multiple cellulases. Many microorganisms can attack amorphous cellulose to some degree, but relatively few taxa can completely degrade highly crystalline cellulose. Cellulose tends to be highly lignified and more difficult to degrade, and both fungi and actinomycetes can obtain access to cellulose in woody tissue due to their hyphal growth form. Termites play an important role in the turnover of lignocellulolytic material and cellulolytic microorganisms were found both in gut, nest, and mound of termites. A termite nest and mound is usually built from a mineral matrix mixed with feces or saliva, depending upon the termite species. Actinomycetes have been frequently found in other termite studies and were dominant in the nest and mound of the soil-feeding termite. The aim of this study is to identify actinomycetes isolated from termite nest. Two isolation methods, Rehydration and Centrifugation (RC) method and Sodium Dodecyl Sulphate added by Yeast Extract (SDS-YE) method, were used for isolation. RC method was used to isolate member of motile rare actinomycetes and SDS-YE method were used to isolate member of the genus *Streptomyces*. Twelve actinomycetes were isolated from the nest sample that has pH 5. Six of them have capability to degrade CMC and showed ratio clear zone from 1.6-2.7 detected by congo red method. Molecular identification, biochemical characterization, and scanning electron microscopy of selected isolates were conducted.

Key words : actinomycetes, identification, termite nest, cellulose

Introduction

Termites live colonize and build nests for themselves. The smallest unit of nest builders are small bricks made of soil, which made worker termites by mixing their saliva as adhesive. Part of the termite nest filled with narrow corridors. On the inside of these halls, there are about one and a half million termite which worked together with remarkable harmony. When we observe the cross-section of a nest of termites, we will find a special chamber for the queen, a number of agricultural areas, storage warehouses and alleyways regulator air conditions. Termites do construction work and repair the nest. In addition, they are also always ready to face an enemy that may come, and grow crops in their nest with plant fungi in some species of termites.

Termites are recognized as one of the major ecosystem engineers in tropical soils (Wright & Jones, 2006). Their effects on soil are caused mostly by their major construction activities, of which their nests are the most complex type. A termite nest is usually built from a mineral matrix mixed with feces or saliva, depending upon the termite species. The nest is characterized by a very compact structure rich in organic matter resulting from the fine mixture of feces and soil particles (Roose-Amsaleg *et al*, 2004). The construction of the nests causes both physical changes (in water-holding capacity, bulk density, and structural stability) and chemical changes (in cation-exchange capacity and organic matter content) in the surrounding environment for microorganisms. For this reason, termite nests are a major functional compartment in tropical soils, comparable to the drilosphere created by earthworms, which can modify the activity and diversity of microbial soil communities. Termites can live solely on wood for food. Termites play an important role in the turnover of lignocellulolytic material and cellulolytic microorganisms were found both in gut, nest, and mound of termites (Bakalidau *et al*, 2002; Watanabe *et al*, 2003; Fall *et al*, 2004 and 2007).

Termite nest material is often poor soil type, because termites build their nests mainly with subsoil that is typically lower in organic matter and nutrient content than topsoil. Further, former mound material is often dense and hard due to the cementing activities of termites, making plant growth difficult. The effect of termites on soil is closely linked to their feeding habits and the type of constructions they build (18). However, the materials of abandoned nests may provide islands of relatively high plant production, where the subsoil is richer in mineral nutrients than the topsoil

or is rich in clay compared to a very sandy surface soil. Within the nests, various different bacterial communities coexist in microenvironments (aggregates) created by the termites (Fall *et al*, 2007).

Actinomycetes are a group of Gram-positive bacteria that have high G+C content. In general, actinomycetes could be divided into two groups, (i) Streptomyces group and (ii) non-Streptomyces group or so-called rare actinomycetes. Actinomycetes are common and ubiquitous in natural substrates, such as soil, where they usually play a significant role in the degradation of the more recalcitrant, naturally occurring organic polymers including cellulose (Williams *et al*, 1984). Many actinomycetes are commercially important, either in the production of antibiotics and other bioactive secondary metabolites, or in useful biological processes (Okami and Hotta, 1988). Streptomyces group is the most abundant and recoverable actinomycetes occurring in soil. Currently, the number of genera in this group is not more than 3 genera, but the number of species of this group is more than 400. While, the number of genera in the rare actinomycetes group is more than a fifty genera. Currently, identification of bacteria required on analysis 16S rRNA gene. Bacteria could be identified precisely and correctly by using molecular methods (Stackebrandt *et al*, 1997).

This is aim of this study for isolation of actinomycetes from termite nest that have ability to degrade cellulose, identification of the isolates using morphological and biochemical characteristics, further, molecular identification of selected isolate by analysing 16S rRNA gene.

Materials And Methods

Soil Sample and Its Treatment

A soil sample from termite nest isolated from Cibinong, West Java, were used as sample. Soil sample previously ground with a blender, were sieved and air-dried, then actinomycetes were isolated.

Rehydration-Centrifugation (RC) Isolation Method

RC method (Hayakawa *et al*, 2000) were employed to isolate actinomycetes from termite nest. RC method is a simple enrichment method incorporating differential centrifugation for the isolation of motile actinomycetes. The detailed method is as follow: an 0.5 g of air-dried soil was put in a conical beaker (46 mm in diameter and 60 mm deep); the sample was added gently with 50 ml of 10 mM-phosphate buffer containing 10% soil extract and was capped loosely with aluminum foil, and incubated statically at 30°C for 90 min to allow liberation of motile zoospores; after that, 8 ml of the flooding solution was transferred into a screw-cap test tube (16.5 x 105 mm) and was centrifuged at room temperature for 20 min at 1,500 x g in a swinging bucket rotor to eliminate streptomycetes and other non-motile actinomycetes from the supernatant; the test tube was allow to settle for 30 min, and a portion (8 ml) of the supernatant containing zoospores was taken for serial dilution with distilled water; aliquots (0.2 ml) of 10⁻⁴ and 10⁻⁵ dilution was plated onto HV agar and was incubate at room temperature for 2–3 weeks. Yeast Extract and Starch (YS) agar containing 0.5% yeast extract and 0.5% starch were used for maintaining of isolates

Sodium Dodecyl Sulphate-Yeast Extract (SDS-YE) Isolation Method

SDS-YE method (Hayakawa and Nonomura, 1989) were employed to isolate actinomycetes from termite nest. The SDS-YE method is a direct isolation of general actinomycetes including the genus *Streptomyces*. The detailed method is as follow: 1 gram of air-dried soil sample was put in a tube containing 10 ml of sterile distilled water and stirred for 1 min; the tube was allow to stand for 1 min to precipitate coarse sand; 0.5 ml of the supernatant was taken and was added to 4.5 ml of sterile 5 mM phosphate buffer (pH 7.0) containing 6% yeast extract as spore activating agent and 0.05% sodium dodecyl sulfate as germicide reagent. The solution was kept at 40°C for 20 minutes and 1 ml for serial dilution were taken with sterile distilled water; and aliquots (0.2 ml) of 10⁻⁴ and 10⁻⁵ dilution was plated onto HV agar and was incubated at room temperature for 2–3 weeks. Yeast Extract and Starch (YS) agar containing 0.2% yeast extract and 10.0% starch pH pH 7±0 were used for maintaining of isolates

Humic Acid, Vitamins, and Antibiotics (HV+Vit+Antibiotics) Agar

HV+Vit+Antibiotics agar was used as isolation medium for actinomycetes. The composition of HV agar (Hayakawa and Nonomura, 1987) was 0.1% Humic acid, 0.002% CaCO₃, 0.001% FeSO₄·7H₂O, 0.171% KCl, 0.005% MgSO₄·7H₂O, 0.05% Na₂HPO₄, B-vitamins, and 1.8% Agar. The pH was adjusted to 7.2. The 1.0g of humic acid was dissolved in 40 ml of 0.4% NaOH and heat at 100°C for 30 min before using in the medium. The 0.5 mg each of thiamine-HCl, riboflavin, niacin, pyridoxin-HCl, inositol, Ca-pantothenate, *p*-aminobenzoic acid and 0.25 mg of biotin were dissolved in 100ml distilled water and filter-sterilized. HV agar supplemented 0.002% nalidixic acid (Sigma Chemical Co., St Louis) was used as the isolation medium. The medium also contained 0.005% cycloheximide (Wako) and kabisidin to suppress fungal growth.

Cellulose Activity Test

The actinomycetes were grown on cellulose methyl carbonate (CMC) agar medium containing 0.5% CMC, 0.075% peptone; 0.05% yeast extract; 0.14% $(\text{NH}_4)_2\text{SO}_4$; 0.2% KH_2PO_4 ; 0.03% $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$; 0.03% $\text{CO}(\text{NH}_2)_2$; 0.03% CaCl_2 ; 0.0005% $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$; 0.00016% $\text{MnSO}_4 \cdot 7\text{H}_2\text{O}$; 0.00014% $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$; 0.0002% CoCl_2 ; 1.2% Agar. The pH of medium was adjusted to 7.0 with 1M NaOH. The agar plates were incubated at 30°C for 5-7 days to allow for the secretion of cellulose. At the end of the incubation, the agar medium was flooded with an 1% aqueous solution of congo red for 15 minutes. The congo red solution was then poured off, and the plates were further treated by flooding with 1M NaCl for 15 minutes. The formation of a clear zone of hydrolysis indicated cellulose degradation. The ratio of the clear zone diameter to colony diameter was measured in order to select for the highest cellulose activity producer. The largest ratio was assumed to contain the highest activity.

Morphological Characterization

Actinomycetes were examined by eye and by using a light microscope and tentatively identified up to group rank based on morphological criteria. Cultures grown on HV agar ISP-2 agar, and YS agar for 3±14 days at 28°C were observed with a light microscope and with a scanning electron microscope (model JSM-5400; JEOL). Samples for scanning electron microscopy were prepared by cutting a block from an agar plate containing the strain, mixing the block in 2% osmium tetroxide vapour at room temperature for overnight, washing gradually with ethanol, dehydrating the cells by freeze-drying, and then sputtercoating them with palladium under vacuum.

Diamino Pimelic Acid Analysis

A piece of culture in solid agar with a diameter of 0.5 cm put into the screw tube containing 500 µL of 6N HCl and autoclave at a temperature 121°C for 15 minutes. Sample solutions and standard of diaminopimelic acid (0.1 mg/mL) were spotted 20 µL on thin layer chromatography (TLC) plate and developed in the TLC chamber with methanol: miliQ: 6N HCl: piridin = 20 mL: 6.5 mL: 1 mL: 2.5 mL as eluent phase for overnight. The plates were sprayed with a mixture of 0.05 g ninhidrin and 25 mL of *n*-butanol, heated 120°C for 5-10 minutes, and immediately analyzed.

Carbon Utilization Tests

The ability of strains to use 18 different sole carbon sources was examined using ISP medium 9 as a basal medium.

16S rRNA Gene Sequence Analysis

Genomic DNA was extracted as described by Saito and Miura (1963) and amplification of 16S ribosomal RNA (rRNA) gene was by PCR mediated using TaKaRa Taq polymerase (Takara Shuzo, Kyoto, Japan) and the primer pairs, 9F (5'-GAGTTTGATCCTGGCTCAG) and 1541R (5'-AAGGAGGTGATCCAGCC). Amplified 16S rRNA gene (1.5 kb) was purified and directly sequenced using an ABI PRISM BigDye Terminator Cycle Sequencing Ready Reaction Kit (Applied Biosystems, Foster City, Calif., USA) as specified by the manufacturer. The sequencing primers were: 9F (5'-GAGTTTGATCCTGGCTCAG), 515F (5'-GTGCCAGCAGCCGCGCGGT), 536R (5'-GTATTACCGCGGCTGCTG), 785F (5'-GGATTAGATACCTGGTAGTC), 802R (5'-TACCAGGGTATCTAATCC), 1099F (5'-GCAACGAGCGCAACCC), 1115R (5'-AGGGTTGCGCTCGTTG), and 1541R (5'-AAGGAGGTGATCCAGCC) (Brosius *et al.*, 1981). An Applied Biosystems PRISM 310 Genetic Analyser performed electrophoresis of the sequencing reaction mixtures. The 16S rRNA gene sequences determined in this study were manually aligned with the published sequences of reference strains available from the EMBL/GenBank/DBJ databases. The CLUSTAL W software package (Thompson *et al.*, 1994) generated evolutionary distances (the K_{nuc} value of Kimura, 1980) and similarity values. A phylogenetic tree was constructed by neighbour-joining (Saitou and Nei, 1987) from K_{nuc} values. The topology of the phylogenetic tree was evaluated by bootstrap re-sampling as described by Felsenstein (1985) with 1000 replicates.

Results and Discussion

This research was conducted to isolate actinomycetes from termite nest. The methods used in the isolation were Rehydration-Centrifugation (RC) Method and Sodium Dodecyl Sulphate-Yeast Extract (SDS-YE) Method. RC method was used to isolate motile zoospore bearing and rare actinomycetes such as genera *Actinoplanes*, *Dactylosporangium*, *Actinokineospora*, *Actinosynnema*, *Catenuloplanes*, *Couchioplanes*, *Geodermatophilus*, *Kineosporia* and *Sporichthya*; while, SDS-YE method was used to isolate *Streptomyces* Group. Humic acid with antibiotics used for isolation medium was used for growing well of actinomycetes and elimination of the growth of other bacteria and fungal contaminants (Hayakawa and Nonomura, 1987). The average of total colony of actinomycetes

obtained in the process of isolation by RC method were less than by SDS-YE method (Table 1). From the morphological test of the colonies, it is indicate that *Streptomyces* Group is abundant in the sample. The pH of the sample was 5 or acid. Actinomycetes generally intolerant of acid and decreased amounts of state environment with a pH below 5.0. The most suitable pH range for actinomycetes is between 6.5-8.0.

All the colony were picked up from agar plates, and twelve representative isolates were selected for further study. One strain was isolated from RC method (08-KR8) and 11 strains from SDS-YE method (08-KR1, 08-KR2, 08-KR3, 08-KR4, 08-KR5, 08-KR6, 08-KR7, 08-KR9, 08-KR10, 08-KR11, 08-KR12).

Cellulose degradation test of isolates was done by growing the isolates on the media containing Carboxy Methyl Cellulose (CMC). Cellulose activity of positive isolates from termite nests is shown in Table 2. The results showed that 6 isolates (08-KR2, 08-KR3, 08-KR6, 08-KR9, 08-KR11, and 08-KR12) had positive ability to degrade CMC through the formation of clear zones around their colony. Actinomycetes that contributing to degrade cellulose is largely derived from the genus *Streptomyces*. The ratio of clear zone is calculated based on the ratio between the diameter of clear zone with a diameter of colony. The 6 isolates was further identified through the phenotypic and genotypic characterization.

Table 1. Number of Actinomycetes in Termite Nest

Isolation Method	Σ CFU/g sample	pH sample
RC	8.7×10^2	5
SDS-YE	1.2×10^5	5

Table 2. Cellulose Activity of isolates

No	Isolate Code	Ratio Clear Zone Cellulose Degradation
1.	08-KR2	1.667
2.	08-KR3	1.688
3.	08-KR6	2.054
4.	08-KR9	1.633
5.	08-KR11	2.125
6.	08-KR12	2.708

Identification through morphological characteristics is done by microscopic and macroscopic observations such as the surface of spores, colony color, shape sporulation, type substrate mycelium, the color of colony reverse, and the color of the pigment dissolved. The results of morphological characteristics of isolates is presented in Table 3.

Table 3. Morfological Characteristic of isolates at 14 days incubation

Isolate Code	Characteristics					
	Spore appearance	Color of colony	Sporulation type	Substrate mycelium	Color of colony reverse	Color of Soluble pigment
08-KR2	Knobby	Pale Vinaceous	Verticillati	Long Branch	Bay	Amber
08-KR3	Smooth	Pale violet	Spira	Long Branch	Sienna	Amber
08-KR6	Hairy	Lavender	Spira	Long Branch	Umber	Amber
08-KR9	Smooth	Lavender	Verticillati	Long Branch	Umber	Amber
08-KR11	Knobby	Grey Lavender	Spira	Long Branch	Umber	Amber
08-KR12	Smooth	Purplish Grey	Spira	Long Branch with Septum	Violet Blue	Umber

Morphological observation of actinomycetes is very important to describe the isolates into the genus level. Type of sporulation with spore chain is a special characteristic of *Streptomyces*. Sporulation type of *Streptomyces* consists of 4 kinds, namely rectiflexibile, retinaculiaperti, spira, and verticillati. Spores rectiflexibile has a straight chain or flexuous, retinaculiaperti has spores with a chain hook and an open circle (usually have a spiral shape with round 3 times), spira has a shape of a spiral spore chains with 2 different types (the spiral closed and open spiral like a spring), and verticillati has spores chain branching with sometimes forming 3 branches. The genus *Streptomyces* produces a branched substrate mycelium and rarely fragmented. Observations with a microscope showing aerial mycelium and spores spira chain as in Figure 1. In the macroscopic, colony of actinomycetes is hard and gripped in the media.

Streptomyces produces substrate and aerial mycelium is pigmented, and some are having a pigment secreted into the medium. Color spectrum of this genus vary white, yellow, purple, gray, to black. Based on these results, it revealed that the isolates were identified into the genus *Streptomyces* (Lechevalier and Lechevalier, 1970).

Cell wall composition of the genus *Streptomyces* has its own unique compared with other actinomycetes and other Gram-positive bacteria. Usually, the cell wall of actinomycetes has a peptidoglycan structure that contains *meso*-diamino pimelic acid in the cell wall, but the genus *Streptomyces* has the form *LL*-diamino pimelic acid. Diamino pimelic acid analysis was done using thin-layer chromatography. The result of diamino pimelic acid analysis of selected isolates is shown in Figure 2. Diamino pimelic acid analysis results for all isolates (08-KR2, 08-KR3, 08-KR6, 08-KR9, 08-KR11, and 08-KR12) showed spots corresponding to the standard *LL*-diamino pimelic acid. This indicates that these isolates belong to the genus *Streptomyces* (Lechevalier and Lechevalier, 1970).

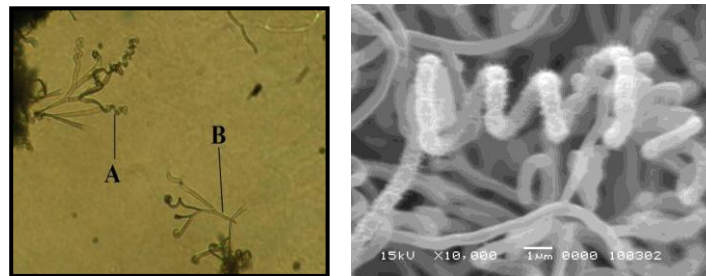


Figure 1. Morphological appearance of 08-KR2 isolate (the genus *Streptomyces*) at 14 days incubation using light microscope and scanning electron microscope. A is spore chain and B is aerial mycelium.

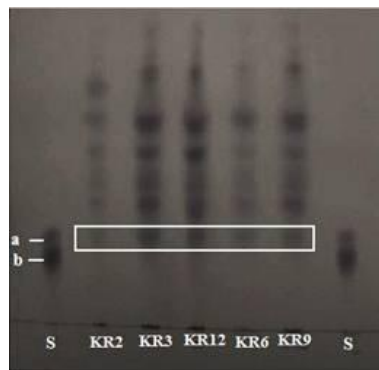


Figure 2. Diamino pimelic acid analysis (a= *LL*-diamino pimelic acid; b= *meso*-diamino pimelic acid; S= Standard diamino pimelic acid).

Utilization of a single carbon source of actinomycetes was conducted based on the method of Pridham and Gottlieb (1966). Carbon source could be chemically pure from contamination of other materials and other carbohydrate sources. Carbon sources used in the sugar utilization were glucose, inulin, lactose, sorbose, melibiose, myo-inositol, starch, galactose, arabinose, mannose, raffinose, ribose, mannitol, ramnose, xylose, melezitose, salicin, and cellobiose. The result of utilization of sugar as the sole carbon source is shown in Table 4. The medium used in this study was ISP No. 9 agar that specific to determine of utilization of sugar as the sole carbon source. Glucose was used as positive control because in general all actinomycetes were able to grow on medium containing glucose, and sugar free medium was used as negative control. The result shows that all isolates capable of using glucose as the sole carbon source. Based on 18 types of carbon sources, 08-KR2 only able to use arabinose and ribose as the sole carbon source, 08-KR3 capable of using mannitol and selobiose, 08-KR6 and 08-08-KR9 capable of using inulin, lactose, sorbose, melibiose, myo-inositol, starch, galactose, arabinose, mannose, ribose, mannitol, ramnose, xylose, melezitose, and cellobiose, 08-KR11 capable of using inulin, lactose, sorbose, melibiosa, myo-inositol, starch, galactose, arabinose, mannose, ribose, mannitol, ramnose, xylose, melezitose, salicin, and cellobiose, and 08-KR12 able to use starch, galactose, arabinose, mannose, xylose, and cellobiose.

The genotypic characterization is one of the methods in the identification of direct contact with RNA or DNA molecules. One common practice is through the genes coding for rRNA approach, such as the 5S rRNA gene, 16S rRNA gene, and 23S rRNA genes. In general, 16S rRNA gene the most widely used for molecular identification of bacteria because it has a size of a relatively small base pair (1.5 Kbp) and easier to handle (Figure 3C). Three isolates

(08-KR02, 08-KR03, and 08-KR12) were analysed their 16S rRNA gene for identification into species level. BLAST Search analysis showed that the 08-KR3 had high DNA similarity (99%) with the existing data center, namely *Streptomyces fulvoviolaceus*. The 08-KR2 and 08-KR12 isolates had low DNA similarity (<96%) with strains existing data centers. The difference between the 16S rRNA gene sequence of isolates with the data center if more or same than >99% showed the same type of data center, while if less than <97% indicates that different types of data centers (Stackebrandt *et al*, 1997). Based of phylogenetic tree compare to other type species of the genus *Streptomyces* in data center, it was shown that 08-KR03 isolate was identified as *Streptomyces fulvoviolaceus* (Figure 3A). Both 08-KR2 and 08-KR12 isolates in Figure 3B are in the same group monofiletik but very much far with other species of the genus *Streptomyces*. 08-KR2 and 08-KR12 Isolates are probably a new species candidates. This proof still need more advanced test.

Table 4. Utilization of Carbon Sources

Carbon Source	Isolate Code					
	08-KR2	08-KR3	08-KR6	08-KR9	08-KR11	08-KR12
Carbon Free	-	-	-	-	-	-
Inulin	-	-	+	+	+	-
Lactose	-	-	+	+	+	-
Sorbose	-	-	+	+	+	-
Mellibiose	-	-	+	+	+	-
Myo inositol	-	-	+	+	+	-
Starch	-	-	+	+	+	+
Galactose	-	-	+	+	+	+
Glucose	+	+	+	+	+	+
Arabinose	+	-	+	+	+	+
Mannose	-	-	+	+	+	+
Raffinose	-	-	-	-	-	-
Ribose	+	-	+	+	+	-
Mannitol	-	+	+	+	+	-
Ramnose	-	-	+	+	+	-
Xylose	-	-	+	+	+	+
Melezitose	-	-	+	+	+	-
Salisin	-	-	-	-	+	-
Celobiose	-	+	+	+	+	+



Figure 3. Phylogenetic tree of isolate based n neighbour joining method

Conclusion

In this preliminary study of isolation and identification of actinomycetes in termite nest that have capability to degrade cellulose, we found some actinomycetes isolates from genus *Streptomyces* in termite nest that have capability to degrade carboxy methyl cellulose (CMC). By Rehydration and Centrifugation (RC) Isolation Method, Rare actinomycetes Group are less found. While, using Sodium Dodecyl Sulphate-Yeast Extract (SDS-YE) Isolation method, *Streptomyces* Group are abundant. By molecular identification, biochemical, and phenotypic characterization, the potential cellulose degrader actinomycetes are belong to the genus *Streptomyces*.

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Screening and Characterization of Actinomycetes Degrading Hemicellulose

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Abstract

Hemicellulose, the second abundant renewable biomass polymer next to cellulose, represent about 20-35% of lignocellulosic biomass. Polysaccharide component of hemicelluloses either linear or branched have found as heteroglycan in higher plants. Based on sugar composition, hemicellulose classified as xylan, mannan, arabinogalactan, and arabinan. Hemicellulose, together with cellulose and lignin is the largest component that make up the structure of plant cell walls. In the last several year, hemicellulase enzyme attracted great interest focused on, not only for academic purpose but also a high possibility of their application in the food industry, animal feed and pulp industry. Mannanase enzyme is also predicted to have the ability as facilitator bleaching process and food/feed industry. Ninety-six isolates of actinomycetes, BTCC (Biotechnology Culture Collection) collection, are screened their ability to produce xylanolytic enzymes and mannolytic enzymes. As results, 40 isolates have the ability to produce xylanolytic enzymes and 23 isolates mannolytic enzymes. Xylanolytic and mannolytic capability had been detection with congo red method. Two isolates, ID06-479 and ID 06-438, are the hinger of xylanolytic and mannolytic capability which has clear zone are 3.7 cm and 3.2 cm in diameter, respectively. Optimisation production of the enzymes for 10 days fermentation showed that 2-days for xylanase with a specific activity on 1.773 U/mg and 4-days for mannanase with a specific activity on 2.790 U/mg. Molecular analysis of 16S rRNA gene of ID 06-479 and ID 06-438 identified that both isolates belong to the genus *Streptomyces* sp.

Key words : Screening, Characterization, Actinomycetes, Hemicellulose

Introduction

Lignocelluloses in nature derive from wood, grass, agricultural residues, forestry wastes and municipal solid wastes (Perez *et.al.* 2002). Several biological methods for lignocellulose recycling, based on the enzymology of cellulose, hemicellulose and lignin degradation, have been suggested. The naturally occurring lignocellulosic plant biomass consists of 20~30% hemicellulosic materials which are heterogeneous polysaccharides found in association with cellulose (Saha, 2000). Hemicelluloses are heterogeneous polymers of pentoses (D-xylose, L-arabinose), hexoses (D-mannose, D-glucose, D-galactose) and sugar acids (Howard, 2003). Unlike cellulose, hemicelluloses are not chemically homogeneous. Hardwood hemicelluloses contain mostly xylans, whereas softwood hemicelluloses contain mostly glucomannans (McMillan, 1993).

Xylan is the most abundant hemicelluloses and xylanases are one of the major hemicellulases which hydrolyse the β -1,4 bond in the xylan backbone yielding short xylooligomers which are further hydrolysed into single xylose units by β -xylosidase (Beg, *et. al.*, 2001). Most known xylanases belong to the GH 10 and 11 families and β -xylosidases are diistributed in families 3, 39, 43, 52 and 54. Bifunctional xylosidase-arabinosidase (Lee *et al.*, 2003) enzymes are found mainly in families 3, 43 and 54. β -mannanases hydrolyse mannan-based hemicellulose and liberate short β -1,4-manno-oligomers which can further be hydrolysed to mannose by β -mannosidases. α -L-arabinofuranosidases and α -L-arabinanases hydrolyse arabinofuranosyl-containing hemicelluloses (Moreira & Filho, 2008). Other xylanases are α -D-glucuronidases which hydrolyse the α -1,2-glycosidic bond of the 4-O-methyl-D-glucuronic acid sidechain of xylans and are found in family 67. Hemicellulolytic esterases include acetyl esterases which hydrolyse the acetyl substitutions on xylose moieties, and feruloyl esterase which hydrolyse the ester bond between the arabinose substitutions and ferulic acid. Feruloyl esterases aid the release of hemicellulose from lignin and renders the free polysaccharide product more amenable to degradation by the other hemicellulases (Prates *et al.*, 2001).

Actinomycetes (Gram-positive bacteria with a high G+C content), the genera *Streptomyces*, *Rhodococcus*, *Corynebacterium*, and *Mycobacterim* have received an increasing amount of attention, particularly in the industrial

fields (Nakashima, *et al.*, 2005). They exhibit potential advantages in the synthesis of secondary metabolites of industrial and medical importance, in the production of amino acids by fermentation, and in bioconversion processes. The compounds they produce as secondary metabolites are valuable for industrial and pharmaceutical purposes, and the enzymes themselves are also valuable (Donnadio, *et al.*, 2002).

During the last decade, the potential biotechnological applications of xylan and xylanases have been of particular interest to researchers (Kulkarni, *et al.*, 1999). At present, the major end products of xylan, which are of considerable importance, are furfural and xylitol. Furfural production is derived mainly from agricultural residues whereas xylitol is obtained from wood residues. The hydrolysis products of xylan (xylose and oligosaccharides) have possible applications in the food industry as thickeners or as fat substitutes and as an antifreeze food additive. In the pharmaceutical industry xylan is found suitable as an agent for 'direct tableting' and, in combination with other components, it can be used for delayed release tablet construction. The xylan hydrolysis products can be subsequently converted to liquid fuel, single cell proteins, solvents and artificial low calorie sweeteners (Kulkarni, *et al.*, 1999).

Indonesia is rich a lignocellulose biomass sources, this is the potential to be useful and product, such as bioconversion to energy, the substrate to organic fertilizer and functional food. Considering that Indonesia is rich in biodiversity, the isolation and identification of industrial important microbes such as actinomycetes is important not only to know the ecology of microorganisms but also to discover novel metabolism. The results of research collaboration between Indonesian Institute of Sciences (LIPI). Indonesia and National Institute of Technology and Evaluation (NITE), Japan have been isolation 3,193 isolate actinomycetes from several regions in Indonesia. In tis study, we've done screening actinomycetes degrading hemicelluloses of isolates that have been isolated from Lombok Island and Cibinong, West Java for organic biodegrade applications. The characterization of enzyme produced by several potential isolates also have been done.

Materials and Methods

Screening Mannolytic and Xylanolytic Isolate.

A total of 96 strains of actinomycetes were obtained from BTCC (Biotechnology Culture Collection), Research Center for Biotechnology, Indonesian Institute of Sciences (LIPI). The strains were isolated from soils in Lombok Island and Cibinong, West Java, Indonesia. The actinomycetes were grown on *locust bean gum* (LBG) agar medium for mannolytic and *birchwood xylan* (BWV) agar medium for xylanolytic test containing: 0.075% peptone; 0.05% yeast extract; 0.14% (NH₄)₂SO₄; 0.2% KH₂PO₄; 0.03% MgSO₄·7H₂O; 0.03% CO(NH₂)₂; 0.03% CaCl₂; 0.0005% FeSO₄·7H₂O; 0.00016% MnSO₄·7H₂O; 0.00014% ZnSO₄·7H₂O; 0.0002% CoCl₂; 1.2% Agar. A 0.5% LBG for mannolytic and 0.2% (BWV) for xylanolytic test. The pH of medium was adjusted to 7.0 with 1M NaOH. The LBG and BWV agar plates were incubated at 30°C for 5-7 days to allow for the secretion of hemicellulose. At the end of the incubation, the agar medium was flooded with an aqueous solution of Congo red (1% w/v) for 15 minutes. The Congo red solution was then poured off, and the plates were further treated by flooding with 1M NaCl for 15 minutes. The formation of a clear zone of hydrolysis indicated hemicellulose degradation. The ratio of the clear zone diameter to colony diameter was measured in order to select for the highest hemicellulose activity producer. The largest ratio was assumed to contain the highest activity.

Production and Preparation Mannase and Xylanase Enzyme

Medium for hemicellulose production contained 0.075% peptone; 0.05% yeast extract; 0.14% (NH₄)₂SO₄; 0.2% KH₂PO₄; 0.03% MgSO₄·7H₂O; 0.03% CO(NH₂)₂; 0.03% CaCl₂; 0.0005% FeSO₄·7H₂O; 0.00016% MnSO₄·7H₂O; 0.00014% ZnSO₄·7H₂O; 0.0002% CoCl₂. A 0.5% LBG for mannolytic test and 0.2% BWV for xylanolytic test was used as carbon source. The pH was adjusted to initial pH 7.0 by 1M NaOH. Fermentation was done in a 300mL Erlenmeyer at the temperature of 30°C with constant agitation speed of 150 rpm. Cells were harvested in late exponential growth phase by centrifuged at 8000 rpm for 20 minutes at 4°C (Wang *et al.*, 2003). The culture filtrates were analysed for mannase and xylanase enzyme activity, as well as protein content.

Xylanase and Mannanase Enzyme Assay

Mannanase activity was assayed using a modified method described by (Hossain *et al.*, 1996), 0.5% LBG as the substrate, which was preliminarily suspended homogeneously in 20 mM phosphate buffer (pH 7.0). The mixture, containing 0.5 ml of the substrate, was incubated at 30°C for 30 minutes. The amount of reducing sugars liberated was determined by using 3, 5-dinitrosalicylic acid (DNS method) (Miller, 1959). The reducing sugars of the reference sample (substrate solution incubated without enzyme and diluted enzyme solution buffer) were deduced from the values of the test samples. One unit of mannanase activity was expressed as µmol of reducing sugars (xylose equivalent) released in 1 min under the above conditions. Xylanase activity was assayed as above, using 0.2% BWV.

Protein Determination

Protein concentration was measured by the absorbance at 280 nm with a spectrophotometer and bovine serum albumin was used as standard.

Thin Layer Chromatography

Products from LBG and BWX hydrolysis were analyzed on silica gel plates (Kieselgel 60) using *n*-butanol : acetic acid : water (2:1:1, v/v/v) as a solvent. Saccharides were detected by spraying the plates with developed solution aniline hydrogen phthalate and heating at 100°C for 10 min (Lopez and Pastor 1998).

Isolation Actinomycetes

Strain ID06-438 actinomycetes which was the highest mannanase activity producer was isolation using SDS-Yeast Extract (SDS-YE) (Hayakawa and Nonumura, 1989) and maintaining using Yeast Starch agar medium (YS) and ID06-479 actinomycetes which the highest xylanase activity producer was isolation using Rehydration-Centrifugation method (RC) (Hayakawa, 2000) and maintaining using YS medium.

Sequence of 16S rRNA Gene and Phylogenetic Analysis

Strain ID06-438 and ID06-479 was identified with molecular analysis. The 16S rRNA gene sequences of the strain were determined. Extraction of DNA was carried out by using Promega DNA Extraction Kit. PCR-mediated amplification of the 16S rRNA gene and sequence determination were performed by Big Dye terminator V3.1 Cycle sequencing Ready Reaction Kit (Applied Biosystem) with the following 2 primer forward 9F (5'-GAGTTTGATCCTGGCTCAG) and reverse 1541R (5'-AAGGAGGTGATCCAGCC). Phylogenetic analysis, the multiple alignments were performed by the program Clustal W (ver. 1.6) (Thompson *et al.*, 1997). The type strains of the species and the accession numbers of the nucleotide sequences were cited from databases. Information of database 16S rRNA gene sequences was obtained from the EMBL/GenBank/DDBJ database. Phylogenetic tree was constructed using neighbour-joining (N-J) method.

Results and Discussions

Screening of Mannolytic and Xylanolytic Isolate

All the actinomycetes used in this study were isolated from soil samples. As they were isolated from soil, there is a possibility that some of the strains are hemicellulose producer. Therefore, a preliminary qualitative analysis for hemicellulolytic activity was conducted by using Congo red dye (Ariffin *et al.*, 2006). After 5-7 days of incubation, all 96 strains of actinomycetes showed signs of growth on LBG and BWX agar and demonstrated positive results in the Congo red test. Since the sole carbon source in LBG and BWX agar was mannose and xylose, respectively, therefore the result of the test was a strong evident that mannanase and xylanase was produced in order to degrade mannose and xylose, respectively. Result test for screening of mannolytic and xylanolytic degrading capability using congo red method is presented in Table 1.

Table 1. Screening of mannolytic and xylanolytic isolate

Isolate	Various Substrate					
	LBG			BWX		
	Diameter zone	Isolate color	Layer zone	Diameter zone	Isolate color	Layer zone
ID 06-078	-	-	-	-	-	-
ID 06-079	-	-	-	-	-	-
ID 06-090	-	-	-	-	-	-
ID 06-092	-	-	-	-	-	-
ID 06-101	-	-	-	-	-	-
ID 06-109	-	-	-	1.80	-	-
ID 06-116	1.40	-	-	1.40	-	-
ID 06-121	-	-	-	-	-	-
ID 06-124	-	-	-	-	-	-
ID 06-127	-	-	-	-	-	-

ID 06-143	-	-	-	-	-	-
ID 06-146	1.96	-	-	-	-	-
ID 06-151	-	-	-	-	-	-
ID 06-153	2.37	-	-	3.14	-	-
ID 06-181	1.75	-	-	-	-	-
ID 06-218	-	-	-	-	-	-
ID 06-221	-	-	-	-	-	-
ID 06-232	-	-	-	-	-	-
ID 06-238	-	-	-	-	-	-
ID 06-246	-	-	-	-	-	-
ID 06-256	3.20	-	-	2.70	-	-
ID 06-264	2.67	-	-	2.60	-	-
ID 06-279	3.20	-	-	-	-	-
ID 06-284	3.62	-	-	3.40	-	-
ID 06-285	3.40	-	-	3.50	-	-
ID 06-293	-	-	-	-	-	-
ID 06-295	-	-	-	-	-	-
ID 06-297	-	-	-	-	-	-
ID 06-299	-	-	-	-	-	-
ID 06-304	-	-	-	3.00	-	-
ID 06-306	-	-	-	-	-	-
ID 06-307	-	-	-	-	-	-
ID 06-308	-	-	-	2.45	-	-
ID 06-309	-	-	-	-	-	-
ID 06-320	2.50	-	-	-	-	-
ID 06-322	-	-	-	-	-	-
ID 06-326	-	-	-	-	-	-
ID 06-327	-	-	-	-	-	-
ID 06-329	-	-	-	2.70	-	-
ID 06-330	-	-	-	3.30	-	-
ID 06-332	-	-	-	2.60	-	-
ID 06-334	-	-	-	-	-	-
ID 06-342	-	-	-	1.70	-	-
ID 06-349	-	-	-	2.70	-	-
ID 06-352	-	-	-	-	-	-
ID 06-354	-	-	-	-	-	-
ID 06-355	-	-	-	1.76	-	-
ID 06-359	1.95	-	-	2.80	-	-
ID 06-361	-	-	-	-	-	-
ID 06-362	-	-	-	-	-	-
ID 06-363	-	-	-	-	-	-
ID 06-373	-	-	-	-	-	-
ID 06-376	-	-	-	-	-	-

ID 06-378	-	-	-	3.50	-	-
ID 06-381	-	-	-	3.00	-	-
ID 06-383	-	-	-	1.30	-	-
ID 06-386	-	-	-	2.10	-	-
ID 06-390	-	-	-	3.34	-	-
ID 06-391	-	-	-	-	-	-
ID 06-393	3.34	-	-	3.20	-	-
ID 06-404	1.30	-	-	3.90	-	-
ID 06-405	-	-	-	-	-	-
ID 06-407	-	-	-	2.40	-	-
ID 06-408	-	-	-	-	-	-
ID 06-411	-	-	-	-	-	-
ID 06-419	2.41	-	-	2.60	-	2
ID 06-420	-	-	-	-	-	-
ID 06-421	-	-	-	-	-	-
ID 06-422	-	-	-	-	-	-
ID 06-425	1.63	Y-B	-	1.70	-	-
ID 06-426	2.49	-	-	2.70	-	2
ID 06-432	-	-	-	1.40	-	2
ID 06-438	4.30	P-B	2	-	-	-
ID 06-439	-	-	-	-	-	-
ID 06-445	1.75	-	-	2.2	-	-
ID 06-448	-	-	-	2.44	-	-
ID 06-452	3.44	-	2	3.45	-	-
ID 06-453	-	-	-	3.50	-	-
ID 06-455	2.90	-	-	3.40	B-P-Y	3
ID 06-456	-	-	-	3.30	-	2
ID 06-463	-	-	-	-	-	-
ID 06-464	-	-	-	-	-	-
ID 06-467	-	-	-	-	-	-
ID 06-472	-	-	-	2.80	-	-
ID 06-479	2.77&4.5	O-B	2	3.70	-	3
ID 06-482	-	-	-	-	-	-
ID 06-485	-	-	-	-	-	-
ID 06-486	3.18	Y-P	2	2.70	-	-
ID 06-488	-	-	-	2.80	-	-
ID 06-489	-	-	-	-	-	-
ID 06-491	2.95	-	-	3.3	-	-
ID 06-496	-	-	-	-	-	-
ID 06-499	-	-	-	-	-	-

Note : Y: yellow, B: blue, P: purple, O : orange color of colony

Screening results showed that 23 isolates have capability to produce mannolytic enzyme, 39 isolates produced xylanolytic enzyme, and 18 isolates produced two enzymes mannolytic and xylanolytic evidenced by the clear zone on agar medium detected with congo red. ID06-479 BWX and ID06-438 LBG gave the highest ratio of clear zone

diameter to colony diameter. This indicated that more xylose and mannose was degraded in BWX and LBG agar plate cultured with ID06-479 and ID06-438 as compared to plates cultured with the other strains. ID06-438 mannolytic degrader isolate and ID06-479 xylanolytic degrader isolate is shown in Fig 1.

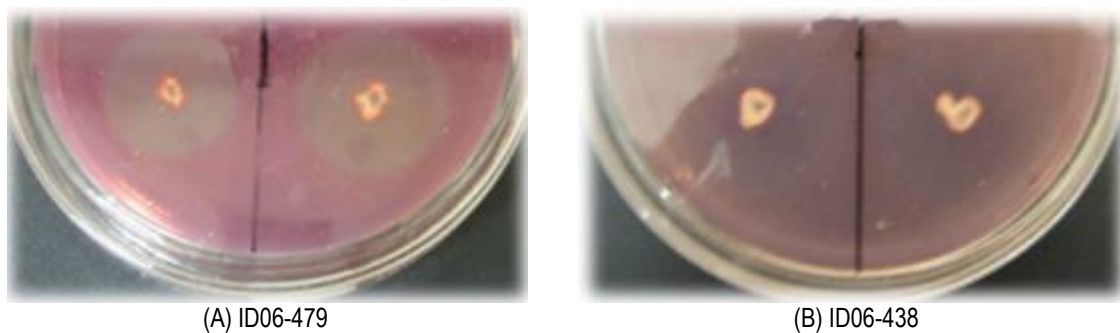


Fig 1. Congo red test for xylanolytic degrader ID06-479 (A) and mannolytic degrader ID06-438 (B)

Production Enzyme and Assay Activity

Figure 2 illustrates mannanase activities, total protein content and specific activity from ID06-438 isolate in the broth medium for mannanase production in 300 mL erlenmeyer. Maximum mannanase activity was obtained after 48-hours of fermentation with the activities recorded were 0.274 U/mL, 0.516 mg/ml and 0.53 U/mg for mannanase enzyme activity, protein concentration, and specific activity respectively. Figure 3 illustrates xylanase activity, total protein content and specific activity from ID06-479 isolate in the broth medium for xylanase production in 300 mL erlenmeyer. Maximum xylanase activity was obtained after 96-hours of fermentation with the activities recorded were 0.283 U/mL, 0.427 mg/ml and 0.662 U/mg for xylanase enzyme activity, protein concentration, and specific activity respectively.

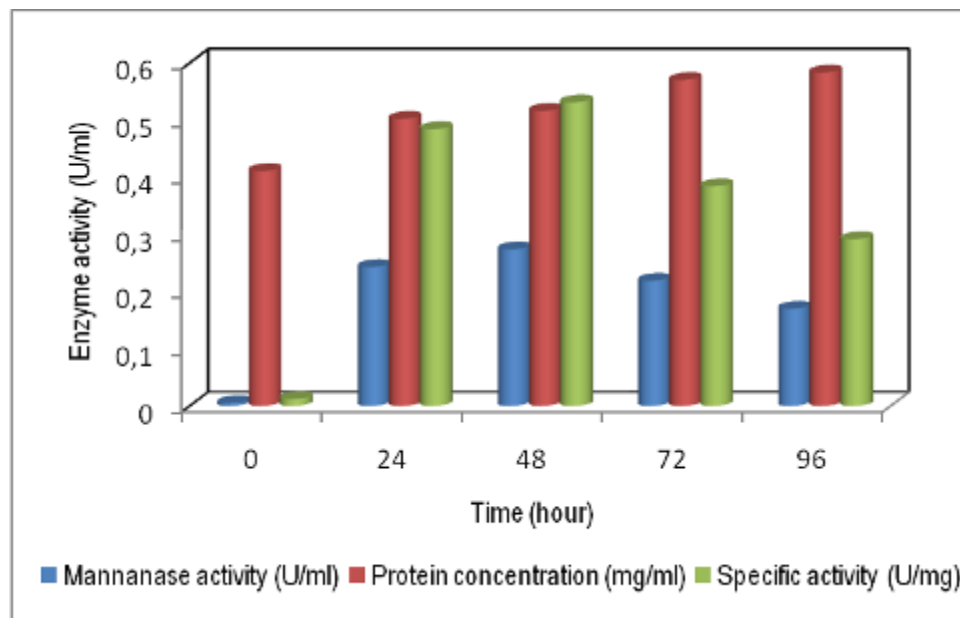


Fig. 2.. Mannanase activity from isolate ID06-438

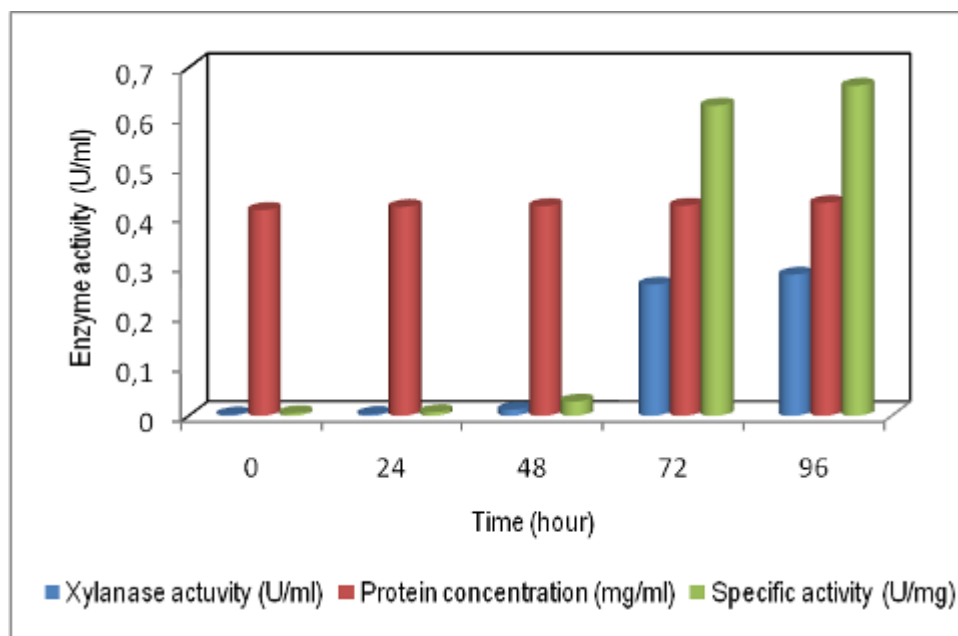


Fig. 3. Xylanase activity from isolate ID06-479

Products of Xylan and Mannan Degradation by Crude Xylanase and Mannanase Enzymes

Hydrolysis products from BWX and LBG were analyzed by silica gel thin layer chromatography. Mannanase and xylanase enzyme was not able to hydrolyse substrate BWX and LBG perfectly. To hydrolyse completely of substrate to monosaccharides, concentration and incubation time of the enzymes was need to increase. Highest hydrolysis product of ID06-479 isolate was on fourth day of incubation (Fig. 4A), and highest hydrolysis product of ID06-438 isolate was on the second day of incubation (Fig. 4B)

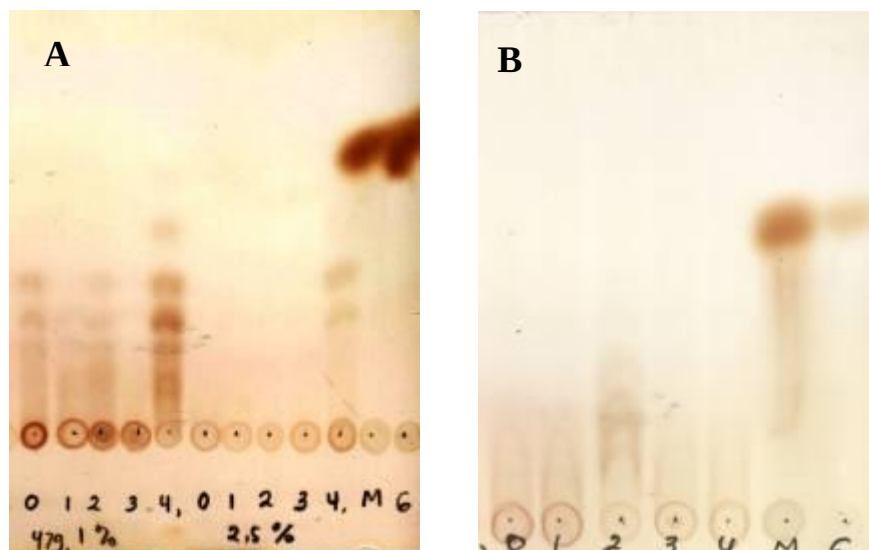


Fig 4. TLC test ID 06-479 (A), ID 06-438 (B), (0) : day-0, (1): day-1, (2) day-2, (3) day-3, (4) day-4, (M) standard mannose, (G) standard glucose.

Molecular Analysis of 16S rRNA Gene

The nucleotide sequences of the 16S rRNA gene of the strains were determined. Phylogenetic tree was constructed by the neighbour-joining (N-J) method based on the 16S rRNA gene sequences. The results revealed that strain ID06-479 exhibited of 16S rRNA gene sequence similarity (95%) with *Streptomyces* sp. CNR880, and ID06-438 exhibited sequence similarity (92%) with *Streptomyces* sp. LJMUEG T2. (Fig. 5)

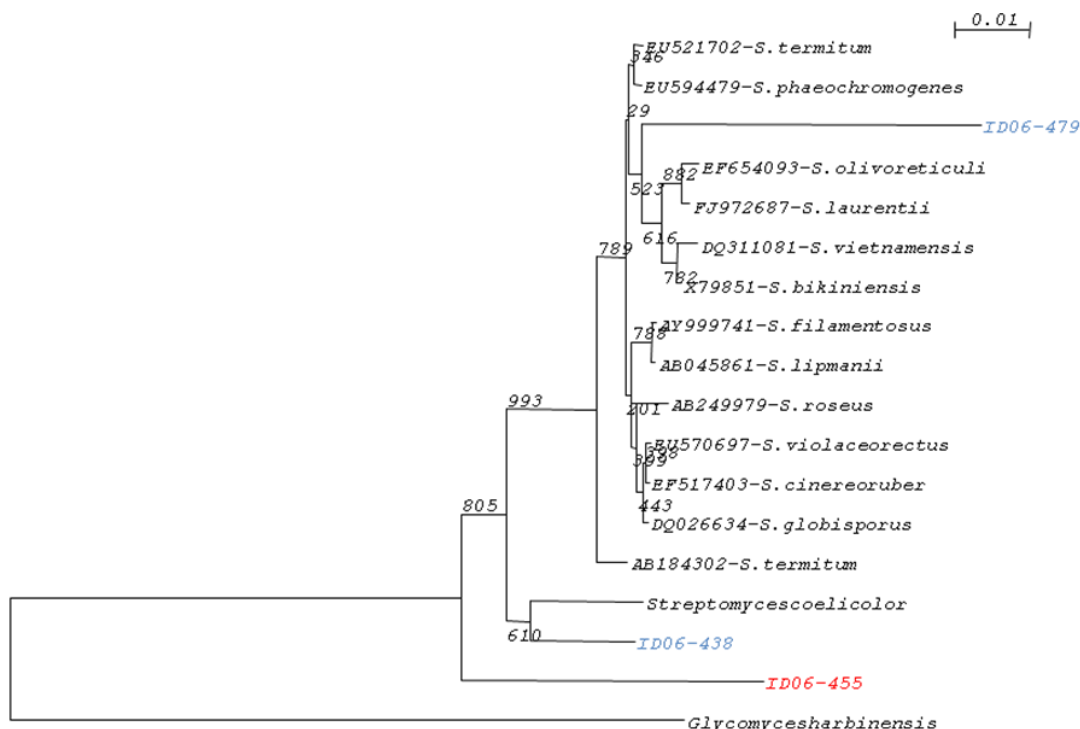


Fig 5. Phylogenetic three analysis ID06-479 and ID06-438

Conclusions

1. Screening hemicellulose enzyme producers from 96 isolates actinomycetes showed that 39 isolates were xylanolytic producing enzyme, 23 were mannolytic producing enzyme, and 18 had bifunctional enzyme. Varied clear zone of degradation on BWX and LBG substrate among the isolates was between 0~4.4 cm
2. The highest xylanolytic enzyme was performed by ID6-479 isolate with 3.7 cm clear zone diameter, optimum enzyme production on 4 day incubation with 0.662 U/mg specific activity, and was identified as *Streptomyces* sp.
3. The highest mannolytic enzyme was performed by ID06-438 isolate with 4.3 cm clear zone diameter, optimum enzyme production on day 2 incubation with 0.53 U/mg specific activity, and was identified as *Streptomyces* sp.

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Components and Antifungal Efficiency of Wood Vinegar from Wood Wastes and Oil Palm Empty Fruit Bunch

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Abstract

The objective of this study was to determine the wood vinegar, collected from different raw materials (wood wastes and oilpalm empty fruit bunch), with different carbonization temperatures (350°C, 400°C and 450°C), as antifungal. Concentrations of wood vinegar were 1, 2 and 3% (v/v). The fungus used was *Aspergillus niger*. The results indicated that the wood vinegar has inhibited the fungi growth. The highest result was on wood vinegar from wood wastes with concentration 3% with average value of anti fungal efficiency was 100%. The growth rate of *A. niger* was decrease as well as increasing the concentration of wood vinegar. Wood vinegar from wood wastes has a higher fungi inhibition than wood vinegar from oilpalm empty fruit bunch. GCMS analysis showed that the mainly bioactive compound is acetic acid and phenol. The contents of organic fraction of wood vinegar, such as ethanoic acid and phenol might be responsible for the difference in antifungal activities among these wood vinegars.

Key words : wood vinegar, antifungal, *aspergillus niger*, phenol, acetic acid

Introduction

Wood vinegar is one of organic compound which is a byproduct from charcoal production. It is a liquid generated from the gas and combustion of fresh wood burning in airless condition. When the gas from the combustion is cooled, it condenses into liquid. Raw wood vinegar has more than 200 chemicals, such as acetic acid, formaldehyde, ethyl-valerate, methanol, tar, etc. Utilization of wood vinegar has been used in several purposes such as industrial product, livestock, household and agriculture (International Bio-Energy, 2003; Yatagai *et al*, 2002, Apai and Tongdeethare, 2001). The production and consumption of wood vinegar have been increasing recently. Today, around 6.000-7.000kl of wood vinegar is produced and consumed annually; mainly for agricultural use (Pangnakon, 2008). Although several ways to use wood vinegar have been known from olden times, there have been few detailed studies of its chemical characteristics. It is necessary to clarify the characteristics of wood vinegar to establish new uses other than agricultural use such as for wood preservatives. The objective of this research were evaluation the toxicity of wood vinegar from different raw materials (wood wastes and oil palm empty fruit bunch) with different carbonization temperatures (350°C, 400°C and 450°C) and with different concentration to the *Aspergillus niger* fungi. These raw material were used because they were wastes, and utilization these wastes aimed to improve their economic value.

Materials and Methods

Preparation of Wood vinegar

Wood vinegar is made from burning wood meal from wood wastes and oil palm empty fruit bunch. Wood wastes consist of *Acacia mangium* (akasia) and *Vitex pubescens* (laban). All the material collected from Pontianak West Borneo Indonesia and converted into wood meals in a Willey mill with 40-60 mesh screens, and air dried to about 12% of moisture content. About 1000 grams of air-dried wood meals were then put in a kiln and burn at temperatures 350°C, 400°C and 450°C. The smoke from carbonization was cooled by the outside air when passing through the chimney occurs to produce pyroligneous liquor. The hot steams condensed into liquid were collected. It called wood vinegar.

Efficacy Test of Wood Vinegar

Efficacy test of wood vinegar as antifungal was carried out using agar media with various concentrations. Antifungal test was conducted according to Loman (1970) in Syafii and Yoshimoto (1993), using Agar Block Test

Methods. *A. niger* culture was from Laboratory Wood Technology Forestry Faculty Tanjungpura University Pontianak West Kalimantan Indonesia. Agar media used was PDA (potatoes dextrose agar) and concentration of wood vinegar was 1, 2, and 3% (v/v). The liquid consist of a mixture of PDA and wood vinegar then put in petri dish. The fungi then isolated in the center of petri dish and then incubation in culture room at 26,5°C. Resistance to decay fungi was evaluated as anti fungal efficiency (AFE) as follows:

$$AFE = \frac{(GC-GT)}{GC} \times 100\%$$

Where:

GC: diameter of fungal growth on control

GT: diameter of fungal growth on treated media agar

Results and Discussion

Characteristic of Wood Vinegar

Wood vinegar from wood wastes and oil palm empty fruit bunch has different colour, from brown and dark brown respectively. The characteristics of wood vinegar from wood wastes and oil palm empty fruit bunch were shown on Table 1. The pH value of wood vinegars ranged from 3.0 to 4.0, specific gravity was between 1.006 and 1.010, and meanwhile temperature was range between 29 to 29.5°C.

Table 1. Characteristic of wood vinegar from different raw material

Material	Carbonization temperature	pH value	Temperature (°C)	Specific gravity
Wood wastes	350	3.0	29.5	1.006
	400	3.0	29.5	1.006
	450	3.0	29.5	1.007
Oil palm empty fruit bunch	350	4.0	29.0	1.010
	400	4.0	29.0	1.008
	450	4.0	29.0	1.010

Antifungal Properties

An experiment of anti fungal activity of each wood vinegar has been carried out. In this experiment the influence of each wood vinegar on the relative growth of fungi was examined. The anti fungal efficiency of each wood vinegar was shown on Figure 1. Average anti fungal efficiency from all wood vinegar was range between 0-100%. Wood vinegar from wood wastes with concentration 3% was the highest anti fungal efficiency value, meanwhile the highest anti fungal efficiency from oil palm empty fruit bunch wood vinegar only 61.11%. This is showed that wood vinegar from wood wastes more stronger than wood vinegar from oil palm empty fruit bunch.

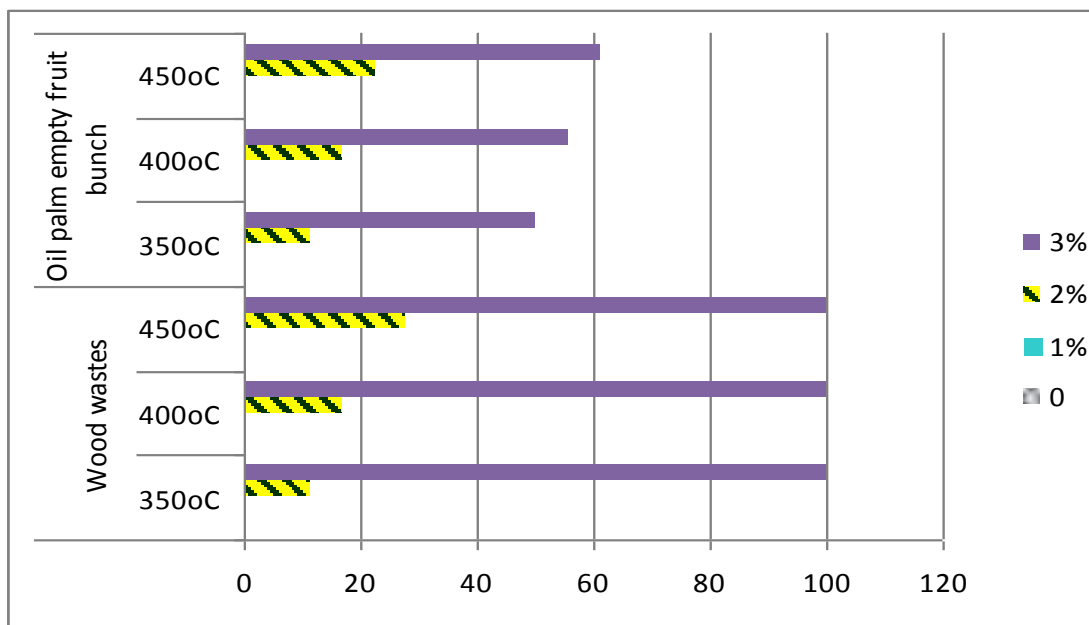


Figure 1. Anti Fungal Efficiency of wood vinegar from wood wastes and oil palm empty fruit bunch in different carbonization temperature and different concentration

The average value of anti fungal efficiency of wood vinegar from wood wastes was range between 0-100%, and from oil palm empty fruit bunch was range between 0-61.11%. When the carbonization temperature get higher, the average antifungal efficiency get more higher. Average antifungal efficiency on wood wastes on carbonization temperature 350°C in concentration 1%, 2% and 3% was 0, 11.11% and 100% and on temperature 400°C was 0, 16.67% and 100% respectively. Meanwhile on carbonization temperature 450°C the average anti fungal efficiency was 0, 27.78% and 100% respectively. Average antifungal efficiency on oil palm empty fruit bunch on carbonization temperature 350°C in concentration 1%, 2% and 3% was 0, 11.11% and 50% and on temperature 400°C was 0, 16.67% and 55.56% respectively. Meanwhile on carbonization temperature 450°C the average anti fungal efficiency was 0, 22.22% and 61.11% respectively. The growth rate of *A. niger* was decrease as well as increasing the concentration of wood vinegar.

The different anti fungal efficiency of wood vinegar from wood wastes and oil palm empty fruit bunch was based on the different of chemical compound on raw materials. It was shown by previous investigators that certain chemical compound plays some role in preventing the subsequent degradation of wood (Inoue *et al*, 2000; Lin *et al*, 2008). Wood vinegar mainly consists of phenolic and acetic acid. Phenolic components such as phenol, guaiacol and cresol which are considered to act as biocidal agents might be responsible for anti fungal properties of wood vinegar. In the investigations of Tongdeethare (2002) demonstrated the results on the anti fungal effect of wood vinegar from bamboo on agriculture field.

Comparison on the anti fungal efficiency of wood vinegar from different raw material, the oil palm empty fruit bunch was weaker than wood wastes. The content of organic fraction of wood vinegars and acetic acid might be responsible for the differences in anti fungal activities among these wood vinegars. Analysis GCMS on wood vinegar from wood wastes and oil palm empty fruit bunch with temperature 450°C was shown on Figure 2 and Figure 3 respectively. The chemical compound were consist of ethanoic acid ($C_2H_4O_2$), butane (C_4H_{10}), acetylcarbinol ($C_3H_6O_2$), phenol (C_6H_6O), furanone ($C_4H_6O_2$), dimethyl ketone (C_3H_6O) and butanoic acid, 2-propenyl ester ($C_7H_{12}O_2$).

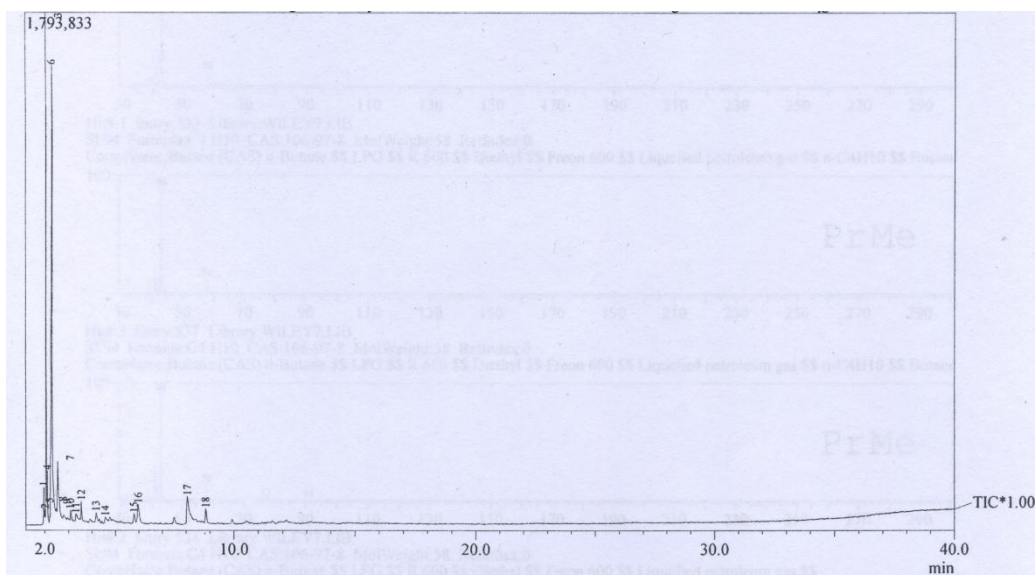


Figure 2. Chromatogram wood vinegar from wood wastes with carbonization temperature 450°C

Table 2. Chemical Compound and Retention Time from Wood Vinegar from Wood Wastes with Carbonization Temperature 450°C

No.	Peak No.	Retention Time (minute)	Area (%)	Height	Chemical Compound
1	6	2.314	47.07	1583189	Ethanoic acid ($C_2H_4O_2$)
2	3	2.059	19.16	1767218	Butane (C_4H_{10})
3	7	2.553	8.86	211450	Acetylcarbinol ($C_3H_6O_2$)
4	17	8.061	5.48	92614	Phenol (C_6H_6O)
5	4	2.112	2.96	181121	Furanone ($C_4H_6O_2$)

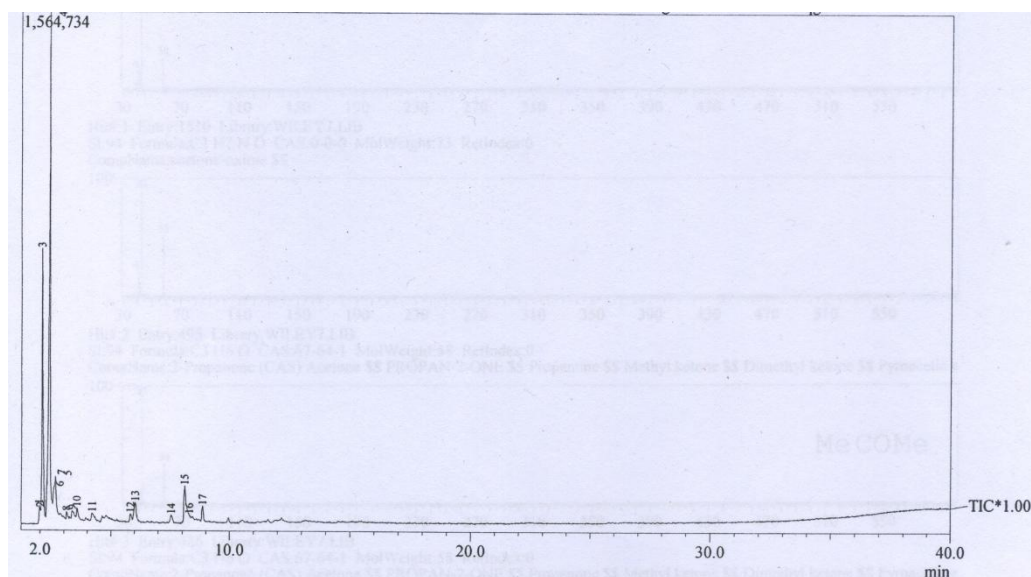


Figure 3. Chromatogram wood vinegar from oil palm empty fruit bunch with carbonization temperature 450°C

Table 3. Chemical Compound and Retention Time from Wood Vinegar from Oil Palm Empty Fruit Bunch with Carbonization Temperature 450°C

No.	Peak No.	Retention Time (minute)	Area (%)	Height	Chemical Compound
1	4	2.381	46.39	1540383	Ethanoic acid (C ₂ H ₄ O ₂)
2	3	2.067	21.04	832117	Dimethyl ketone (C ₃ H ₆ O)
3	5	2.626	9.68	135403	Butanoic acid,2-propenyl ester (C ₇ H ₁₂ O ₂)
4	15	8.094	7.04	113090	Phenol (C ₆ H ₆ O)
5	13	6.032	3.09	58151	Furanone (C ₄ H ₆ O ₂)

Conclusion

The average value of anti fungal efficiency of wood vinegar from wood wastes was range between 0-100%, and from oil palm empty fruit bunch was range between 0-61.11%. The growth rate of *A. niger* was decrease as well as increasing the concentration of wood vinegar and the carbonization temperature. Wood vinegar from wood wastes more stronger than wood vinegar from oil palm empty fruit bunch. The highest value of anti fungal activities was on wood vinegar from wood wastes with carbonization temperature 450°C and concentration 3%. Analysis GCMS on wood vinegar from wood wastes and oil palm empty fruit bunch with carbonization temperature 450°C showed that the chemical compound consist of ethanoic acid (C₂H₄O₂), butane (C₄H₁₀), acetylcarbinol (C₃H₆O₂), phenol (C₆H₆O), furanone (C₄H₆O₂), dimethyl ketone (C₃H₆O) and butanoic acid,2-propenyl ester (C₇H₁₂O₂). The content of organic fraction of wood vinegars and acetic acid might be responsible for the differences in anti fungal activities among these wood vinegars.

Acknowledgements

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Antitermitic Activity of Wood Vinegar and Its Components

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Abstract

The termiticidal activity of wood vinegar and its components have been studied. Two kinds of wood vinegar made from mixed chips of *Acacia mangium* and *Vitex pubescens* and oil palm empty fruit bunch with carbonization temperatures 450°C exhibited high termiticidal activities against *Coptotermes curvignathus*. Concentrations of wood vinegar used were 1%, 2% and 3% (v/v). Wood samples from karet wood (*Hevea brasiliensis*) measuring 10×10×20 mm was preservation with wood vinegar using dipping method for 48 hour. Evaluated termiticidal activity was conducted with no-choice feeding. The result showed that all wood vinegar exhibited high termiticidal activity. The contents of organic fraction of wood vinegars, ethanoic acid and phenol might be responsible for the differences in termiticidal activities among these wood vinegars. GCMS analysis showed that mainly bioactive compound of these wood vinegar were ethanoic acid and phenol.

Key words : antitermitic activity, wood vinegar, *Coptotermes curvignathus*, phenol, acetic acid

Introduction

Indonesia is a tropical country and has approximately 4.000 species of woods. About 15-20% of these species are classified into first and second classes (durable wood classes) and the remaining species are classified as a non durable species. In addition, the future of wood supply will be coming from plantation forest which dominated by fast growing species. These woods are mainly undurable woods; therefore it has to be treated with chemical preservatives before used. On the other hand, the use of conventional preservatives would be a big problem from the environmental dimension. According to the above conditions, the development of the new type of preservatives will be one of the most socially demanded subjects. One of the new types of preservatives which can be explored is wood vinegar. Wood vinegar is one of organic compound and byproduct from charcoal production. It is a liquid generated from the gas and combustion of fresh wood burning in airless condition. Utilization of wood vinegar has been used in several purposes such as industrial product, livestock, household, and agriculture (Pangnakorn, 2008; Xinxi, 2004; International Bio-Energy, 2003; Tongdeethare S, 2002; Apai and Tongdeethare, 2001). Although several ways to use wood vinegar have been known from olden times, there have been few detailed studies of its antitermites activities. The objective of this research was evaluation the toxicity of wood vinegar from two different raw materials (wood wastes and oil palm empty fruit bunch) with different concentration to the *Coptotermes curvignathus* termites. These raw material were used because they were wastes, and utilization these wastes aimed to improve their economic value. The *C. curvignathus* termites were used in this study because it causes extensive damage to any kind of wood species in Indonesia.

Materials and Methods

Preparation of Wood Vinegar

Wood vinegar is made from burning wood meal from wood wastes and oil palm empty fruit bunch. Wood wastes consist of *Acacia mangium* (akasia) and *Vitex pubescens* (laban). All the material collected from Pontianak West Borneo and converted into wood meals in a Willey mill with 40-60 mesh screens, and air dried to about 12% of moisture content. About 1000 grams of air-dried wood meals were then put in a kiln and burn at temperatures 450°C. The smoke from carbonization was cooled by the outside air when passing through the chimney occurs to produce pyroligneous liquor. The hot steams condensed into liquid were collected. It called wood vinegar.

Wood Preservation

Karet (*Hevea brasiliensis*) wood was used as antitermites test. Sapwood blocks of wood measuring 10 mm (T) × 10 mm (R) × 20 mm (L) were used as the food source for termites. Concentration of wood vinegar was 1%, 2% and 3% (v/v). Wood preservation using dipping methods. The wood was dipping for 48 hour and then air dry for 24 hour before tested to termite.

Antitermites Activity

Antitermites test was conducted according to Sornnuwat, *et al* (1995). The glass bottle with volume of 180 cm³, 4.5 cm in diameter and 11.5 cm in height was used as a container. Thirty gram of sand sieved through 20 meshes was filled in the bottle and moistened with 6 ml of distilled water. One of each block was buried in the sand of glass bottle. 220 termites which contain of 200 workers and 20 soldiers were introduced into the bottle. Each bottle was plugged with cotton wool and kept in the dark under ambient room condition for 21 days. After 21 days, wood blocks were taken out from the containers, cleaned and oven-dried and reweight to determine percentage weight loss from the equation:

$$\text{Weight loss (\%)} = (W_1 - W_2) / W_1 \times 100$$

Where, W_1 : weight of wood block before exposure to termite

W_2 : weight of wood block after exposure to termite

Number of dead termites was recorded at the end of the test. Mortality test was determined from the equation :

$$\text{Mortality (\%)} = (N_1 - N_2) / N_1 \times 100$$

Where, N_1 : number of initial workers

N_2 : number of dead workers

Results and Discussion

Characteristic of Wood Vinegar

Wood vinegar from wood wastes and oil palm empty fruit bunch has different colour, from brown and dark brown respectively. The characteristics of wood vinegar from wood wastes and oil palm empty fruit bunch were shown on Table 1. The pH value of wood vinegars ranged from 3.0 to 4.0, specific gravity was between 1.007 and 1.010, and meanwhile temperature was range between 29 to 29.5°C.

Table 1. Characteristic of wood vinegar from different raw material

Material	pH value	Temperature (°C)	Specific gravity
Wood wastes	3.0	29.5	1.007
Oil palm empty fruit bunch	4.0	29.0	1.010

Termiticidal Activities

Result of the research showed that wood vinegar was increased the durability of Karet wood against *C. curvignathus* termites. Average value of weight loss was 6-25% and the lowest wood weight loss was on wood vinegar from wood wastes in concentration 3%. This is showed that wood vinegar from wood wastes stronger than wood vinegar from oil palm empty fruit bunch. The wood weight loss was decrease as well as increasing the concentration of wood vinegar. The average value of wood weight loss was shown on Figure 1.

Weight loss of Karet wood which preserve with wood vinegar from wood wastes was range between 6-20%, meanwhile on wood vinegar from oil palm empty fruit bunch was range between 10-25%. Average weight loss on wood vinegar from wood wastes in concentration 1%, 2% and 3% was 20%, 16% and 6% respectively. Meanwhile average weight loss on wood vinegar from oil palm empty fruit bunch in concentration 1%, 2% and 3% was 25%, 20% and 10% respectively. In the investigation of Yatagai *et al* (2002) demonstrated the termiticidal activity of wood vinegar with resulting average weight loss between 5-25%. The wood vinegar used was made from the mixed chips of *Cryptomeria japonica* and *Pseudotsuga menziesii*; chips of *Quercus serrata* and chips of *Pinus densiflora*. The termite used was *Reticulitermes speratus*. This investigation has a similar result with our research, although the wood vinegar was made from different material. It is concluded that certain chemical compound in wood vinegar plays some role in preventing termites attack on wood. Wood vinegar mainly consists of phenolic and ethanoic acid. Phenolic components such as phenol, guaicol and cresol which are considered to act as biocidal agents might be responsible for anti termites properties of wood vinegar (Higashino *et al*, 2005).

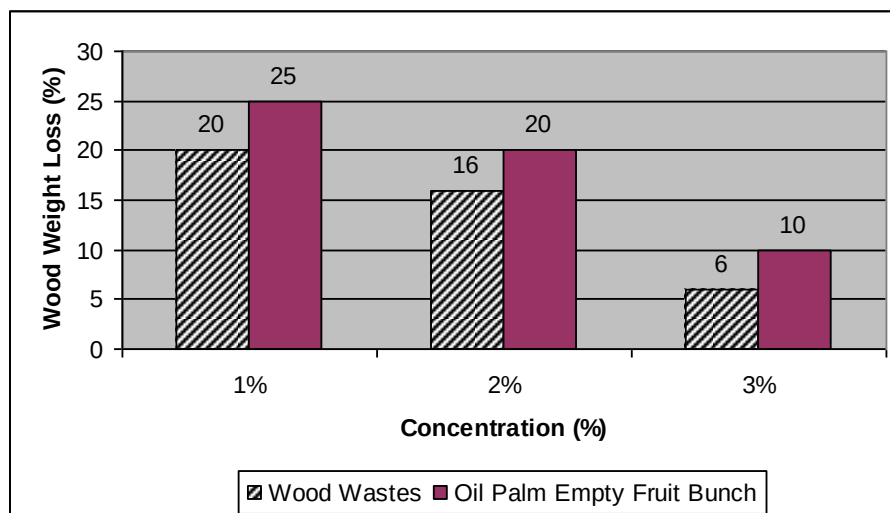


Figure 1. Weight loss of Karet wood after preserve with wood vinegar from different raw material by subterranean termites *C. curvignathus* attack

Termites mortality was range between 40-98%. Termites mortality was higher on wood vinegar from wood wastes than from oil palm empty fruit bunch. The average mortality value on wood vinegar from wood wastes was 60-98% and on wood vinegar from oil palm empty fruit bunch were 40-70%. The optimum concentration was 3% both on wood vinegar from wood wastes and oil palm empty fruit bunch. Average termites mortality on wood vinegar from wood wastes in concentration 1%, 2% and 3% was 60%, 80% and 98% respectively. Meanwhile average termites mortality on wood vinegar from oil palm empty fruit bunch in concentration 1%, 2% and 3% was 40%, 60% and 70% respectively. Figure 2 explained the mortality value of termites.

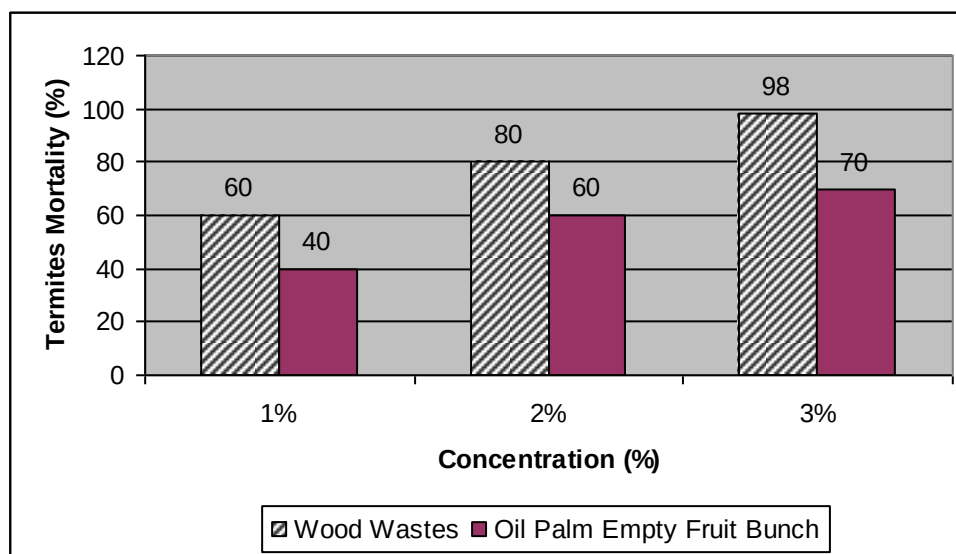


Figure 2. Termites *C. curvignathus* mortality on wood after preservation with wood vinegar from different raw material

Comparison on the antitermites properties of wood vinegar from different raw material, the oil palm empty fruit bunch was weaker than wood wastes. The content of organic fraction of wood vinegars and acetic acid might be responsible for the differences in anti fungal activities among these wood vinegars. Analysis GCMS on wood vinegar from wood wastes and oil palm empty fruit bunch was shown on Figure 3 and Figure 4 respectively. The chemical compound were consist of ethanoic acid ($C_2H_4O_2$), butane (C_4H_{10}), acetylcarbinol ($C_3H_6O_2$), phenol (C_6H_6O), furanone ($C_4H_6O_2$), dimethyl ketone (C_3H_6O) and butanoic acid,2-propenyl ester ($C_7H_{12}O_2$).

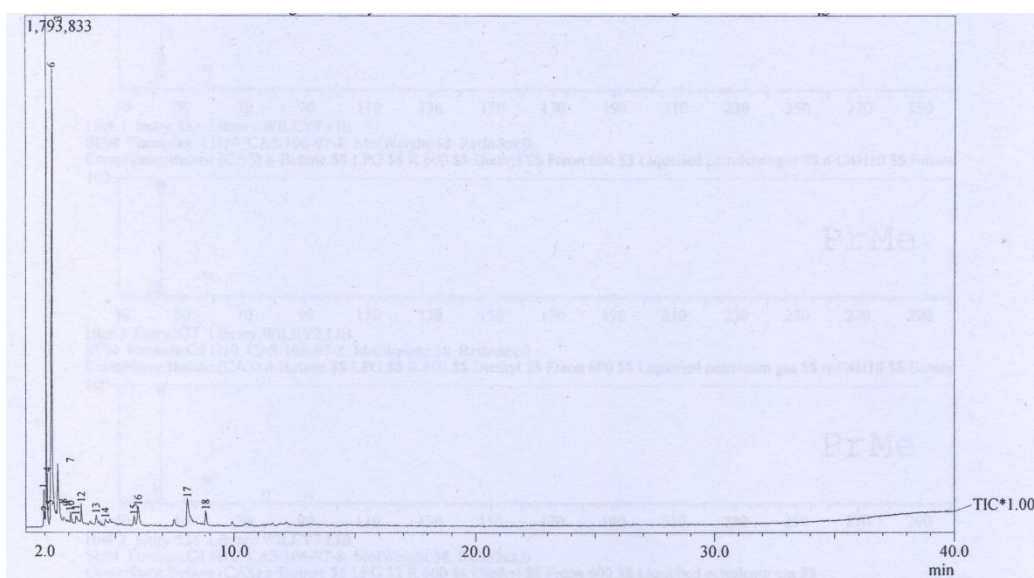


Figure 3. Chromatogram wood vinegar from wood wastes with carbonization temperature 450°C

Table 2. Chemical Compound and Retention Time from Wood Vinegar from Wood Wastes with Carbonization Temperature 450°C

No.	Peak No.	Retention Time (minute)	Area (%)	Height	Chemical Compound
1	6	2.314	47.07	1583189	Ethanoic acid ($C_2H_4O_2$)
2	3	2.059	19.16	1767218	Butane (C_4H_{10})
3	7	2.553	8.86	211450	Acetylcarbinol ($C_3H_6O_2$)
4	17	8.061	5.48	92614	Phenol (C_6H_6O)
5	4	2.112	2.96	181121	Furanone ($C_4H_6O_2$)

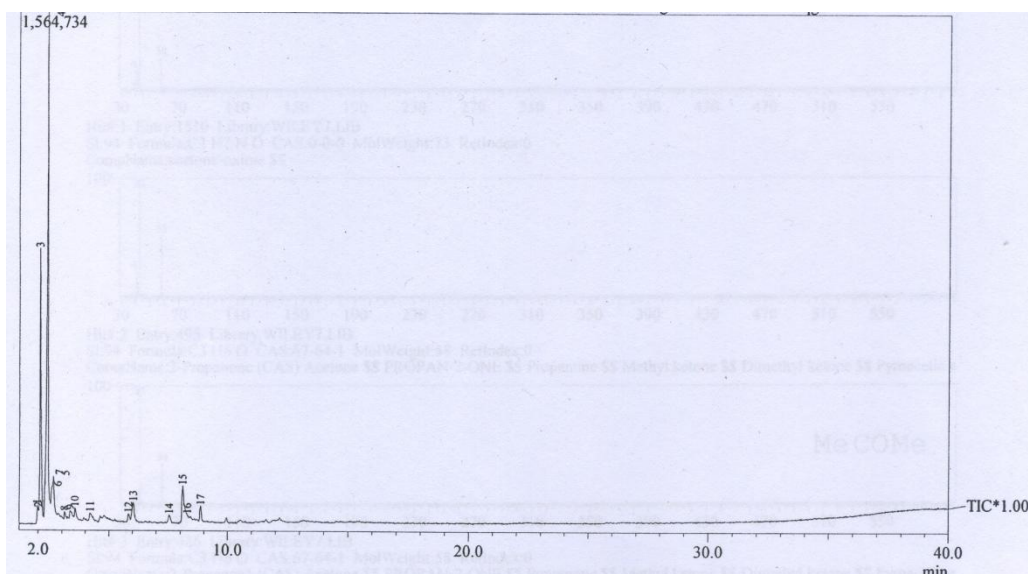


Figure 4. Chromatogram wood vinegar from oil palm empty fruit bunch with carbonization temperature 450°C

Table 3. Chemical Compound and Retention Time from Wood Vinegar from Oil Palm Empty Fruit Bunch with Carbonization Temperature 450°C

No.	Peak No.	Retention Time (minute)	Area (%)	Height	Chemical Compound
1	4	2.381	46.39	1540383	Ethanoic acid (C ₂ H ₄ O ₂)
2	3	2.067	21.04	832117	Dimethyl ketone (C ₃ H ₆ O)
3	5	2.626	9.68	135403	Butanoic acid,2-propenyl ester (C ₇ H ₁₂ O ₂)
4	15	8.094	7.04	113090	Phenol (C ₆ H ₆ O)
5	13	6.032	3.09	58151	Furanone (C ₄ H ₆ O ₂)

Conclusions

Termiticidal activities of wood vinegar from wood wastes and oil palm empty fruit bunch was high. Weight loss of Karet wood which preserve with wood vinegar from wood wastes was range between 6-20%, meanwhile on wood vinegar from oil palm empty fruit bunch was range between 10-25%. The weight loss was decrease as well as increasing the concentration of wood vinegar. Termites mortality was range between 40-98%. The average mortality value on wood vinegar from wood wastes was 60-98% and on wood vinegar from oil palm empty fruit bunch were 40-70%. Antitermites properties were higher on wood vinegar from wood wastes than oil palm empty fruit bunch. The optimum concentration was 3% both on wood vinegar from wood wastes and oil palm empty fruit bunch. Analysis GCMS on wood vinegar showed that the chemical compound consist of ethanoic acid (C₂H₄O₂), butane (C₄H₁₀), acetylcarbinol (C₃H₆O₂), phenol (C₆H₆O), furanone (C₄H₆O₂), dimethyl ketone (C₃H₆O) and butanoic acid,2-propenyl ester (C₇H₁₂O₂). The content of organic fraction of wood vinegars and acetic acid might be responsible for the differences in antitermites activities among these wood vinegars.

Acknowledgements

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Evaluation of Bistrifluron as an Above-ground Bait against Subterranean Termite *Coptotermes gestroi* (Wassman) in Indonesia

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Abstract

Bistrifluron 1.0% as active ingredient was evaluated as a toxicant in above-ground termite baits against *Coptotermes gestroi* (Wassman) in Indonesia. Results indicated that after 6 weeks the colonies were completely eliminated. The average consumption of active bait until the colonies are eliminated is 120 g (1.2 g bistrifluron as active ingredient).

Key words: Bistrifluron, above-ground station, baiting, *C. gestroi*.

Introduction

Baits are an important tool for termite prevention and control programs. Conventional termite treatments rely primarily on soil-applied liquid termiticides since the 1950s (Su, 2005). However, there are a number of situations where a baiting system may be preferred over a liquid treatment; may be used along with a liquid treatment. With baiting systems, termites obviously must find and eat the bait in order for the chemical to be effective. It is important to realize that the current bait systems (the bait stations and their contents) have been research looking at possible chemical attractants that could be used for this purpose. Just as with baits used for cockroaches, ants, and rodents, the termite bait stations contain materials that the manufacturers have determined are attractive food sources for the termites. Laboratory studies have shown that some of these materials may be "preferred" or more acceptable as food compared to the surrounding wood. Termites find the stations during their normal foraging activities, just as they might find any other food source. The acceptability of the "food" in the station results in more termites being "recruited" or coming to feed on it. There is no way to predict how soon termites will find and feed on in-ground bait stations, so an important part of the baiting strategy is to install the stations around the entire structure and to specifically target known or suspected areas of termite activity (e.g., near tree stumps). Little is known how termites forage in nature and no reliable techniques have been developed to ensure that termites locate baits (Deborah *et al.* 1999). For that reason, placements of bait stations are of almost importance. Use of above ground baits significantly improves bait acceptance rates, as these can be placed on or nearby areas with visible termite activity.

Baiting is a long term, reduced-risk approach to termite control. Unlike most conventional insecticides, the impact of termite baits is not immediate. By design, the currently-used baits contain slower-acting chemicals that may take several days or weeks to kill individual termites depending upon the age of the termite and the type of chemical in the bait. This delayed effect is crucial because it provides time for the termites to carry the bait back to the colony and feed it to other termites within the nest. As a result, it may take several months before the entire colony is substantially reduced.

This study was to evaluate the performance of bistrifluron termite bait against *Coptotermes gestroi* in Indonesia.

Materials and Methods

Bait : One concentration (1.0%) of bistrifluron (Xterm 1B) termite bait and blank matrix as control in the form of above-ground bait stations were evaluate. These were provided by Sumitomo Chemical Enviro-Agro Asia Pacific Sdn. Bhd. Malaysia.

Site : Two storage buildings with active infestation of subterranean, *Coptotermes gestroi* located in Bogor City, West Java, Indonesia were used in this experiment

Installation of Above-Ground Stations

Houses with active termite infestation areas were identified. Four Stations were installed with blank bait first to areas where termites galleries and damage to wooden structures were identified. Prior to placement the areas were cleaned of dusts and other debris, taking care not to disturb the termites. Above Ground station were first attached to the damage areas, then sealed with 1 mm thick of tape (black color cellophane tape). 2 blank bait cartridges were then inserted and the stations sealed with additional tape to reduce light and air penetration.

Installation of Treated Bait in Above-Ground Stations

At inspection, selected stations infested with *Coptotermes gestroi* were replaced with **bait cartridges**. A few blank baited stations were left to act as monitoring stations. The bait stations were observed every week to evaluate the presence of termites and when the bait was 2/3 consumed cartridges were replaced. The evaluation continued until the termite activity in the monitoring stations was eliminated. The total consumption of treated bait and the period of elimination was calculated. Monitoring was then continued for 3 months, with all active baits replaced with blank baits, making sure that termite re-infestation was not immediate, indicating colony elimination.

The signs of colony elimination were :

1. Decreased termite activity
2. The ratio of soldiers : workers increases
3. Dis-orientation
4. The color of workers becomes marble white, caused by accumulation of uric acid.
5. Fungus growth on termite bodies and the presence of dead soldiers / workers.

After Colony Elimination

The test sites were monitored for a further three inspections to look for possible new or re-infestation. New or re-infestations, would result in the above baiting cycle being repeated.

Results and Discussion

Tests were initiated, with blank bait placement, on the 24th January, 2008 (Table 1). All monitoring stations were inspected weekly to evaluate the condition of the stations. Baits with less than 20% remaining matrix were replaced.

On 12th February, one of the infested stations (Station 3), was replaced with a 1.0% bistrifluron-based bait cartridge.

On 12th March, a second active bait was placed as the previous bait cartridge was empty.

By 31 March, dead termites were found in all stations with no evident termite activity. Active bait cartridges were then changed with blank bait.

The Signs of Colony Elimination

All signs of colony elimination were noted as quickly as 4 weeks after feeding on the active baits commenced, with an increase in the ratio of soldiers : workers; noticeable dis-orientation of workers and soldiers; the appearance of marble white workers, and noticeable fungus growth on the dead bodies of termites.

The Total Consumption and Elimination Time

The treated bait was installed in Station 3 on 12th February and at observation on 31st March, all stations contained no termites. It is concluded that after 6 weeks the colony had been completely eliminated. At this time it was determined that the total consumption of active bait was 120 g (1.2 g bistrifluron as active ingredient).

As the bait matrix (pelletised cellulose) was designed to have crevices in between, more termite could feed on the bait simultaneously because of higher surface area. This trait is concurrent to the findings of Evans and Gleeson (2001) where loosely folded paper bait was removed at a faster rate and had more than four-fold the amount of paper bait removal compared to tightly rolled paper bait.

Conclusion

Xterm 1B with 1.0% of bistrifluron as active ingredient was evaluated as a toxicant in above-ground termite baits against *Coptotermes gestroi* in Indonesia. Results indicate that after 6 weeks the colonies were completely

eliminated. The total consumption of active bait to effect colonies elimination was 120 g (1.2 g bistrifluron as active ingredient).

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Table 1. The date observation and the condition each above-ground termite baits against *C. gestroi* in Indonesia

Station	January 2008		February 2008				March 2008					April 2008	
	24	31	12	15	19	29	12	19	25	26	31	7	16
1	blank bait	Low attack	Low attack	Low attack	Low attack	Low attack	Low attack	No termite activity	No termite activity	No termite activity	No termite activity	No termite activity	No termite activity
2	blank bait	Low attack	Low attack	High Attack	High Attack	High Attack	High Attack	High Attack	disorien-tation	disorien-tation	dead	blank bait	No re-infestation
3	blank bait	Low attack	Xterm I	High Attack	High Attack	High Attack	Xterm II	disorien-tation	dead	dead	dead	blank bait	No re-infestation
4	blank bait	No Attack	No Attack	No Attack	No Attack	No Attack	No Attack	No Attack	No Attack	No Attack	No Attack	No Attack	No Attack

The Efficacy of CC-Organic Chemicals for Wood Packaging Protection against Powder Post Beetle *Heterobostrychus aequalis*

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Abstract

Wood packaging material made of unprocessed raw wood is a pathway for introduction and spread pests, so National Plant Protection Organizations (NPPOs) require standard treatment such as Fumigation, KD, CPI, and Irradiation for wood packaging protection. Unfortunately, most of these treatment are high-cost process. Based on this, the treatment by copper chromium (CC complex) combined by natural organic compound is proposed for alternative effective treatment with lower cost. The test method was conducted according to Indonesia National Standard (SNI) No. 01-7207-2006, and the bioassay test will be subjected toward powder post beetle *Heterobostrychus aequalis*. The result showed that treated wood packaging by 10 ppm Copper Chromium-organic compound (1:1) gave A grade test scale, while untreated specimens remain on C grade caused by some bite pattern of insect attack.

Key words : CC-Organic Compounds, Wood Packaging, *Heterobostrychus aequalis*

Introduction

Wood packaging products are commonly made from low durability wood material. The unprocessed raw wood material is pathway for pests introduction and spread such as anobiidae, bostrychidae, lyctidae, etc. Based on this National Plant Protection Organizations (NPPOs) require standard treatment such as Fumigation, KD, CPI, and Irradiation for wood packaging protection. All these treatment are already regulated in International Standards for Phytosanitary Measures 15 (ISPM 15). But, the ISPM 15 refers to europe climate and condition approach which is kindly different with the tropical countries like Indonesia. The humidity in tropical countries considered much higher than subtropical countries.

Wood packaging products in europe are made from softwood such as pines, with age-known raw wood material from plantation. It is different compared to tropical countris, where wood packaging product is commonly made from hardwood material with various kind of wood species and unknown age. Considered of these condition the ISPM 15 for Indonesian application needs some modification to addapt climate condition, simple method, cheaper treatment and environmental friendly.

According to the ministry of agriculture regulation No. 12/Permentan/OT.140/2/2009, wood packaging product must clean from pest and fungi attack. Some treatment are needed to fulfill the regulation requirement such as heat treatment, fumigation with methyl bromide, irradiation and other treatments according to ISPM 15. Unfortunately, most of these treatment are high-cost process. Based on this, the treatment by copper chromium (CC complex) combined by natural organic compound is proposed for alternative effective treatment with lower cost. The test method was conducted according to Indonesia National Standard (SNI) No. 01-7207-2006, and the bioassay test will be subjected toward powder post beetle *Heterobostrychus aequalis*.

Material and Methods

The chemical solution consists of combination of sodium bichromate, copper (II) sulphate, *Nicotiana tobaccum* and *Eugenia carryophyllata* extractives. The test blocks were subjected to powder post beetle according to Indonesian National Standard (SNI) 01-7207-2006. Wood plate samples treated by chemical substance solution, 10 ppm CC-organic compound (1:1), then subjected to the powder post beetle attack in laboratory scale. Every test system contains pair of wood plate separated by aluminium plate at the centre. Ten larvae of powder post beetle *Heterobostrychus aequalis* at the age of six weeks were put in the hole of aluminium plate and covered by wood plate sample on both side. All samples gathered in a large covered cased and kept at room temperature in dark condition for

six weeks test periode. Samples preference after test characterized by test scale below, and test value obtained from avarege value of sample preference.

Table 1. Degree of attack and sample damage of powder post beetle, *Heterobostrychus aequalis*

Grade	Sample Preferences	Test value
A	Sound	0
B	Some insect bite pattern	40
C	Light attack, narrow lane of insect bite pattern	70
D	Weight attack, deep lane and wide of insect bite pattern	90
E	Heavy attack, more than 50% of sample fed by insect	100

Results and Discussions

The bioassay test result presented on table 2. Wood raw material used in this test are from lesser durability wood, rubber wood (*Hevea brasiliensis*).

Table 2. The result of powder post beetle test

Wood Specimens	Test Value	Grade Level
Untreated wood	66,67	C
Wood treated by CC-organic compound (1:1)	0	A

Based on data, test coded untreated sample showed low resistance agains powder post beetle attack, resulted average test value 66,67 and classified into Grade C, while the other one showed good resistant. Figure 1 shows sample preference before test, compared to untreated wood after test subjection. Figure 1.b shows the light attack of *Heterobostrychus aequalis* left Light attack, narrow lane of insect bite pattern. Untreated wood was unable to prevent insect attack, consider on damage caused.

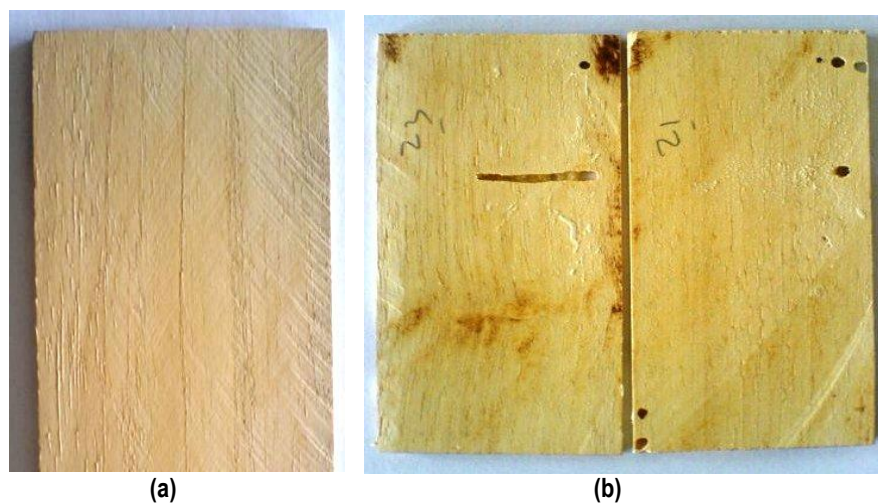


Figure 1. Sample preference of Untreated, (a) sample before test; (b) Control/untreated wood.

Figure 2 shows wood plate treated by CC-organic compound (1:1), compared to sample preference before test. The test generated all wood samples treated showed resistance against powder post beetle attack. Displayed on figure 4.b, there are no *Heterobostrychus aequalis* attack pattern. The test result generated A grade.

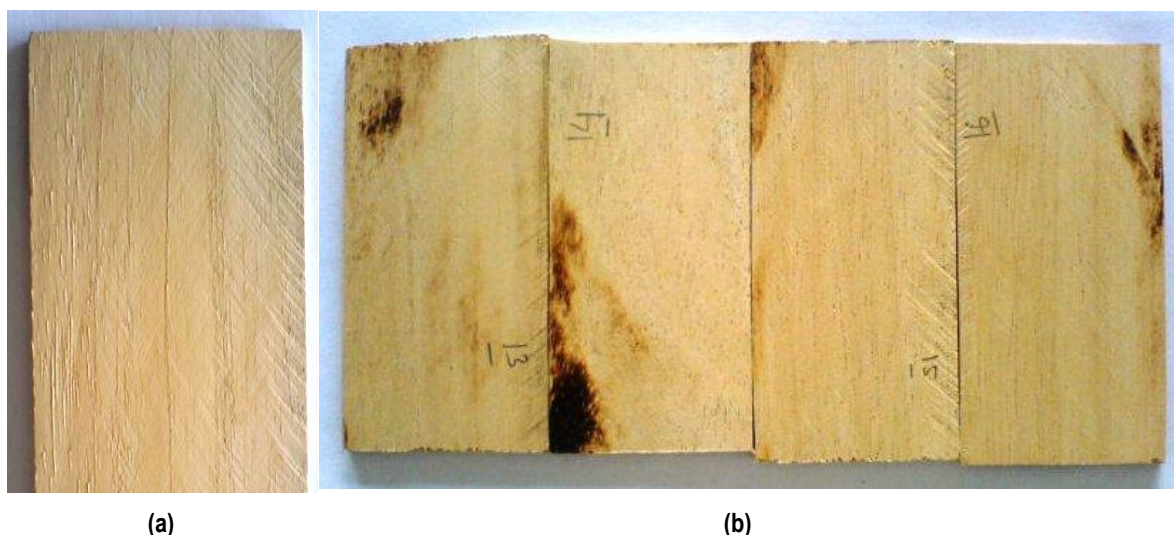


Figure 2. Sample preference of Wood treated by CC-organic compound, (a) sample before test; and (b) wood treated by CC-organic compound.

Instrumental chemistry analysis was conducted to determine retention of copper chromium-organic compound into wood material. Atomic Absorption Spectrophotometry (AAS) is conducted to determine anorganic components, copper and chrom, while High Performance Liquid Chromatography (HPLC) is conducted to determine the existence of organic compound. Wet destruction method use aquaregia ($\text{HNO}_3:\text{H}_2\text{SO}_4 = 1:1$) toward wood specimens was done as preparation procedure before AAS analysis. AAS flame system analysis was performed and the result presented in table 3 below.

Table 3. Anorganic compound (*copper chromium complex*) of treated wood specimens

Sample Specimens	Parameter	Copper Chromium Contain (mg/l)
CC-Organic compound solution	Cu	4603
	Cr	3963
Wood treated by CC-organic compound (1:1)	Cu	2,4
	Cr	2,060
Untreated wood	Cu	0,075
	Cr	0,020

HPLC analysis was performed to characterize the existence of organic compounds, *Nicotiana tobaccum* and *Eugenia carryophyllata* extractives. Sample preparation was conducted by milling wood sample to powder size and extracted methanol. The results presented in figure 3.

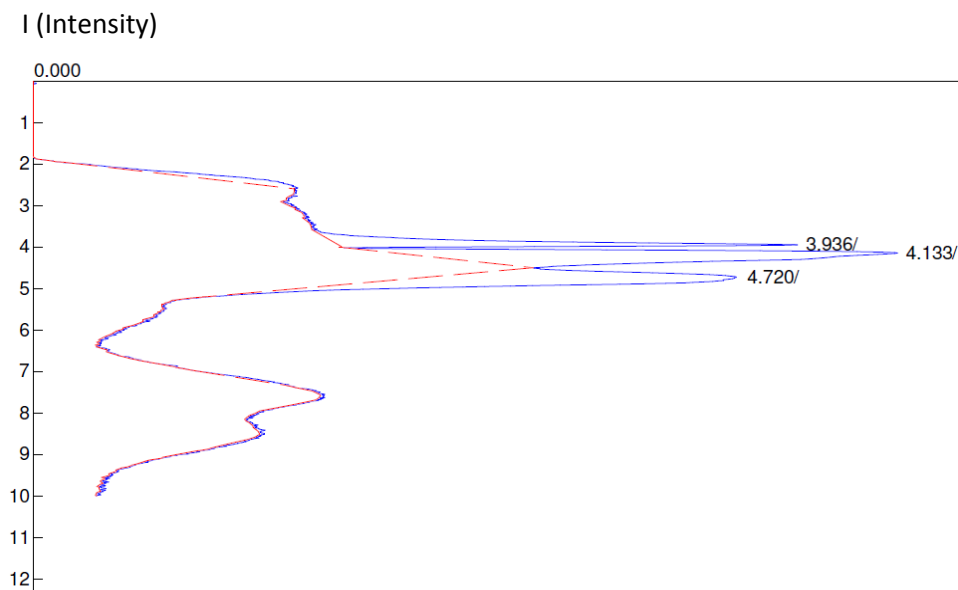


Figure 3. Chromatogram of wood treated by CC-Organic compounds

Based on the The chromatogram, there are four peak retention. according to *Alltech Catalog Chromatography*, nicotine is identified at 4,133 minute time retention and eugenia carryophyllata extractives showed in 7,5 minute time retention.

Conclusion

Wood packaging product treatment with 10 ppm Copper Chromium-Organic Compounds (1:1) is effective to prevent the attack of powder post beetle, *Heterobostrychus aequalis*.

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Termicidal Activities of *Abrus Precatorius* L. Leaves Extract against Subterranean Termite *Coptotermes gestroi*

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Abstract

Research on analyzing termicidal activity of *Abrus precatorius* L. leaves extract against subterranean termite *Coptotermes gestroi* has been conducted. To obtain active compounds, Leaves of *Abrus precatorius* L. extracted with methanol and evaporated by vacuum evaporator. The yield of methanol extract was 20,39%. Termicidal activities was analyzed by subjecting various concentration of *Abrus precatorius* extract toward *Coptotermes gestroi* in force feeding test method. Subterranean termite, *Coptotermes gestroi* mortality rate was observed per two days periods until two weeks test period. The result showed that the good mortality of *Abrus precatorius* L. leaves extract obtained in 10% w.t and 8% w.t concentration, while 100% mortality rate showed in twelfth days and fourth days test period. The lethal concentration (LC) value of *Abrus precatorius* L. leaves extract resulted LC₅₀ and LC₉₅ value in 4.59 and 8.94 concentration.

Key words : termicidal activity, *Abrus percatorius* L., *Captotermes gestroi*

Introduction

The awareness of synthetic pesticide negative effect toward environment, has risen intention of many researcher to find new alternatives biopesticide agent. Considered on the large biodiversity, Indonesia has potential resources of secondary metabolite with many bioactive compounds. On the contrary, as tropical country, Indonesia is appropriate habitat for more than 200 termite species. Gurbel (2008) reported that termite is one of the most destructive insect which causes serious damage toward building construction. In Asia, 22 millions US \$ per year was allocated for termite control and building repairing caused by termite attack (Su & Scheffrahn, 2003). Khrisna and Weesner (1969) said that subterranean termite, *Captotermes gestroi*, is the most destructive and dangerous termite. This termite not only attack building construction but also furniture and goods from cellulose-based material. This attack causes terrible damage about 63-90% building in Malaysia, Thailand, Singapore (Gurbel, 2008) and Indonesia (Prasetyo and Yusuf, 2004). The study of bio-based wood preservatives is proposed to give alternative effective treatment against termite attack. This kind of study is very important to reduce chemical-based pesticide which has negative effect towards environment and humanosphere.

This paper will discuss about termicidal activity of *Abrus percatorius* L. leaves extract against subterranean termite, *Captotermes gestroi*. *Abrus percatorius* L., classified into *leguminosae* family, is reported has bactericidal activities compounds, such as tryterpenoid glycyrrhetic acid (Syafii W., 2001). Sornnuwat et. al. (1995) also reported that alkaloid compounds of *Abrus percatorius* L. such as trygonelline, choline and hypaphorine, showed good activities against spider mite pathogen insect, *Tetranychus urticae* Koch. Other study reported anti-fungal activities against *Aspergillus tamari* and *Aspergillus niger* (Dimetry, 1992), while insecticidal activities against mosquitoes, locust and spider mite was reported by Jamil et. al. (2007).

Material and Method

Abrus percatorius L. obtained from Bogor, dried and powdered to 40 mesh size. 167,43 g *Abrus percatorius* L. powder remain into methanol by maceration method, and then extract solution evaporated at 50 °C and pressure 1 atm. Condensed extract dried over water bath to obtain dried extract. Phytochemical screening analysis was done to qualitatively identify secondary metabolite compounds.

The bioassay test method against *Coptotermes gestroi* referred to Setiawan et. al. (2008). This force feeding test method use paper disc as termite bait. Paper disc was treated by extract with various concentration above, while

control specimen use paper disc treated by pure methanol. All of the test paper disc was entered into desicator for six hours to evaporate methanol solvent. Then, fifty workers and five soldiers of *Coptotermes gestroi*, and extract-treated paper disc was entered into petri disc coated by plaster Paris 3 mm. The Bioassay test periode will run for 14 days. Termite mortality was observed per two days periods and in the final period observation, the mass loss of paper disc also determined.

$$\text{Mortality percentage} = \frac{(R1 - R2)}{R1} \times 100\%$$

Where, R1 = Total termite quantity before test
R2 = Total termite quantity after test

$$\text{Weight loss percentage} = \frac{(ODS1 - ODS2)}{ODS1} \times 100\%$$

Where, ODS 1 = oven-dried sample before test
ODS 2 = oven-dried sample after test

Letal concentration value, LC₅₀ and LC₉₅, was observed use linier regression method based on termite mortality rate versus extract concentration, according to the formula:

$$Y = aX + b$$

Where, Y = Mortality
X = Concentration
a = X variable (slope)
b = intercept

Result and Discussions

The extraction of *Abrus precatorius* L. leaves gives 20,39% yield extractives. Phytochemical analysis result displayed on table 1. It shows that *Abrus precatorius* L. leaves extract contain mainly secondary metabolite compounds, with alcaloid, tannin, flavonoid, and glycosidic group remain high intensity.

Table 1. Phytochemical analysis of *Abrus precatorius* L. leaves methanol extract

Group Name	Concentration/Intentisity
Alcaloid	++++
Saponnin	+++
Tannin	++++
Phenolic	+
Flavonoid	++++
Tryterpenoid	++
Steroid	+
Glycocide	++++

(Note, (-) = negative; (+) = low concentration; (++) = medium; (+++) = high; (++++ = very high)

The bioassay test against *Coptotermes gestroi* was conducted on various concentrations of *Abrus precatorius* L. leaves extract. Figure 1 shows relation between concentration and termite mortality rate. The observation begin after two days tes. The higher extract concentration the higher termite mortality rate, while in control specimens there were no termite mortality during test.

Terminicidal activities of *Abrus precatorius* L. leaves extract take effect in day six. Test block with 10% w.t. extract concentration gave 100% termite mortality in day twelve, while 8% w.t. extract concentration achieved it in the end of test periode. Compared to other related study, *Abrus precatorius* L. leaves extract show higher terminicidal activities than *Antiaris toxicaria* leaves extract and *Picrasma javanica* bark extract (Tarmadi et. al., 2008 and Setiawan et. al., 2008), which just gave 90% termite mortality after ten days test at the same concentration. Control specimens,

used paper disc treated by methanol, show no termite mortality founded. It can be concluded that solvent doesn't influence termite mortality rate.

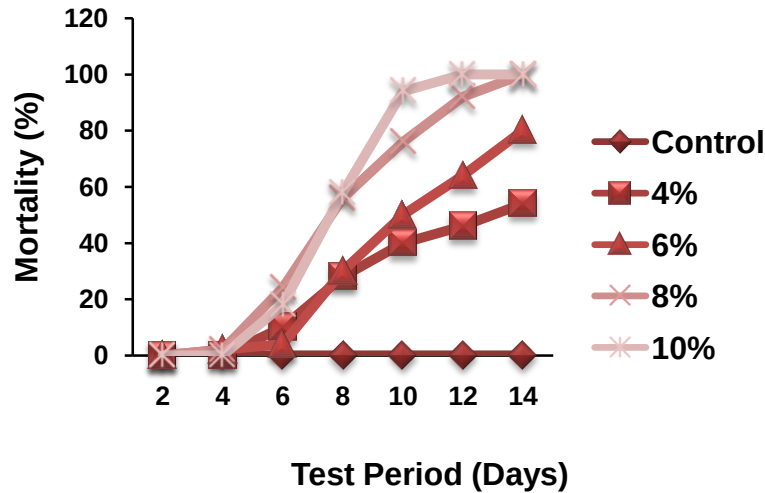


Figure 1. Termite mortality rate of *Abrus percatorius* L. leaves extract

Other parameter observed is weight loss percentage. This will describe the typical of *Abrus percatorius* L. termicide activities, whether anti-feedant or non-repellent character. Figure 2 shows there are no correlation between concentration and sample weight loss. Termite is still able to feed the bait, even in the highest extract concentration. It indicates that *Abrus percatorius* L. leaves extract has non-repellent characteristic and termite mortality is caused by extractive compounds toxicity after consuming the bait.

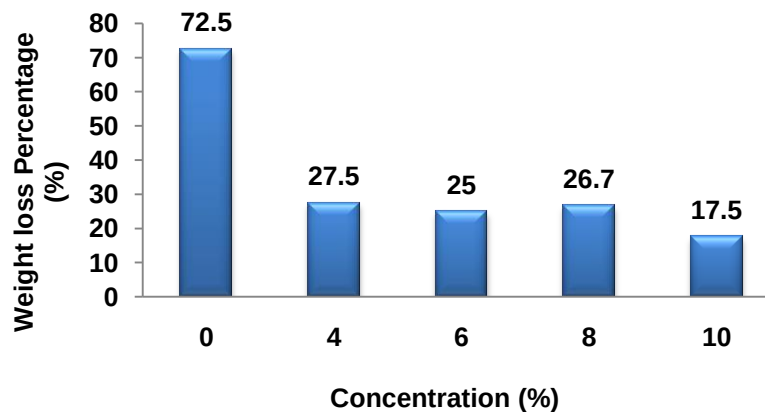


Figure 2. Sample weight loss percentage of *Abrus percatorius* L. leaves extract

Based on termite mortality rate obtained, lethal concentration value, LC_{50} and LC_{95} , can be simulated by regression formula. Figure 3 shows the correlation between concentration and termite mortality in day twelve. The LC_{50} value is 4.59, means *Abrus percatorius* L. leaves extract with concentration 4.59% w.t. can kill 50% test population of subterranean termite, *Coptotermes gestroi*, in 12 days test. In other hand, the LC_{95} value is 8.94. The determination of LC_{50} and LC_{95} value is very important for further study.

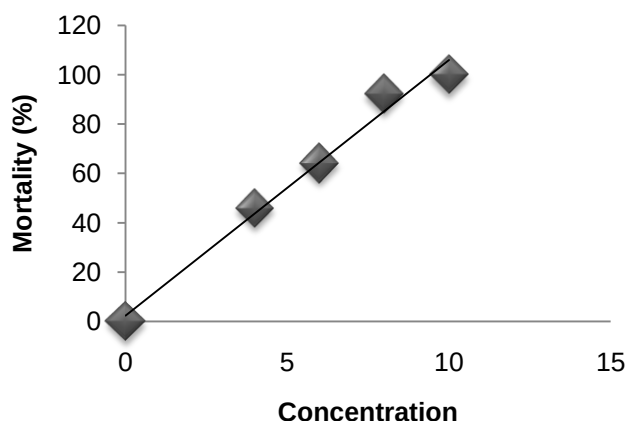


Figure 3. linear curve of *Abrus precatorius* L. leaves extract concentration versus termite mortality

Conclusion

Abrus precatorius L. leaves extract show termiticidal activities against subterranean termite, *Coptotermes gestroi*. Considered to sampel weight loss data, *Abrus precatorius* L. leaves extract give non-repellent characteristic. The value of LC₅₀ and LC₉₅ are obtained at 4.59 and 8.94 %.

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The Effication of *Areca catechu* L Kernel extract against Subterranean Termite *Coptotermes gestroi*

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Abstract

Research on the efficacy of *Areca catechu* L. kernel extract against subterranean termite *Coptotermes gestroi* has been conducted. Subterranean termite is one of the most dangerous pathogen insect against wood. It has wide distribution and caused tremendous economical loss. *Areca catechu* L is traditionally well known as medicine but not yet studied its chemical active compounds. To obtain active compounds, *Areca catechu* L. kernel was extracted with methanol and evaporated by vacuum evaporator. Terrestrial activities analyzed by subjecting various concentration of *Areca catechu* L extract toward *Coptotermes gestroi* in force feeding test method. Termite mortality was observed per two days periods until fourteen days. Research result shows that extract of *Areca catechu* L. kernel with concentration (w.t) 10% and 8% had causing 62% and 55% termite mortality on last observation. Whereas extract of *Areca catechu* L. kernel with concentration (w.t) 4% and 6% had causing 33% and 48% termites mortality on last observation.

Key words : *Areca catechu* L. kernel, termiticide, *Coptotermes gestroi*

Introduction

The Exploration on natural extractives which have good potential termiticidal activities, are intensively studied in regard to negative impact of chemical-based wood preservatives. As tropical country, Indonesia is well-known has more than 200 termite species. Subterranean termite, *Coptotermes gestroi*, is one of the most destructive and dangerous termite. More over, this termite attack has risen high economic loss until billions Rupiah per year (Prasetyo and Yusuf, 2004). In other hand, availability of durable wood is in scarce resources because of a stiff price and limited supply from natural forest. Consequently, most building use less durable wood so it will be susceptible toward termite attack. Based on this background, chemical treatment with proven wood preservatives agent is required to protect building construction against termite.

Tarmadi et. al. (2007) reported that leave and barks extract of bintaro (*Carberra odollam*) and kecubung (*Brugmansia candida*) have high termiticidal activities. Guswenrivo et. al. (2005) reported that diethyl ether fraction of *Piper betle* L. leave extract also gave high termite mortality rate. Other natural extractives reported by Tarmadi et. al. (2007) to be good potential termiticidal activities, such as sirsak (*Annona muricata*), srikaya (*Annona squamosa* L.) dan cengkeh (*Eugenia aromaticum*).

This paper will study about the efficacy of *Areca catechu* L. seed kernel extract against subterranean termite, *Coptotermes gestroi*, and its potency to be natural-based wood preservatives agent. *Areca catechu* L. is well-known as traditional medicine which has anti-oxidant and anti cancer activities.

Material and Method

Areca catechu L. kernel obtained from Bogor, dried and powdered to 40 mesh. 683,46 g pinang seed powder remain into methanol by maseration method, and then extract solution evaporated at 40 °C. Condensed extract dried over water bath to obtain dried extract. Bioassay test was done in various pinang seed kernel extract concentration, 4%, 6%, 8%, and 10% (w/v). The bioassay test method against *Coptotermes gestroi* referred to Guswenrivo et. al. (2005) and Prianto et. al. (2005). This force feeding test method use paper disc as termite bait. Paper disc was treated by extract with various concentration above and entered into desicator for six hours to evaporate methanol solvent. Then, fifty workers and five soldiers of *Coptotermes gestroi*, and extract-treated paper disc was entered into petri disc

coated by plaster Paris 3 mm. The Bioassay test period will run for 14 days. Termite mortality was observed per two days periods and in the final period observation, the mass loss of paper disc also determined.

Percentage mortalities =
$$\frac{(R1 - R2)}{R1} \times 100\%$$

Where, R1= Total termite quantity before test
R2= Total termite quantity after test

Weight loss percentage =
$$\frac{(ODS1 - ODS2)}{ODS1} \times 100\%$$

Where, ODS 1 = oven-dried sample before test
ODS 2 = oven-dried sample after test

Result and Discussion

The extraction of *Areca catechu* L. kernel generate about 13,05% yield extractives. Termite mortality rate of *Areca catechu* L. kernel extract presented in figure 1, shows that extract with concentration 10% w.t and 8% w.t give termite mortality at 62% and 55%. The higher extract concentration the higher termite mortality rate. Based on the bioassay result, the extract with 10% concentration shows termicide activity, while concentration below doesn't give significant result.

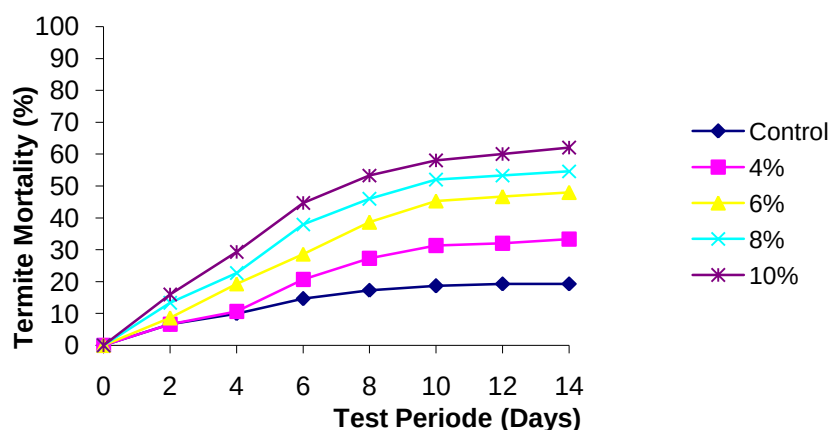


Figure 1. Termite mortality rate after 14 days test

The efficacy of *Areca catechu* L. kernel extract against subterranean termite, *Coptotermes gestroi*, is less effective compared to Piper betle L. leaves extract (Guswenrivo *et al*, 2005), Azadirachta indica leaves and bark extract (Prianto *et al*, 2005), leaves and bark extract of Carbera odollam and Brugmansia candida (Tarmadi *et al*, 2007), seed and leaves extract of Annona muricata L. (Prianto *et al*, 2008), those give 100% termite mortality.

Table 1. Phytochemical analysis result of *Areca catechu* L. kernel extract

Group Name	<i>Areca catechu</i> L. kernel	<i>Annona muricata</i> L. seed*	<i>Sapindus rarak</i> seed*
Alkoloid	+++	-	-
Saponim	++++	++++	++
Fenolik	++++	+	-
Flavonoid	++++	++++	++++
Triterpenoid	++++	++	++++
Steroid	-	-	-
Glycoside	+++	++++	++++

*Prianto *et al* (2008)

Note:
 - = Negative
 + = Low
 ++ = Medium
 +++ = High
 ++++ = Very High

Phytochemical analysis shows that *Areca catechu* L. kernel extract contain saponnin, phenolic, flavonoid, tryterpenoid and glycosidic group (see table 1). Compared to *Annona muricata* L. and *Sapindus rarak* seed extract, *Areca catechu* L. kernel extract shows the same intensity of flavonoid. Even shows the higher intensity of phenolic and alcaloid groups, *Areca catechu* L. kernel extract only give 62% termite mortality rate. It's assumed that termite mortality was caused by toxical extractives compounds, and not by common group even qualitatively detected.

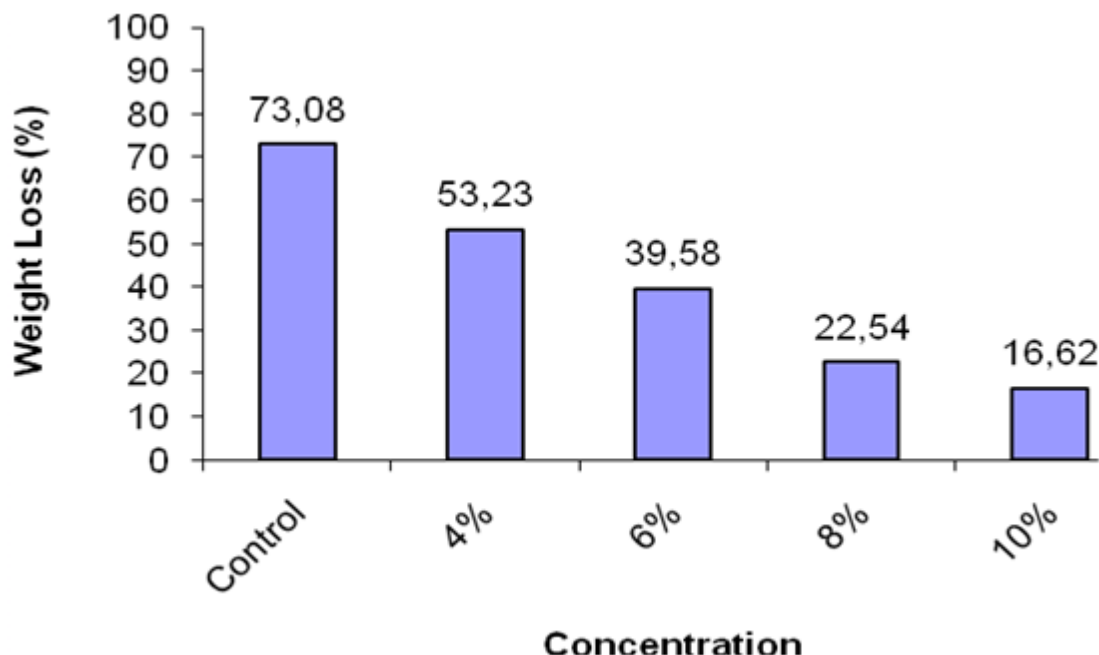


Figure 2. Weight loss percentage of paper disc during the test

Termite consumption rate on the bait displayed on figure 2, confirms that the higher extract concentration the lower sample weight loss. Falah et. al. (2005) said that the lower paper disc consumptin by termite on the higher extract concentration indicated that extract was able to increase sample durability against termite attack. This extract is assumed contain toxical compound which infect protozoa and causes termite mortality after indigestable of cellulose (Tarmadi et al, 2007).

Conclusion

Areca catechu L. kernel extract with 10% w.t. gives effect on mortality of subterranean termite *Coptotermes getroi*, and has potency to be developed as bio-based wood preservatives agent in the future.

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Exploration of Extract of Pinus (*Pinus merkusii*) and Ki Hiyang (*Albizzia procerra* Benth) Barks as Natural Preservatives

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Abstract

The extractive from Kihyang bark and Pine bark has important role in the development of *Coptotermes curvignatus* and *Schizophyllum commune* Fr.

Recently, Research about bioactive from wood or barks as natural preservative were developed. This research was carried out to find out the bioactive from Pine bark and Kihyang bark against subterranean termite *C. curvignatus* and White rot fungi *S. commune* Fr.

N-hexane soluble fraction from Kihyang bark and Pine bark showed the highest antitermite activity. It is shown by the highest mortality and the lowest decreased of consumption (weight loss) compared with extract from ethyl acetate and ethyl ether soluble fraction.

For anti fungal activity, the extractive from ethyl acetate soluble fraction of Kihyang bark showed the highest value. It can suppress the growth of mycelium. The extractive from Ethyl ether from Pine bark showed the similar result.

Key words : Extractive, Kihyang, Pine, White rot fungi, *Coptotermes curvignatus*, *Schizophyllum commune* Fr.

Introduction

The most part of Indonesian wood 85.7% are classified into low durability. Durability of wood can be increased by using synthetic preservative. The life time of wood can be increased by applying chemical compound into wood.

Utilization of chemicals preservative were effective to control wood destroyer organism population, like termite or fungi. But it has lead to new problem. The chemical ingredients are harmful for humans and pollute the environment because it is non biodegradable. Therefore, alternative material should be found to substitute chemical preservative.

Wood was naturally durable to the wood destroyer organism, because of extractive containing in the wood that was toxic to the wood destroyer organism. Extractive from that wood or bark can be an alternative for anti termite or anti fungi.

The advantages of using natural preservative were toxic for wood destroyer organism and environmentally friendly.

It is well known that extractive was responsible for natural durability of wood. As like wood, bark has some substance that protects the plant against destroying organism. Shibutani et al (2004) reported that bark of *Picea glehnii* Sieb et zucc contained stilbenes, and especially *piceid* had the largest feeding deterrent effect against the subterranean termite *Reticulitermes speratus*. The acetone extracts from the bark of 51 different deciduous tree species were investigated to determine their anti fungal activity against plant pathogenic fungi (Mori et al 1997). Falah et al (2005) has reported that bark from some tropical hardwoods (Mahogany, Sonokeling, Manii and Johar) contain chemical compounds with anti termite activity.

To achieve that goal, it is needed to explore bioactive contained in bark., and test them to wood destroying organism like subterranean termite or white rot fungi. A study on evaluation of anti termite and anti fungal activity of extract of Kihyang and Pine Bark was carried out to know the possibility of bark extractive as natural preservative

Materials and Methods

Materials

Barks that used in this research were bark from Pine (*Pinus merkusii*) and bark from Kihyang (*Albizzia procera* Benth) . To assay the toxicology of the extract, we used subterranean termite, *Coptotermes curvignatus* Holm and White rot fungi *Schizophyllum commune* Fr.

Solvent that used in this research was Acetone, n hexane, ethyl ether and ethyl acetate.

Methods

As amount as 2000 g bark meal (Oven dry weight) from *Pinus merkusii* and *Albizzia procera* Benth which passed through a 40 -60 mesh was extracted with acetone with ratio 1:3 for 48 hour and then was evaporated at the maximum temperature 40 C to concentrate it. The residue was then successively fractionated with n-hexane, ethyl ether and ethyl acetate to give their soluble fraction.

The general scheme of this successive fractionation is presented diagrammatically in Figure 1.

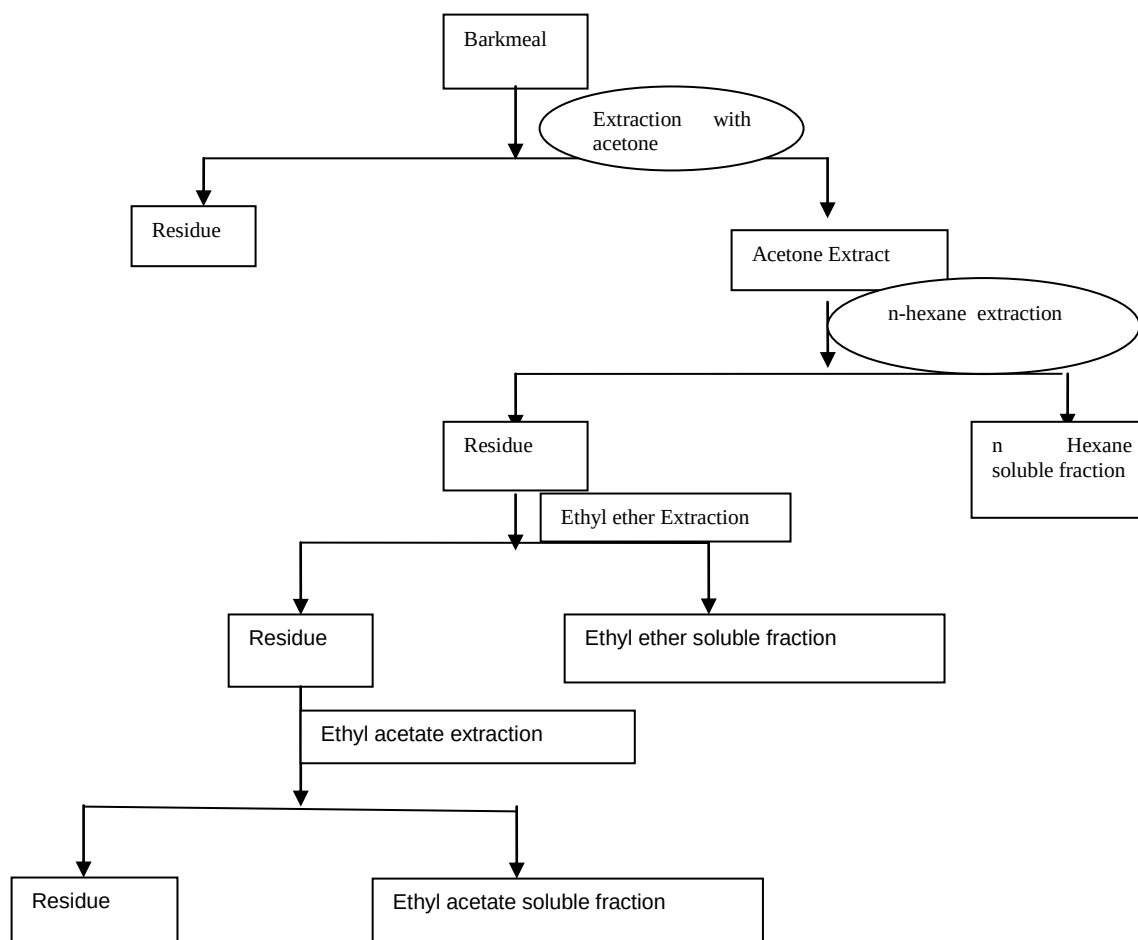


Figure 1. Scheme of Successive Fractionation

Antitermite Test

Antitermites test was carried out according to modified cellulose pad methodes from Steller and Labosky (1984). A subterranean termite, *Coptotermes curvignathus* Holmgren, was used in this study. Air-dried Cellulose paper pads were treated with the extract of 4 kind of extractive from Pine and Kihyang bark at the various concentration 0, 2, 4 and 6% W/W). The pads were air dried and then 10 mg of sterilized soil and 5 ml of distilled water were added to keep confort and maintain relative humidity at saturation.

The cellulose paper pads were placed into glass and covered with alluminium foil and placed in the environmental chamber for 4 weeks. Fifty termites were added to each cup. Surviving termites were counted at the end of feeding. Weight loss of the pads after 4 weeks was also used to quantify termite attack. The test was replicated in triplicate for each species and fraction. Control using pads without bark extract were also evaluate to determine the extract effect.

Antifungal Activity.

To know the effect of extractive from Pine and Kihiyang bark againsts the growth of fungi, we used bioassay test with several modification. Atifungal activities were investigated againsts white rot fungi *Schizophyllum commune* Fr.

The soluble extract at specific concentration (2, 4 and 6 % V/V) was added into Potato dextrose agar. The agar was poured into petri dish and gelled. The previously cultured fungus was pulled out with a cork borer, and the fungus was incubated with the test plate 27 °C for a week. Percent of inhibition againsts fungus was calculated. Control using agar without bark extract solution were also evaluated to determine the extract effect. The test was replicated in triplicate for each species and fraction.

Result and Discussion

Percentage of Extractive

The content and composition of extractive that has been extracted from Kihiyang bark and Pine bark was provided on the Table 1.

Table 1. Content and Composition Extractive from Kihiyang Bark And Pine Bark

Fractions	woods species	
	Kihiyang	Pine
n-hexane soluble	1.38	0.17
Ethyl ether soluble	1.22	0.50
Ethyl acetate soluble	0.97	0.22
Residu (insoluble)	0.63	1.10
Acetone extract	4.20	2.00

Table 1 showed that total amount of extractive (acetone extract) from Kihiyang bark and Pine bark were 4.20 % and 2.00% of oven dry woods respectively. The content of extractive from Kihiyang bark showed higher value than extractive from Pine Bark.

The extractive from Kihiyang bark and Pine bark vary in quantity and quality. They also showed different color in the different fraction. The Acetone extract was dark brown, ethyl acetate soluble fraction was reddy brown, n –hexane solubefraction was yellowish green and ethyl ether was yellowish brown. The color of the extraction showed that chemical compound that extracted from different fraction was vary.

Antitermite Test

Bark Extract from Kihiyang

Mortality and weight loss test was done to know the mortality of termite after feeding cellulose paper disk treated with extract of Kihiyang and Pine bark, and weight loss of that paper disk.

The termite mortality and weight loss of paper disc are summarized in Figure 2, and Figure 3. Figure 2 indicates that each extract show characteristic in the end of the test. In the Kihiyang bark extract shows the biggest termite mortality got in n hexane soluble that reach 55.66%. The ethyl ether, ethyl acetate soluble and residue (unsoluble) of Kihiyang bark extract give termite mortality less than 50%

Increasing concentration of the extract will increase mortality of the termite. The average of mortality was 30 until 50%. From figure 2, we can also see that Kihiyang bark extract increased the mortality of termite compared to blank. Termite was dead after consuming cellulose pad treated with extract of Kihiyang bark. The addition of extract (n-hexane, ethyl ether, and ethyl acetate soluble fraction) and residue into cellulose pads resulted in marked increased of termite mortality.

Figure 3 showed that weight loss of cellulose pads treated with extract of Kihiyang bark was less than weight loss of paper disk untreated with extract of Kihiyang Bark. Applying extract of Kihiyang bark will decrease the

weight loss of cellulose pads. Increasing concentration of Kihyang bark extract caused decreasing weight loss of cellulose pads.

In this case, n hexane soluble Kihyang Bark extract showed highest toxicity to the termite. It's possible that n-hexane soluble fraction contain antitermite substance

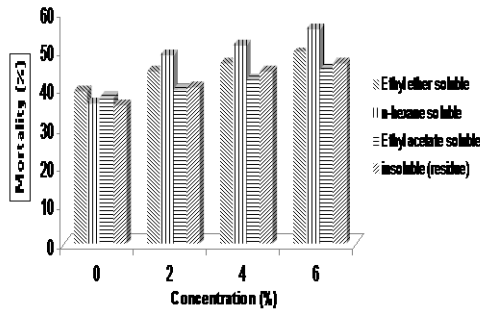


Figure 2. The Effect of Bark extract of Kihyang aganits Mortality of *C. Curvignatus*

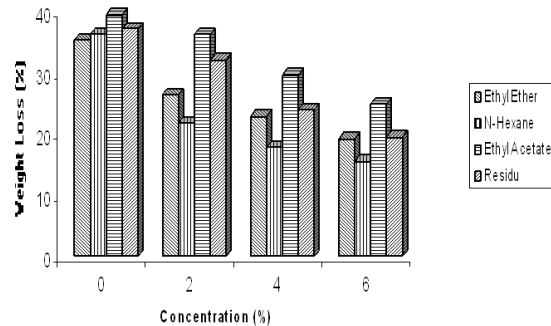


Figure 3. The Effect of Bark Extract of Kihyang Againts Weight Loss of Paper Disk

Pine Bark Extract

Result of the experiment showed that mortality of the termite vary in the different treatment. Each Extract soluble fraction gave different effect because of different compound.

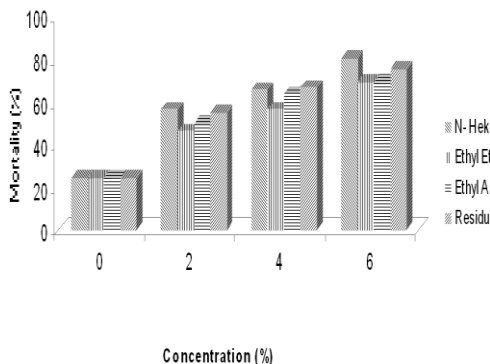


Figure 4. ffect of Pine Bark Extract towards Mortility of *C. Curvignatus*

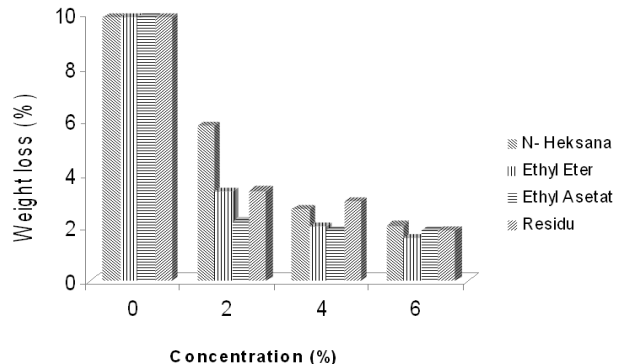


Figure 5. Effect of Pine Bark Extract against Weight loss of Paper Disc

Increasing Pine bark extract concentration from 2-6% will increase mortality of termite from 24.67% - 80.67%. (Figure 4). Poisoning effect from each fraction of extract Pine bark is varied.

The highest value of mortality as much as 80% was reached by applying n-hexane soluble fraction into cellulose pads as much as 6%. For the other fraction like ethyl acetate and ethyl ether reached 69.33% and 72.67% of mortality at same concentration

Figure 5 showed that addition of extract solution fraction from Pine bark decreased the weight loss of cellulose pads at the concentration Of 2-6%. The weight loss of untreated cellulose pads was much higher compared to cellulose pads treated with extract of Pine Bark. The weight loss decreased by increasing concentration of extract applied at cellulose pads. It showed that the addition of extract increased the resistance of cellulose pads to termite attract.

Based on the termite mortality and weight loss of paper pad (Figure 4 and Figure 5) it was shown that n-hexane soluble fraction and ethyl ether soluble fraction from Extract Pine bark might contain chemical compounds with antitermic activity. These fractions have potential as termicide.

The Growth of Mycelia *Schizophyllum commune* Fr.

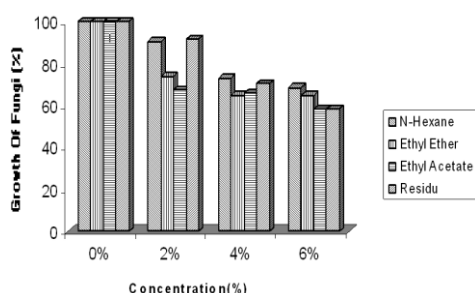


Figure 6. The Effect of kihyang Baerk Extract Againsts Growth of Fungi

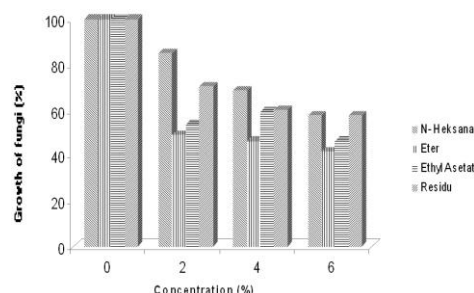


Figure 7. The Effect of Birk Extract of Pine against Growth of Fungi

Based on Figure 6, it was seen that applying Kihyang bark extract into medium can suppress the growth of *Schizophyllum commune*. All of fraction tends to decrease the growth of fungi caused of extractive that was applied into PDA medium.

In the case of extract from Kihyang bark (Figure 6). The highest suppression growth was produced by ethyl acetate soluble fraction at concentration 6%. This result was similar to acetone soluble extract.

Based on Figure 7, it can be explained that extractive from Pine bark produce such compound that can inhibit the growth of fungi. It can vary, depend on the fraction and concentration of the extractive.

It can be seen that ethyl ether soluble fraction from Pine bark extractive produce inhibition growth agent higher than that from ethyl acetate, n-hexane soluble fraction and residu (insoluble fraction). Increasing concentration of extractive, give higher inhibition effect..

It was proposed that the extractive from Pine bark made enzyme inactive. Enzyme has important role in decompose carbohydrate into simple glucose that easily consumed by fungi for metabolism process.

Zabel and Morrel (1982) stated that there is some compound well known can inactivate enzyme. Enzyme inhibition or poison can be potentially used as fungicide or preservative.

Enzymatic controlling mechanism at fungi that attack wood was vary depend on the type of the rotting. In General, enzym was controlled by 2 step mechanisme i.e To induce or suppress the synthezise of enzym and inhibit its activity. Varadi (1972) in the Eaton and Hale (1993) explained that Phenolic compound can suppress the activity of selulase and xilanase at white rot fungi *Schizophyllum commune* and soft rot fungi *Chaetomium globosum*.

Conclusion

Extractive content that soluble in Aceton for Kihyang Bark was 4.2% and 2.0% for Pine Bark, respectively.

The n-hexane soluble of Kihyang Bark extract and the n-hexane soluble of Pine Bark extract shows the highest antitermic substance (Itis showed by highest mortality and lowest weight loss of cellulose paper disc) compared to ethyl acetate and ethyl ether soluble of Kihyang Bark and Pine Bark extract .

In the case of antifungal activity, ethyl acetate soluble of Kihyang Bark extract showed the highest Inhibition growth of *Schizophyllum commune*. Eventhough ethyl ether soluble of Bark Pine extract showed the highest inhibition growth of *Schizophyllum commune*.

Extractive from Kihyang Bark and Pine Bark have important role in the growing of subterranean termite *C.curvignathus* and inhibition of fungal growth of *Schizophyllum commune* Fr

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Effect of Soursop Seed Oil Extract (*Anona muricata* L) on Dry Wood Termite *Cryptotermes cynocephalus* Light Mortality and Attack Degree

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Abstract

Soursop (*Anona muricata* L) seed oil extract in various concentration were tested to find out its effectiveness against dry wood termite (*Cryptotermes cynocephalus* Light) attack. Fifties dry wood termite worker were put into petridisk containing 7 cm filter paper sample which had been soaked into soursop seed oil extract for 2 minutes in eleven different concentration, i.e 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% dan 100% (v/v). The result showed concentration of soursop seed oil extract were significantly influence mortality and attacking degree of dry wood termite. The 100% average of termite mortality was showed by concentration treatment of 60% or more, whereas highly resistance sample was shown by concentration treatment of 40% or more.

Key words : extract of soursop seed oil, dry wood termite, mortality, attack degree

Introduction

One threat of the use of wood as a construction material and furniture is the attack of wood destroying organisms such as fungi, termites, beetle wood powder and marine borers. About 80 - 85% of 4000 wood species have low durability, which means vulnerable to attack wood destroying organisms (Oey Djoen Seng 1964). Therefore, efforts in preventing a damaging organisms to increase wood lifetime must be done.

To increase the lifetime of low durability wood, it needs to be preserved. Until now, almost all wood preservatives is a synthetic material that can negatively impact the environment. For that reason, we need other alternatives that are more environmentally friendly, such as botanical pesticides.

Some plant species known have been widely used as a botanical pesticide because of its active ingredient. One of the potential crop plant was developed as a pesticide is soursop plant (*Annona muricata* Linn). These plants are tropical plants which widely spread in Indonesia. Some parts of plants, especially leaves and seeds, can be utilized as a pesticide. Utilization of this plant as an insecticide, has been tested in some insects, such as the larvae of flies *Chrysomya bezziana* (Muharsini *et al.*, 2006), and termites (Irawati *et al.*, 2007).

This paper presents the results of efficacy studies of soursop seed extract oil to the dry wood termite attack tested in various concentrations. The goal was to obtain the lowest effective concentration to prevent dry wood termites *Cryptotermes cynocephalus* Light attacks.

Materials and Methods

Seed Extract Preservative Soursop.

Preservatives soursop seed extract obtained from the Central Research Spices and Medicinal Plants Bogor. Soursop seed extract dilutions performed using water and added 1% tepol as emulsifiers. The concentrations were 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% (v / v).

Sample Test

A sample test is a filter paper with a diameter fit to the petridisk. Sample test dipped in a solution of soursop seed extract for 2 minutes. Each of concentrations used five replications. After dipping, the samples test were air dried until completely dry.

Testing of Dry Wood Termites

The dry sample tests were put into the a petridisk and fifty dry wood termite workers were added. Sample test was stored in a dark room for 4 weeks.

Observations and Data Analysis

Observations made include termite mortality and wood protection degree. Percentage of mortality of termites determined at the end of the test. Termite mortality express as a ratio between the number of dead termites in the overall number of termites, such as the following formula:

$$Mi = \frac{JRMi}{JRSi} \times 100\%$$

Where: Mi = Mortality of termites in the test sample,

JRMi = number of dead termites in the test sample,

JRSi = total number of termites in the test sample.

Degree of wood protection by dry wood termites attack is determined according to (Martawijaya and Sumarni, 1978) (Table 1). Termite mortality data obtained was analyzed by analysis of variance to determine the influence of various treatments. To find out which treatment was significantly different, Duncan's test were done.

Table 1. Degree of protection tests on samples of dry wood termite attack

Attack condition	Value	Sample condition
< 5%	100	No attack
6 – 15%	90	Light attack
16 – 50%	70	Medium attack
51 – 90%	40	Heavy attack
>90%	0	Extremely heavy attack

Results and Discussion

The average mortality of dry wood termites were shown in Table 2. The results of analysis of variance showed a concentration range of soursop seed extract have real impact on mortality of termites. Meanwhile the average percentage of dry wood termite mortality in the control of the data was 30.4%, which indicates acceptable.

Mortality associated with the toxicity of insecticides. The higher the percentage of insect mortality, the higher the toxicity of these insecticides. An insecticide is effective if at low concentrations can cause high insect mortality. For termites, an insecticide is effective if it can cause 100% mortality of termites.

Table 2. The average percentage of dry wood termite mortality

Concentration (%)	Mortality (%)
Control	30,4a
Tipol 1	32,4a
10	64,4ab
20	86,0c
30	74,4b
40	94,0c
50	98,8c
60	100c
70	96,0c
80	100c
90	98,8c
100	98,4c

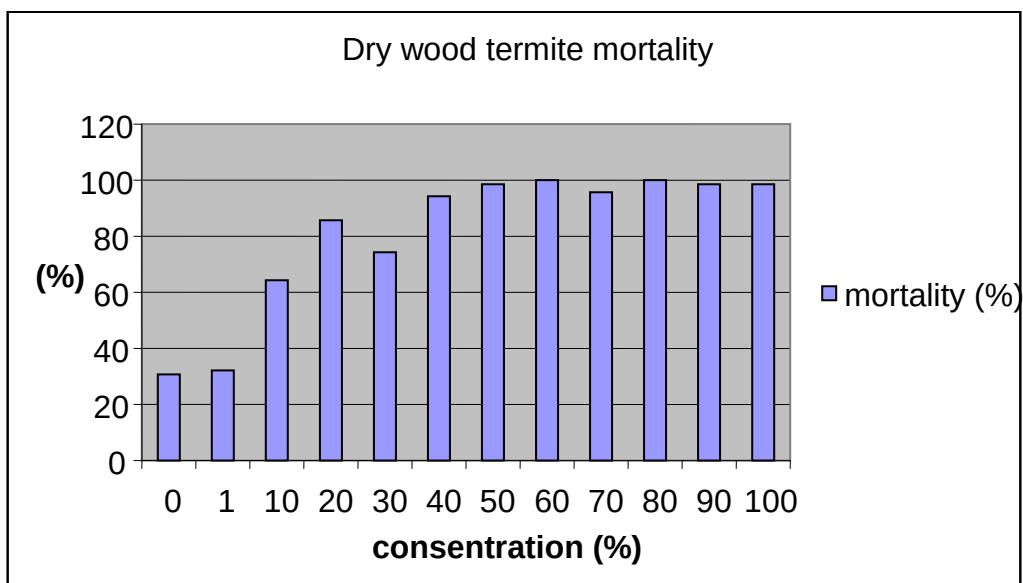


Figure 1. The average percentage of dry wood termite mortality

Soursop seed extract known to contain annonain and squamosin included in the group asetogenin (Lounderhausen *et al.*, 1991 in Muharsini *et al.*, 2006). These chemical compounds can inhibit the metabolism of insect cells that can cause insect mortality. Annonain and squamosin are cytotoxic and neurotoxic causing cell death in insects. When these compounds contact or enter the body will hinder the bond with the enzyme NADH cytochrome c reductase and cytochrome complex I sub-units located in the mitochondria of insects. As a result the cell loses energy and stops the cell respiration (Lounderhausen *et al.*, 1991b in Muharsini *et al.*, 2006).

The average degree of protection against the test samples of dry wood termite attack is presented in Table 3. In all treatment concentrations, the test samples showed only a light damage, ie the concentration of 10%, 20% and 30%, and the whole, ie the concentration of 40% to top. This is different from the conditions of samples test of the control which were destroyed.

Table 3. The average degree of protection against the test samples of dry wood termite attack

Concentration (%)	Average of attack value	Sample condition
Control	0	Extremely heavy attack
Thypole 1	70	Medium attack
10	92	Light attack
20	98	Light attack
30	98	Light attack
40	100	No attack
50	100	No attack
60	100	No attack
70	96	Light attack
80	100	No attack
90	98	Light attack
21	100	No attack

Conclusions

The average percentage of mortality of 100% achieved in 60% concentration of treatment, while the degree of termite attack on the whole test sample indicated by the treatment with a concentration of 40%. This shows soursop seed extract effectively prevent the dry wood termite attacks on the concentration of 60%.

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The Utilization of *Lantana camara* Extract as a Natural Wood Preservative

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Abstract

The objective of this research is to study the effectiveness of leaves of *Lantana camara* extraction in mortality of *Neothermes* sp and weight loss of samples of *Alstonia scholaris* in order to provide the basic information about the utilization of the essential oil as a natural wood preservative. The extract was impregnated into samples sized 2 cm x 2 cm x 1 cm in vacuumed for 15 minutes. This research is arranged by complete-random design with five concentration treatments and five replications, along with observation technique. The result of the experiment showed that *L.camara* leaf extract of 25 % caused 96.8 % mortality of termite (the highest proportion), whereas 0 % concentration caused the lowest mortality rate, 76 %. The result also revealed that the lowest loss weight was experienced by samples containing *L.camara* leaf extract of 25 %. On the other hand, the highest loss weight occurred in 0 % extract samples. There is a tendency for samples containing the extract to experience lower loss weight than other samples which have no extract concentrated. It because of the content of *L. camara* leaf extract which is toxic and has bad smell causing the termites ignored or stopped to eat it. The extract concentration also caused the higher number of dead termites, because they died after eating it.

Key words: *Lantana camara* leaf extract, effectiveness, mortality, weight loss

Introduction

Developments of settlement and building are now growing very fast, consequently, demand for wood increase rapidly. The types of desirable wood are strong and durable which is used to fulfill the demand. Because of that, this wood more and more become expensive in price. Not only that, the wood is occasionally available all the time to be ordered. Conversely, stock of woods with less durable, stable and strong are more available in order (Hadjib and Sumarni, 2000). Many methods have been previously conducted to prolong the use of that wood such as chemical and physical preservation, however those methods will effect harmfully to environment (biotic factors and abiotic factors). At the recent time, back to nature is one of the efforts, and it is now being developed increasingly by finding natural material to be used as friendly preservation material.

Walton (2006) stated that leaves and seeds of *Lantana camara* contain tripenoid in which it is poisonous compound. Extraction of *Lantana camara* can be used as biocides. Moreover, extract of the leaves can also be used to inhibit activities of bacteria, fungi, insect, and nematode. Furthermore, extract of *Lantana camara* contains poisonous compound where it can poison pest and weeds. Based on its nature characteristic, the extract of *Lantana camara* can expectantly also inhibit activities of wood destructive organism, mainly termite (*Neothermes* sp). Hopefully, extract of *Lantana camara* will be able to be completely developed as one of alternative material for natural wood preservative.

This research is aimed to study effectiveness of extract of leaves of *Lantana camara* in inhibition of activities of wood decay organism, and the result of this research can provide basic information for the utilization of essential oil as wood preservative.

Materials and Methods

Time and Location

This research was carried out from April to December 2008 on laboratory of wood processing and laboratory of wood technology in forestry faculty the state university of Papua.

Material and Research Equipment

Materials were leaves of *Lantana camara*, *Alstonia scholaris*, termites (*Neotermes* sp), technical methanol. While, the equipments were glass-medium, plastic-medium (from glass-package of beverage), evaporator, a set of glass-equipment, a set of vacuum machine, and termite testing tool.

Research Method

Experiment method with observation technique was applied and a complete random design with 5 treatments and 5 replications was set. The treatments are:

- Xa = impregnated-sample of 0 % of *Lantana camara* extract
- Xb = impregnated-sample of 25 % of *Lantana camara* extract
- Xc = impregnated-sample of 50 % of *Lantana camara* extract
- Xd = impregnated-sample of 75 % of *Lantana camara* extract
- Xe = impregnated-sample of 100 % of *Lantana camara* extract

Then, mathematical model of this experimental design is:

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$$

Y_{ij} = respond of each treatment and replication

μ = general mean

τ_i = effect of each treatment

ε_{ij} = error of each treatment and replication

Procedure

- a. Preparation includes making of sample of *Alstonia scholaris* in size 2 cm x 2 cm x 1 cm, then the samples were dried by oven. While, testing medium used mixing of soil and sand where amount of soil is two-fold than amount of sand in the medium. Next, leaves of *Lantana camara* were cut into small size, then the leaves were dissolved in methanol solution for 48 hours to get extract of *Lantana camara*. While, each treatment would be put 25 termites which have been specially treated where termites were fasted in a week.
- b. Extract was distilled to evaporate methanol, then the levels of concentration which consist of 25 %, 50 %, 75, and 100% of the extract were made. Whereas, concentration 100% of the extract is stock solution.
- c. Each sample of treatments was put in vacuum machine to impregnate the extract to sample for 15 minutes. After that, those samples would be air-dried for 1 day and then, the samples were put into each treatments and replication.
- d. Testing of anti-termite would be calculated after 6 weeks through measuring mortality of termite and loss weight of samples of *Alstonia scholaris* causing by termite activity. Formulas of the testing are :

$$\text{Mortality of termite (\%)} = \frac{\sum \text{Dead termites}}{\sum \text{Total of termites in testing}} \times 100 \%$$

$$\text{weight loss of sample (\%)} = \frac{b_0 - b_1}{b_0} \times 100 \%$$

Explanations: b_0 : weight of sample before testing (gram)

b_1 : weight of sample after testing (gram)

Data Analysis

Data are analyzed by F-test (analysis of variance) and if respond of treatments are significantly different, then honest significant difference test would be used to differentiate among the treatments.

Result and Discussion

Mortality of Termite (%)

Result of analysis shows that among treatments are not significantly different in mortality of termite. Average of the mortality of termite of each treatment can be seen in figure 1 on left, while the average of mortality of termite of each treatment in every week can be also seen in figure 1 on right.

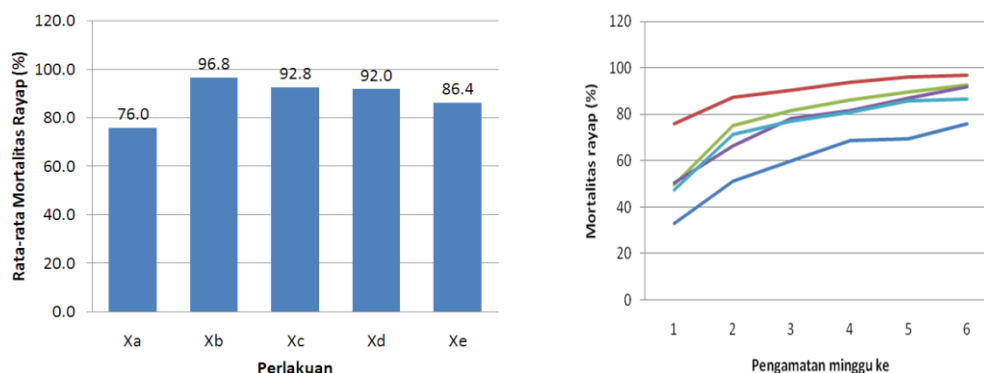


Figure 1. Average of mortality of termite

Figure 1 actually shows tendency among treatments in term of amount of dead termites. The treatment that was impregnated by 25 % extract of *Lantana camara* (Xb) causes the highest in amount of dead termites, while amount of dead termite in treatment without impregnation (0 %) extract of *Lantana camara* (Xa) is the lowest.

Observation in every week could shows that amount of dead in the treatments grew gradually. Of the 5 treatments, the highest in mortality of termite is the treatment that was impregnated by 25 % extract of *Lantana camara* (Xb), whereas the lowest in mortality of termite is the treatment without impregnation (0 %) of extract *Lantana camara* since the first week until sixth week. Wuryaningsih (2008) stated that extract of 60 % *Lantana camara* in water solution can effectively poison insect *P. unionalis* in 5 days where mortality of insect is 46.7 %.

Increase of mortality of termite was due to active poisonous compound that can poison termites, as a result of this effect, termites died when they ate impregnated-sample of extract of *Lantana camara*. Furthermore, Because of active poisonous compound, this extract can be used as anti-bacteria, insecticide, and nematocide (Saksena and Tripathi 1985 quoted in Sonibare and Effiong, 2008). Moreover, *Lantana camara* contains some essential oil which is dominated by 1, 8-cineole (15.8%), sabinene (14.6%). Those compounds are toxic and anti-bacteria (Sonibera and Effiong, 2008). Similar statement is stated by Isroi (2008) that extract of *Lantana camara* is one of bio-pesticides. It is as repellent and antifeedant which can repel insects. *Lantana camara* is inedible for insects, for that reason, in anti-termite testing, termites could not eat sample, so they perished and eventually dead.

While, dead termites were also seen in treatment without impregnation of extract of *Lantana camara*. As it happened, termite can eat one another to perform new colony as a one of characteristic of termite is cannibalistic. It also happened in the treatments that were impregnated by extract of *Lantana camara* where some dead termites were killed by other termites because termites cannot eat sample in those treatments.

Weight Loss of Sample (%)

Result of analysis shows that among treatments are significantly different in weight loss of sample. Hence, average of the weight loss of sample of each treatment is presented in figure 2.

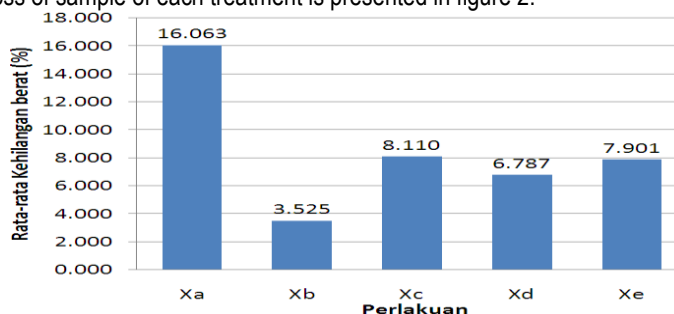


Figure 2. Average of the weight loss of sample

By using honest significant difference test (level of confidence = 95 %), each treatment can be divided as following table below.

Table 1. The comparison among treatments

Treatments	xa	xb	xc	xd	xe
Average of weight loss of sample	16.063	3.525	8.110	6.787	7.901
Notation	b	a	ab	ab	ab

Notation : same letter indicate that between treatments are not significant
different letter indicate that between treatments are significant

As clearly presented on table 1, treatment (Xb) that was impregnated by 25 % of extract of *Lantana camara* differs significantly from other treatments, in addition, amount of weight loss of sample in this treatment (Xb) is 3.525 % of weight sample where it is the lowest in average of weight loss of sample. While, of the 5 treatments, treatment without extract of *Lantana camara* in impregnation (Xa) showed the highest in average of loss weight of sample by 16.063 % of weight sample. This treatment was more edible for termite therefore the sample is harmless so that termite can eat the sample. Accordingly, sample weight in this treatment (Xa) was reduced rapidly than other treatments.

According to result above, it was estimated that impregnation in treatment impregnated by 25 % of extract of *Lantana camara* (Xb) can penetrate deeper compare with other treatments. It was due to the lower concentration of extract of *Lantana camara*, so that it was possible the extract to enter deeper into sample. For that reason, the deeper extract of *Lantana* can be impregnated, the more amount of extract of *Lantana* enters to sample. Thus, sample which contains more poisonous extract can causes termites become dead after eat the sample.

Another explanation can be added that amount of weight loss of samples in impregnated-treatment by concentration of extract of *Lantana camara* are lower than treatment without impregnation. It was happened because termites dislike small and taste of the impregnated-treatments.

Conclusions

1. Even though the treatments are not significantly different in mortality of termite, but tendency of mortality of termite shows that treatment without impregnation is lower than other treatments those are impregnated by concentration of extract o *Lantana camara*.
2. Amount of weight loss of sample of in 5 treatments are significantly different one another where impregnated-treatment by 25 % of extract of *Lantana camara* is lowest while treatment without extract of *Lantana camara* is highest. Generally, only a few of sample can be eaten by termites in impregnated treatment by extract of *Lantana camara*.
3. Characteristics of extract of *Lantana camara* are toxic, repellant, antifeedant for termites, so that termites dislike small and taste of the extract and they would not eat that sample. For those reasons, amount of weight loss of sample in impregnated-treatments is low.

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Effect of *Eurycoma longifolia* Jack on Growth and Testosterone Level in Male Chicken

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Abstract

Since a long time ago, people believe that *E. longifolia* could act as an aphrodisiac. Based on the assumption, this research was conducted to examine the biological activity of *E. longifolia* root non-polar fractions in male chicks. Samples were extracted using acetone 70% and applied in White Leghorn male chicks. Adaptation phase was conducted for 7 days. Treatment phase was conducted from day 8 to 21. On day 21, the chicks were weighed and then euthanized so that their comb, liver, bursa of Fabricius, and testis could be decapitated to be weighed and analyzed. The blood was also extracted to analyze the testosterone level. The animals were divided into 4 groups for the treatment; the first group was administered to 0.5 ml of corn oil as the blank, the second group was exposed to 0.417 mg/kg body weight (bw) of methyl testosterone as positive control, the third group was exposed to 0.417 mg/kg bw of *E. longifolia* acetone extract, fourth group was exposed to 0.834 mg/kg bw of *E. longifolia* acetone extract. This research employed Complete Random Design with five repetitions as the experimental design. Results showed that acetone root extract of *E. longifolia* give no aphrodisiacs activity in this research.

Key words : *Eurycoma longifolia*, anabolic, androgenic, testosterone, chicken

Introduction

The search of aphrodisiac has been conducted since the beginning of humanity, some searched for the answer from the nature and some others tried to synthesize it. Turner (1956) defined aphrodisiac as chemical substances used to arouse and stimulate sexual energy or lust. Some popular ingredients for aphrodisiac are Yohimbe tree from Africa, Ginko leaves and nuts from Asia, and other natural ingredients. Indonesia has several herbs that are believed to be aphrodisiacs such as zinc, sea leech, green shellfish, Javanese som, and *E. longifolia*.

E. longifolia has an economic aspect that should be explored further especially related to its usage as aphrodisiac. *E. longifolia* root extract is currently used by some people as the ingredient of *jamu* (Indonesian traditional potion). *E. longifolia* is an herb that has not been exploited optimally. From his research, Fudholi&Pramono (1986) stated that 3 out of 8 *jamu* that were distributed in the society to increase male vitality contained *E. longifolia* root extract with various compositions. Empirically, *E. longifolia* is believed to be able to heal malaria, fever, corroding urine and could act as aphrodisiac.

Based on the aforementioned description regarding the people's belief in *E. longifolia*, the research objective is to identify the activities of organic fractions from *E. longifolia* as aphrodisiac and then compare it with the effects of methyl testosterone. The result of this research is expected to be able to give initial information in the usage of *E. longifolia* root as herb to heal impotence.

Materials and Methods

Steroid Extraction

E. longifolia root in this research was acquired from Borneo Island. Before the treatment, it was previously dried under sun light and ground until *E. longifolia* powder with the size of 100 mesh was produced.

Steroid extraction was conducted by putting *E. longifolia* root powder into two bottles (10 g each). The first bottle was added by 50 ml of acetone 70% and the second tube was added ethanol 70%. Then all of the bottles were kept for 24 hours in a refrigerator with the temperature of 4 °C. The solution was then filtered; the filtrate was vaporized

in an oven with the temperature of 60 °C until it was completely dry. The precipitate was dissolved in ethanol with the concentration of 10 mg/ml and then analyzed using thin layer chromatography. The static phase employed was gel silica 60 F254 with 20 cm length and the dynamic phase employed was ethanol: ethyl acetate (1:1). The value of R_f was determined by measuring the distance of the sample spot migration (Stahl 1969).

Phytochemistry Test (Harborne 1987)

Alkaloid test was conducted by dissolving 1 g of *E. longifolia* powder into 5 ml of chloroform that contains 5 drops of ammonia. The mixture was then stirred and filtered into a tube. The filtrate was added 10 drops of H₂SO₄ 2 M, then it was shaken and the acidic fraction was separated. The sample was dripped to spot plate; positive test result was signified by the emergence of white precipitation by adding Meyer reagent and the emergence of brown precipitation by adding Wagner reagent.

Flavonoid test was conducted by adding methanol to 1 g of *E. longifolia* powder until it was completely soaked. The mixture was heated and filtered; the filtrate was then dripped into spot plate. The positive test result was signified by the emergence of red color by adding 1-5 drops of NaOH 10%.

Saponin test was conducted by adding 5 ml of water to 1 g of *E. longifolia* powder. The mixture was heated for 5 minutes. Then it was cooled down and shaken intensely. Positive test result was signified by the emergence of stable bubbles for 10 minutes.

Tannin test was conducted by adding 5 ml of water to 1 g of *E. longifolia* powder. The mixture was heated for several minutes and filtered. The filtrate was then added 5-10 drops of FeCl₃ 1%. Positive test result was signified by the emergence of dark blue or greenish black color.

Phenol test was conducted by adding 5-10 drops of FeCl₃ 1% to 1 g of *E. longifolia* root in a tube. Positive test result was signified by the emergence of purple, blue or green color.

Quinone test was conducted by adding water to 1 g of *E. longifolia* root. The mixture was boiled for 5 minutes and filtered. The filtrate was then added NaOH 15%. Positive test result was signified by the emergence of red color.

Molisch test was conducted by adding water to 1 g of *E. longifolia* root. The mixture was then filtered. The filtrate was then decanted into a tube and added 2 drops of Molisch reagent. Then the solution was added 3 ml of H₂SO₄ through the tube's wall slowly until two layers were created in the fluid. Positive test result was signified by the emergence of reddish purple ring on the meeting of the two fluids.

Bioassay

The laboratory animals employed in the research were 20 day one White Leghorn chicks (DOC) acquired from PT Charoend Pokphand. The animals were adapted for 7 days and were given standard feed BR-1 and *ad libitum* drinking water. During the treatment phase, the test animals were divided into 4 groups. Group I was administered with 0.5 ml of corn oil as the blank. Group II was administered with 0.417 mg/kg bw of methyl testosterone as positive control based on the dosage of methyl testosterone to human (Rosen 2007). Group III was administered with 0.417 mg/kg bw of *E. longifolia* acetone extract. Group IV was administered with 0.834 mg/kg bw of *E. longifolia* acetone extract. All of the administrations were dissolved in 0.5 ml of corn oil and those were given every day to the animals for 14 days. On the end of treatment, the animals were weighed and euthanized so that the comb, heart, bursa of Fabricius, and testis could be taken; the decapitated organs were then weighed. The blood from each animal was extracted 1 ml and the blood serum was separated, then the serum acquired from all of the animals from one group was mixed to be analyzed its blood testosterone concentration. The concentration of testosterone was measured using Electro Chemiluminescence Immuno Assay (ECLIA).

Results and Discussion

Steroid Extraction

The extraction result indicated that ethanol 70% produced more residue than acetone 70% (Table 1). Even so, the spot produced from thin layer chromatography indicated that acetone 70% spot was larger than the spot of ethanol 70%; therefore, the solvent used to extract *E. longifolia* in the research was acetone 70%.

Table 1 TLC spot on ethanol 70% and acetone 70%

Solvent	<i>E. longifolia</i> Powder (g)	Precipitate (g)	Percentage (%)	Spot 1 Area (mm ²)	Spot 2 Area (mm ²)
Ethanol 70%	10.00	0.1358	1.36	50.24	56.72
Acetone 70%	10.00	0.0934	0.93	78.50	122.66

Based on Table 1, the best solvent used in extracting *E. longifolia* root was acetone 70%. Even though acetone 70% produced less residues compared to ethanol 70%, acetone 70% spot was larger than ethanol 70% spot in Thin Layer Chromatography test.

Phytochemistry Test

The result of the examination indicated that *E. longifolia* root contains alkaloid, saponin and steroid (Table 2).

Table 2 Phytochemistry test of *E. longifolia* acetone extract

Compound	Test Result
Alkaloid	+
Flavonoid	-
Saponin	+
Tannin	-
Quinone	-
Phenol	-
Steroid	+

Phytochemistry test was an initial test to identify the presence of secondary metabolite in the analyzed sample. The result of phytochemistry test signified that *E. longifolia* acetone extract contained alkaloid, saponin, and steroid (Table 2). Alkaloid is the largest group from secondary metabolism product compound in plants. The function of alkaloid in plant has been reported as the growth controller and insect repellent. Saponin is a glycoside that consists of terpene and sterol. Saponin acts as anti-microbe. The presence of alkaloid and saponin supported the people's belief that *E. longifolia* root could act as anti malaria. Steroid in *E. longifolia* root was expected to have aphrodisiac effect and it would be measured through anabolic and androgenic effects in male chicks (Sambadan *et al.* 2004).

The anabolic characteristic is caused by testosterone's effect in the growth of tissue, muscle cells, erythrocyte, and bone. The growth would indirectly increase the weight of an individual. Fennel&Scannes (1992a) proved that a turkey that was given testosterone and other androgenic compounds showed an increase of body and other tissues weight such as breast muscle and heart.

Bioassay

Figure 1 presented the fact that there was no treatment that produced significant effect upon the body weight growth during the treatment ($P>0.05$). This fact signified that *E. longifolia* root acetone extract does not have anabolic effect. Even so, the body weight growth in all treatments was larger compared to group I as the control. The largest body weight growth was achieved by group III, followed by group II. This result is in accordance to the research of Ibrahim (2001) that the intake of methyl testosterone in small amount tends to increase body weight. The body weight increase in group IV was lower than group II and III even though the dosage of the extract that was given twice in the group was larger than group III. The result is in accordance to Fennel&Scannes (1992b). Statement that the intake of androgen in high dosage would decrease body weight. The body weight decrease that happened was related to the hormonal needs of the body in trace amount. Hormonal excess would be an inhibitor in metabolic reactions so that the growth would be hampered. Testosterone would also suppress the secretion of growth hormone and somatotropin.

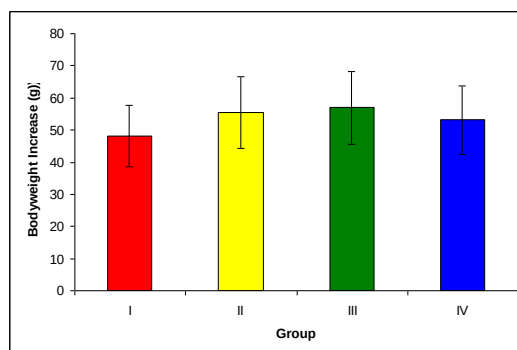


Figure 1 Chicken bodyweight increase during treatment

Based on Duncan Multiple Range Test (DMRT) in the weight of test animal's liver, only group III that had a significant liver weight compared to the control group ($P < 0.05$) (Figure 2). It is in accordance to the statement of Romero *et al.* (1976) that the intake of testosterone in small dosage would increase the liver weight while the intake of testosterone in high dosage would decrease liver weight.

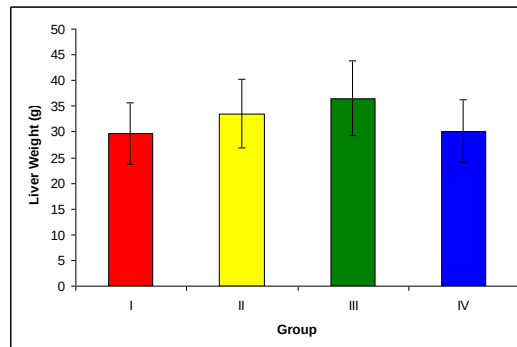


Figure 2 Chicken liver weight at the end of research

Figure 3 presented the fact that there was no treatment that produced significant effect to bursa of Fabricius ($P > 0.05$), including group II that was given methyl testosterone. While according to Romero *et al.* (1976) the intake of testosterone and other androgenic substances would decrease the weight of bursa of Fabricius in chicken. Bursa of Fabricius acts as defense gland; this gland is located between cloaca and large intestine. Androgen would slowly trigger the involution of bursa of Fabricius when given to the chicken on the first 7 weeks.

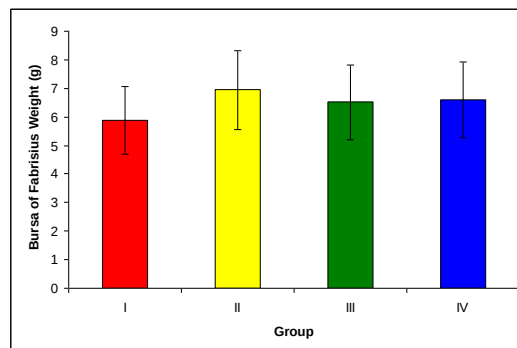


Figure 3 Chicken bursa of Fabricius at the end of research

Figure 4 presented the weight of all test animal groups' comb by the end of the treatment. Bursa of Fabricius would involute when the chicken reached sexual maturity and bursa of Fabricius atrophy could be reached earlier through testosterone intake. This fact is supported by the Fennel&Scannes (1992a) research that proved that male turkey that was given testosterone showed bursa of Fabricius weight decrease. This condition happened because testosterone caused the failure of follicle cells production in the bursa embryo. The damage is related to the lysis characteristic of steroid hormone that inhibits the production of humoral thymus by oxidizing ascorbic acid to dehydroascorbate; it indirectly causes the degeneration of peripheral lymphoid organ such as bursa of Fabricius. Androgenic characteristic affects secondary sexual characteristics; in chicken, they comprise comb, wattle, and testis (Akhlaghi&Zamiri 2007).

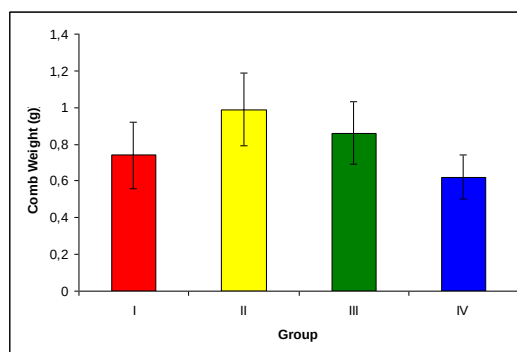


Figure 4 Chicken comb weight at the end of research

Figure 5 presented the weight of all test animal groups' testis by the end of the treatment. Figure 4 and 5 presented the fact that there was no treatment that produced significant effect to the weight of comb and testis ($P>0.05$). It signifies that *E. longifolia* root acetone extract does not have androgenic effect.

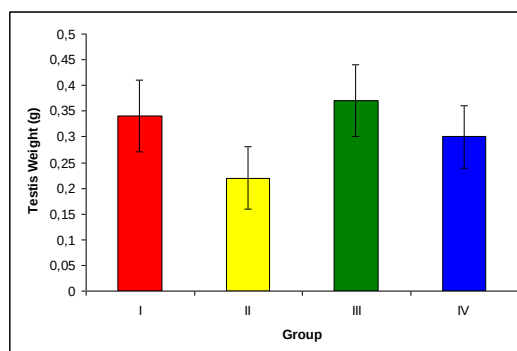


Figure 5 Chicken testis weight at the end of research

The result of testosterone blood serum measurement was presented in Table 3. The aforementioned result was confirmed by the blood serum testosterone concentration measurement (Table 3). Because testosterone in chicken's body plays a role in stimulating the growth of chicken, the weight increase of its secondary sexual organs, and the weight decrease of its defense gland (Tchernitchin AN&Tchernitchin N 1992). The measurement conducted was consistent with the data acquired and it signified that *E. longifolia* extract does not have any aphrodisiac activity.

Table 3 Chicken testosterone serum concentration at the end of research

Group	Treatment	Testosterone Concentration (ng/dL)
I	Control	39.19
II	0.417 mg/kg bw methyl testosterone	25.74
III	0.417 mg/kg bw <i>E. longifolia</i> extract	11.45
IV	0.834 mg/kg bw <i>E. longifolia</i> extract	-

Conclusions

The conclusion of this research is that even though *E. longifolia* acetone extract contains steroid, it seems to have no aphrodisiac activity. It could be seen from the insignificant increase of the chicken body, comb, wattle, and testis weight. The intake of methyl testosterone and *E. longifolia* extract in this research decreased the concentration of testosterone in male chicks.

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Hypouricemic Effect of *Swietenia macrophylla* Bark Extracts on Serum Uric Acid Levels in Hyperuricemic Rats

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Abstract

Bark has been used as a source of remedies for the treatment of many diseases in some countries. In this study, mahogany (*Swietenia macrophylla*) bark extracts was investigated for its hypouricemic effect. The effect of hot water and methanol extracts from *Swietenia macrophylla* bark on the serum uric acid levels was investigated using the rats pretreated with chicken liver juice as an animal model for hyperuricemia. Serum uric acid level was determined by 3,5-dichloro-2-hydroxybenzene sulfonic acid (DHBS) method. The hyperuricemia rats were induced with the liver juice by oral administration at the dose of 25 ml/kg for 4 weeks. Oral administration of hot water and methanol extracts at the dose of 500 mg/kg for 7 days reduced the serum uric acid levels by 27.9% and 21.0%, respectively. The effect of the extracts is less potent than that of allopurinol, which reduced the serum uric acid level by 66.6%. However, both extracts were able to elicit hypouricemic action in the hyperuricemic rats.

Key words : *Swietenia macrophylla*, bark extract, hypouricemic effect, uric acid level

Introduction

Swietenia macrophylla (Meliaceae) or mahogany is well-known for its fast growth, adaptability, good shape, and high value. For many generations, it has the most popular exotic tropical timber species in the trade and been commercially important timber tree in neotropical forests extending from southern Mexico to along the southern Amazon basin of Bolivia, Brazil and Peru. The rich red colour, durability, and workability of the timber have made it one of the most valuable tropical hardwoods. The seed was used for leishmaniasis and abortion medicine by Amazonian Bolivian ethnic group (Bourdy *et al.* 2000), and for antimalarial remedy in Indonesia (Soediro *et al.* 1990). The antimalarial activity of a *S. macrophylla* methanolic seed extract was evidenced against *Plasmodium falciparum* (Murnigsih *et al.* 2005). The bark extracts has been used as astringents for wounds and used occasionally for tanning leather because of rich mahogany red color. *S. macrophylla* is commonly called as big-leaf mahogany or Honduras mahogany to distinguish with *Swietenia mahagoni* JACQ. which is called little-leaf mahogany or west indian mahogany. However, antihyperuricemic activity of *S. macrophylla* bark has not been evaluated.

Hyperuricemia is a condition resulted from the overproduction and/or underexcretion of uric acid and is greatly influenced by a high dietary intake of nucleic acids. This condition has been associated with gout, a disease which is mainly caused by the deposition of monosodium urate crystals in joints tissues. Hyperuricemia and gout appear to be rapidly increasing worldwide. They frequently cause metabolic syndrome disorder and increased cardiovascular disease. Weight reduction, decreased alcohol consumption and dietary purine intake may help to decrease blood uric acid. However, the patients will still need medication to control their hyperuricemia.

Natural products, mainly of plant origin have long been used in traditional medicine for the treatment of hyperuricemia. Dietary flavonoids have their potential beneficial effects on human health. Flavonoids are well known to possess antioxidant activity (Pietarinen *et al.* 2006). The antioxidant activity of flavonoids may bring benefit for hyperuricemia and its complications. In previous study, we have isolated three flavonoids from acetone extract of *S. macrophylla* bark, namely swietemacrophyllanin, catechin, and epicatechin (Falah *et al.* 2008). In this study, *S. macrophylla* bark was evaluated for its hypouricemic effect on serum uric acid levels in hyperuricemic rats.

Materials and Methods

Extraction of Mahogany Bark

Bark was stripped from *S. macrophylla* trunk, collected from Sumedang, West Java, Indonesia in February 2009. Chipped bark was ground in a Wiley mill and screened to give 40-80 mesh bark meal in size. The voucher specimen was deposited in the Department of Forest Product Technology, Winaya Mukti University, Bandung, Indonesia. Bark meal (40-80 mesh, 3000g air dried) was extracted three times with acetone (5L) for 48h at room temperature, followed by methanol to give an acetone extract and a methanol extract, respectively. Another the 3500 gram bark meal was boiled in hot water (100°C) for a 4 hour to get a hot water extract.

Animals

Male Sprague-Dawley rats (6 weeks old, n=35) were obtained from The National Agency of Drug and Food Control of Indonesia. They were fed with a standard laboratory diet and allowed food and water ad libitum for an acclimatization periods of 2 weeks prior to experiments. The animals were divided into five groups of seven each and housed individually during the experimental period.

Animal Model of Hyperuricemic in Rats

A hyperuricemic animal model was induced with chicken liver juice suspended in 0.5% sodium carboxymethylcellulose (CMC-Na) by oral administration at the dose of 25 ml/kg body weight for 5 weeks. Blood was collected from the tail vein of the rats and then were centrifuged at 3000 rpm for 15 min. Supernatant serum was collected and stored until assayed. Blood collecting was undertaken on the starting (0) day, 14, 28, and 35 days of experiment.

Study Design and Treatment of Animals

Thirty five of rats were divided into five groups. In group 1, the normal control group, each animal received only water as vehicle. In group 2 and 3, the animals received chicken liver juice at the dose of 25 ml/kg and allopurinol at the dose of 3.3 mg/kg body weight, respectively. In group 4, methanol extract of mahogany bark was orally administered at the dose of 500 mg/kg together with chicken liver juice at the dose of 25 ml/kg. In group 5, the hot water extract was orally administered at the same dose of methanol extract together with the same dose of the chicken liver juice. The administration of allopurinol, methanol and hot water extracts was carried out daily for seven days on last week, while the chicken liver juice was given for 5 weeks.

Measurement of Uric Acid

Serum uric acid levels were determined by the 3,5-dichloro-2-hydroxybenzene sulfonic acid (DHBS) method (Fossati *et al.* 1980).

Results and Discussion

The initial mean serum uric acid levels of population were 2,79 mg/dL. The statistical analysis showed that serum uric acid levels are not significantly different among the groups. It means that the serum uric acid of treatment groups are homogen with the normal group. The administration of chicken liver juice in the rats for 28 days resulted in a significant elevation of the mean serum uric acid levels reaching to 3.65 mg/dL. This level was statistically a significant different from serum uric acid level of normal rats (Table 1).

Table 1. Serum uric acid levels in hyperuricemic rats after oral administration of chicken liver juice (pre- and post-intervention values are shown in 28th and 35th days, respectively)

Groups	Serum uric levels (mg/dL)		
	The starting (0) day	28th day	35th day
Hyperuricemic control	2.86 ± 0.18 ^a	3.79 ± 0.35 ^b	3.75 ± 0.46 ^c
Allopurinol	2.86 ± 0.51 ^a	3.63 ± 0.30 ^b	1.21 ± 0.10 ^a
Hot water extract	2.72 ± 0.69 ^a	4.00 ± 0.64 ^{bc}	3.05 ± 0.39 ^b
MeOH extract	2.63 ± 0.52 ^a	3.64 ± 0.29 ^b	2.87 ± 0.29 ^b
Normal	2.90 ± 0.28 ^a	2.95 ± 0.27 ^a	2.85 ± 0.63 ^b

In normal group, rats received only a water as vehicle, while the others received a chicken liver juice for 35 days experiment; Duncan procedure, the same letter(s) indicated not significant different ($P < 0.05$)

Allopurinol, hot water and methanol extracts were separately administered by oral at the last 7 days of 35 days experiment. Treatment with hot water and methanol extract produced insignificant decrease when compared to that of allopurinol. Allopurinol, a xanthine oxidase inhibitor (XOD), exhibited a remarkable reduction of serum uric acid levels in hyperuricemic rats and the levels were lower than normal rats. Allopurinol is the sole XOD inhibitor under the clinical application. The xanthine oxidase (XOD) is molybdenum-containing enzyme that catalyzes the conversion of hypoxanthine to xanthine and xanthine to uric acid in the purine catabolic pathway. To date, the only commercially available XOD inhibitor is allopurinol, a purine analogue.

Reduction of serum uric acid levels was observed for pre- and post-intervention of the bark extracts and allopurinol in each group. Oral administration of allopurinol, hot water and methanol extracts reduced the serum uric acid levels compared the hyperuricemic control rats. Oral administration of hot water and methanol extracts at the dose of 500 mg/kg for 7 days reduced the serum uric acid levels by 27.9% and 21.0%, respectively. Reduction percentages of serum uric acid levels in the rats treated with both extracts and allopurinol were compared with hyperuricemic control rats (Figure 1)

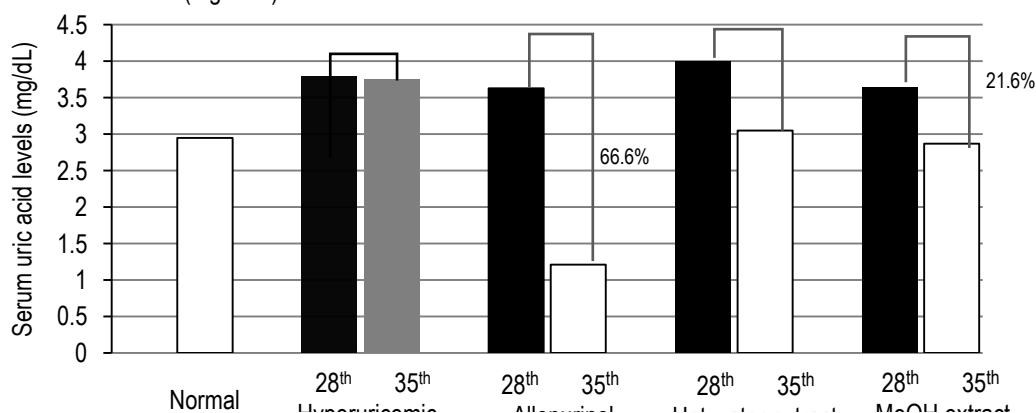


Figure 1. Serum uric acid levels reduction in hyperuricemic rats induced by *S. macrophylla* bark extracts and allopurinol (percentages of reduction were obtained from the treated animals for a week or the 35th day compared to pre-intervention value in that of the 28th day)

These data showed that reduction of serum uric acid levels from hot water extract is higher than that of methanol extract. The effect of both extracts was not statistically significant different among them. Those hypouricemic effect are less effective than that of allopurinol which reduce the uric acid level by 66.6% at the dose of 3.3 mg/kg. However, both extracts were able to elicit hypouricemic action in the hyperuricemic rats. Serum uric acid levels in hyperuricemic rats treated by both of extracts reduced to reach the levels are not significant different with normal group.

Hypouricemic effect of both extracts and allopurinol on the uric acid levels of hyperuricemic rats is shown in Figure 2. These data showed that serum uric acid levels of methanol extract group are lower than that of hot water extract group compared to hyperuricemic control group. Hypouricemic effect of both extracts is lower than that of allopurinol, but their serum uric acid levels was insignificant different with normal rats. Hot water and methanol extracts of *S. macrophylla* bark exhibited hypouricemic effect in hyperuricemic rats.

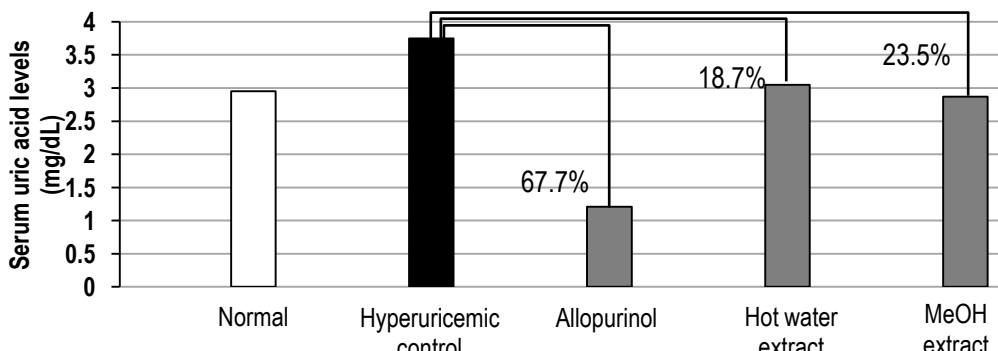


Figure 2. Hypouricemic effect of *S. macrophylla* bark extracts and allopurinol on serum uric acid levels in hyperuricemic rats

The hypouricemic effect of both extracts was suggested by reducing uric acid production with inhibition of XOD. From *S. macrophylla* bark, we have isolated and identified flavonoid compounds, namely catechin, epicatechin, and swietemacrophyllanin, a phenylpropanoid-substituted catechin (Falah *et al.* 2008). Flavonoids possess hypouricemic action in hyperuricemic rats due to their inhibitory effect on XOD activity (Nguyen *et al.* 2005).

Conclusion

The administration of chicken liver juice in the rats for 28 days resulted in a significant elevation of the mean serum uric acid levels, and significantly different with serum uric acid level of normal rats. Oral administration of hot water and methanol extracts at the dose of 500 mg/kg for 7 days reduced the serum uric acid levels by 27.9% and 21.0%, respectively. Those hypouricemic effect are less effective than that of allopurinol which reduce the uric acid level by 66.6% at the dose of 3.3 mg/kg. However, both extracts were able to elicit hypouricemic action in the hyperuricemic rats.

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Potency of Infusarium Kayu Gabus or Pule (*Alstonia scholaris*, R. Br.) Bark as Anti Hypercholesterolemia

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Abstract

Kayu Gabus or Pule (*Alstonia scholaris*, R. Br) grows in Indonesia and has been utilizing as tradisional medicine in the form of Infusarium. Research on the effect of providing infusarium to hypercholesterolemia rats been done. The purpose of this preliminary research is to recognize the effect of infusarium Kayu Gabus bark on total cholesterol level, LDL-cholesterol, triglyceride level, and the condition from fatty acid of male Wistar rats in hypercholesterolemia condition.

The results indicate that providing of infusarium (4 ml/kg/bw/day) during 14 and 28 days, can decrease total serum cholesterol level of male Wistar hypercholesterolemia respectively as follows: 25,68% (from 185,323 mg/dl to 133,154 mg/dl) and 37,23% (from 185,232 mg/dl to 111,221 mg/dl). The decreasing of concerned serum total cholesterol is followed by the increasing of HDL-cholesterol 21,31% (14days) and 36,01% (28 days), and the decreasing LDL-Cholesterol level 56,01% (14 days) and 77,67 & (28 days). However triglyceride level is still in normal condition. In addition, the activities of anti hypercholesterolemia are also supported by the changes of histopathology liver (especially fatty liver) indicating recovery of fatty liver.

Key words : Infusarium, hypercholesterolemia, fatty liver

Introduction

Cardiovascular diseases are the primary cause of death for almost 50% people of USA. Among the diseases is coronary heart (attack). Recently, this coronary heart (attack) disease has been increasing anxiously, and even, it continuously raises to the highest level as the primary cause of death for the people of 40 years old and higher in developing countries living in big cities (Sulistiyani, 1996). The disease relates, among other, with high level of total cholesterol and the level of LDL- cholesterol contained in the blood, and it is often called as hypercholesterolemia (Linder 1992).

The first effort to overcome the disease is by diet therapy. But if the therapy is failed, the alternative is by providing medicines to decrease the level of cholesterol.

Nowadays, there has been found commercial medicines used to decrease the level of cholesterol. Among them are: Kolestiramin and Kolestipol (Bergman and Wardlaw, 1974), Nicotinic Acid (Vacek, et al. 1995), Klofibrat and Probucol (Marinetti, 1990), and Mevinolin (Lovastatin, Pravachol, etc.) (Bhagavan, 1992).

Although there has been found benefits in using such commercial medicines, there are also constraints and problems instead. Among the crucial problems are expensive price and indefinitely free of side effects and aggravated damages.

In Indonesia, since monetary crises, the price of such commercial medicines has been increasing more expensively and burdening people heavily. Therefore, many sufferers of the disease move to traditional medicines and use medicinal plants (herbal). In addition, many Indonesian people also believe that the traditional medicines have very little side effects or even have not at all which are harmful for the people.

Among the Indonesian origin plant is Kayu Gabus or Pule (*Alstonia scholaris*, R.Br.) which have been utilizing as traditional medicine by our people such as for diabetes mellitus, high blood pressure, and also for decreasing the level of cholesterol. So far, the stock of this traditional medicine is just in the form of infusarium or boiled in the water. Scientific study of this traditional medicine, however, has not been conducted progressively.

Objectives

Based on the background mentioned above, the objectives of this study and research is to recognize the effects of providing infusarium of Kayu Gabus bark on the level of total cholesterol, the level of LDL-cholesterol, HDL-cholesterol, triglyceride, and the condition of fatty acid liver of male Wistar rats with hypercholesterolemia.

Material and Method

Kayu Gabus bark (*Alstonia scholaris*, R.Br.) used is taken from Cianjur (West Java Province). The animal used for the experiment is White Rats of male Wistar strain, obtained from Nutrient Division of Diponegoro Unit, Universitas Indonesia, Jakarta.

The materials or chemical substances used in this research are: cholesterol, corn oil, standard feed for rats, aqua destilata (distillated water), aqua bidestilata (bi-distillated water), the kit to measure total cholesterol (method CHOD-PAP, Siedel, *et al.* 1981), and HDL-cholesterol level (method of sedimentation, Bustein, *et al.* 1970; Lopez Virella, *et al.* 1977), LDL-cholesterol level (method PVS), and triglyceride level (method GPO-PAP) which have been obtained from Boehringer-Mannheim.

Preparing/Making Infusarium

Dried Kayu Gabus bark is crushed becoming small pieces (wood powder). Five hundred grams of the powder is measured and poured by 2 litre of water (aquadest), then it is boiled until the volume become less than 1 litre. After cooling, it is filtered or sieved, and the residue is discarded, while the filtrate is then measured exactly become 1 litre by aquadest.

Bioessay Test

At the stage of this research, there are 14 White Rats of male Wistar strain used, which are divided into two groups, namely Group A and B, by 7 rats respectively. The stage of this research itself covers the following phases:

1. The phase of adaptation. All experimented rats (Group A and B) are put into several cages. Each cage is contained by one rat respectively, which is allowed for one week adaptation. During the adaptation phase, all experimented rats are feeded with standard feed and drinking water of *ad libitum*.
2. The phase of increasing total cholesterol serum (for Group A). And it is treated that the total cholesterol level is up to >130mg/dl. Namely the total cholesterol level is higher than the normal condition. During this phase, Group A is feeded by standard feed with high cholesterol content, propil tio urasil 20 mg/kg body weight/day, and provided with drinking water *ad libitum*. At the early period of this phase, and every 2 or 3 weeks, and also at the end of this phase, the total cholesterol level is measured (using the kit for measuring the total cholesterol level from Boehringer-Mannheim; Siedel, *et al.*, 1993). While Group B is continuously feeded by standard feed and drinking water *ad libitum*.
3. The phase of bioessay test (for Groups A and B through 2x2 weeks treatment or until the experimented animals achieving its normal cholesterol level). Group A is treated with infusarium of Kayu Gabus bark by a dose of 4 mg/kg/body weight/day, standard feed, and drinking water *ad libitum*. At the early period of this phase, and every 2 or 3 weeks, and also at the end of this phase, the total cholesterol level is measured (using the kit for measuring the total cholesterol level mentioned above. Also their LDL-cholesterol level, HDL-cholesterol level and triglyceride level. Observation is also performed on the fatty liver of the rats both in Group A and B mentioned above.

Analysis on Hispathology Liver

The phase of analysis on hispathology liver is consisted of fixation, dehydration, blocking, cutting, coloring, and microscope analysis. The process of fixation is conducted using buffer formalin 10% for 24 hours. After the fixation is completed perfectly in 24 hours, then the samples are slashed into pieces flimsily then they are treated through dehydration process for 24 hours, using alcohol and selena. After 24 hours, they are, then, treated by vacuum kit to suck the remainder water. The next process is blocking where the samples are blocked, using paraffine, so that at the time of cutting, they aren't moved. Then, they are cut, using microton in a size of 3 micron. After being cut, the sheet obtained, then, are placed on the object glass to be ovened for 3 minutes. After being ovened, then, they are treated by coloring process. The result, in the form of preparative, is then, observed using microscope by 100x times magnification to see the condition of the liver, particularly the fatty liver condition.

Results and Description

The Result of Activity Test on Anti-hypercholesterolemia from the Infusarium of Kayu Gabus Bark

After providing a diet with high cholesterol content and drinking water *ad libitum* for 140 days (20 weeks), the cholesterol content/level of the experiment rats serum Group A increase up to the the average level of 185.232 mg/dl. The content/level shows that the experiment rats have been experienced hypercholesterolemia.

Furthermore, the experiment rats of Group A are provided with infusarium of Kayu Gabus bark through a sonde lambung (gastric) by 4 ml/kg of body wieght/day (0.056%(b/v)/kg body weight/day). While Group B is poured with aquadest by 4 ml/kg body weight/day.

The result of this experiment shows that the rats of Group A are experiencing a decrease on cholesterol content/level after 14 days of treatment, namely by 25.68% and 37.23% after 28 days of treatment.

The cholesterol content/level of the rats serum experiment until 28 days treatment returns to its normal condition, like the condition of Group B. Thus, the result shows that the infusarium of Kayu Gabus bark has a proper potency to be developed as the material for anti-hypercholesterolemia medicine.

Tabel 1. The Total Cholesterol Level of the Rat Serum

Groups	Replication	Early cholesterol Level (0 day) (mg/dl)	Early cholesterol Level in hypercholesterolemia (140 Days) (mg/dl)	Cholesterol Level during Treatment			
				(14 days)		(28 days)	
				[cholesterol] mg/dl	decrease (%)*	[cholesterol] mg/dl	decrease (%)*
A Infusarium	1	69.100	156.975	88.550	-43.62	106.375	-32.23
	2	83.950	226.550	140.875	-37.82	111.550	-50.76
	3	83.375	186.875	143.750	-23.08	97.175	-48.00
	4	72.450	195.500	150.650	-22.94	116.725	-40.29
	5	83.375	115.000	127.075	+10.5	95.450	-17.00
	6	87.975	142.025	101.775	-28.34	105.800	-25.51
	7	74.175	273.700	179.400	-34.45	145.475	-46.85
Average		79.186	185.232	133.154	-25.68	111.221	-37.23
B Standard	1	87.975	81.075	78.200	-3.55	78.200	-3.55
	2	87.400	87.975	80.500	-8.50	92.000	+4.57
	3	78.200	75.900	81.075	+6.82	77.050	+1.51
	4	86.250	89.125	-	-	-	-
	5	85.675	87.400	96.025	+9.87	85.675	-1.97
	6	90.275	74.750	90.850	+21.54	89.700	+20.01
Average		85.963	82.704	85.330	+5.24	84.525	+4.11

The decrease of the cholesterol level mentioned above is followed by the increase of HDL-cholesterol level and the decrease of LDL-cholesterol level, reaching both the HDL-cholesterol level and LDL-cholesterol level of the healthy experiment rats (which are fed by standard feed). But the triglyceride level does not show any significant difference. In other words, the triglyceride level is still in the level of its normal condition (Table 2).

Condition	Average LDL-cholesterol level (mg/dl)	Average HDL-cholesterol level (mg/dl)	Average triglyceride level (mg/dl)
Hypercholesterolemia	121.683	48.349	64.600
2 weeks treatment (14 days)	53.529	58.651	67.510
2 x 2 weeks treatment (28 days)	27.171	65.760	66.750

The activity of anti-hypercholesterolemia from this infusarium of Kayu Gabus bark is supported by the change of liver hispathology condition (particularly the fatty liver) which shows a slight recovery on the fatty liver condition.

Conclusion and Recommendation

Conclusion

1. The infusarium of Kayu Gabus bark (as a stock of traditional medicine) has a potency for anti-hypercholesterolemia medicine. The infusarium by the dose 4 ml/kg body weight/day can decrease the total cholesterol content/level of the rats serum of Rats of male Wistar strain which are in hypercholesterolemia condition by 25.68% after 14 days of treatment, and 37.23% after 28 days of treatment
2. The decrease of the total cholesterol content/level of the rats serum of Rats of male Wistar strain with hypercholesterolemia condition caused by providing the infusarium is followed with the decrease of LDL-cholesterol level and the increase of HDL-cholesterol level up to its normal level. While the triglyceride level is still in the level of its normal condition. In addition, providing the infusarium can be recuperative process for fatty liver of male Wistar rats with hypercholesterolemia.

Recommendation

There is a need to carry out a further research on the potency of anti-hypercholesterolemia of solvent fraction from active material in the Kayu Gabus bark and compare its potency with cholesterol reducer medicines which have been commonly used in Indonesia. Further research also needed to recognize the mechanism of anti-hypercholesterolemia from the active fraction.

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Isolation of an Naphthoquinone from *Eleutherine americana* with Antifungal Activity

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Abstract

Natural compounds could potentially serve as effective alternatives to conventional antifungal or antimycotoxigenic agents. Our previous work on the screening of Indonesian plants having antifungal activity has proven that the methanolic extract of the bulb of *Eleutherine americana* possess potent antifungal activity against *Tricophyton mentagrophytes*. *Eleutherine americana* is a small plant belongs to Iridaceae family. The bulbs of this plant has long been used as a medicinal plant to cure coronary disorder, hepatitis and genital diseases. To the best of our knowledge, *E. americana* has never been the subject of deep investigation into antidermatophyte activity. The bulbs of *E. americana* was extracted with methanol at room temperature followed by solvent-solvent fractionation to yield respective soluble fractions. Bioassay-guided fractionation of *n*-hexane soluble fraction in the methanolic extract of the bulb of the plant led to the isolation of **1** as an active compound. Identification of the compound done by MS, ¹H, ¹³C and two dimensional-NMR analyses elucidated the compound as a 9-methoxy-1,3-dimethyl-3,4-dihydro-1H-benzo(g)isochromene-5,10-dione. The isolated compound displayed potent activity to inhibit the growth of *T. mentagrophytes* at relatively low concentration (40 µg/disk) in comparison to a commercial antidermatophyte, miconazole. The result showed a potential of the isolated compound to be applied as an antidermatophyte agent.

Key words: Antidermatophytes, bioactive compound, bioassay, *Eleutherine americana*, naphthoquinone.

Introduction

Dermatophytes are a specialized group of fungi which affect keratinous tissue of humans and of other vertebrates, causing superficial infections including dermatophytosis. Dermatophytoses generally respond well to topical antifungal therapy, although local therapy may be inappropriate for extensive infections or for infections affecting the nails or scalp. Indonesia as a tropical country serve a good environment for many fungi, including dermatophyte to grow. In general, the dermatophytes are divided into *Trichophyton*, *Epidermophyton* dan *Microsporum* (Weitzman and Summerbell 1995; Larone 1996). In recent years the number of infections caused by these fungi has increased considerably (Jessup et al. 2000; Fernando-Torrez et al. 2001).

Application of antifungal drugs for systemic mycoses, such as amphotericin B and nystation still faces several side effects such as nephrotoxicity and irritation. Recent investigation stated that there is a significant increase on the case of *nephrotoxicity* due to uses of amphotericin B (Georgopapadakou and Walsh 1994), accumulation of pathogen fungal resistance (Carledge et al. 1997; Metzger and Hoffmann 1997) and negative effect on the uses of griseofulvin and azole derivatives (fluconazole, itraconazole, ketoconazole) on the human health, such as gastrointestinal, liver function and respiratory disorders (Mackay-Wiggan et al. 2002).

Eleutherine americana is a small plant that has been applied to cure cancers, liver disease, kidney disorder, heart disorder, gout, diabetic and gastric ulcer in the traditional manner. Some quinones and carboxylic acid derivatives with anticancer activity have been isolated from the plant (Komura et al. 1983; Jinzhong et al. 2006). Here we reported the isolation of a naphthoquinone from *E. americana* with antidermatophyte activity.

Materials and Methods

General

Chemical reagents used were of the high purity. UV absorption of the isolated compound was measured with Aurora UV-Vis Spectrophotometer (Aurora Instrument, Canada). ¹H and ¹³C NMR spectra were recorded on a JEOL JNM-AL400, operating at 400 MHz for ¹H and 100 MHz for ¹³C. Chemical shift was stated as δ in ppm and TMS was

used as an internal standard. Electron impact (70 eV) GC–MS experiment was carried out with a Shimadzu QP5050A (Shimadzu corp, Japan) Gas chromatograph coupled with a Shimadzu 17A Mass spectrometer (Shimadzu corp, Japan). Column chromatography was performed on a Wakogel C-200 (Wako Pure Chemicals, Japan). For TLC, aluminium sheets silica gel 60 F₂₅₄ (Merck, Germany) were used. Spots were detected under UV light or after they were sprayed with sulfuric acid or 2,4-dinitro phenyl hydrazine.

Plant Sample

E. americana was collected from Karang Paci, Samarinda, East Kalimantan in 2007. Bulbs of the plant were sliced, air dried and converted into plant meal with a blender.

Fungal Culture

Trichophyton mentagrophytes was used as a test fungus. The isolates were subcultured onto potato dextrose agar (PDA) plates at 28°C. Stock inoculum suspensions of each isolate were prepared for each experiment from 7 to 14 day old cultures grown on PDA. The fungal colonies were covered with ca. 5 ml of distilled water, and suspensions were made by gently probing the surface with the tip of a Pasteur pipette. The resulting mixture of conidia and hyphal fragments was filtered and transferred to a sterile tube. The densities of these suspensions were adjusted with a spectrophotometer at a transmittance of 75%.

Extraction and Fractionation

Powdered bulb of *E. americana* (ca. 3 kg) was extracted with metanol for 48 hours at room temperature. The extraction was performed three times. Extract solution was filtered with a Whatman no 2 (Whatman International Ltd., England). The solvent was removed with a rotary evaporator at 40°C under reduced pressure. The gummy extract was kept in a vacuum oven to dryness to give brown solid extract (271 g). Part of the methanolic extract (133 g) was subjected to a solvent-solvent partition to yield *n*-hexane (32 g), diethyl ether (49 g), ethyl acetate (3.5 g) and water (43 g) soluble fractions. Each respective soluble fraction was subjected to an antidermatophyte activity assay against *T. mentagrophytes*.

Antidermatophyte Assay

Antidermatophyte assay was conducted with a agar diffusion on a paper disc. Twenty-milliliter aliquots of sterile molten PDA were transferred to Petri dishes and allowed to solidify. The PDA plates were inoculated with 100 µL of inocula suspension spread uniformly on the surface of the plates. A sterile paper disc (6 mm i.d) containing 10 µL of extract (equals to 2 g plant meals) was applied to the surface of each inoculated plate. The plates were incubated in the dark at 25°C for 48 hours. Zones of inhibition around the discs were measured in mm. The control plate contained acetone and medium only. Miconazole (10 µg/disc) was used as a positive control. Incubation was conducted for 5 days.

Bioassay-guided Isolation

n-Hexane soluble fraction from the methanolic extract of the bulb of *E. americana* was the most active and, therefore subjected to a further investigation. A silica gel column chromatography of the soluble fraction gave 8 fractions (D.1 - D.8) based on the TLC profile. An active fraction D5 (450 mg) was subjected to repeated column chromatography over silica gel with elution of *n*-hexane-Me₂CO or C₆H₆-Me₂CO at a gradient system. An active compound **1** (98 mg) was isolated from the fraction after recrystallization from acetone and ethanol. Characterization of the isolated compound was conducted by mass spectroscopy and NMR spectroscopy analyses.

Compound 1

Yellow needles; blue fluorescence at UV 365 nm, positive with 2,4-dinitrophenyl hydrazine; ¹H-NMR spectrum (DMSO-*d*₆, 400 Mhz) δ: 1,36 (3H, d, *J*=6.5 Hz, Me-3), 1,54 (3H, d, *J*=6,5 Hz, Me-1), 2,20 (1H, dd, *J*=11,0, 19,0 Hz, H-4β), 2,75 (1H, dd, *J*=2,4, 18,1 Hz, H-4α), 3,96 (1H, m, H-3), 4,00 (3H, s, OMe-9), 5,01 (1H, q, *J*=6,7 Hz, H-1), 7,28 (1H, d, *J*=6,7 Hz, H-8), 7,64 (1H, t, *J*=6,7 Hz, H-7), 7,74 (1H, d, *J*=6,7 Hz, H-6); ¹³C-NMR spectrum (DMSO-*d*₆, 100 Mhz) δ: 19,4 (CH₃-1), 21,3 (CH₃-3), 29,1 (C-4), 56,3 (OCH₃-9), 61,9 (C-3), 66,3 (C-1), 118,2 (C-6), 118,8 (C-8), 119,0 (C-14), 133,4 (C-13), 135,1 (C-7), 138,9 (C-12), 146,9 (C-11), 159,3 (C-9), 181,9 (C-10), 183,7 (C-5). EI-MS *m/z*: 272,07 (M)⁺ consistent with C₁₆H₁₆O₄.

Results and Discussion

Antidermatophyte assay of the soluble fractions from the methanolic extract of the bulb of *E. americana* informed that the *n*-hexane soluble fractions possessed the most activity to inhibit the growth of *T. mentagrophytes*. Repeated silica gel column chromatography combined with recrystallization of the active fractions yielded compound **1** as yellow needles. Compound **1** was positive against 2,4-dinitrophenyl hydrazine indicated the presence of carbonyl group at the structure. Mass spectrum of compound **1** showed a molecular ion peak at m/z 272 (M^+) matched with $C_{16}H_{16}O_4$. NMR spectra (^1H and ^{13}C -NMR) displayed signals for sixteen carbons and integration of sixteen hydrogen atoms. ^{13}C -NMR spectrum showed signals for two carbonyl groups (δ 181.9 and 183.7), two methyl carbons (δ 19.4 and 21.3) and an aromatic methoxyl group (δ 56.3). Furthermore, ^1H -NMR spectrum of **1** displayed a signal for hydroxyl at δ 9.65 (1H, s); three aromatic protons at δ : 7.28 (1H, d, $J=6,7$ Hz, H-8), 7.64 (1H, t, $J=6,7$ Hz, H-7) and 7.74 (1H, d, $J=6,7$ Hz, H-6), two methyls at δ 1.36 (3H, d, $J=6.5$ Hz, Me-3), 1.54 (3H, d, $J=6.5$ Hz, Me-1) and a methoxyl at δ 4.00 (3H, s, OMe-9). Based on the analysis of the spectral data and comparison to that of reference (Hara et al. 1997; Shibuya et al. 1997), compound **1** was identified as eleutherin, a 9-methoxy-1,3-dimethyl-3,4-dihydro-1H-benzo(g)isochromene-5,10-dione. The chemical structure of **1** was presented in Fig 1.

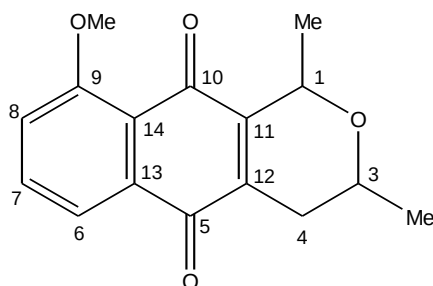


Fig 1. Chemical Structure of **1**, an Antidermatophyte Compound from *Eleutherine americana*.

Antifungal activity of compound **1** against a dermatophyte, *T. mentagrophytes* was evaluated with an agar diffusion assay. The result of antidermatophyte assay of compound **1** was presented in Fig 2. The results showed that compound **1** at the concentration of 10, 20, 40, 60 and 80 mg/disk and miconazole, a commercial antidermatophyte at 10 mg/disk displayed 7, 8, 13, 16, 17 mm and 14 mm of inhibition zone to *T. mentagrophytes*, respectively.

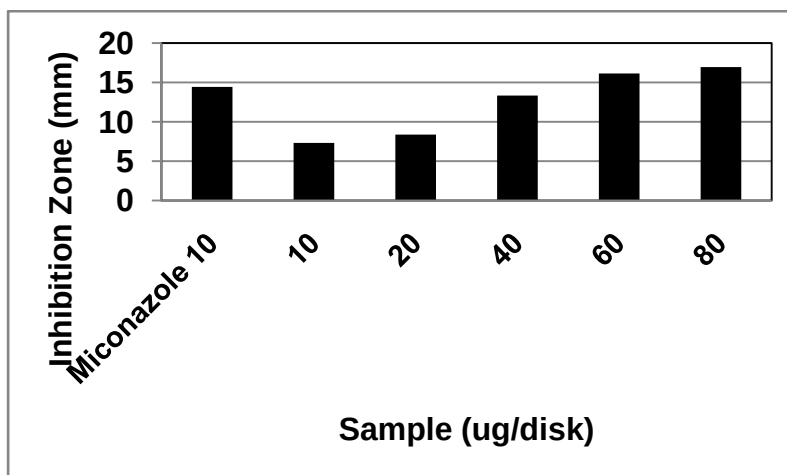


Figure 2. Antidermatophyte activity of **1** against *T. mentagrophytes*

The result also informed that at 10 mg/disk, compound **1** possessed lower antidermatophyte activity than miconazole. However, compound **1** has possibility to be applied with lower side effect. Based on the result, compound **1** seemed to possess a concentration-dependent activity. Dermatophytes have the capacity to invade keratinized tissues (skin, hair and nails), producing dermatophytosis (Makimura et al. 1998). Dermatophytoses ranks among the most common and widespread infectious diseases worldwide, and *Trichophyton rubrum* and *Trichophyton mentagrophytes*, which cause infections of skin and nails, are two of the most frequently isolated dermatophytes (El

Fari et al. 1999). Effective dermatophytosis treatment by means of application of topic antifungal preparations is a challenge. This condition has directed to intensive search for more effective, cheaper with wide-ranging antidermatophyte spectrum, ease of use and lower side effects substances. Compound 1 (eleutherin) is a naphthopyran having 1,4-naphthoquinone moiety and several naphthopyran compounds were reported as natural phytochemicals (Brimble et al. 1999; Li et al. 2007). Anti-tumor activity of eleutherin with mechanism on the inhibition of topoisomerase II and selective inhibitory activity has been published (Khrishnan and Bastow 2000) .

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Jomo (*Arthocarpus* sp.) Bark as Raw Material for Traditional Crafting in East Kalimantan

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Abstract

Jomo (*Arthocarpus* sp.) bark had been used as raw material of traditional bag, hat, clothes, etc by rural people in East Kalimantan. The aims of this research were to analysis the anatomical structure (cell dimension and structure) of Jomo bark and comparing it to five barks of wood species. The material was taken from sub-province Kutai Kartanegara. Surface structure of jomo bark is more flattened, scab, rather shallow grooved within very thin layer. The outer bark is brown with whitish pocked inner bark is yellowish to yellow. The structure of ray is straight, the cells is homogenous with small dilatation similar to *fagus* type. Axial parenchyma is diffuse, fiber is irregular diffuse in aggregate but scattering even in all surface. The fiber is longest (5799 μm) than bark of laban tulang (931 μm), repih (1649 μm), sengon (1342 μm), sungkai (1038 μm) and

binuang laki (1869 μm). The diameter of fiber of jomo bark (31 μm) is bigger than laban tulang (23 μm), repih (25 μm), sengon (15 μm), sungkai (24 μm) and binuang laki (19 μm) as well as the diameter of lumen (16.65 μm) is bigger than others: laban tulang (9.8 μm), repih (10.17 μm), sengon (5.92 μm), sungkai (7.03 μm) and binuang laki (8.14 μm). The thickness of fiber wall of jomo is 7.21 μm , the other bark are laban tulang (6.38 μm), repih (7.21 μm), sengon (4.53 μm), sungkai (8.60 μm), and binuang laki (5.64 μm). The quality of jomo bark fiber is better than others. According to the fiber quality classification, this is the quality of jomo: Rankel ratio (III), Felting Power (I), Flexibility ratio (III), Muhlsteph ratio (III) and Coefficient of Rigidity (V).

Based on the fiber dimension and its quality, jomo bark is more resilient, elastic and easy to convert be cloth raw material by handmade.

Key words: bark, jomo, fiber, cell dimension, quality.

Introduction

A long time before industrialization period, the people still used very simple material cloth as body cover namely made from bark (*bark cloth*) or animal leather. Since the development era, cloth from wood bark gradually was been changed. But nowadays, in the certain place, the rural people in east Kalimantan, they use that unique material for many purposes as handicraft or ceremonial tools, and believed that has a magic power. (Anonym, 2002).

Bark of jomo used not only for cloth but for bag, pocket, hat, rope and so on. But their motive is very variable depend on the recent model.

The interesting point is why they only use material from this species, namely bark of "kayu jomo" (*Arthocarpus* sp.). In this case, the researcher want to know, throughout anatomical and biological point of view, the reason why this bark is very strong and liable for this purpose.

Materials and Methods

The research was conducted in Anatomy/Biology Laboratory. Forestry of Faculty. Mulawarman University. Samarinda

The material was taken from district Birawa, sub-province Kutai Kartanegara. The bark of jomo (*Arthocarpus* sp.) family Moraceae, and the other 5 bark species taken from surrounding area. There are: 1. Laban tulang (*Vitex pinnata* L) Family: Verbenaceae; 2. Repih (*Mangifera gedebé* Miq) Anacardiaceae; 3. Sengon (*Paraserienthes falcataria* (L) Nielson) Leguminosae. 4. Sungkai (*Peronema canescens*) Verbenaceae and 5. Binuang laki (*Duabanga mollucana* Blume) Sonneratiaceae.

Bark was chosen from the stem (ca. 3 years old) in the breast high, and where the people always taken for their material. Sample (dimension 1 cm x 1 cm x bark thickness) was cut from the tree carefully with joining their cambium with its small of xylem. Observation on solid bark was done by binocular microscope, and the slicing material (30-50 μm) was shown under the light research microscope. For measuring fiber dimension, the small sample of bark in function zone was maze rated by boiling process by means acetic acid and hydrogen peroxide.

Data was analyzed through compare the measuring value and showing of photo.

Results and Discussion

Macroscopic Feature

The color of uter bark is greenish brown with whitish pocked, inner bark is yellowish to yellow. Surface structure of jomo bark is more flattened, scab, rather shallow grooved within very thin layer for about 2, 05 mm. The structure of ray is straight, the cells is homogenous with small dilatation similar to *fagus* type. The boundary between active and non active phloem is very clear. Following figure the color of bark, and inner bark structure.



Figure 1. Surface of bark in jomo (*Artocarpus* sp.)



Figure 2. The inner bark jomo (*Artocarpus* sp.)

Color of bark surface usually follow the color of ritidome which always decayed process. Evenmore the outer ritidome is influenced by surroundings atmosphere. The parenchyma tissue shrinkage course of drying and become crockery.

Bark thickness is influenced by many factors, such as: species, age, location in stem, climate, soil and so on. But according to measuring in all part of bark in jomo, principally it has not much difference each other with average 2,05 μm . This is classified "very thin". Active phloem is differ clearly to non aktive phloem zone. The ray cells in radial view are shown homogenous.

The following figure is cross section, where the position of active and non active phloem, as well as cambium and xylem zone is shown.

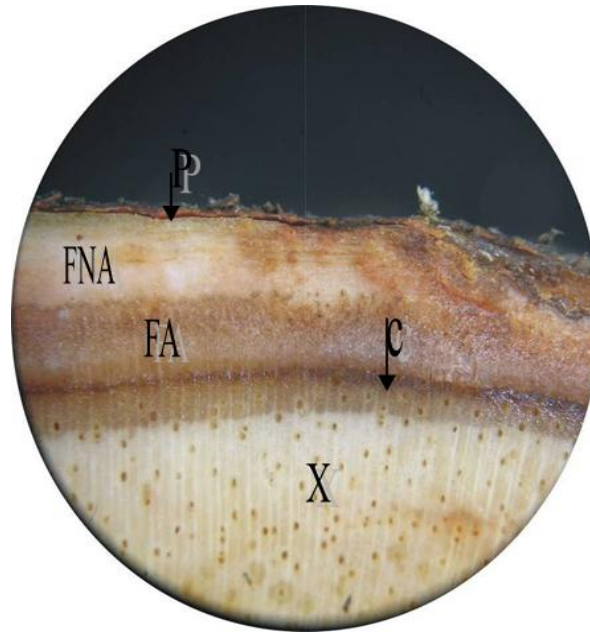


Figure 3: Cross section on ploem and xylem of jomo
 Note: FNA : Floem Non Aktif; P : Peridem; X: Xylem; FA : Floem Aktif; C: Cambium

Rays:

Rays on the cross section is straight on active phloem to wavy with small dilatation similar to *fagus* type in outer bark or the cell becoming shattered in the non aktive phloem zone. That phenomenon coursed by advancing of cork cells from phellogen activity. Consequently the correlation between live inner part and dray outer part is disturbed.

Axial Parenchyma:

The structure of axial parenchyma in jomo is irregular in diffuse to diffuse in agregat.

Fiber:

According to **Tjitosoepomo (1977)** the type of fiber is scattered, or in diffused in aggregate. By this type, the location of fiber becomes even in all surfaces and hence the strengthness is also proportional even in all tissue. That is why jomo is suitable for making cloth material. Normally, the bark with more fiber is more strength and flexibility than bark which less of fiber.

Periderm:

Phellem in bark of jomo content of 7 to 12 layers, that influence to ritidome type. Developing of periderm is differ and depend on age of tree. That can start from young tree, adult, and even it can not develop ritiidoma anymore. The trees with thin fellem make ritidome relesead easily.

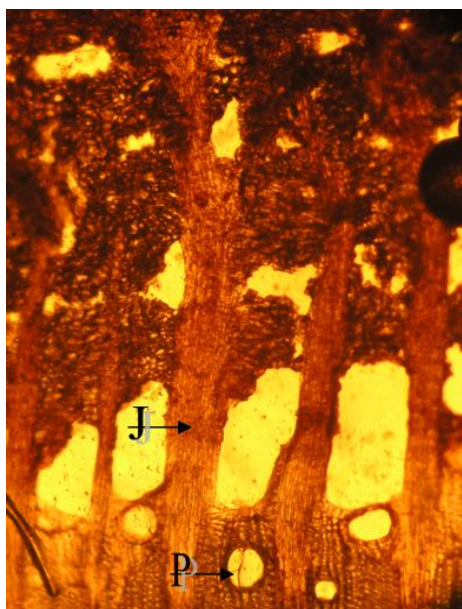


Figure 4. Rays in cross
Note: J: Rays of Phloem; P: Pore in Xylem.

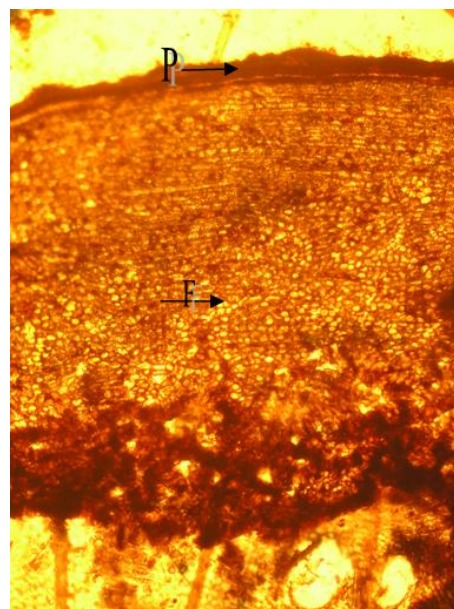


Figure 5: Cross section in jomo.
Note: F: fiber; P: Periderm; AP : Axial Parenchima

Fiber Dimension and Classification of Fiber

Table: 1. Value in average of fiber, fiber dimension and classification from six species are shown bellow.

Bark species	Length of fiber		Diameter of Fiber		Diameter of Lumen		Wall thickness	
	value	Classification	value	Classification	value	Classification	value	Classification
Jomo	5799	Very long	31	big	16,6	Big	7,2	Medium
Laban Tulang	931	Very short	22,6	Medium	9,8	small	6,3	Medium
Repih	1649	Medium	24,6	Medium	10,1	medium	7,2	Medium
Sengon	1342	Short	14,9	Medium	5,9	small	4,5	Thin
Sungkai	1038	Short	24,2	Medium	7	small	8,6	Thick
Binuang Laki	1869	Medium	19,4	Medium	8,1	small	5,6	Thin

The average of length of fiber (according to **Wagenführ (1984)** in bark of jomo is extrem very long in bark of repih and binuang laki is in medium (1649 μm - 1869 μm), and short classification (1038 μm - 1342 μm) in sungkai and sengon. The other hand in laban tulang is very short (931 μm). Course of very long fiber in jomo be predicted to make bark of jomo very strong and not easy to break as cloth material

The average of fiber diameter in bark of tulang, repih, sengon, sungkai, and binuang laki classified into "medium" (14,98 μm - 24,60 μm), but in jomo in class "big" (31,08 μm) according to **Klemm (1928)** in **Casey (1960)**.

Diameter of lumen in bark of laban tulang, sengon, sungkai and binuang laki is :small" (5,92 μm - 9,80 μm). , "medium" in repih (10,17 μm), but in jomo has "big" lumen (16,65 μm).

Wall thickness in bark of sengon and binuang laki is thin (4,53 μm - 5,64 μm). The average of wall thickness in jomo, laban tulang, dan repih classified "medium" (6,38 μm - 7,21 μm), The other hand fiber wall thickness in sungkai is "thick" (8,60 μm) , according to **Wagenführ (1984)**.

From technology point of view, form of length and wall structure of fiber is very important in fiber industries.

The even of fiber distribution, the very long fiber, the medium wall thickness and big of lumen course of fiber in jomo easy to flatened. That is appropriate with the process how to make cloth material in jomo, that must be pressed continuously.

Fiber derivate value is combination between value of many factors, such as in jomo: value of Runkel Ratio (class III), Felting Power (class I), Flexibility Ratio (class III), Coefficient of rigidity (class IV), and Muhlsteph ratio (class III) and length of fiber (class I).

Base on the above value the quality of pulp / fiber in jomo is classified to the class II, but the other hand, fiber in other species namely in sengon, laban tulang, binuang laki, repih, sungkai included to class III.

The following Tables are the average value of fiber on investigated six species

Table: 2 .Average value of Runkel Ratio from six fiber bark species.

No	Bark species	Runkel Ratio		
		Average	Class	Value
1	Jomo	0,9	III	50
2	Laban Tulang	1,4	IV	25
3	Repih	1,5	IV	25
4	Sengon	1,7	IV	25
5	Sungkai	3,2	IV	25
6	Binuang Laki	1,6	IV	25

Table: 3 .The average value of Felting Power from six fiber bark species.

No	Bark species	Felting Power		
		Average	Class	Value
1	Jomo	388,6	I	100
2	Laban Tulang	110	I	100
3	Repih	181,5	I	100
4	Sengon	267,1	I	100
5	Sungkai	186,4	I	100
6	Binuang Laki	278,5	I	100

Table: 4 .The average value of Ratio Flexibility from six fiber bark species.

No	Bark species	Flexibility Ratio		
		Average	Class	Value
1	Jomo	0,5	III	50
2	Laban Tulang	0,4	III	50
3	Repih	0,4	III	50
4	Sengon	0,3	IV	25
5	Sungkai	0,2	IV	25
6	Binuang Laki	0,4	III	50

Table: 5 .The average value of Coefficient of rigidity from six fiber bark species.

No	Bark species	Coefficient of rigidity		
		Average	Class	Value
1	Jomo	0,48	IV	25
2	Laban Tulang	0,74	IV	25
3	Repih	0,77	IV	25
4	Sengon	0,87	IV	25
5	Sungkai	1,6	IV	25
6	Binuang Laki	0,81	IV	25

Table: 6 .The average value of Muhlsteph ratio from six fiber bark species.

No	Bark species	Muhlsteph ratio (%)		
		Average	Class	Value
1	Jomo	71,5	III	50
2	Laban Tulang	80,4	IV	25
3	Repih	81,5	IV	25
4	Sengon	84	IV	25
5	Sungkai	90,6	IV	25
6	Binuang Laki	81,6	IV	25

Table: 7 .The average value of **length of fiber from** six fiber bark species.

No	Bark species	length of fiber		
		Average	Class	Value
1	Jomo	5799	I	100
2	Laban Tulang	931	III	50
3	Repih	1649,4	II	75
4	Sengon	1342	III	50
5	Sungkai	1038,4	III	50
6	Binuang Laki	1869,4	II	75

Conclusion

Based on some factors such as the fiber-cells distribution, fiber dimension and its quality, as well as thickness of inner-bark, jomo bark is more resilient, elastic and easy to convert be cloth raw material by handmade.

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Raw Material Inventory System in a Rattan Small Scale Industry

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Abstract

The aims of this study were to evaluate raw material inventory system and identify influencing factors. This study was conducted at a small scale rattan industry in Macassar City. The collected data were rattan supply, rattan consumption for five years (2004-2008) and cost about inventory management and operational. Data analyze have been conducted base on Economic Order Quantity (EOQ) backorder. The results indicated that rattan order was depend on stock condition. Optimum order of batang (*Calamus zollingeri*) rattan was 19.07 ton and 330 days cyclus or order frequency 0.9 times a year. Re-order must be executed when the stock available were 1.4 ton. Optimum order of lambang (*Calamus ornatus* Blume) rattan was 11.19 ton and 570 days cyclus or order frequency 0.5 times a year. Re-order must be executed when The stock available were 0.6 ton. Optimum order of tohiti (*Calamus Inops* Becc) rattan was 11.78 ton and 540 days cyclus or order frequency 0.6 times a year. Re-order must be executed when the inventory available are 0.6 ton. The several factors influenced that the inventory systems were season, price, and consumer order.

Key words : rattan industry, EOQ, inventory system

Introduction

Background

Before 1986, Indonesia is the largest rattan exporter in the world, rattan-processing industry, while the national at the time have not been developed. Since 1986, with the Minister of Trade Decree No. 274/KP/X/1986 ban on derived rattan exports, national rattan processing industry is experiencing rapid growth, increasing from only 20 companies to be 300 companies. While the rattan processing industry in foreign countries (Taiwan and Europe) that rely on supply of raw material from Indonesia are experiencing bankruptcy and shifts its business to Indonesia, particularly in the area of Cirebon. In further development of the export rattan and rattan policy derived reopened in 2005, with the Minister of Trade Decree No. 12/M-DAG/PER/6/2005 about Export Rattan certainty, national rattan processing industry the development began hampered and business activities has become sluggish, so the impact on the occurrence of unemployment, bad debts, reduced foreign exchange earnings and declining contribution national rattan processing industry. Conversely the competitor countries such as China, Taiwan and Italy industry of their rattan rise again and develop very rapidly (Waluyo, 2008).

Prolonged economic crisis lead to competition between the companies including the rattan processing industry is becoming increasingly strict. Only companies that are able to press the cost of production with minimal possible without reducing the quality of the products that can survive. One way to press the cost of production with pressing a total cost of supply of raw materials as minimum as possible, both in the cost of orders, storage, loss, and damage of materials.

The decreasing productions of cane for the limited resources of raw materials cause problems for the industry, especially for half-finished rattan industry. The low interest for people to become rattan farmers with the cultivation of rattan trigger the self-help weight problems faced by industry in the supply of raw materials. Inventories of raw materials need to be able to meet the needs of the production plan, because if the supply of raw materials can not be met, will prevent the production process. The delay in the schedule of products that consumers can be harmful in terms of company image that is less good. Meanwhile, if the supply of raw materials could increase the cost of redundant storage, destruction, and loss of materials. Inventories of efficient and effective raw materials can be done through planning and controlling, so that the production process is not hampered due to run out of raw materials or raw materials ordered have not received.

Based on the description, so research is needed that can provide information for industry about how the planning and controlling of effective and efficient raw material supply system. This meant that the process of production

can be done well, there is no deficit supply so that half-finished rattan processing industry can operate optimally and is able to anticipate the lack of availability of raw materials through the supply system of good raw material.

Objective of Research

The aim of this research is to evaluate raw material inventory system and identify influencing factors.

Methods

Methods of data collection and analysis that conducted in this research are as follows:

- a. Evaluation of system company raw material supply
 1. Observation : Observations activities made is direct observation in the field and interviews of leadership/staff who are appointed by the company for taking data how the system of raw materials purchase/procurement carried out, and the factors that affect the system the available raw material supplies, what advantages and inadequacy, and how the production process with the method used now.
 2. Collecting secondary data :Collecting secondary data on the company, a public company data, a brief story of the company, data type and the amount of supply of raw materials and production for 5 years (2004-2008), and the data source of raw materials.
- b. Determine economic Supply system the with the method of *Economic Order Quantity* (EOQ) backorders .

$$Q = \sqrt{\frac{2SD}{H}} \sqrt{\frac{H+B}{B}}$$

To know Optimum Order Frequency/year (F) and Optimum Cyclic distance on each order by using formula belows :

$$F = \frac{D}{EOQ}$$

$$T = \frac{EOQ}{D}$$

Where :

- Q = EOQ = The economical scale on order amount
- D = Y = Demand (inventory needed forecasted per year)
- S = One frequency order (knowing by observation)
- H = Saving Cost per unit per year
- B = backordering cost per unit per year
- I = backorders cost
- F = Frequency of order within a period
- T = time of order (year)

Results and Discussion

System Evaluation of Raw Material Supply

The rattan raw materials used by the industry were identified coming from several areas in Sulawesi, Central Sulawesi, Southeast Sulawesi, South Sulawesi and West Sulawesi . The raw materials were purchased through collectors in the forms of individual, companies, farmer groups, CV, and other business trades. To anticipate the occurrence of shortages of raw materials, the industry has a business unit empowering local communities in harvesting rattan cultivation.

The purchase of raw materials is based on stock condition where the purchases will be made when the stock less then requirement or if the market availability of the raw material in large quantities. In certain circumstances, a purchase will be made if the company considers that the market price is profitable.

Analysis of Raw Material Supply System

The needs of raw material (rattan)

The number of raw materials consumption during the last 5 years (2004-2008) was 413.5 tons with an average of 82.7 tons per year. In general, the purchase of raw materials tended to fluctuate. It decreased from 105.4 ton in 2004 to 63.9 tons in 2005, then increased 129.0 tons in 2006 and again decline to 43,9 ton in 2008. Based on the types of rattan, the consumption of raw materials, respectively from the largest to the smallest was batang rattan (90.64%), lambang (6.67%) and tohiti (2.2%). The high purchase of batang rattan primarily because more easily obtained from farmers and rattan collectors as well as market demand for this type is higher because of its generally straight and large in diameter. As for other types of rattan, but acquisition is relatively less because there are few, are also less attractive to the market. The summary of raw material consumption is shown in Tabel 1.

Table 1. The summary of raw material consumption

Year	Volume of rattan raw material (ton)			Total
	Batang	Lambang	Tohiti	
2004	102,6	2,8	0,0	105,4
2005	58,4	5,4	0,1	63,9
2006	114,6	9,5	4,9	129,0
2007	62,1	7,3	1,9	71,3
2008	37,1	2,6	4,2	43,9
Number	374,8	27,6	11,1	413,5
Average	75,0	5,5	2,2	82,7
%	90,64	6,67	2,68	100,00

The amount of the raw materials needed by an industry in a given period can be predicted through the preparation of the forecast demand on the basis of rattan material usage rate. Based on raw material consumption data as shown in Table 1, the needed raw materials for the next year can be identified by using periodic data with least squares method (Table 2).

Table 2. The number of raw material needed for each type of rattan

Type of rattan	Number (Ton)
Batang	17,12
Lambang	5,91
Tohiti	6,54
Total	29,57

Ordering costs

Ordering costs consist of the costs of expedition ordering process, labor, telephone administration, packaging and weighing process, shipping, and supporting goods. Ordering costs consist of: ordering raw materials (Rp.8.000.000), transportation (Rp.1.750.000), retribution (Rp.3.000), labor (Rp.160.000) and administrative costs (Rp.200.000). The total number of ordering costs are Rp. 10.113.000.

Storage Costs

Storage costs consist of the cost of storage facilities (lighting, heating or cooling), capital, obsolescence, insurance inventories, inventory taxes, security and inventory handling. The amount of storage cost are Rp. 2,528,250 (25% of the total ordering cost)

Backordering Costs

Backorder cost is calculated based on the extra cost of the expedition cost due to delays in supply decreasing the quality of rattan with the amount of Rp. 1.500.000, in average.

Results of analysis of optimum ordering purchases (Q), optimum ordering frequency in a year (F) and the optimum cycle distance for each group of rattan species are shown in Table 3.

Table 3. Optimum ordering purchases, optimum ordering frequency in year and optimum cycle distance

Type of rattan	Q (Ton)	F (number/year)	T (day)
Batang	19,07	0,9	330
Lambang	11,19	0,5	570
Tohiti	11,78	0,6	540
Number	42,04	2,0	1440

Based on the analysis in the table above, Optimum order of batang (*Calamus zollingeri*) rattan was 19.07 ton and 330 days cyclus or order frequency 0.9 times a year. Re-order must be executed when the stock available were 1.4 ton. Optimum order of lambang (*Calamus ornatus* Blume) rattan was 11.19 ton and 570 days cyclus or order frequency 0.5 times a year. Re-order must be executed when The stock available were 0.6 ton. Optimum order of tohiti (*Calamus Inops* Becc) rattan was 11.78 ton and 540 days cyclus or order frequency 0.6 times a year. Re-order must be executed when the inventory available are 0.6 ton

The optimal numbers of units for each ordering time for batang rattan, lambang rattan and tohiti rattan were 19.07, 11.78 and 11.19, respectively. The higher the number of the unit the higher the ordering frequency.

Factors Influencing Inventory Systems

1. Season

The purchase of raw materials was frequently done during dry season (March-September) and decreased during rainy season (October-February). The purchase made during rainy season has high risk levan damage because of rot or fungi attacks.

2. Price

The price has significant effect in purchasing raw materials. Although inventory is sufficient for the production process, but if the bid price of raw materials from suppliers considered to be of benefit to the company, the purchase can be done. In contrast, although the raw material supply is running low, the purchase price can be deferred until an agreement considered to be appropriate.

3. Order

Purchase of raw materials is adjusted by the amount of incoming orders. If there is order in large numbers, then the purchase of raw materials made in large quantities, and vice versa.

Conclusion

1. Raw materials supply system in this industry is based on the amount of inventory (stock). Inventory system is not economical and does not provide optimal benefits for the company, although it has been supported by a good storage system and adequate.
2. Optimum order of batang (*Calamus zollingeri*) rattan was 19.07 ton . Optimum order of lambang (*Calamus ornatus* Blume) rattan was 11.19 ton and tohiti (*Calamus Inops* Becc) rattan was 11.78 ton.
3. Several factors influencing the inventory systems were season, price, and order.

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The Possibility of Seaweed Wastes Usage as Raw Material of Papermaking

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Abstract

Study of utilization seaweeds waste as pulp raw material of specialty paper has been investigated. Seaweeds waste from food jelly industries was pulped using- sodium and with sodium at temperature 100 °C for 60 minute in rotary digester. Bleaching pulp was done by using hydrogen peroxide and gets the pulp with 70 % ISO brightness. The drainage process of hand sheet making is very slowly and assisted by a vacuum pump. Handsheets from blending seaweeds pulp with the other pulp can reduce the strength as revealed by the decreasing of tear index and tensile index.

Key words: Sea weeds Waste; specialty paper.

Introduction

Demand of paper grows continuously along with the growth of population and technology development. According to Wong (1998) in Siringiringo (2001) the growth of paper and board consumption in developing countries is 2-3 % annually.

The opportunities of Indonesian pulp and paper export are widely open and has $\pm$ 2% world market shared right now. IPPA (2000) said that Indonesia becoming one of pulp and paper producer in global trade. In 1999 Indonesia reached the 11 position in world paper producer which produced 6.9 million ton paper per annum.

The renewable cellulose resources from wood and non-wood are plentiful available. Log supply for Indonesian wood industries is about 20-40 million m³ per annum (Forest Watch Indonesia, (2003). Indonesian wood supply for industries decreases right now and need for seeking an alternative cellulose resources.

Some of Indonesian food industries produce seaweed waste which rich in cellulose content. Therefore seaweed waste can be used as alternative raw materials for paper industries. This research tries to find out the possibilities of seaweed waste tube raw material of papermaking.

Application area of the red algae pulp described in this paper can be very broad. Filter paper, cigarette apery, surface layer of multiplies paper or paperboard, security paper, edible paper, medical paper, and food paper are small examples of the application. In the area of making high density or transparent paper, the red algae pulp yield goes up to 20 to 35% and drainage of the furnish is much faster than the one for white paper application. One of the advantages of the red algae pulp over wood fibers is no need of refining even in making high density paper. (Yung Bum Seo, 2006)

Theory

Seaweed

Seaweed is a low level plant in Thallophyta division, i.e. the plant that can not be recognized the part of stalk, root, and leaves in the body structure. The whole body namely Thallus (Dudding, 1971 in Sinaga, 1999). Seaweed (Rhodophyta) is ocean resources which do not much used in industries. The former researches show that from 21 types of seaweed, there are 13 types can be used in industries economically. These main types are *Boodlea composite* from Chlorophyceae class and *Padina japonica*, *Laurencia galandulifera*, *Boergeresia forbesii* and *Hypnea pannosa* from Rhodophyceae class.

Growth distribution of seaweed is uniform and grouped, grow without root, and attach to substrate as fibentos. Soegiarto *et al.* (1978) states that seaweed is a basic ocean plants at up to 200 m sea depth or as long as sun shine passing through.

There are over 10,000 described species of red algae¹. Dring² reported that 27.1% of all known species of marine plants are red algae. Sheath estimated the fresh water red algae represent about 3% of the total number of red algae species. Although red algae have been consumed by humans for at least 2,800 years, their full agronomic and

biotechnological potential has yet to be realized. The utilization of red algae was suggested in the area of polyelectrolyte, pharmaceutical products, human nutrition, antimicrobial activity, polysaccharide production, etc (Kinch, 2003). Chemical composition of red algae consists of mostly polysaccharide, much less protein, trace of lipid, and inorganic materials. We tried to use red algae for the production of papermaking raw material to replace wood fibers.

Seaweed contains of gel and alginate acid. Gel properties is influenced by temperature, concentration, pH, sugar content, and sulfate ester (Selby dan Wyne, 1973). Strength of the gel could be lower with decreasing pH. Hardness of the gel increase by decreasing sugar content, but the cohesiveness lower (Glicksman, 1983). Some industries such as textile, paper, photography, shoe shiner, teeth paste, fish and meat canned, and for museum and criminology, use the gel as an additive (Aslan, 1998). Alginate acid use as in industries as thickener, emulsifier, or buffer. The industries that use alginate are foods, cosmetics, shampoo, pharmacy, paper, ceramic, photography, insecticides, and wood proofing. Indonesia still use imported alginate as much as 2,663.5 ton.

Some research found that ocean algae contain 5-53 % cellulose and the rest sticky liquids. The sticky contains 89.02% alginate acid, 6.27% gel, 3.41% karadenan, 0.83% manitol, 0.17% laminaran, mineral salts and water (Polunin, 1990 *dalam* Sinaga, 1999).

Table 1: Chemical composition of sea weeds

Type	Lignin (%)	Cellulose (%)	Pentosan (%)
Alginat	20,19	40,14	3,46
Gracilaria	13,02	72,02	2,34
Cantoni	4,02	45,89	1,17

Chemical composition of red algae consists of mostly polysaccharide, much less protein, trace of lipid, and inorganic materials. We tried to use red algae for the production of papermaking raw material to replace wood fibers. In the cells of red algae, there are large amounts of mucilage materials such as agarose and carrageenan, which can be easily extracted by hot water and weak, environment-friendly chemical treatment. After extraction of mucilage materials, the red algae cells are bleached to be used for papermaking raw materials. We used mostly the red algae (*Rhodophyta* in scientific classification) in the family of *Gelidiaceae*, where three types of genera such as *Gelidium*, *Pterocladia*, and *canthopeltis* exist. The shape, the growing rate, and the amount of rhizoidal filament in the *Gelidiaceae* can be the criteria of utilization in pulp and paper area.

Soda process find out by Burgess and Watt in 1851, and used for the first time in England in 1855 for chemical pulp making. Cooking liquor for this process is sodium hydroxide which can dissolve lignin but do not attacking cellulose. Cellulose is the main component needed in papermaking.

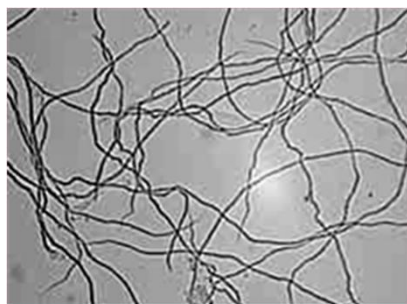
Soda process has some disadvantages, such as lower delignification compared to sulphate and sulphite process. The effectiveness of soda process is decrease due to the decreasing of cooking liquor concentration at the beginning as consequences of active alkali consumption by lignin, extractives, and cellulose. Therefore the Kappa number becoming high. But soda process has advantages of lower environmental effects compared to sulphate.

Papermaking

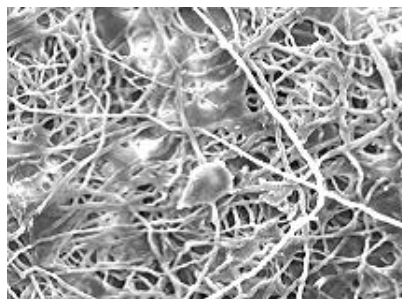
Papermaking starts with the preparation of stock or furnish. Furnish is the blending of fiber, water and chemical additives. Furnish then spread out in the paper machine to form a web or sheet, following by pressing and drying. The composition of the fiber determines the final properties of the sheets. The source of the fiber can be many things as long as it has cellulosic fiber. Seaweed is known has cellulosic fiber, so we can hope that it can be a raw material of papermaking.

Seaweed Handsheet

Fig. 1 shows what look alike of seaweed filament in the original form, and how it is in the handsheets networks. In the handsheets, seaweed fiber is "glued" to form a matrix of handsheet. Most probably, the glue comes from the gel part of the seaweed pulp. This is the fact that seaweed fiber can form a network of handsheets.



Filament of seaweeds



Sheet of Seaweeds Pulp

Figure 1. The original Seaweed Filament and Seaweed in the Sheets

Methodology

In this research has been used bleached pulp and seaweed waste coming from North Jakarta. Chemical materials consist of sodium hydroxide (NaOH) as cooking liquor, aqua DM, bleaching chemicals, phenolptalein, Chloric Acid, KMnO_4 , KI, Na_2SO_3 and starch.

There are also used some laboratory equipments such as rotary digester, refiner, vacuum pump, beaker glass, blender, magnetic stirrer, flat screen, thermometer, infra red moisture tester, pH meter, tear tester, tensile tester, bursting tester, and optical tester.

Seaweed wastes are cut up to 5 cm, dried, and weighed for 400 g bone dry. Seaweed cooked in rotary digester, using 5% NaOH, 100°C temperature, 1 : 5 ratio, for 90 minutes. Following that pulp is washed and refined for disintegration of fiber, and screened for determination of yield and kappa number.

Pulp Bleaching

Seaweed pulp treated by one stage bleaching using chlorine dioxide at 5.34 g/l concentration, 10% pulp consistency, and 60°C temperature for one hour. Pulp then washed by aqua DM.

Handsheet Making

Handsheet made from some pulp compositions as follow :

Table 2. Handsheet Composition

Composition	Seaweeds pulp (%)	Abaca pulp (%)
1	70	30
2	30	70
3	60	40
4	40	60

Results of Experiment

Yield of seaweed cooking is 33.89 – 43.09 %. The low value of yield caused by too many fiber dissolved at cooking, bleaching, and washing. Seaweed fiber form a gel and dissolved well in water. Separation of this fiber from water is considerably difficult.

In 30 minute refining time, freeness value of 55°SR is reached for 30 % seaweed pulp and 72°SR for 70% seaweed pulp. It is clear that the addition of seaweed pulp influence the freeness value. The pulp refinability is lower due to increasing seaweed pulp content. It seems that seaweed pulp can not be fibrillated caused by its gel form. The ideal value of freeness, i.e 40°SR , is reached by 30% seaweed pulp composition at 10 minutes refining time.

Physical Properties of Seaweeds Pulp

Tear Index

The tear index at 40% seaweed pulp composition and 40°SR freeness is $7.78 \text{ Nm}^2/\text{kg}$, while at 60°SR freeness is $5.47 \text{ Nm}^2/\text{kg}$. For 40 – 60 % seaweed pulp composition, the value of tear index is $5.28 - 3.61 \text{ Nm}^2/\text{kg}$. Comparing to usual pulp (abaca, see Fig 2) tear index of handsheets contain seaweed pulp is lower. The low of tear index bring the authors to the hypothesis that the flexibility of handsheets is reduced. This reduction cause the load of

tearing support by only small area, means less fiber involve in tearing event. The low of flexibility is caused by setting or hardening effect of the gel from seaweed fiber.

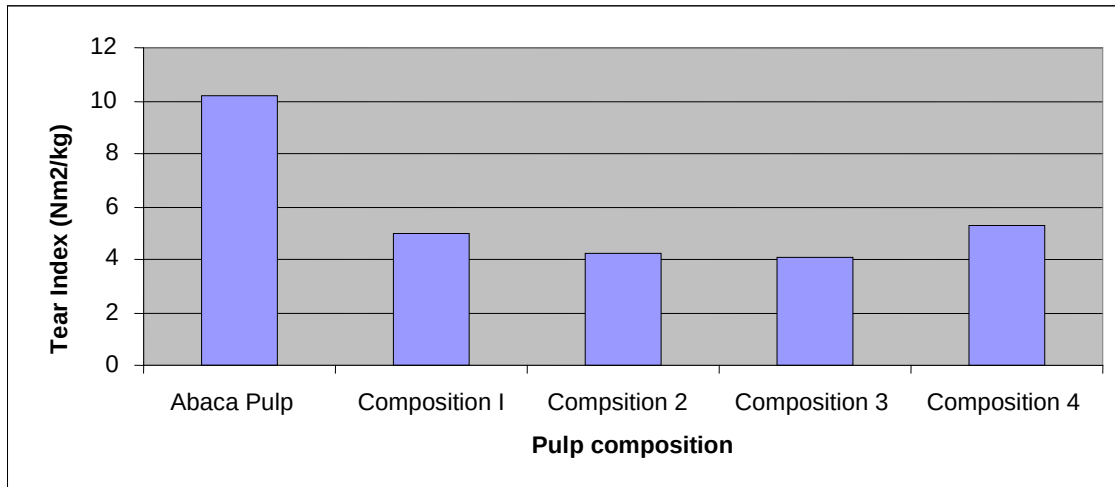


Figure 2. Tear Index of Handsheet at 40 °SR

As we can see from Fig. 3, the influence of various beating or refining time is similar for each composition. Generally, increasing the beating time caused the tear index of the sheets reduced. This may be caused by the distribution of seaweed fiber is more uniform at the increasing of beating time. So the effects of seaweed fiber reveal more. Tear index is significantly depend on handsheet flexibility. It is suppose to be that seaweed pulp decrease the flexibility of handsheet due to hardening effect of seaweed when it is dried. Handsheet with seaweed pulp more stiff than the other one that only filled by small amount of seaweed pulp.

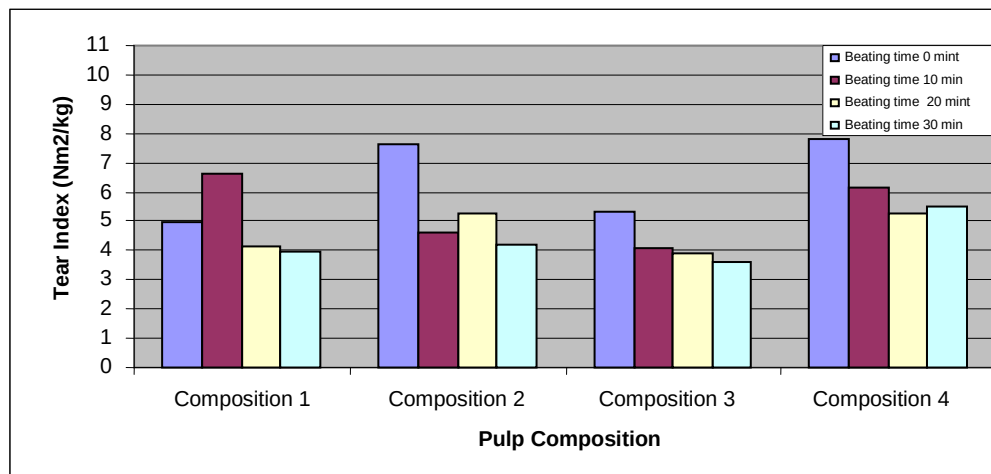


Figure 3. Tear Index of Handsheet at Various Refining

From Fig 4 it can be seen that handsheets contain seaweed pulp have lower tensile index. The decreasing of tensile index is caused by the facts that there is no fibril (fine fiber) in seaweed fiber. Fibril is very important to increase inter fiber bonding. The gel of seaweed only fill the matrix structure of handsheets. But there is slightly influence of seaweed content, that is, increasing tensile index when the content is decrease.

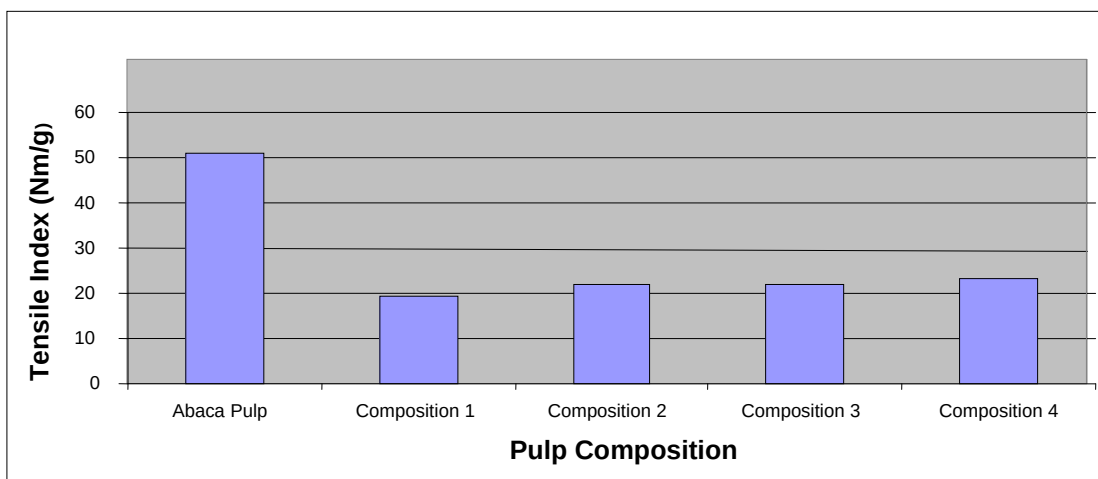


Figure 4. Tensile Index of Handsheets at 40°SR

The influences of seaweed pulp content at various refining degree can be seen on Fig. 5. For unrefine pulp (beating time 0), composition 2 reach the highest value of tensile index, but decrease as the increasing of refining time. It seems that seaweed pulp alter the internal fiber bonding at insreasing beating time. For each composition, seaweed pulp content only slightly influence the tensile index.

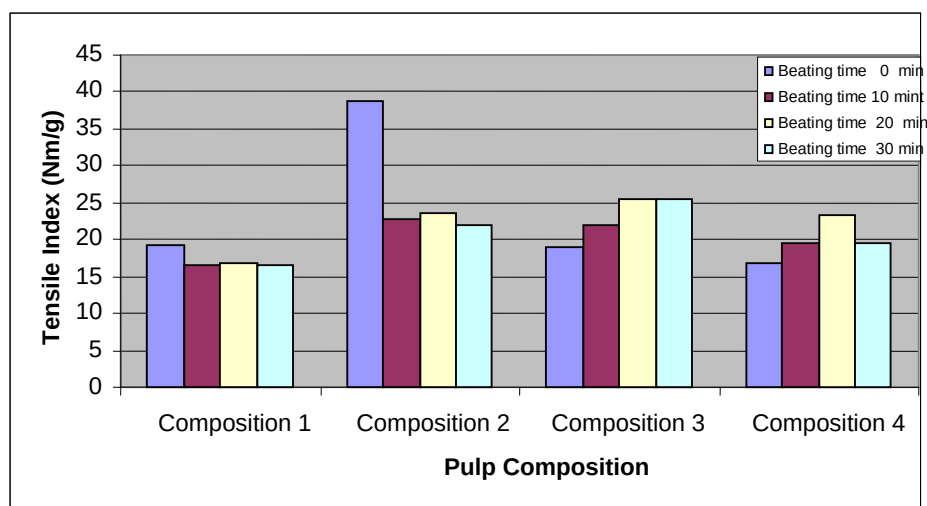


Figure 5. Tensile Index of Handsheets At Various Refining

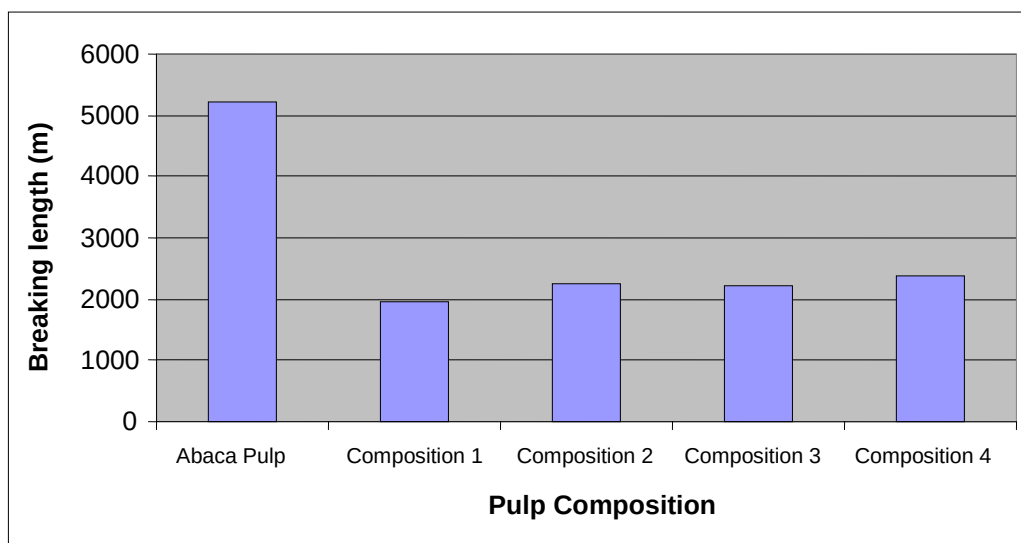


Figure 6. Breaking length of sea weeds pulp

Fig 7 shows that the addition of seaweed pulp into handsheets decrease its brightness. Brightness value is 54.33 %ISO for 30% composition of seaweed pulp, and 23.1 %ISO for 70% composition. These may be caused by the facts that seaweed pulp come in the gel form and the increasing of pulp content cause the light less scattered, so the brightness decrease

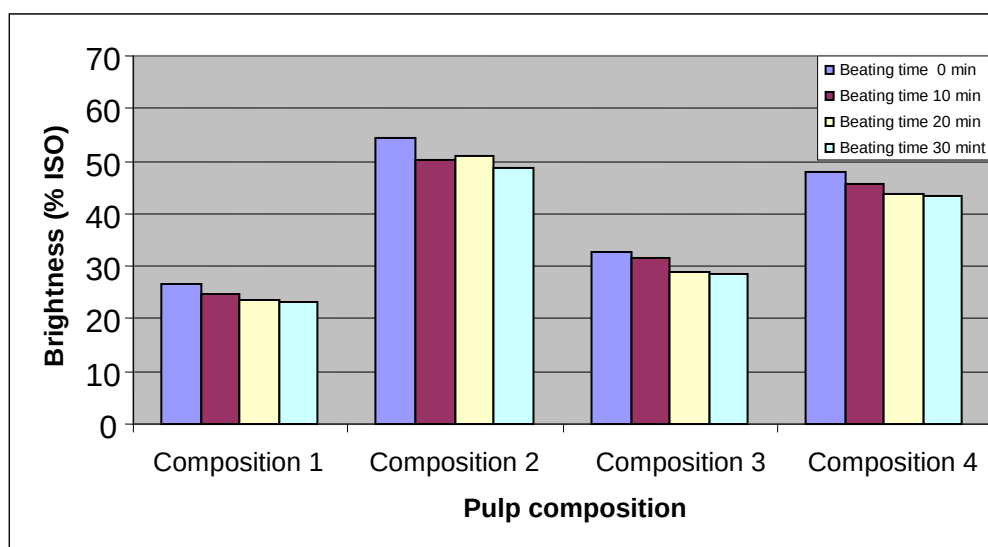


Figure 7. Brightness of Handsheets.

Pulp Opacity

The addition of seaweed pulp into handsheet, do not influence very much its opacity. But comparing with handsheet which do not contain the seaweed pulp, it is more more transparent. The opavity relatively constant. The same phenomena also occur for the same handsheet at various refining level. The gel-like of seaweed pulp contributes to handsheets transparency. This transparency cause the the light passing through easily. That's why the opacity values were not influence by seaweed pulp.

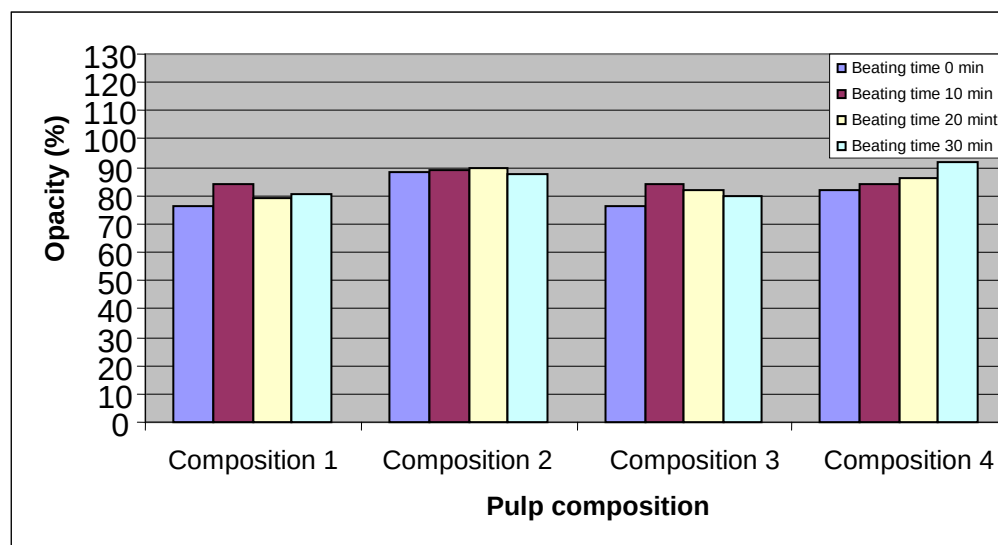


Figure 8. Opacity of Handsheets

Seaweeds paper gave higher opacity and brightness without lowering tensile strength at equivalent basis weight. There were some difficulties in runnability due to low freeness of the seaweeds furnish, but found to be manageable when the papermachine was slightly modified.

Conclusions

Seaweed pulp is possible to be a raw materials of papermaking with some notifications. Seaweed pulp decrease the rate of stock drainage, that must be attended in real papermaking. The seaweed pulp also decrease the strength of the sheets as revealed by the reduction of tear and tensile index.

Acknowledgement

The authors would like to express many thanks to Mr. Sudarmin, Mr. Teddy, and Mrs Cucu, who have assisted laboratory works for preparing all the experiment data.

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Appendix: Sea weeds pulp testing

Sea weeds pulp composition	Beating time (minute)	Freeness (°SR)	Gramage (g/m ²)	Tear Index (Nm ² /kg)	Burst Index (MN/kg)	Tensile Index (Nm/g)	Breaking length (m)	Brightness (% ISO)	Opacity (DH/DP)
Sea weeds Pulp 70%	0	55	54.5	16.20	1.922	63.15	6433	26.763	76.18
	10	65	58.5	21.56	-	54.31	5531	24.70	83.928
	20	68	53.25	13.58	-	54.51	5551	23.72	79.261
	30	72	55.50	13.03	-	53.02	5492	23.10	80.368
Sea weeds Pulp 30%	0	40	64.0	24.89	1.618	127.12	12955	54.33	88.364
	10	40	60.25	15.43	-	74.06	7551	50.22	89.018
	20	45	63.12	17.18	-	76.90	7836	51.10	89.786
	30	55	59.37	13.70	-	71.67	7306	48.60	87.542
Sea weeds Pulp 60 %	0	50	57.01	17.44	1.843	61.91	6316	32.53	76.17
	10	55	54.5	13.26	-	71.43	7277	31.52	84.332
	20	60	56.5	12.79	-	83.66	8522	28.92	82.03
	30	65	53.5	11.82	-	83.40	8503	28.57	79.879
Sea weeds Pulp 40%	0	40	56.0	25.42	1.843	55.35	5639	47.88	81.981
	10	45	58.25	20.17	-	63.47	6463	45.71	83.798
	20	52	57.62	17.26	-	76.17	7159	43.56	86.447
	30	60	50.50	17.89	-	63.51	6473	43.3	91.557

Properties of Fluff Pulp from Kenaf (*Hibiscus Cannabinus* L.)

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Abstract

High quality fluff pulp can be made from long bast fiber of kenaf, which is separated from parenchyma cell and other substances by mechanical process. The separated fiber bundles of 2-3 m length need to be cut into 3-5 cm before pulping. In the present experiments, fluff pulp was prepared by the use of soda process with the following parameters: active alkali of 12%, 14% and 16%; liquor to solid ratio of 1:4; maximum temperature at 165 °C; and time to max temperature and time at max temperature was for 1.5 and 2 hours, respectively. An elementally chlorine free (ECF) bleaching with O₂ED₁D₂ sequences was carried out to bleach the resulting pulp. Fluffing was done either in a willemill or shredder with and without super absorbent polymer (SAP) treatment. Treatment with SAP was varied from 10-30%. It was found that yield and kappa number was in the range of 61.83–65.01% and 10–14, respectively. Other properties such as brightness, extractives content, viscosity, and knots was higher than 89 % GE, 0.01%, 4.76 cp, and 5 %, respectively. Absorbent capacity of kenaf pulp in the present experiment was ranged from 7.03-18.78 g/g. It is dependent on the active alkali, SAP concentration and methods of fluffing. Most of examined properties met the requirement of commercial diapers. SAP treatment was significantly increased absorbent capacity of the fluff pulp.

Key words: kenaf, fluff pulp, absorbency, SAP, ECF

Introduction

Fluff pulp is usually bleached chemical, mechanical or chemimechanical pulp known also as fluffing or comminution pulp. It is mostly used for absorbent material in disposable diapers, bed pads, and hygienic personal products (Brunsvik 1987, Rismijana et al. 1992). Demand on fluff pulp is increasing due to the fast growing demand of natural absorbent material. Several decades ago world consumption of fluff pulp has reached over 2 million tons/year with a prediction of 0.5-1% annual growth rate (Brunsvik 1987). Indonesia alone, in the year of 2005 with hers 3.3 million children below three years has consumed 79.200 tons of fluff pulp, in which most of required fluff pulps for absorbent material are imported from Europe, United State and Australia. There is no existing mill of fluff and kenaf pulp in Indonesia. Therefore, opportunity to invest in fluff pulp industry in Indonesia is still promising. Lacking information on processing technology of kenaf might have been the cause of low interest in investment on kenaf pulp production. However, few investigations on kenaf have been carried out by the Center for Pulp and Paper in cooperation with Leces Pulp and Paper mill, and also by the Center for Research and Development of Tobacco and Fiber Plant of Indonesia. The results indicated that kenaf is very potential source of high quality fiber (Risdianto and Haroen 2004). In addition, these authors have noted that Australia and China have produced kenaf pulp for high quality commercial paper and it is more expensive than non bleached kraft pulp.

Fluff pulp must be low in extractive content, since extractive is hydrophobic and reduce the capability of pulp to absorb water (Field 1982). On the other hand, fluff pulp requires high cellulose content, low pulp viscosity, high content of long fiber and low primary fines content (Soderhjelm and Nordfeldt 1979), thus render pulp to absorb more liquid.

Cotton has been primarily the most preferred natural absorbent material for diaper and other hygienic products. Unfortunately, cotton is expensive and difficult to obtain. Other sources of hydrophilic natural material such as cellulose fiber (Gallary 1973) from wood and kenaf are potential to substitute cotton fibers. Most of wood based fluff pulps are currently derived from softwood. Its long fibers can generate fluff pulp with higher absorbency than that of short fiber (Field 1982). Many sources of non wood fiber have been also known to have long fibers, such as that of kenaf. It is a fast growing plant that can be harvested within 140-150 days (Mimms et al. 1993) and productivity of 2-2.5 tons (bd) per Ha (Kangiden et al. 1996). Furthermore, it has been reported to have a good prospect for fluff pulp,

utilized in the preparation of jute bags, carpets and high quality non-woven (Risdianto and Haroen 2004). Tests have been also intensively carried out for kenaf sorbents to remove heavy metals, pesticides and oil in city run off water (Rowell and Stout 2007). Defiberization (fluffing) is prominent step for kenaf pulp to reached satisfying absorbency (Risdianto and Haroen 2004).

As for most of non wood fiber sources, kenaf fluff pulp production is best suited with soda process. This is due to its low lignin content and soda process is more environmentally friendly as well as more economical than that of superior kraft process (Risdianto and Haroen 2004). Even though kenaf can grow fast, problems such as sustainable plantation, fiber handling, storage and transportation remain to be solved. Once the problems are solved, fluff pulp from kenaf is expected to grow in the future.

The present experiment is intended to determine the properties of fluff pulp from kenaf based on a more environmentally friendly process.

Materials and Methods

Figure 1 indicates the flow diagram of the present investigation. Kenaf stalk was chipped into 3-5 cm length followed by moisture content measurement. Soda pulping of the chips of kenaf was carried out in a 1600 grams (OD) capacity of rotary digester. Active alkali charges of the process was 12% (PK-12), 14% (PK-14) and 16% (PK-16) based on oven dry weight of chips with the liquid to wood ratio of 1:4. Total cooking time was set for 3.5 hours consist of impregnation time for 1.5 hours and time at maximum temperature (165 °C) for 2 hours. The resulting pulps were then screened and washed before bleaching process. Kappa number was measured after pulp washing in order to determine appropriate bleaching condition. Pulp were bleached following ECF bleaching methods with $OD_0ED_1D_2$ bleaching sequences. Table 1 indicates the conditions of bleaching process carried out in the present experiments.

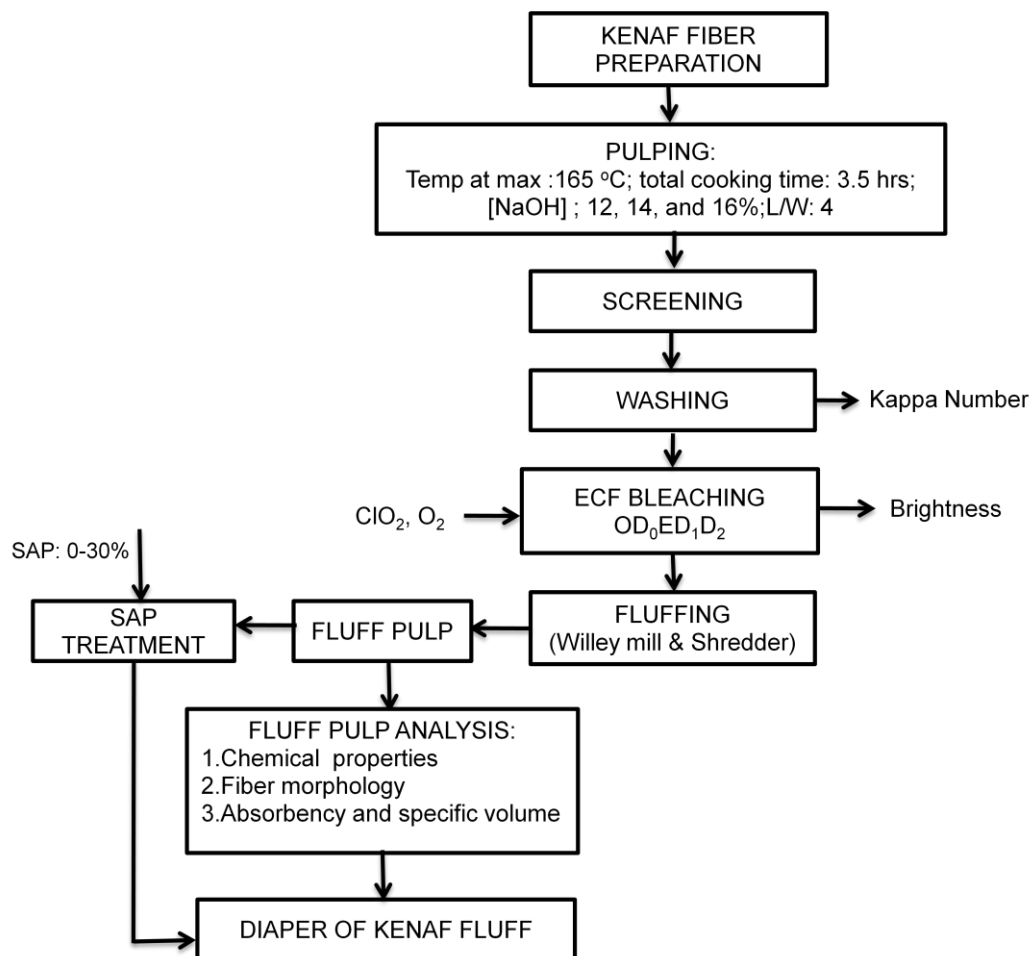


Figure 1. Diagram of the present investigation.

Table 1. The conditions of Bleaching process for fluff pulp of Kenaf

Parameter	Stages of bleaching				
	O	D ₀	E	D ₁	D ₂
Time (min)	60	60	60	180	180
Temperature (°C)	100	70	70	75	75
Pressure of O ₂ (psi)	87	-	-	-	-
Consistency (%)	10	10	10	10	10
ClO ₂ (%)	-	0.22 KN*	-	1	0.5
NaOH (%)	1	-	2	-	-
MgSO ₄ · 7H ₂ O (%)	0.5	-	-	-	-

a. O = Oxygen bleaching; E = Alkaline extraction with NaOH; D₀, D₁, and D₂ are initial, second, and third ClO₂ bleaching, respectively
b. *(%) active

Results and Discussion

Pulping Properties

Soda process was used to pulp kenaf chips in the present experiments. In this pulping system, hydroxyl anion from NaOH is the active species that reacts with lignin and other components of kenaf fibers (Mimms et al. 1993). The resulting pulp was then bleached with an ECF bleaching method following the sequences of OD₀ED₁D₂. Chlorine dioxide used in this ECF bleaching sequences is more environmentally benign with satisfying brightness and physical strength of the resulting pulp (Nakamata 2004).

Figure 2 indicates that lower screened yield and kappa number is achieved when using higher active alkali. In general high yield (above 60%) and low kappa number (below 15) were resulted from the current pulping of kenaf chips. It seems that all chips were well cooked in all level of alkali active. These are indicated by negligible percentage of rejects.

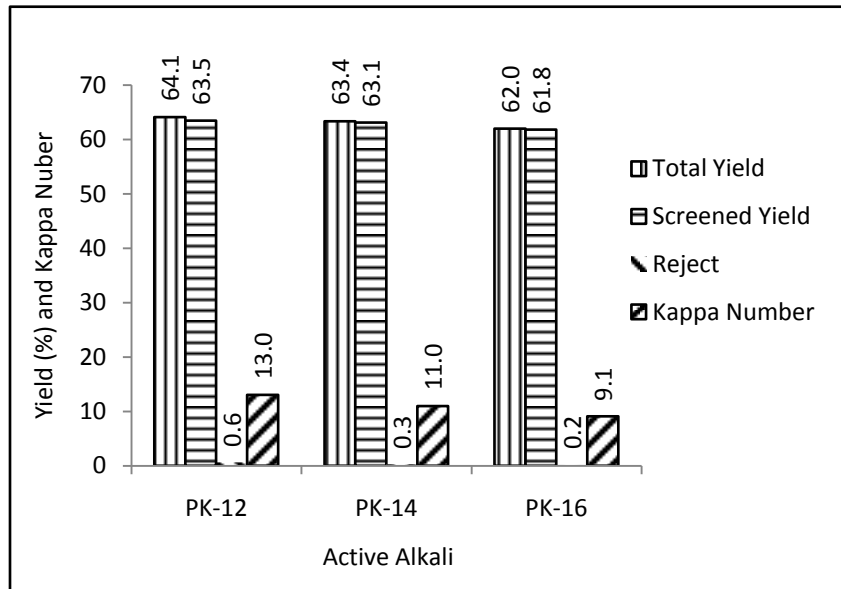


Figure 2. Yield and Kappa Number of Soda Kenaf Pulp.

Kappa number indicates residual lignin in pulp (Casey 1980) and can be used to determine chemicals requirement in bleaching phase. The resulting kappa number from pulping with active alkali of 14% and 16% were insignificantly different. It was thought that at 14% alkali active the resulting pulp will have a high bleachability with satisfying fluff pulp quality.

Black liquor properties were also determined. Table 2 listed the values of total solid, pH, residual total and active alkali, organic and inorganic content of the resulting black liquor. Increasing active alkali clearly increased total

solid of black liquor that reached 16.17% at 16% active alkali. Present total solid of black liquor was considered quite high compared to that normally of 9% for non-wood soda pulping process. Higher active alkali in cooking liquor resulted in lower residual active alkali, an indication of better chemical efficiency. This could be an indication of better swelling and liquor penetration with more alkaline pulping system. The lowest residual active alkali was found in cooking with 16% active alkali as shown by Table 2. In industrial scale, residual alkali is recovered and the organics are burned to produce energy (Mimms et al. 1993).

Table 2. Black liquor properties of kenaf pulping

Sample	Total Solids %	Residual		Organic	Inorganic	pH
		Total Alkali	Active Alkali			
PK-12	13.26	7.04	10.21	3.14	96.86	12.10
PK-14	14.54	8.25	9.20	3.68	96.32	12.12
PK-16	16.17	12.47	5.99	4.29	95.71	12.22

Chemical and Optical Properties of Pulp

Lignin is hydrophobic substance that inhibits the pulp to absorb more liquid. Furthermore, lignin contains chromophoric group that darken the pulp. Thus, considering the use of the present pulp for commercial diaper, it is important for it to be free of lignin. An ECF bleaching method was employed to bleach the pulp. Table 3 indicates that the brightness of kenaf pulp bleached with O-D₀-E-D₁-D₂ sequences was reaching 89%, which is higher than that of Stora and commercial diaper fluff. Low extractives, low residual chlorine and high cellulose content (above 80%) are other important requirements of fluff pulp (Field 1982). As indicated by Table 3, all important requirements of fluff pulp from kenaf were better than these of Stora and commercial diapers. With the residual chlorine measured as AOX of less than 0.1, fluff pulp of kenaf is safe for hygienic products such as diaper. It will also function as a good absorbent material considering its high α -cellulose content.

Table 3. Chemical properties of kenaf fluff pulp.

Component	Fluff Pulp		Commercial Diapers
	Kenaf	Stora Fluff *	
Extractives, %	0.01- 0.07	0.15 - 0.30	0.1
α -cellulose, %	80.54-90.11	82.67- 86.87	85 - 90
Viscosity, cp	4.76	6.78- 6.87	-
Brightness, % ISO	89, 46	85-86	86
pH	6.5	6.0	-
Moisture content, %	9.2	8.0	-
AOX, kg/ton	0.05	< 0.1	-
Knot, %	5	- 8	-

*) Source: Stora Fluff EF, 1994.

Fiber Morphology of Kenaf Fluff

Fiber length of kenaf was found in the range of 1.95-5.00 mm with the average of 2.98 mm. Classification of fiber length by Klemm (Casey 1980) put kenaf fiber in the class of long fiber (> 1.96 mm). It is comparable to the fiber length of Stora fluff and commercial diapers. Fiber length distribution of kenaf is indicated by Figure 3. Kenaf can be a primary choice for absorbent material due to its long fiber (>1.96 mm). Long fiber can provide high surface area, good interfiber bonding and high absorbency.

Absorbency of Kenaf Fluff Pulp

The most important output of the fluff pulp production is its high liquid absorbency that can substitute imported fluff. Normally, dry cellulose fiber are hygroscopic that can absorb water from any source. However, cellulose can never be found a 100% dry. Extreme dryness can change the molecular structure of cellulose (Gallary 1973). Water absorption in the fluff pulp is classified into three ways by this author, i.e. water adsorption, water absorption, and capillary water.

Water absorbency of kenaf fluff pulp is determined by the water present via hydrogen bonding with hydroxyl group of cellulose and water molecules trapped in the cavity of cellulose fibril system. The amount of water trapped in the cellulose fibril system is the maximum absorbent capacity of the cellulose (Field 1982, Soderhjelm 1979).

Absorbency capacity of kenaf fluff from PK-14 and PK-16 found in the present experiment is comparable to that of Stora fluff and commercial diapers. Absorbency capacity of the pulp varied depends on fluffing methods (Willemill vs. shredder). Absorbency of shredded fluff was higher than that of Willemill fluff due to higher exposure of the shredded fluff. Willemill fluff contains more fines and cut. Absorbency found in the present experiment was in the range of 7.03-9.20 g/g, which is close to 8.0–9.5 g/g of that of Stora fluff (0% SAP treatment at Table 4).

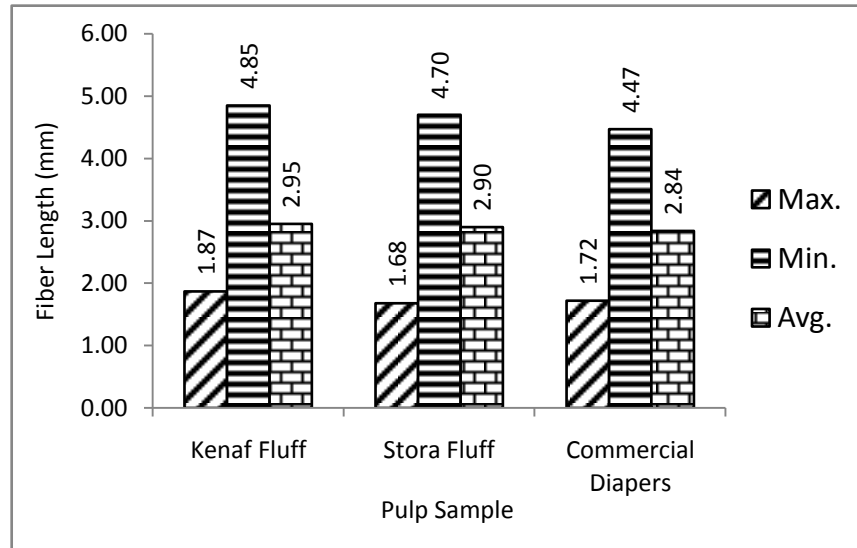


Figure 3. Fiber Length distribution of kenaf fluff pulp compared to that of commercial fluff pulp.

Absorbency Improvement by SAP Addition

Super absorbent polymer (SAP) can improve the liquid absorbency of a material (Field 1982). Thus, in order to increase absorbency of kenaf fluff to a level comparable to that of commercial fluff, SAP with varied concentration was added to kenaf fluff. Table 4 indicates that a 10% SAP addition to kenaf fluff pulp from PK-12 increased its absorbency by 53%, i.e. from 7.03 g/g into 10.76 g/g. While a 30% SAP addition increased its absorbency up to 96%. The quantity of SAP addition must be properly determined due to its expensive price (Branon 1990, Visoli 1997).

Table 4. SAP addition and 30 seconds absorbency capacity (g/g) of kenaf fluff pulp.

Sample	Willemilled Fluff				Shredded Fluff			
	SAP (%)				SAP (%)			
	0	10	20	30	0	10	20	30
PK-12	7.03	10.76	11.98	13.78	9.05	12.17	13.08	14.90
PK-14	9.12	12.10	14.62	15.49	9.20	14.10	16.62	17.99
PK-16	9.11	13.63	15.07	16.42	9.03	14.63	16.47	18.78
Stora Fluff	8.0 - 9.5							
Commercial Diaper	8.6 - 15.9							
100% SAP	25 - 30							

Specific Volume of Kenaf Fluff Pulp

Specific volume of fluff pulp indicates the ratio of a unit volume of fibers to a unit of fibers weight. Higher value of specific volume indicates the fluff is fluffier. The specific volume of kenaf fluff obtained in the present experiment (via Willemill and shredder) was in the range of 5.80-7.84 cm³/g. These values depend more on the method of defiberization process than on the cooking or bleaching processes. Table 5 indicates the values of fluff specific volume. The specific volume of fluff produce with Willemill was lower than these of with shredder machine. This was due to more fine and soft in the Willemill fluff and more voluminous fluff of shredder fluff. The fiber of fluff resulted from shredder was also coarser than these resulted from Willemill. Specific volume affects the forming of network fiber tube, which will increase liquid absorbency when more tube is formed (Stora Enso 1994).

Tabel 5. Specific volume (cm³/g) of kenaf fluff pulp

Sample	Willemilled Fluff				Shredded Fluff			
	SAP, %				SAP, %			
	0	10	20	30	0	10	20	30
PK-12	5.80	6.20	6.82	6.97	7.24	7.58	7.69	7.73
PK-14	5.85	6.22	6.87	7.01	7.28	7.66	7.72	7.84
PK-16	5.80	6.27	6.85	6.98	7.27	7.64	7.74	7.81
Stora Fluff	6 – 19							
Commercial Diapers	7.3 -21.2							

Conclusions

Present experiments indicated that chemical properties of kenaf fluff mostly comparable to or even better than those of Stora fluff and commercial diapers. AOX content was very low, thus the fluff will be very safe and suitable for hygienic products such as diapers. Fluff pulp from kenaf was found to be in the class of long fiber.

Absorbency capacity of Willemilled fluff was only comparable to those of the fluff of Stora and commercial diapers when produced from pulping process with 14 and 16% alkali active. However, with the addition of 10% SAP the absorbency capacity of all level of alkali active increased to the level of those of Stora and commercial diapers. While shredded fluff did not require any SAP addition to reach absorbency capacity of the fluff of Stora and commercial diapers. Similar finding was found with the fluff's specific volume.

Acknowledgements

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The Utilization of Sawdust as an Alternative Energy

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Abstract

The purpose of this research was to measure the caloric value of sawdust briquette in different sizes of sawdust and density in order to assess the suitability of the use of sawdust as briquette and to determine which of them is the best as briquette material. Method used was descriptive by tabulation. The result revealed that the caloric value of each briquette 4190,6 kal/g of *Intsia* sp, followed by 4284.9 kal/g of *Pometia* sp and 4348.2 kal/g of *Pterocarpus indicus*. Each caloric value of these species are lower in comparison with caloric values of their solid wood. The high caloric value of briquette made from *Pterocarpus indicus*'s sawdust due to the enormous content of resin. The utilization of sawdust become briquette as energy source is one of alternatives in waste management of sawmills.

Key words : sawdust briquette, caloric value, resin, alternative energy, waste management

Introduction

Recently, development of wood processing industrial in Indonesia sharply increased, but the development has not been followed with management of adequate industrial disposal so that the waste only castaway is free and even potency to reduce environmental quality. Sawdust waste yielded by processing industry of wood admits of exploited to assorted of product which will give added value, one of them is sawdust briquette.

Processing of sawdust become briquette had several beneficial, beside had good appearance it also easy to arranging in the stove, has reasonably price, substitute of fossil fuel and could reduced disposal from wood industrial.

Caloric value is the quality indicator of wood as energy source. In order to test of sawdust eligibility as an alternative energy, testing of briquette caloric value form sawdust is needed. The result of this research is not only applicable to assess the eligibility usage of powder as briquette but also determines best types of wood as component of briquette

Materials and Methods

Material and Equipment of Research

Material applied is sawdust from processing industrial disposal of wood and furniture from species *Pometia* sp (Matoa), *Intsia* sp (Merbau), and *Pterocarpus indicus* (Lingua), tapioca flour, and water. Equipment applied is oxygen calorimeter bomb, equipment of press hidraulik, oven, a set glass equipments, filter 10 and 20 meshes, sprayer, and press hydraulic machine.

Research Procedure

A. Making of Powder Briquette

Briquette is made by mixing sawdust with tapioca flour glue. Amount of glues applied by 10% powder total weight. Process of briquette is with mixing sawdust with glue then is pressed. Briquette is made with different compactibility and wood particle size. Wood particle size 10 and 20 meshes with 2 replicating. Briquette density applied were 0.4 g/cm³, 0.6 g/cm³, and 0.8 g/cm³.

B. Data collecting Procedure

Collecting data including determination of powder moisture content, wood specific gravity and sawdust briquette caloric value.

C. Data processing

Result of research analysed descriptively by tabulation.

Results

Moisture Content and Wood Specific Gravity

Table 1. Moisture content of sawdust and wood specific gravity

No.	Wood species	Water Content (%)	Specific Gravity*
1.	Pometis sp	14.2	0.50 - 0.9
2.	Intsia sp	16.4	0.52 – 1.04
3.	Pterocarpus sp	16.1	0.39 – 0.94

* Specific gravity of solid wood at air-dried condition (PICA,1981)

Third waste saw powder moisture content of wood type applied as component of briquette has come near air-dried wood water content causing is assessed has earned direct process to briquette. Average of wood specific gravity at air-dried condition from third of briquette material wood type varies from medium category specific gravity that is 0.60-0.75 until weight that is 0.75-0.90.

Briquette Caloric Value

Table 2. Briquette caloric value based on wood species

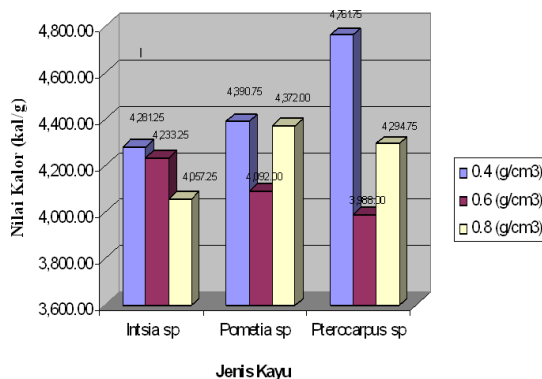
No.	Wood species	Caloric value (kal/g)
1.	Pometis sp	4190.6
2.	Intsia sp	4284.9
3.	Pterocarpus sp	4348.2

Pterocarpus sp (lingua) simply has higher level caloric value compared to two other wood species. This difference anticipated because of existence of resin content in lingua. Haygreen and Bowyer (1982) expressing that heat value of resin approximately heat value twice wood, hence resin contained wood has higher caloric value than wood without resin. In general sawdust briquette caloric value from third of wood species pertained lower than solid wood caloric value. Solid wood caloric value for *Pometia* sp is 4715 kal/g, and *Pterocarpus* sp 4813 kal/g, while *Intsia* sp has not there are data (Martawajaya et al, 2005).

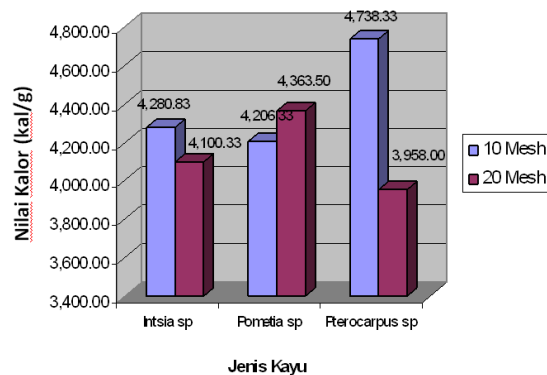
Seen that third caloric value of the wood species are not so different. Panshin and de Zeeuw (1970) reporting that difference of caloric value between wood species ranges from 5% - 8%. The caloric value of hardwood around 4930 kal/kg while group of softwood 5220 kal/kg.

Personally the low sawdust briquette caloric value influenced by mixing of agglutinant so that happened improvement of water content. Wood caloric value influenced by level of material dryness. High water content will influenced heat value, combustion efficiency as well as temperature yielded. (Haygreen and Bowyer 1982).

Briquette caloric value based on density and size of sawdust at Figure 1.



(a) The caloric value based on the density



(b) The caloric value based on the size of sawdust

Briquette caloric value based on density and size of sawdust varies without existence of improvement tendency or impairment based on density and sawdust size. Regarding research of Suparno, Praptoyo and Iswandaru (2002) that density factor doesn't have an effect on reality to result of caloric value. This is because of weight applied

in examination is same (1 gram) so that many masses tested is equally relative. With relatively small weight, density factor will not so clearly emerges level of caloric value. Density of briquette and sawdust size only have an influenced in hardness and number of material applied. Difference of caloric value resume influenced by difference of moisture content each briquette. The higher density caused higher of water content so the caloric value decreased.

Conclusion

1. Average of powder briquette caloric value from *Intsia* spp is 4190.6 kal/g, *Pometia* spp 4284.9 kal/g and *Pterocarpus indicus* 4348.2 kal/g, lower than solid wood caloric value.
2. Briquette made from *Lingua* sawdust has higher level heat caloric value from type *Intsia* sp and *Pometia* sp. Height level of *Lingua* sawdust briquette caloric value caused by existence of resin content in wood *lingua*.
3. Exploiting of saw powder becomes briquette as component of burning is one of alternative of industrial waste treatment of wood processing.

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The Influence of Oven Temperature and Time Periods on the Yield of *Sterculia foetida* Seed Oil Production using Hydraulic Pressing Method

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Abstract

The purpose of research was to understand the influence of temperature and time periods in an oven of *Sterculia foetida* seed on the yield of oil production using hydraulic pressing method. The study was expected to give the information concerning the processing of *Sterculia foetida* oil in order to result in maximum production suitable for new source energy. Results showed that the oven temperature and time periods have a significant effect on the produced oil, but there was no significant effect of temperatures and time periodic interaction. Oven methods have a very significant effect to yielded oil. Oven method resulted in higher level yield compared to the treatment without oven. Maximum yield of oil (35.06%) was obtained at the treatment of temperature 100°C during 45 minutes, while control treatment was only 18.84%. The influence of temperature and time periods on the yield of *S. foetida* seed oil were found to be linear in which each increase temperature causes increase 0.16% in the yield, and each increase in the minute tend to increase 0.21% in the yield.

Key words : *Sterculia foetida* Linn., *S. foetida* oil

Introduction

Indonesia as a tropical country has a variety of plants that can be developed as a raw material for the production of alternative energy to replace fossil fuels, either in the form of bioethanol as a substitute for a premium or biodiesel as a substitute for diesel oil. Biodiesel has combustion properties very similar to diesel oil, which can be used directly on the engine fuel diesel oil without changing the engine (Sugiono, 2008). Biodiesel can be made from environmentally friendly biological materials such as: palm oil, the distance the fence, and soybeans.

One of the raw materials that can be used as a substitute fuel source is kalumpang (*Sterculia foetida* Linn.) That can produce the oil from its seeds. In order to maximize the results obtained oil, it is needed to know the proper methods, both in terms of treatment of raw materials and equipment needed. The methods most widely used in household industries are small scale with hydraulic compression methods because the price of this tool is less expensive and can be modified themselves even obtained the yield lower. Therefore, to increase the yield produced, then the compression process given before treatment is the provision of raw materials through oven heat. Heating is one step in the process of oil processing which aims to unite and gather the items so that in the process of oil seeds pressing, the oil can be issued with a maximum amount. This study aims to determine the influence of temperature and duration of oven seeds yield oil kalumpang with hydraulic pressing method which can provide information about kalumpang oil processing to get the most that can be used as a renewable energy source diversification.

Materials and Method

Oil Extraction

Making kalumpang seed oil (seed oil extraction kalumpang) is based on the procedures of Nurcholis and Sumarsih Rasheed's (2007) which has been modified as follows

1. Dry kalumpang beans that have been separated from his skin are cleaned from materials that are not desirable, such as fruit skin and dirt, then removed from the meat seeds manually.
2. Seed meats are crushed using a blender
3. Weighing the crushed seed meats as much as 350 grams.
4. Putting into the oven the the crushed seed meats at a temperature of 40 ° C (Treatment PA1). Old heating 15 minutes, 30 minutes, and 45 minutes (treatment PB)
5. To extract seed meats by using hydraulic pressing tool

6. After the oil is not flowing, the remaining seed bungkils are removed
7. Raw kalumpang oil produced is filtered
8. Separating oil from the gum by using the sentrifusi method
9. Weighing the previous bottles that have been labeled
10. Pouring filtered oil into the labeled bottle and then weighing to determine the weight of oil
11. Repeating treatment PA1 3 times
12. Next, performing the procedure 1 to 9 in accordance with treatment prescribed oven at a temperature of 60 ° C (Treatment pa2), temperature 80 ° C (Treatment PA3), and oven at a temperature of 100 ° C (treatment PA4) respectively during 15 minutes, 30 minutes, and 45 minutes (treatment PB)
13. To compare, oil extraction is also carried out without oweb treatment (PC treatment).

Variable Observations

Yield

The resulting oil yield is calculated by the formula :

$$\text{Yield} = \frac{\text{output}}{\text{input}} \times 100\%$$

dimana :

output : Heavy oil (gram)

input : Weight of raw material of kalumpang seed meat(350 gram)

Draft Experiment

Experimental design model used in this study is to design Square Divided (Rpt) with the basic design Complete Random Design (RAL) with 2 factors, oven temperature treatment (as a factor A) which consists of 4 levels, namely PA1 (40 °C), pa2 (60 °C), PA3 (80 °C) and PA4 (100 °C) and oven time periods treatment (as factor B) which consists of 3 levels, namely PB1 (15 minutes), PB2 (30 minutes) and PB3 (45 minutes), as a comparison made without oven treatment (control) in which each treatment is repeated 3 times.

According Gaspersz (1994), a general model of experimental design used is as follows:

$$Y_{ijk} = \mu + A_i + \delta_{ik} + B_j + (AB)_{ij} + \varepsilon_{ijk};$$

$$\begin{aligned} i &= 1, 2 \\ j &= 1, 2, 3, 4 \\ k &= 1, 2, 3 \end{aligned}$$

Where

Y_{ijk} = The observed values (response) on test-k to obtain the i-th level of factor A and level j of the factor B

μ = The real average value

A_i = Additive effect of the level of the i-factor A

δ_{ik} = influence of error that appears in the i-th level of factor A in the-k test, often called the main plot error (error a)

B_j = Additive effect of the level of the j-factor B

$(AB)_{ij}$ = Interaction effect of the i-level factor A and level j of the factor B

ε_{ijk} = Influence of error on the test-k to obtain the level of the i-factor A and level j to factor B, often referred to as the plots son error (error b)

To determine the effect of each treatment, then further tests done Beda Real Truth (BNJ) with the following formula:

$$W = q_{\alpha} (p \cdot fe) \cdot Sy$$

Dimana : W = BNJ test value

q_{α} = Tukey table value

p = Number of treatment

fe = Error-free degrees

Sy = Median standard error ($Sy = KTG/r$)^{1/2}

(KTG = Middle squared error, r = Number of replications)

Results and Discussion

Oil extraction method used in this study was mechanically pressed with hydraulic press that produces a low yield of oil. Therefore, early oven treatment is needed raw materials to process one. This is in accordance with the statement Hambali et al. (2008) prior to the pressing process, first seed pretreatment given for the provision of hot or warm temperatures. Heating can be done by heating the oven in order to agglomerate protein in the seed. Made to coagulation protein extraction efficiency, 80% of the amount of oil contained in seeds may be out of meat.

Value of the average yield kalumpang oil from each treatment, with a weight of fresh material each 350 grams for each test can be seen in Fig 1.

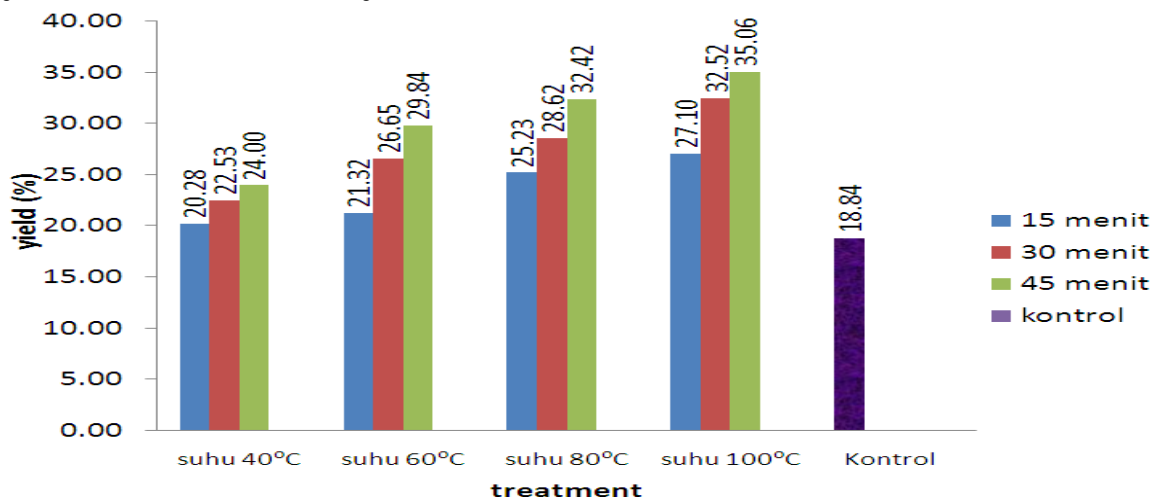


Fig 1. The Results of Average Oil Yield of Kalumpang Seeds

Fig 1 shows the increasing tendency of the resulting yield values to the rising of oven's temperature and the length of time to bake. The Value of the average yield produced at the highest oven methods, namely the treatment at the temperature 100 ° C for 45 minutes with a yield of 35.06% while the lowest yield produced at the treatment temperature 40 ° C for 15 minutes to yield 20.28%.

The results of various printed kalumpang seed oil yield at different oven temperature treatment showed that the oven temperature effect very real. This means that the yield of kalumpang seed oil generated oven influenced by temperature during the pressing process. To find the difference between the treatments of raw materials at oven temperature of the oil yield kalumpang, further testing performed use the Real Truth Different test (BNJ) the results can be seen in Table 1.

Table 1. The BNJ Test Results of Percentage of kalumpang Oil Yield at each Treatment of Oven Temperature

Oven Temperature Treatment	Average Yield (%)	BNJ Test Results (w=1,836)
A4 (100 °C)	31,56	a
A3 (80 °C)	28,75	b
A2(60 °C)	25,93	c
A1 (40 °C)	22,27	d

Description: The same letter means there is no significant different in the real level of 1%

Data in Table 1 show the average yield produced at the highest oven temperature treatment the 100 °C and 31.56% respectively at a temperature of 80 °C 28.75%, the temperature is 60 °C 25.93%, and the lowest is at a temperature of 40 °C 22, 27%.

After further testing using the Real Truth Different test (BNJ), it continued by analysis of orthogonal polynomials in Fig 2.

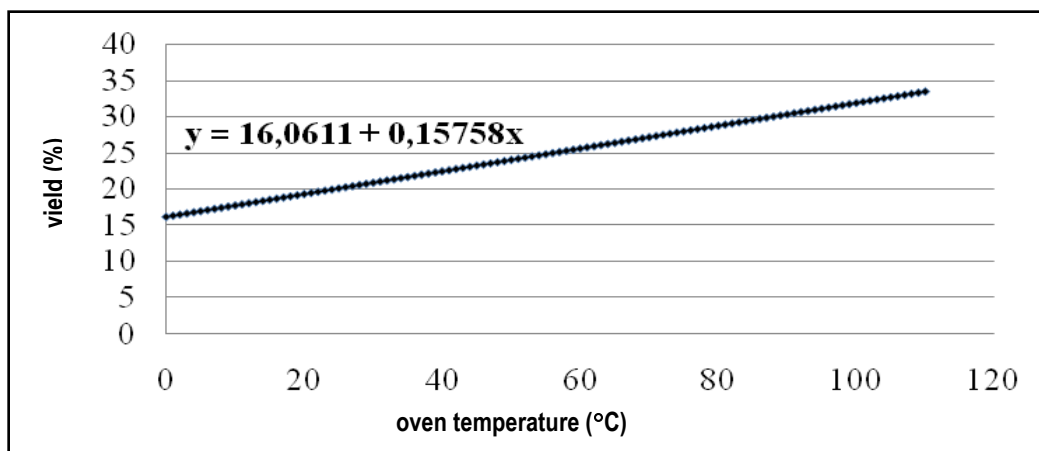


Fig 2. The influence of oven temperature curve Against Oil Seed Yield Kalumpang seed oil yield

Fig 2 shows that the influence of oven temperature on yield kalumpang seed oil is a linear function. This means that the addition of oven temperature will tend to increase Kalumpang seed oil yield. Any increase in oven temperature for 1 °C tend will incline yield of 0.15758%.

The results of various printed kalumpang seed oil yield in different oven time period treatments showed that oven time period treatments. This means that the yield of kalumpang seed oil produced is influenced by oven time periods. To find the difference between the treatments of raw materials and oven temperature of the kalumpang oil yield, further testing was used using the Real Truth Different test (BNJ) the results can be seen in Table 2.

Table 2. BNJ Test Results Percentage Yield Differences on Each Kalumpang Oil Oven Treatment duration

Oven Treatment Temperature	Average Yield (%)	BNJ Test Results
B3 (45 menit)	30,33	A
B2 (30 menit)	27,58	B
B1 (15 menit)	23,48	C

Description: The same letter means no significant different in the real level of 1%

Table 2 shows the average value produced the highest yield on oven treatment for 45 minutes is then 30.33%, respectively for 30 minutes ie 27.58% and the lowest is for 15 minutes ie 23.48%. After further testing using the Real Truth Different test (BNJ), it is followed by analysis of orthogonal polynomials in Fig 3.

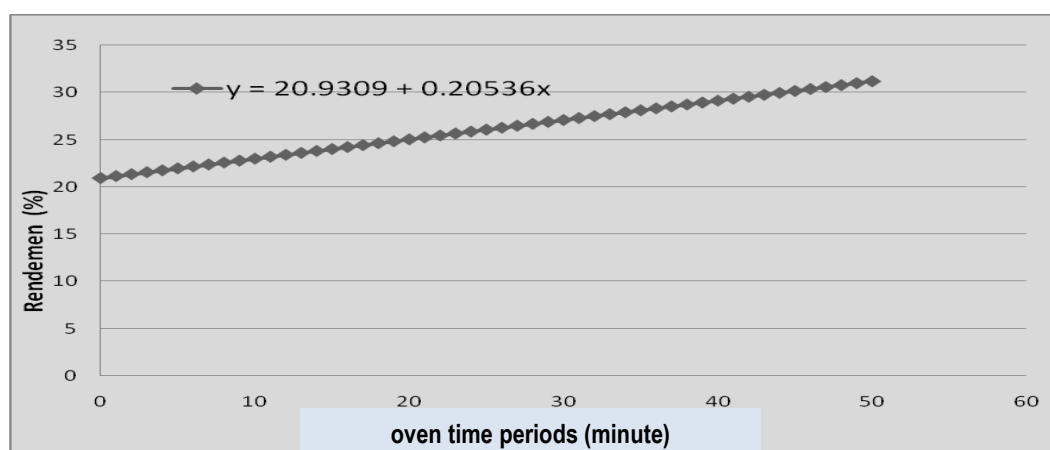


Fig 3. The Curve of Influence of Oven Time Periods againsts Kalumpang Seed Oil Yield.

Based on Fig 3, it shows that the influence of oven timer kalumpang seed oil yield is a linear function. This means that the addition of oven timer will tend to increase the yield of seed oil kalumpang. Any increase in a time periods for 1 minute oven tend increase yield of 0.20536%.

The results of various printed kalumpang seed oil yield in the interaction between temperature treatment and the oven timer treatment showed that there was no interaction between the oven temperature treatment ratings and treatment. This means that no significant interaction had effect on yield of oil produced. The influences of the oven temperature were not determined by the length of time to bake, but higher temperatures and oven time periods had more effects.

Based on the results obtained, it showed that without the oven treatment (control) it produces a low yield of oil. This is because the oil contained in seeds can not be taken out completely. According to Wahyudi and Panggabean (2008) prior to pressing, the seeds that have been destroyed should be heated at high temperature first. It aims to facilitate the separation of fat from which the more fat and to lower water levels. While treatment with the oven methods yield produces more oil the oven temperature at a certain level indicates a tendency to raise the yield of oil. This is because the high temperature allows the oil to become more dilute, so the oil is more easily taken out of the seed. This is consistent with that proposed by Wibowo (2007), that is, heat treatment on the seed caused proteins found in the seeds clotted (clot), and caused the outbreak of emulsion between oil and protein. It made easier for oil to flow out while the protein remained in the oilcake. The oven time periods showed that the oven time periods a certain level shows the tendency of increasing oil yield. This is caused by a oven long allow oil to come out with a maximum. According to Darmawan (2006) the warming in a way dioven can provide a constant heating and evenly on every surface material so that when pressed, the oil are issued more

Previous research conducted by Baba (2008) using the method of boiling the raw material with a temperature of 80% before pressing the yield results obtained as follows: during the 15 minutes that is 13.947%, for 30 minutes which is 13.206% and for 45 minutes is 8.397%. In research Gautama (2008) by using the method of steaming at a temperature of 80 °C yield the results obtained respectively for 15 minutes ie 14.37%, for 30 minutes ie 10.79% and for 45 minutes is 7.43%. The data above show that the oven treatment produces more yield than the method of boiling and steaming methods

Conclusion

Based on the results of research has been done, it can be concluded that:

1. Oven method performed has very real effect on the average yield of kalumpang oil produced
2. Temperature and oven time periods has very real effect on the average yield of kalumpang oil produced
3. The interaction between temperature and duration of oven is not real because the higher temperatures and oven time periods the higher the resulting oil yield will tend
4. The highest yield is produced at a temperature of 100 °C for 45 minutes ie 35.06% and the lowest yield is produced at a temperature of 40 °C for 15 minutes which is 20.28%.
5. Any increase in temperature for 1°C tends to increase yield 0.15758%, and any increase in oven time periods for 1 minute tends to increase the yield of 0.20563%.

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Cultivation of *Pleurotus ostreatus* on Various Lignocellulosic Waste Biomass

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Abstract

Growth and biological efficiency ratio (BER) of Oyster mushroom, *Pleurotus ostreatus* (Jacq.:Fr.) Kumm was studied on various lignocellulosic waste biomass such as wood sawdust, palm oil fiber, imperata grass and mixed of them. Palm oil fiber was the best substrate in fruit body production and BER of *P. ostreatus*. The fast fruiting time for *P. ostreatus* was obtained after 31 days of inoculation from mixed of wood sawdust and imperata grass (1:1, wet wt/wet wt). Imperata grass was the least suited lignocellulosic biomass for mushroom cultivation. Palm oil fiber and wood sawdust were recommended used for mushroom cultivation.

Key words : Oyster mushroom, lignocellulosic, biomass, biological efficiency ratio (BER)

Introduction

Human relationships with mushrooms are ancient and fascinaty. Egyptians believed that they were a gift from the god Osiris. Mushroom has been collected and consumed for more than 2000 years in Greece, China and Japan (Futty, 2003). People have long been interested in mushroom for their nutritional and medicinal aspects. Mushroom are healthy foods, poor in calories and fat, rich in vegetable protein, chitin, vitamins and minerals. The most cultivated species in Indonesia is *Pleurotus ostreatus* and *Lentinus edodes* that are now widely produced (Suriawiria, 2003).

Cultivation of Oyster mushroom (*Pleurotus* spp) has increased tremendously throughout the world during the last few decades (Chang, 1999). This mushroom accounted for 14.2 % of the total world production of edible mushroom in 1997 (Chang, 1999). Although commonly grown on sterilized straw of wheat or rice, they can be cultivated on wide variety of substrates that contain lignin and cellulose (Das and Mukherjee, 2006). Oyster mushroom cultivation can play an important role in managing organic wastes which have become problematic for disposal (Baysal, et. all, 2003). Mushrooms cultivation help manage problematic organic wastes since agricultural and food processing by – products can be used as cultivation media (Futty, 2003).

In the present paper, growth and biological efficiency ratio (BER) of Oyster mushroom, *P. ostreatus* on various lignocellulosic waste biomasses were studied. We herein report that palm oil fiber waste was a suitable substrate for cultivation of oyster mushroom compared with wood sawdust, imperata grass and mixed of them. Imperata grass was the least suited lignocellulosic biomass for mushroom cultivation. Palm oil fiber and wood sawdust were recommended used for the mushroom cultivation.

Materials and Methods

Mushroom Strain

Pleurotus ostreatus (Jacq.:Fr.) Kumm was collected from tissue culture laboratory of the state Polytechnic of Agriculture Samarinda and was maintained on potato dextrose agar (PDA) pH 7.0 containing 20% potato extract, 2% dextrose and 2% agar (Parjimo and Andoko, 2007).

Substrates Preparations

Instead of wood sawdust, all of the substrates (lignocellulosic biomass) were chopped to 1-2 cm long pieces and air-dried. Before using, the substrates were added with supplementary material. Air- dried substrate (1 kg) was mixed with CaCO₃, rice brain, tapioca and 75 % of water (Parjimo and Andoko, 2007). Then, the mix substrates were put into 18 cm x 35 cm polythene bag/baglog. Then after tightly closed the bags were sterilized in an autoclave at a

temperature of 121 °C, then after 15 min of sterilized the bags were left to cool and inoculated with mycelium of *P. ostreatus* at an approximately amount of 2 % of the fresh weight substrate.

The bags were subsequently placed into an incubation room at 25 ± 2 °C under dark condition. After completion of spawn running, the bags were placed into a growing chamber set environmentally (growing chamber) at room temperature (± 25 °C) and 80-90 % RH. Large holes were made in the top of baglog to allow the normal growth of fruit bodies. Water was sprayed for maintaining moisture up to the desired level in the form of fine mist using a nozzle. The data concerning spawn running (mycelia growth) was recorded after completed colonization of the substrate, pinhead and fruit body formation were observed.

Mushrooms were harvested in clusters from the substrates manually, three days after pinhead initiation. Biological Efficiencies Ratio (BER) of mushrooms was calculated from the rations of weight (1 kg) of fresh mushrooms harvested per kg of dry substrates, respectively.

Results and Discussion

Spawn Running (Mycelia Development), Pinhead and Fruit Body Formation

Time periods of phases of the cultivation and yield of oyster mushroom are given in Table 1. The most rapid spawn running, pinhead and fruit body formation was obtained just after 31 days of inoculation of mix sawdust and imperata grass (1 : 1 wet wt/wet wt) .

Table 1. Time periods of phases of the cultivation and yield of oyster mushroom at various substrates

Sample Treatment	Spawn Running – Pinhead (days after inoculation)	Average Yield of Mushroom (g)			
		1 st Flush	2 st Flush	3 st Flush	4 st Flush
A	34	44	53	64	78
B	46	55	65	69	85
C	56	76	87	99	107
D	31	38	47	58	72
E	55	73	84	98	104

Note : A = wood Sawdust D = mix of wood sawdust and imperata grass (1 : 1 wet wt/wet wt)
 B = imperata Grass E = mix of wood sawdust and palm oil fiber (1 : 1 wet wt/wet wt)
 C = palm oil fiber

Productivity of oyster mushroom was found to be highest in the first flush of production and gradually decreased as long as long term period of cultivation. Time periods of the first flush until fourth flush need 38 – 72 day after inoculation for D (the fastest time) and the longest time was C sample treatment (palm oil fiber substrate) took place in 56 days after inoculation and need 76 – 107 day after inoculation for the first flush until fourth flush.

Previous report showed that spawn running of *P. ostreatus* on various types of substrates was done after 2 – 3 of inoculation (Ahmad, 1986). In addition, pinhead and fruit body formation will be obtained after 23 – 27 days of inoculation, and our results were inline with this finding.

Temperature and RH at Growing Chamber

Temperature and relative humidity rate at growing chamber from March – June was observed and given in Figure. 1.

Mushroom growth and fruit body formation are greatly influenced by various environmental factors such as biotic and biotic include temperature, humidity, light and pH (Ganny and Gooding, 1987; Stamets, 1993). For spawn running pinhead and fruit body formation, oyster mushroom need 80 – 90 % RH and 25 °C, respectively (Suriawiria, 2002). In this study, temperature and relative humidity applied was suitable for growth of mushroom. Whatever, growth of oyster mushroom was tolerant enough at 70 % of relative humidity.

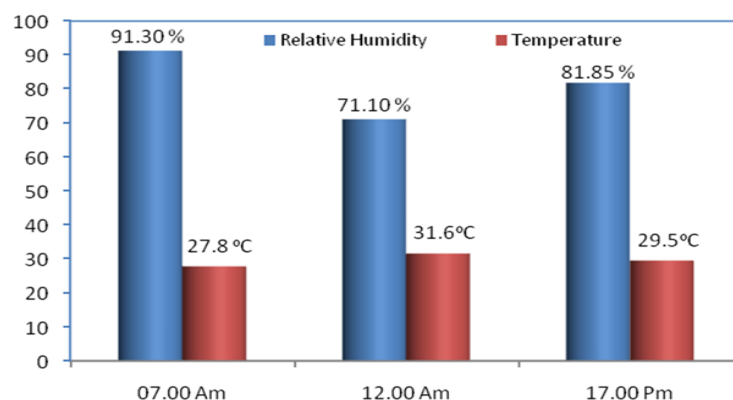


Fig. 1. Temperature and relative humidity rate at growing chamber from March – June

Biological Efficiency Ratio (BER)

BER of oyster mushroom production on various lignocellulosic waste biomasses are given in Figure. 2. Among the various lignocellulosic biomass used, the highest growth and BER of oyster mushroom production was obtained on palm oil fiber (treatment C) and followed by mix of palm oil fiber and wood sawdust (1 : 1 wet wt/wet wt) and wood sawdust itself. The highest growth of mushroom on palm oil fiber was not only observed on individual flush but also in accumulated conditions.

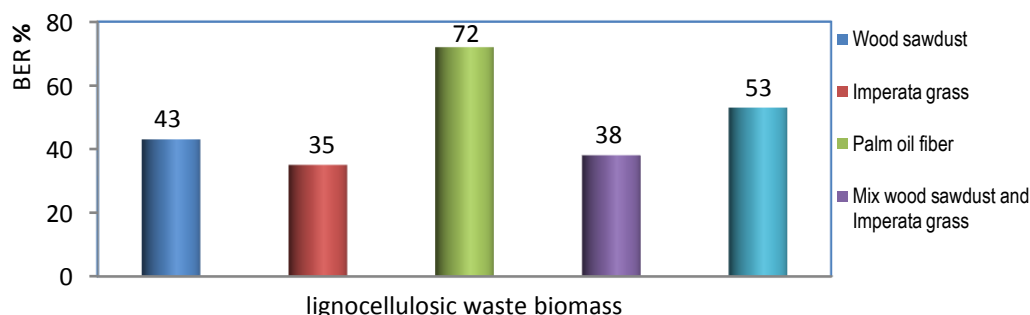


Fig. 2. Biological efficiency ratio (BER) of oyster mushroom on various lignocellulosic biomasses

The data obtained from ANOVA (Analysis of Variance) and LSD test for continued test applied at 95 % confidence to know about the effect of used various substrates (Table 2). The increase of yield indicates that using various substrates compared.

Table 2. Variance analysis of oyster mushroom BER on various lignocellulosic biomass

Source of variance	DF	Sum of squares	Mean square	F-Ratio	F-Table	
					5 %	1 %
Treatment	4	26,685.80	6,671.45	372.71**	2.44	3.47
Error	145	2,595.03	17.90			
Total	149	29,280.83				

** = Highly significant (LSD 1 %)

In Table 2, sample treatment had highly significant for the value of BER itself. After LSD test at Table 3, we found that cultivation of oyster mushroom was positively affected by kind of substrates used (wood sawdust and palm oil fiber).

Table 3. BER rate of different value for oyster mushrooms sample treatment

BER Rate (%)	BER Rate (%)				LSD	
	E (53)	A (43)	D (38)	B (35)	5 %	1 %
C (72)	**	**	**	**	9.06	11.90
E (53)	-	*	**	**		
A (43)	-	-	ns	ns		
D (38)	-	-	-	ns		

** = Highly significant (LSD 1 %)

* = Significant (LSD 5 %)

Fauzi, et al (2006) was reported that palm oil fiber content 87% holosellulose, 22% lignin, and 32% of other materials. Meanwhile, Palm oil fiber as substrate had the main source of nutrients, one of the crucial factors that greatly affect growth and fructification (Moore,1998; Dommondon, et, al., 2003).

Conclusions

In conclusion, palm oil fiber is suitable lignocellulosic material for Oyster mushroom cultivation. Palm oil fiber can be used as enriched substrate for cultivation of the oyster mushroom, a valuable and highly nutrient fungal type. Imperata grass was the least suited lignocellulosic waste biomass (substrate) for the mushroom cultivation and it was not recommended to use. Instead of palm oil fiber, mixed of palm oil fiber and wood sawdust also recommended to use.

Acknowledgments

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Synchronous Growth Hypothesis (SGH) for Estimating the Maturation Age within Hardwood Stem: On the Basis of Radial Variations between Annual Diameter Growth Rate and Dimensions of Xylem Elements within the Stem

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Abstract

In the basis of comparing the both radial variations between annual diameter growth rate of the stem and dimensions of xylem elements within the stem of Kuri (*Castanea crenata*), a new hypothesis called synchronous growth hypothesis (SGH) was proposed for estimating nondestructively the maturing age (demarcation age) of wood quality. Vessel diameter (VD), vessel element length (VEL) and fiber length (FL) are known as indicators for deciding the demarcation age (t_0) between juvenile and mature wood portion within the hardwood stem. Instead of use these anatomical indicators, we found out that the annual diameter growth rate is possible to use as a new indicator of the wood quality assessment. Especially the maximum point of annual diameter growth rate (t_1) was nearly same to the demarcation age t_0 [FL] derived from the radial variation of FL, and another maximum point of mean annual diameter growth rate (t_2) was similar to the maturing age t_0 [VDe] calculated from the radial variation of early wood vessel lumen diameter (VDe). Both indices of t_1 and t_2 are useful for estimating demarcation point nondestructively within the stems. This new hypothesis (SGH) is able to apply for establishing hardwood quality control or high quality timber production or pup fiber production from the certain hardwood species.

Key words: synchronous growth hypothesis (SGH), maturation age, radial variation, annual diameter growth rate, fiber length, vessel diameter, vessel element length, ring number from pith, Gompertz growth function, nonlinear segmented regression (NLSR) analysis, demarcation age, juvenile wood, mature wood, *Castanea crenata*.

Introduction

Wood quality always depends on the size and the structure of xylem elements. In the xylem formed in core portion of the stem near the pith called juvenile wood, the size of xylem elements in this portion increase rapidly from pith to outward, and this rapid increment of the dimensions of xylem elements generates wood quality variation. In hardwoods, some kinds of the dimensions of xylem elements have been used for deciding the boundary (demarcation) between juvenile wood portion and mature wood portion. The estimated demarcation ages are varied depend on the used indicator of xylem elements. And the period of forming juvenile wood is also varied in species by species. For example, the wood of *Acacia mangium* formed juvenile wood for less than 4 years (Honjyo et al. 2005), but *Poplar* spp. formed it for more than 15 years (Huwang & Furukawa 2000).

The Aloni and Zimmermann hypothesis (Aloni & Zimmermann 1983) and the Lev-Yadun and Aloni hypothesis (Lev-Yadun & Aloni 1995) suggested that the sizes of xylem elements were governed by the concentration (or flow) of phytohormone (such as auxin) which was synthesized in young leaves, and they considered that the distance from young leaves to the cambium would make influence on the size of xylem elements. The authors considered that stem growth might affect on the wood quality maturing when these hypothesis is correct.

Therefore, this study focused on the relationship between wood quality maturation represented by cell sizes, and growth rate of the diameter (or girth) of hardwood stem.

Synchronous Radial Variations between Diameter Growth Rate and Xylem Elements Sizes

Outline of Sample Trees (Table1)

In regard to the relationships between radial variations of wood fiber length (FL), earlywood vessel lumen diameter (VDe), which are typical anatomical indicators representing wood quality of hardwoods, and the stages of diameter growth, which are decided by the Gompertz growth function (Liao *et al.* 2003), are discussed here by using 16 different disks taken out from different height above ground from 4 Kuri (*Castanea crenata*) trees. The Kuri trees usually grow in temperate zone, and is belong to *Fagaceae*, and it is a typical ring porous-wood with uiseriate ray, and its xylem properties are excellent against biodegradation and beautiful brown color. The outline of samples are shown in Table 1.

Table 1. Summary of the samples.						
Tree No.	Sample No.	Sampling heights (above ground)	Number of rings	Mean ring width (mm)	Radius (mm)	Excentricity ratio (S/O) ^{a)}
A	A-1	1.3m	42	2.1	107	1.14
	A-2	3.8m	40	2.1	96	1.14
	A-3	6.3m	35	1.8	78	1.18
	A-4	8.8m	25	1.6	48	1.17
B	B-1	1.3m	44	2.4	122	1.20
	B-2	3.8m	34	1.6	65	0.55
	B-3	6.3m	32	2.5	91	1.08
	B-4	8.8m	26	1.9	61	1.33
C	C-1	1.3m	43	2.6	122	1.18
	C-2	3.8m	37	2.1	93	1.02
	C-3	6.3m	30	1.9	65	0.87
	C-4	8.8m	23	1.6	49	1.20
D	D-1	1.3m	34	2.8	102	0.80
	D-2	3.8m	33	2.5	90	1.01
	D-3	6.3m	30	2.3	75	0.99
	D-4	8.8m	23	1.7	45	0.98
a): Sample side radius divided by opposite side radius.						

Diameter Growth Curves of the 16 Disks (Fig 1, Table2)

The curves of cumulative annual ring width against ring number from pith, which correspond to the diameter growth curve, are similar to sigmoid patterns as shown in Fig.1. All of the patterns were able to fit to the Gompertz growth function. The coefficient of determination (R^2) of the function fitting exceeds 0.98 shown in Table 2.

The Gompertz growth function is defined as follows (Liao *et al.* 2003):

$$y = A \exp(-e^{-at}) \quad (1)$$

In here, y represents cumulative ring width [mm], t is ring number from the pith, A is upper asymptote, a , b are parameter estimated, respectively. Age t_1 is the point where the current annual increment reach to the maximum annual growth rate and that occurs at boundary between early stage and middle stage of diameter growth. On the other hand, age t_2 is the point at which mean annual increment reach to the maximum and that occurs at boundary between middle stage and late stage of diameter growth (Kataoka 1992). The function of current annual increment is the first derivative of the equation (1), as defined follows:

$$y' = Ab \exp(-e^{-at}) e^{-at} \quad (2)$$

The function of mean annual increment (y/t) is defined as follows:

$$\frac{y}{t} = \frac{A \exp(-e^{-at})}{t} \quad (3)$$

Age t_1 is equal to a/b , and age t_2 was determined by using solver tool of MS Excel. Age t_1 is the maximum annual growth point, and age t_2 correspond to the maximum mean annual growth point. Both t_1 and t_2 ages of each disk obtained from different ground levels in the sample trees were listed in Table 2.

In this study the relationship between maximum annual growth points (t_1 and t_2) and saturation point of sizes (length or diameter) of xylem elements will discuss later.

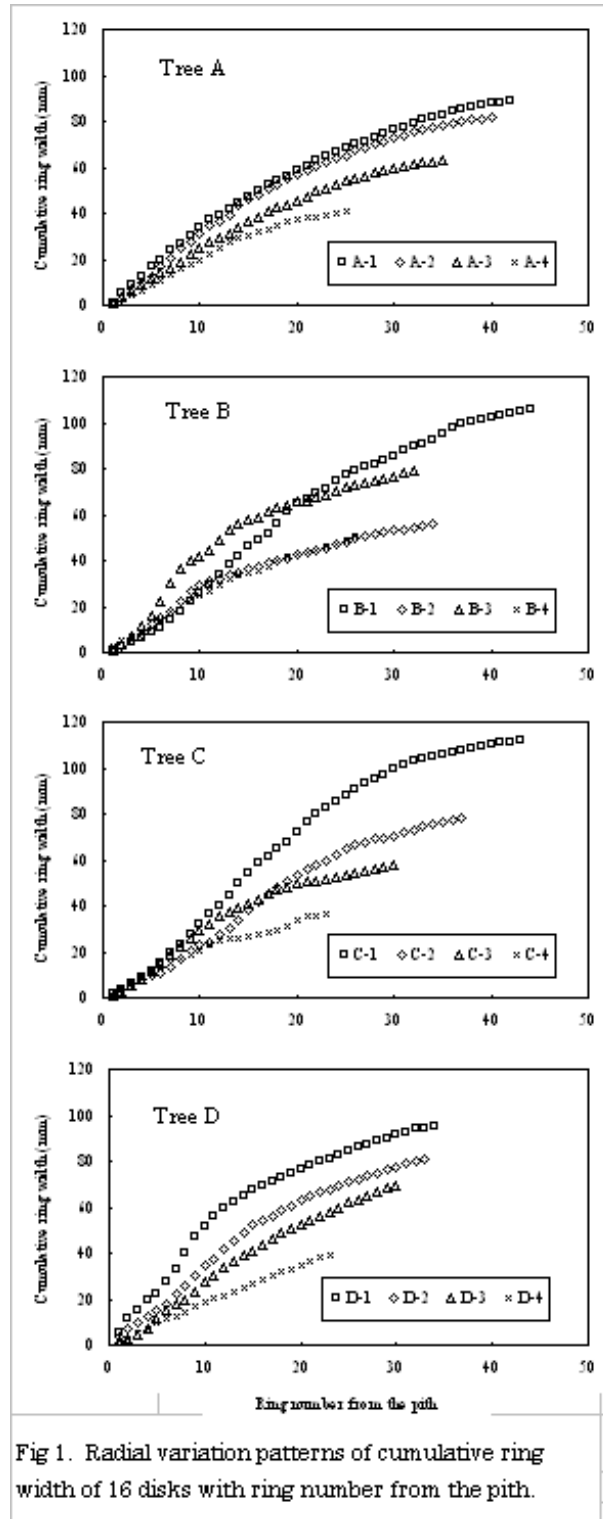


Fig 1. Radial variation patterns of cumulative ring width of 16 disks with ring number from the pith.

Table 2. Results from the Gompertz growth function for estimates the age (year) at the maximum points of current annual increment (t_1) and mean annual increment (t_2) for diameter growth of each sample.				
Tree No.	Sample No.	Estimated parameters		R^2
		t_1	t_2	
A	A-1	11		0.9947
	A-2	11	15	0.9951
	A-3	11	15	0.9974
	A-4	8	13	0.9990
B	B-1	14	22	0.9978
	B-2	8	11	0.9838
	B-3	7	11	0.9907
	B-4	8	11	0.9959
C	C-1	13	20	0.9995
	C-2	13	20	0.9992
	C-3	8	12	0.9979
	C-4	7		0.9876
D	D-1	7		0.9925
	D-2	9	13	0.9983
	D-3	11	16	0.9963
	D-4	10	14	0.9956
Note: The age t_2 in A-1, C-4, and D-1 could not be estimated.				

Radial Variations of the Dimensions of Xylem Elements within 16 Disks (Fig. 2,3, Table3)

Radial variations of FL at different height above ground are shown in Fig.2. The shortest FL appeared near the pith, then increase rapidly toward outward. In the outer part of the stem, the value of FL become to be more or less constant (Tree D), decrease slightly (Tree A, Tree B, some samples of Tree C), and slightly increase then decrease (some samples of Tree C).

Radial variation of VDe at different height above ground is shown in Fig.3. The VDe became the smallest near the pith, increase rapidly toward outward. In the outer part of the stem, the value tended to be more or less constant (Tree B and some samples of Tree C), be stabilize then decrease (Tree A, some samples of Tree C and Tree D), and slightly increase (some samples of Tree D).

In the earlier stage ($0 < t < t_1$) of diameter growth, both FL and VDe showed a rapid increase toward outward. In the middle stage ($t_1 \leq t \leq t_2$), FL showed a tendency becoming stabilizing but VDe showed still gradually increased. In the late stage ($t_2 < t$) of diameter growth, FL tended to be constant or showed a slight decrease trend, but VDe tended to be constant or showed a slight increase trend (Fig.2,3). The VDe increased gradually for a long period comparing to the FL increment.

Maturation age (t_0) on the basis of FL and VDe has been calculated by using the nonlinear segmented regression (NLSR) analysis proposed by Peszlen (1994), that is, a quadratic function with a plateau model was fitted to the plots of FL and VDe against ring number (t) from pith.

Maturation (demarcation) ages (t_0) decided by NLSR method based on the FL and VDe were often different as shown in Table 3. The value of $t_0[\text{VDe}]$ was generally larger than $t_0[\text{FL}]$. Previous papers had reported that the maturation ages of $t_0[\text{FL}]$ based on FL and $t_0[\text{VDe}]$ from vessel lumen diameter (VD or VDe) were almost the same (Furukawa & Hashizume 1987; Helińska-Raczkowska & Fabisiak 1991; Helińska-Raczkowska 1994; Lei *et al.* 1996). Those suggestions were inconsistent with the result of this study; this may owe to the methodological difference such as the estimation method of maturation age and tree species used for the studies.

Comparing the maturation age $t_0[\text{FL}]$ based on FL among different stem heights, those were higher in lower stem heights in Tree C and Tree D, but no definite tendency was observed in other trees. On the other hand, the

maturation age t_0 [VDe] on VDe was higher in the lower stem heights in Tree A, Tree B, and Tree C, but no definite tendency was observed in Tree D.

The result of spearman's rank correlation between the maturation age in FL and VDe indicated and mean ring width and sampling position at different heights indicated that the maturation age of FL was not related to neither mean ring width nor sampling positions (heights), and that of VDe was related positively to mean ring width and negatively to sampling heights.

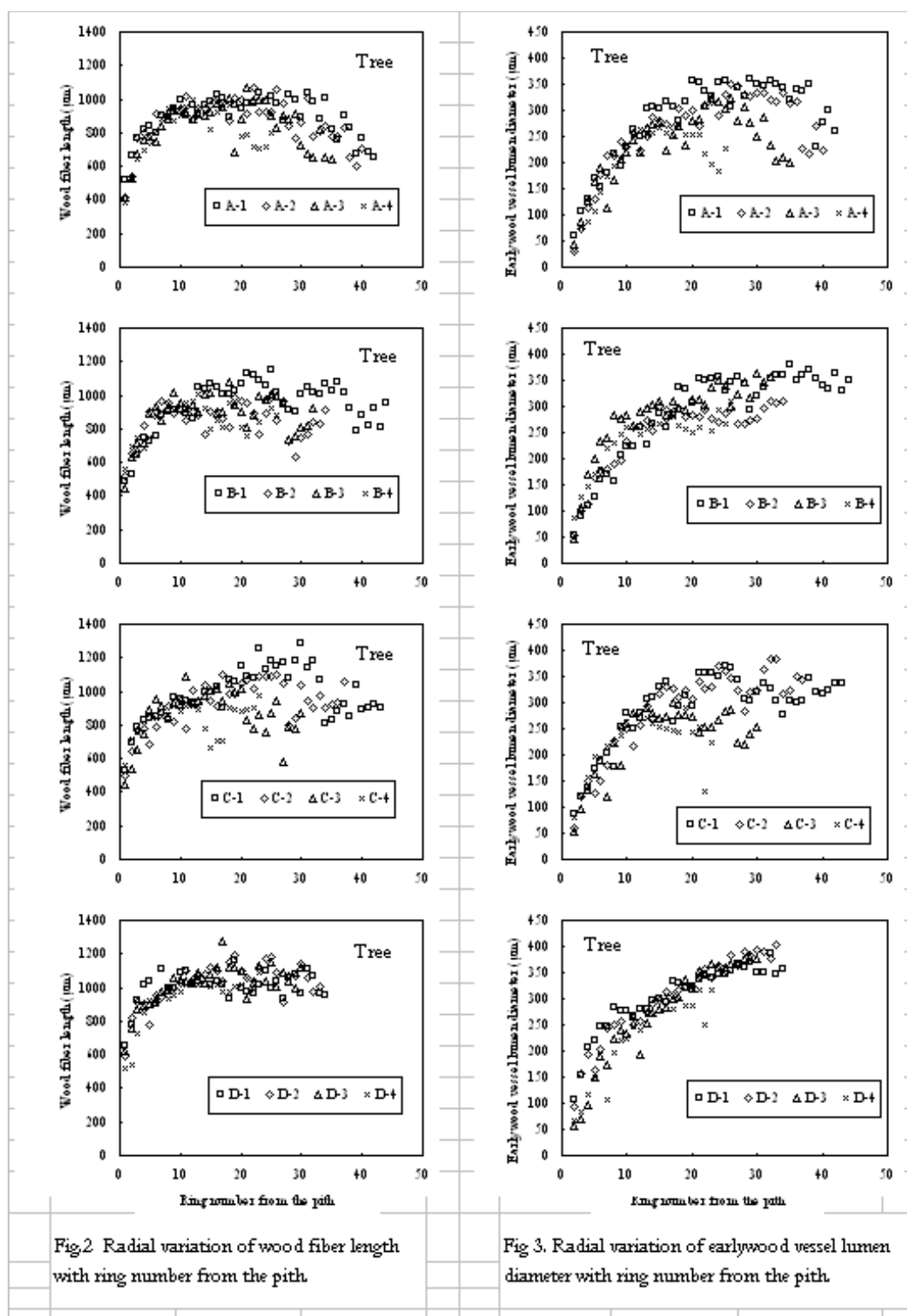


Table 3. Results from non-linear segmented regression (NLSR) analysis for estimating the maturation age (t_0 , year) of wood fiber length (FL) and earlywood vessel diameter (VDe) in each samples					
Tree No.	Sample No.	t_0		R^2	
		FL	VDe	FL	VDe
A	A-1	9	22	0.3765	0.8712
	A-2	7	19	0.4468	0.8198
	A-3	9	18	0.4628	0.7512
	A-4	8	13	0.6925	0.9009
B	B-1	15	27	0.7072	0.9584
	B-2	6	17	0.4690	0.9570
	B-3	8	13	0.6388	0.8969
	B-4	9	14	0.6422	0.9338
C	C-1	20	20	0.4790	0.8783
	C-2	18	23	0.6713	0.9220
	C-3	7	14	0.5490	0.8341
	C-4	6	11	0.4550	0.7020
D	D-1	5	28	0.6326	0.9152
	D-2	14	36	0.7170	0.9604
	D-3	13	30	0.7521	0.9569
	D-4	9	19	0.9303	0.9142

Discussion and Conclusions (Table4, Fig.4)

Maturation (demarcation) age (t_0) calculated by **NLSR method** based on the radial variations of FL and VDe was related either to **age t_1 or age t_2** . The maturation age of FL (t_0 [FL]) was seemed to relate to age t_1 and that of VDe (t_0 [VDe]) was generally related to age t_2 as shown in **Table 4**. The both t_0 value (**t_0 [FL]** in **Fig.4**) calculated from FL and t_0 (**t_0 [VDe]** in **Fig.4**) from VDe were close to either t_1 or t_2 value, this means that the t_1 or t_2 value is possible to estimate from outside of the stem only by measuring the diameter of the stem nondestructively. This means that when the nondestructive method for detecting the timing of juvenile wood formation will be established, it will become an epoch-making method for hardwood forest management and/or production of hardwood timber with favorite properties.

It was suggested that FL and vessel lumen diameter(VD) may relate to the distance from young leaves to cambium (Aloni & Zimmermann 1983) and amount of crown (Kijidani et al. 1994, 1995). In addition, it was suggested that diameter increment of the stem also related to the distance from the tree top and amount of crown and those factors affected the diameter growth curve (Zeide 1994). Young leaves are the place of synthesis of phytohormone (Aloni 2001) and production of assimilates. We considered that the distance from young leaves and the crown amount might affect the size of wood fibers and earlywood vessels. Age t_1 corresponds to the inflection point of the Gompertz growth curve and it can be calculated by means of the asymptote value divided by e (Zeide 1993). Therefore, as far as the demarcation ages depend on the Gompertz growth function, the extent of the juvenile wood portion will calculate to about **37% in radius** of the ultimate stem diameter (asymptote value of diameter) formed for tree's life. Of course this 37%-juvenile-wood hypothesis will be required to verify by further studies.

The relationship between t_1 and t_2 calculated from the Gompertz growth curve and t_0 [FL] calculated from FL and t_0 [VDe] from VDe are represented schematically in **Fig.4**. In this schematic diagram t_1 is correspond to t_0 [FL] and t_2 is in agreement with t_0 [VDe] like as Kuri tree. In regard to the demarcation age of hardwood trees, two types will exist: some trees belong to t_1 type and other trees are t_2 type. We are investigating to confirm these two types in 30 species of hardwood trees (Tuchiya and Furukawa 2009). As a conclusion of this study we can say that the maturation timing of hardwood quality can estimate on the basis of the continuous observation (periodical measuring) of the diameter or the girth of the stem from outside without dissecting inside it. It will be worth to apply this new hypothesis (SGH) for estimating the maturing timing of fast-grown species such as *Acacia mangium*, *Acacia auriculiformis*, *Casuarina* spp., *Eucalyptus* spp., *Gmelina* spp., *Paracerianthes (Albizia) falcataria* or other valuable species for supplying paper fibers. Because paper industries always require best quality of pulp fiber defined by appropriate fiber length and density and enough amount of wood fibers.

Table 4. Maturation ages (t_0) of wood fiber length (FL) and earlywood vessel diameter (VDe) and the ages at boundary between the early and the middle stages (t_1), the middle and the late stages (t_2) of diameter growth.

Sample No.	Maturation age (yr) estimated from nonlinear segmented regression analysis		Age (yr) estimated from the Gompertz growth function	
	t_0 (FL)	t_0 (VDe)	t_1	t_2
A-1	9	22	11	
A-2	7	19	11	15
A-3	9	18	11	15
A-4	8	13	8	13
B-1	15	27	14	22
B-2	6	17	8	11
B-3	8	13	7	11
B-4	9	14	8	11
C-1	20	20	13	20
C-2	18	23	13	20
C-3	7	14	8	12
C-4	6	11	7	
D-1	5	28	7	
D-2	14	36	9	13
D-3	13	30	11	16
D-4	9	19	10	14

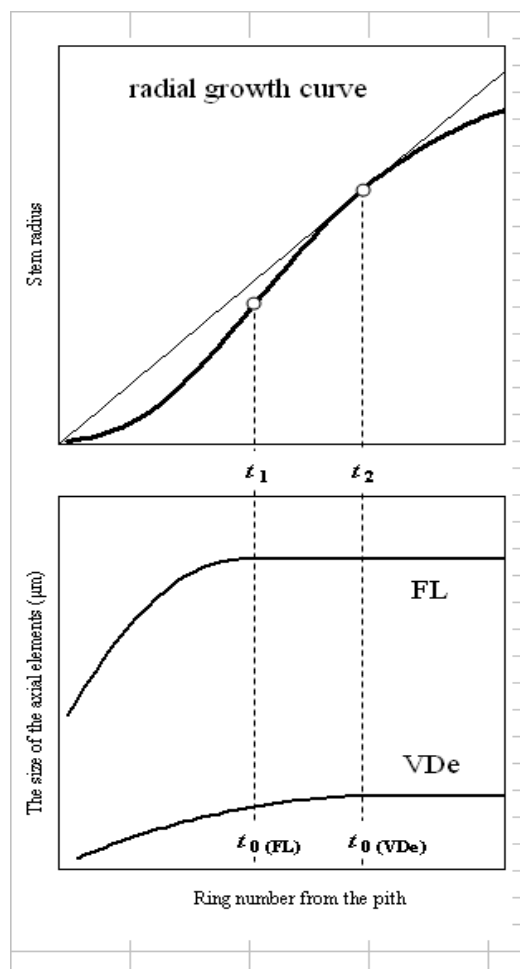


Fig.4. Schematic diagram of relationship between the diameter (or girth) growth curve and the radial variations of xylem elements sizes. The t_1 corresponds to the maximum growth rate, and t_2 represents the maximum mean annual growth rate. Both t_1 and t_2 represent the demarcation ages of hard- wood trees, some trees are t_1 , another trees are t_2 .

(cited and altered from Tsuchiya & Furukawa; IAWA 30,1, 2009)

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APPENDIX: Background of this new concept of Synchronous Growth Hypothesis (SGH);

Body growth: All biological creatures are always growing with time passing. Their bodies sizes are begin to grow just after born, and their growth rate changes through their life time. Early period of the life time the body sizes is growing slowly, then the growth rate become increase until the maximum point (t1) of growth rate, then gradually the growth rate decrease until the maximum point (t2) of mean growth rate. Beyond the t2 point, the growth rate decrease and gradually close to the constant value, which correspond to the ultimate size of the creature. Therefore the growth curve depicts usually the sigmoid curve similar to the S shape. In the case of tree, the growth curve of the diameter or the girth shows typical sigmoid curve and their curve fit beautifully to the Gompertz function.

Cell growth: The body of the biological creature consisted from huge numbers of cells, and the individual cell also grows simultaneously and synchronizing to the growth of the body size. May be the both growths of body size and cell size are well harmonized and synchronized. This means that the change of cell size reflects that of body size. Exchange the words we can know the maturation timing of the individual cell growth by means of the careful watching of the change of the body size. Therefore the body growth always accompanying the cell growth, and the cell growth always reflects the body growth. In the case of tree, the growth of cell length or cell diameter reflects the diameter growth, and when the cell sizes reach to the maximum point (t0) we think that the wood quality becomes mature, and simultaneously the diameter growth rate also close to the t1 point or t2 point. As a conclusion the t0 point of cell dimension is almost the same to the t1 point or t2 point of the diameter growth curve.

Growth Models of Teak Plantation in Different Management Regime in East Kalimantan

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Abstract

Teak (*Tectona grandis* Linn.f) is one of the best – known and highest economical timber in Indonesia. Furthermore, teak plantation in exotic regions also enables to be done. Until 1975, it is registered about 774,000 ha of teak planting area which most exist in Java, South-East Sulawesi, West Nusa Tenggara, Maluku, Lampung, and Bali. It has been planted in large scale, including in East Kalimantan. As planted in large scale elsewhere in Indonesia, East Kalimantan has contributed more than 1.000 ha; planted by private sector $\pm$ 856 ha, government enterprise $\pm$ 175 ha, and local community. In general, growth and yield of plantation depend largely on the condition of planting site particularly soil and climate. The objectives of this study were to analyze and predict the growth of teak in different management regimes. This study was carried out in some places. Located in Samboja, Tenggarong Seberang, and Sebulu Sub districts Kutai Kartanegara Regency; Batu Cermin Village Sempaja, Samarinda. Muara Karangan Sangkulirang Sub district East Kutai Regency. Research also observed growth of different age (1, 4, 5, 6, 7, 9, 11, and 25 years); the plantation was monoculture (tended and untended) and intercropping system). It is concluded that management regime, tended monoculture support better diameter and height growth. Diameter increment age 4 – 11 years 3.6 cm/year and dominant height increment 2.6 m/year

Key words: teak, growth, management regime, plantation, planting site.

Introduction

Teak (*Tectona grandis* Linn. f) belongs to the family Verbenaceae, which is predominantly tropical or subtropical in distribution. Teak has world wide reputation as paragon among timber trees. Teak is a unique species whose timber is most aristocrat amongst the timbers of Indian subcontinent. There is virtually no use to which timber can be put and teak can not be employed (Tewari, 1992 in Haque, 2000).

In Indonesia, teak located in part of Java and several small islands such as in Muna, Kangean, Sumba, and Bali (Mahfudz, *et al.*, 2004). Furthermore, teak spread around to several other islands. In the age of Dutch colonization, a large scale of teak plantation was held in a large part of Central Java and East Java (Tini and Amri, 2003). Some information mentioned that teak forests in Java were planted by Hindu merchants in the beginning of the 14th Century. Other information mention that the occurrence of teak forests in Java is the results from an introduction by the Hindus in 7th Century (Howard, 1948; Letomeux, 1957; van Alphen de Veer, 1957 in Suseno, 2000).

Public opinion that teak cultivation only as long-term assessment and not interesting for investor, cause of teak classified as slow growing species. Teak does not regenerate easily or abundantly in its natural range and is rare outside in its range.

Several factors such as low seed set, poor germination, climate, pest and diseases, competition from other vegetation and fire are responsible for poor natural regeneration of teak (Dasappa, 1989; in Nadgauda, *et al.* 2000).

Factors of environment and genetic influence plant growth. Growth values of plant determined by interaction of genetic factor and environment factor from the site. In order to get growth characteristic that we want, we must manipulate environment and genetic factors (Purwanto, 2003).

Teak plantation will growth better on clay, sandy clay, or sandy loam soil texture. According to the physiological characteristic for support optimal growth, teak requires soil depth condition and optimum soil acidity (pH) around 6.0. But, in case of several region, with low pH level (4 - 5), apparently teak also indicate has good growth. Because of its sensitivity to the low value of the oxygen exchange in soil, so the soil which has porosity and good drainage will make grow of teak better, because the plant root respiration and nutrient absorb easier (Sumarna, 2004).

Java teak can grow on all soil type. Although, teak distribution very large and more founded on limestone formation, but it is not the fact that teak only can growth on that soil types. At Java island, there are also found good teak forest growth on soil was formatted from eruption has less lime. Also, soil with lime already dissolved teak could be growth. This is a fact, that lime is not absolute requirements for teak growth. In general, teak never chose special chemical properties (Poerwokoesoemo, 1953).

Physical and chemical properties of conventional teak plant will determined by land condition, climate, and also site environment. On lowland forest area with optimal soil nutrient, rain fall 750 – 1,500 mm/year, air temperature 34 – 42°C, and relative humidity $\pm$ 70%, will produced wood quality in cambium structure with 0.4 – 1.8 cm thick of bark, smooth fiber with clear brown color. Color of heartwood brown to dark brown and gold brown (Sumarna, 2004).

There are 19,785,973 ha land in East Kalimantan, 51.8% non forest area (Forestry departement, 2007). It is already tried to be planted by teak. Teak plantation done by various side, neither the government, private, nor the farmer/ individual. In connection with plantation of teak by the society in East Kalimantan it is necessary to obtain the teak prospect.

Information of teak cultivation prospect should be found, cause of public interest in develop teak cultivation. Interesting of teak are (1) high quality and high value of teak wood; (2) promotion from producer of teak seedling about superiority seedling; (3) open area without economic value. In connection with plantation of teak by the society in East Kalimantan it is necessary to obtain the prospect of teak cultivation.

This article attempts to address some information of the condition of planting site for teak cultivation in East Kalimantan. Inform to public about growth of teak and its properties. The result of this research is expected useful for the government and society especially in planting site directive and management of teak plantation in East Kalimantan.

Materials and Methods

Site Description

This study was carried out in East Kalimantan Indonesia, especially in Samboja Sub district, Sebulu Sub district, Teluk Dalam Village Tenggara Seberang Sub district Kutai Kartanegara Regency; Batu Cermin Village Sempaja Samarinda Ilir Sub district Samarinda City, and PT Sumalindo Lestari Jaya II Site Muara Karang East Kutai Regency. East Kalimantan geographically lie 04°22' N, 02°22' S and between 113°38' – 119° E.

The climate characteristic of the region was classified as tropical rainy, isothermal climate with hot summer and rainfall maximum 1500 – 4500 mm/year. Average air temperature is 26°C, different temperature between day and night 5 – 7°C. Minimum air temperature occur on October to January, and maximum air temperature occur on July to August. Average relative humidity $\pm$ 86% and average wind speed 5 knot/hour (Anonym, 2004).

Geomorphologically, East Kalimantan dominated by system of high, rugged, strongly folded and faulted mountains; hogbacks and cuestas; piedmont areas, low mountains and rugged hills, and rugged hill to undulating plains (Ohta, *et al.*, 1992). However, the physiography of the western part of this province is rather smooth. The altitude ranges between 1 – 1500 m above sea level (Anonym, 2004).

Soil in this region developed Middle-Late Miocene and Early Miocene rocks dominating the geology of the province. These rocks have a thickness of approximately of muddy sandstone and mudstone. Also coal layers are abundant. Early Miocene rocks are largely calcareous mudstones with interbedded limestone, coaly sandstones and occasional tuff beds. Typic Paleudults and Typic Hapludults are the major soil in the region. The Ultisols have the largest area in East Kalimantan, about 34.82% of this region (Anonym, 2004; and Ohta, *et al.*, 1992).

Research Object

Five 20 m x 20 m plots were established in each site to measure the growth of teak (*Tectona grandis* Linn. F). Teak stand from various ages, those are 1, 4, 5, 6, 7, 9, 11, and 25 years old were investigated. Diameter and height of stand used as parameters.

Height and diameter data from measurement result at research location then compared, to obtain which stand with good prospect and recommended as stand sample for teak planting in future. Parameter which used to compare growth of stand is height dominant. Height dominant are average height of 100 trees which spread through in 1 ha areal (Sutisna, 2005).

Data Analysis

STATGRAPH PLUS 4 program use for data analysis.

Results and Discussion

Generally, rainfall necessity for teak grow 750 mm/year minimum and 2,500 mm/year maximum. Nevertheless, explained by Sumarna (2004) that high rainfall in East Kalimantan were not limiting factor for teak grow, because teak still could be grow at area with rain fall 3,750 mm/year. Number of wet and dry month in East Kalimantan exemplified in Table 1.

Table 1. Wet and Dry Season (month) in East Kalimantan

Location	Period	Wet Season (month)	Dry Season (month)
Samboja ¹⁾	1995 – 2004	8 – 12	0 – 3
Sebulu ²⁾	1999 – 2005	6 – 12	0 – 3
Muara Karang ³⁾	1998 – 2005	5 – 10	0 – 5
Samarinda ⁴⁾	1995 – 2004	7 – 12	0 – 4

Source : ¹⁾ Meteorological and Geophysics, Balikpapan (2005); ²⁾ Agriculture dept. Sebulu (2005);

³⁾ PT Sumalindo Lestari Jaya Unit II Site Muara Karang (2005);

⁴⁾ Meteorological and Geophysics, Temindung Samarinda (2005)

Number of average droughts in East Kalimantan range 3 – 5 month, fulfill one of necessary requirement for teak plantation (Hardjodarsono, 1976; Atmosuseno and Duljapar, 1996; Tini and Amri, 2003). Rainfall in physical and physiologically has influence on characteristics of leaf fall and wood quality. In area with clear dry season (3 – 5 month) leaf fall of teak will be done (Hardjodarsono, 1976) and artistic annual ring formed (Sumarna, 2004).

In research area, belongs to high rain fall classification, no leaves fall teak stand. According Sumarna (2004), in area with high rain fall (> 1.500 mm/year), actually teak never leaves fall and annual ring formed non fancy wood, wood quality classified in class II – III, for example teak planted in Sukabumi – West Java (rain fall > 2,500 mm/year).

Growth of Teak Stand

Values of stand growth (increment of diameter and height) arranged from the lowest. Increment of dominant diameter (d_{dom}) exemplified in Table 2 and dominant height (h_{dom}) in Table 3.

Batu Cermin research plot excluded from the arrangement because height measurement on useable trunk only, whereas the other plots measurement up to total height. If Batu Cermin data included in data analysis, low increment of Batu Cermin plot could induce all increment values become low. Likewise with plot of PT SLJ II (1 year) excluded from arrangement, because the values still average values not increment values.

Table 2. Arrangement of Dominant Diameter (cm/year) Increment of Teak Stand at Research Plots

No.	Research Plots	Age (year)	Increment of d_{dom} (cm/year)
1.	PT SLJ II	11	2.4
2.	PT SLJ II	9	2.5
3.	PT SLJ II	6	2.7
4.	Sebulu (Ex.KTI)	7	2.7
5.	Teluk Dalam	5	3.3
6.	Samboja – 1	5	3.4
7.	Samboja – 2	5	3.8
8.	PT SLJ II	4	4.6
Average			3.2

On the average of dominant diameter increment there are four plots has values of increment less than average values, and four plots more than average values. PT SLJ II (4 years) research plot the highest value.

Decreasing increment of diameter occurred together with increasing of stand age. It is might be cause by constriction of life space for crown of tree because of the trees bigger and bigger and need thinning, and/or decreasing of genetic potential for diameter growth on the trees older and older.

Table 3. Arrangement of Dominant Height (m/year) Increment of Teak Stand at Research Plots

No.	Research Plots	Age (year)	Increment of h_{dom} (m/year)
1.	PT SLJ II	11	1.8
2.	PT SLJ II	9	2.0
3.	PT SLJ II	6	2.1
4.	Sebulu (Ex.KTI)	7	2.1
5.	Samboja-2	5	2.7
6.	Samboja-1	5	2.8
7.	Teluk Dalam	5	3.1
8.	PT SLJ II	4	4.1
Average			2.6

On the average of dominant height increment there are also four plots has values of increment less than average values, and four plots more than average values. PT SLJ II (4 years) research plot has the highest value.

Research plot on PT SLJ II (4 years) has increment diameter and height better than other plots. According of stand history, this plot has several silvicultural operations better than other plots in PT SLJ II, for example weed control, and intensive tend from plantation till 3 years, so in 4 years the teak stand healthy, robust, and straight trunk. This plot lies on along road, flat site and very clean compare with the other plots. It would be different matter estimate a lot of influence in stand growth rate of plot 4 years cause by accumulation of weeding material on the edge of plot. Accumulation of weeding material decomposed becoming organic matter has nutrients supplier for plants.

Comparing data of teak growth in research plots and other location, exemplified in Table 4.

Table 4. Teak (*Tectona grandis* Linn. F) Growth in Some Locations

Location	Age (year)	Seed/ seedling source	Diameter (cm)	Total height (m)	Increment of diameter (cm/year)
Ciamis, West Java	4	JPP ¹⁾	10.19	8.83	2.55
Ciamis, West Java		JPP ¹⁾	12.13	10.78	3.03
Bojonegoro, East Java		JPP ¹⁾	7.99	7.04	2.00
Ngawi, East Java		JPP ¹⁾	9.56	8.77	2.39
Cepu, Central Java		JPP ¹⁾	8.89	7.89	2.22
Samboja, East Kalimantan		- ²⁾	9.10	9.07	2.10
S. Durian, South Kalimantan		Sragen ¹⁾	10.50	7.60	2.62
Sabah, Malaysia		JS ⁵⁾	19.40	14.00	4.85
Sabah, Malaysia		JS ⁵⁾	14.90	11.50	3.73
PT SLJ II, East Kalimantan		Perhutani ³⁾	13.20	15.40	3.30
Samboja, East Kalimantan	5	PT Kaltimex ³⁾	15.30	11.40	3.10
Samboja, East Kalimantan		PT Kaltimex ³⁾	17.60	12.30	3.50
Teluk dalam, East Kalimantan		Cepu ³⁾	12.80	12.20	2.60
Cepu, Central Java	6	JPP ¹⁾	10.82	11.76	1.80
Sumedang, West Java		- ⁴⁾	10.14	9.20	1.69
Tenggarong, East Kalimantan		- ⁴⁾	6.92	7.91	1.15
Palu, Central Celebes		- ⁶⁾	11.50	9.62	1.90
PT SLJ II, East Kalimantan		Perhutani ³⁾	11.50	10.80	1.90
Samboja, East Kalimantan	7	- ²⁾	9.90	10.80	1.40
Sebulu, East Kalimantan		- ³⁾	16.40	13.10	2.30
Sebulu, East Kalimantan	7,5	- ²⁾	8.92	6.27	1.19
Inhutani II, South Kalimantan	8	Cepu ¹⁾	17.20	14.80	2.15
PT SLJ II, East Kalimantan	9	Perhutani ³⁾	16.80	14.40	1.90
Rantau, South Kalimantan	10,5	Java ¹⁾	11.10	10.30	1.06
Cepu, Central Java	11	JPP ¹⁾	17.51	16.00	1.59
PT SLJ II, East Kalimantan		Perhutani ³⁾	19.10	16.40	1.70
Batu Cermin, Samarinda East Kalimantan	25	Yogya ³⁾	29.80	10.70 ^{*)}	1.20

Note: JPP = Jati Plus Perhutani (teak produced by a state owned enterprise) JS = Jati Super (super teak) Source: 1) Murtinah (2006); 2) Sigit, *et al.* (2002); 3) Primary data; 4) Biantary (2004); 5) Abbas, *et al.* (2001); 6). Taiyeb (2007).*) useable height. Perhutani = a state owned enterprise.

Growth of teak in research plots better than other locations. Generally growth of teak in East Kalimantan till 11 years better than growth of teak in Java and Palu.

Some factors should be considered while comparing growth rate of one tree species at some places, namely:

- (1) Land suitability (soil fertility and rainfall); the availability of nutrient forest soil in East Kalimantan are low, but period of tree growth longer because of short drought season.
- (2) Density in tree stand; plantation in East Kalimantan always wider than plantation in Java, so diameter increment of plant in East Kalimantan bigger than in Java, especially if comparing average of diameter increment, and not increment diameter of dominant trees which not effected by stand density.
- (3) Tending; better growth resulted by intensive tending; effect of tending might be stronger than difference of genetic quality.

Wood Properties

Solid teakwood is used for construction, ship building, especially as deck planks, furniture, carpentry, and many other applications which require wood with good dimensional stability. Wood properties of teak which grow in East Kalimantan compare with other site (Saradan, East Java, and Tawao, Malaysia) already observed by Abbas, *et al.* (2001), result of study was exemplified in Table 5.

Table 5. Test Result in Plain View of Teak From Different Site

Wood Properties	Saradan (East Java)	Samarinda (East Kalimantan)	Tawao (Malaysia)
Color	Attractive, combine white, brown	White, ordinary yellow	White, ordinary yellow
Border between sap wood and heartwood	Clear	Clear	Clear
Annual Ring	Clear	Not clear	Clear
Strength	Moderate	Rather strength	Moderate
Aromatic	Special aromatic, although dried wood	No aromatic (after drying)	No aromatic (after drying)
Age (year)	20	20	5
Provenance	Saradan, East Java	Gunung Cermai, Samarinda	Tawao, Sabah, Malaysia

Source : Abbas, *et al.* (2001).

Between Java teak and Kalimantan teak are color and aromatic, conspicuousness different. Java teak has beautiful color , combine white and brown, has special aromatic although dry wood. Kalimantan teak has white color and ordinary yellow, no aromatic after drying.

Wood properties of teak from Sebulu and Samboja observed by Sigit, *et al.* (2002) Research result was exemplified in Table 6.

Table 6. Wood Properties of Teak From Sebulu and Samboja

Wood Properties	Teak from Sebulu (9 years)	Teak from Samboja (9 years)	Teak from Java (atlas Kayu)
Physical Properties			
Wood density (gr/cm ³)	0.56 – 0.59	0.57 – 0.62	0.62 – 0.75
Durable class	-	-	II
Shrinkage/contraction (T)(%)	2.96	2.13	5.2
Shrinkage/contraction (R)(%)	2.64	1.89	2.8
T/R ratio	1.12	1.13	1.86
Mechanical Properties			
Strength class	III	III	II
MOE (1000 kg/cm ²)	388.81	306.91	127.7
MOR (kg/cm ²)	412.72	383.86	1,031
Anatomy Properties			

Wood Properties	Teak from Sebulu (9 years)	Teak from Samboja (9 years)	Teak from Java (atlas Kayu)
Length of fiber (μm)	1,260.71	1,249.5	1,316
Fiber wall thickness (μm)	2.50	2.75	3.3
Diameter of fiber (μm)	23.32	27.15	24.8
Percentage of fiber (%)	60.77	57.97	-
Percentage of parenchym (%)	-	5.97	-
Diameter of pore (μm)	163.3	173	20 – 40
High of pore (μm)	338	293	-
Number of pore/ mm^2	3.6	2.6	3 – 7
Frequency of pore (%)	18.41	14.01	-
Width of radial (μm)	54	71	50 – 100
High of radial (μm)	413	610	500 – 2000
Number of radial/ mm^2	3	4.5	4 – 6
Percentage of radial (%)	20.82	22.05	-
Fiber Derivat Properties			
Runkel ratio	0.27	0.25	0.36
Muhlsteph ratio (%)	38.29	36.41	46.14
Fiber woven capacity	54.07	46.02	53.06
Fiber stiffness	0.11	0.10	0.13
Fiber Flexibility	0.79	0.80	0.73

Note: MOR = Modulus of Rupture; MOE = Modulus of Elasticity. Source : Sigit, et al. (2002).

Wood density of teak from Sebulu and Samboja ranges from 0.56 – 0.59 gr/cm^3 and 0.57 – 0.62 gr/cm^3 . Wood density has close relationship with wood strengthen, more and more high wood density more and more wood strengthen (Sigit, *et al.* 2002). Refers to mechanical properties of teak from East Java and classification of wood strengthen in Indonesia, teak which grow in Samboja and Sebulu predicted belongs to classified wood strength III and could be used for wood construction materials.

Conclusions

- 1) Increment of dominant diameter 3.2 cm/year, and increment of dominant height 2.6 m/year, from teak stand 4 – 11 years.
- 2) Dry season in East Kalimantan generally occurred about 3 – 5 month, it is requirement for teak growth
- 3) Some factors should be considered while comparing growth rate of one tree species at some places, namely; land suitability, density in tree stand, and tending.
- 4) Wood density of teak from Sebulu and Samboja ranges from 0.56 – 0.59 gr/cm^3 and 0.57 – 0.62 gr/cm^3 .
- 5) Teak from Samboja and Sebulu predicted belongs to classified wood strength III and could be used for wood construction materials.

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The Effect of Logging on Peat Land Conditions: A Case Study at a Peat Swamp Forest Company in Riau

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Abstract

Logging operation in a peat swamp forest may give negative contributions to peat land, i.e. bulk density (BD), moisture content (MC), subsidence, water fluctuation, and green house gas (GHG) release. The efficient, effective, and environmental friendly logging technique should be implemented to reduce those negative impacts. A study was carried out in PT Arara Abadi, Riau from May 2008 to April 2009. The aim of the study was to find out the effects of logging on peat land conditions. Data collected were subsidence, water fluctuation, and a peat sample for analyzing the content of CO₂ and CH₄ in laboratory. Data presented in the form of tabulation by calculating the mean values. The results revealed that: (1) logging activities in this area could reduced peat BD and become subsidence; (2) the average of subsidence was 4.72 cm/year similar in 23.75 cm/5 years. This value was smaller than the number mentioned in PP No. 150 year 2000 about standard criteria of soil damage for biomass production (35 cm/5 years for peat depth of ≥ 3 m or 10%/5 years for peat depth < 3 m); (3) the average of water table and water level each are 63.77 cm and 63.84 cm. Reduction of land cover caused by logging could increase the effective rainfall; (4) the average of CO₂ and CH₄ release before logging were 0,9595 tone/ha/year (CO₂), 0,6263 tone/ha/year (CH₄), and after logging about 0,7982 tone/ha/year (CO₂), 0,1243 tone/ha/year (CH₄).

Key words: Negative impact, peat swamp forest, logging.

Introduction

Peat soil is a kind of soil with water condition is saturated or always wet and consists of organic materials i.e. decayed tree residues and tree roots with its depth is more than 50 cm. One problem is organic carbon released in CO₂ and CH₄ emitted to atmosphere as a result of peat soil organic material decomposition (Sabiham & Sulistyono, 2000). Peat land is an important natural resource for human being. A peat land has two unique functions, i.e. as a habitation of biovariation like vegetation and animal, and terrestrial carbon stock.

Peat land decomposition level will affect bulk density (BD). Peat BD could be considered as the most important characteristic from a peat land significantly caused by another characteristics (Andriesse, 1988). Peat land BD depends on the kind of original vegetation which composed peat soil and decomposition level and water and mineral content.

Kyuma (1987) stated that BD value is determined by organic materials decomposition and mineral content. Peat soil has lower BD than mineral soil has, i.e. 0.05-0.40 g/cm³. This condition cause the peat has low power support. Furthermore, if peat soil is opened and dried caused of drainage, a peat will "shrink" or be subsidence that decreased the peat top soil.

Channel development on a peat land caused decreasing the water table, so decomposition process is faster on top of water table. Beside that, the channel caused subsidence. Goosen (1967) showed that the channel affected the increaseing of BD and subsidence and decreasing soil water retention in peat soil Albarta, Canada. After 7 years of channel development, the average of BD (depth of 0-40 cm) was increasing about 63% and soil water retention decreased from -5 to -15,000 cm or 66% more than in peat area without channel.

Soil water is water that fills a part or whole soil pore, both pore between soil aggregate and pore between composing particle of soil aggregate (Rachman, 1992). The amount of water that can be resisted by a kind of soil depends on soil particle size distribution (texture) and soil particle composition (structure). Both of physical characteristics are the most determining for soil moisture content (MC). Rido (1997) stated that amount of water which could be absorbed depends on the soil organic material content.

Channel development on a peat land was used to solve the high peat water content, up to 90%. Since the channel was developed, a peat area has become the source of CO₂ because of the increasing peat oxidation. On the other side, the increasing of water table could change peat area to CH₄ resource that is more effective as green house gas (GHG) than CO₂ (Anonim, 2006).

Logging in a peat land may negatively contribute to BD, MC, subsidence, water table fluctuation, and GHG emission. Based on this, so the aim of the study was to find out the effect of logging on a peat land condition.

Materials and Methods

Study Site

The research was conducted in May 2008 to April 2009 on the working area of PT. Arara Abadi Logging Concession, felling site 365, Berbari District. This logging concession was located in Forest District of Siak, Forest Service of Riau Province, Indonesia. Based on geographical location, this forest group was located between 00° 47' - 01° 09' NL (Northern Latitude) dan 102° 04' - 102° 13' EL (Eastern Longitude) (Figure 1).

The topography was mainly sloping between 0-8% with the elevation 8-100 m above sea level. The soil area was dominated by organosol fibrist. Based on Schmidt and Ferguson's Classification, the type of climate in this research area was categorized as "A" with monthly rainfall of 218.3 mmm and did not have dry month. The vegetation in the area was dominated by *Acacia crassicarpa*. Tree density was 600-800 trees/ha (for diameter of 10 cm and up). The undergrowth in average had rare density.

In the Company's Annual Work Plan 2008, log production was estimated at 6,765,630.02 m³/year with average of 4,000,000 m³/year taken from 44,747.46 ha land (Anonim, 2008). The light-weight equipments used in this research were stationary, measuring meter, stick meter, ring sample, spade, tube, aluminium foil, vacuum bottle, plastic bag.



Figure 1. Study site map in PT. Arara Abadi, Riau-Indonesia

Research Procedure

The stages of this research including:

1. BD and MC

Taking peat sample by ring method on before and after logging area each are 2 replications, i.e.

- Taking peat sample on flat top peat and cleaned, then ring was located on that.
- Peat around ring digged up by a spade or a knife.
- Ring was pressed up to ¾ part to peat, put another ring above, then press again.
- Ring within a peat was digged up by a spade and separated both tube.
- Close the tube by alluminium foil.
- Peat sample was analyzed in Soil Laboratorium in P3HKA, Bogor, Indonesia.

2. Subsidence
 - Plot 100 m x 100 m, measure the soil depth by stick meter.
 - Stick meter was drawn in to soil up to "0" sign was on the top soil.
 - Subsidence was measured by located stick meter on 5 location purposively.
 - Subsidence was measured every month in 12 months.
3. Soil Water Fluctuation
 - On plot, set up 5 observation spots purposively.
 - In each observation spot, make a hole with 15-40 cm in diameter.
 - Measure soil water depth with measure meter from top peat up to top soil water.
 - Soil water fluctuation was measured every month in 12 months.
4. CO₂ and CH₄ Release
 - Take peat sample on before and after logging area, each are 2 replications with a minimum peat sample size of 3.5 kg for each sample.
 - Peat sample taken from a top peat with the maximum depth of 20-25 cm.
 - Peat sample were analyzed by burning it in a lab.
 - The gas came out while its burning caught by gas inhaler in plastic bag.
 - Gas in plastic bag was moved to vacuum bottle.
 - Gas sample were analyzed in Lab Pengujian Balai Besar Litbang Pasca Panen Pertanian Cimanggu, Bogor, Indonesia.
5. Making notes conducted for general data of field condition, and the secondary data about the company acquired from company's profile and through interview with employees.

Data Processing

Field data, which included BD, MC, subsidence, soil water fluctuation, and CO₂ and CH₄ release were presented in the form of tabulation by calculating the mean values.

Results and Discussion

Bulk Density (BD) and Moisture Content (MC)

Peat soil's BD varied between 0.01 to 0.20 g/cm³, it depended on composer peat material maturity (Noor, 2001). Generally, there is a commitment from the researchers that peat land has BD value less than 0.3 g/cm³ (Sabiham, 2006). The lower the peat maturity, the lower BD value with peat BD of fibrist<hemist<sapric (Noor, 2001). The low BD caused low land support power, so vegetation has constraints in anchoring its root, and using a mechanized tool on the land with low BD could be difficult. The result of BD and MC presented on Table 1.

Table 1. Bulk density and moisture content before and after logging

Sample	MC (%)	BD (g/ml)
A1	23.30	0.17
A2	16.38	0.16
B1	18.57	0.14
B2	22.63	0.18

Remarks: A = Before logging; B = After logging; MC = Moisture content; BD = Bulk density.

Table 1 shows that the average of BD before logging is 0.17 g/ml (MC is 19.84%) and after logging the BD is 0.16 g/ml (MC is 20.6%). That can be said that logging in a peat area decreased BD value. This condition is not good, because if peat soil in a low BD, it would increase peat soil drying, so peat could be subsidence. Wahyunto *et al.* (2005) stated that if peat soil have been in over dried condition, it will cause a damage and irreversible drying to peat colloid. Hence, peat could be changed as a carbon and could not absorb a nutrition and water preserved anymore, furthermore, it means loss vegetation growth.

Peat MC indicated that a peat power in catching the water, then it's important for peat land management. The average of MC after logging is bigger than before logging. It indicated that a higher MC in peat soil caused a low BD, peat become weak and have low power to hold the weight. This result is similar to Nugroho, *et al.* (1997) and Widjaya (1997).

Subsidence

The result showed that BD after logging was low, this value would decrease the peat top soil (subsidence). Subsidence acceleration is mostly affected by the peat depth, where the deeper peat, the bigger subsidence acceleration (Barchia, 2006). The deeper channel, the faster subsidence and a peat decomposition. Hence, a peat depth and a water hold power would decrease. The result of subsidence is presented in Table 2.

Table 2. Subsidence caused by logging

Plot	Subsidence added (cm)				
Month	1	2	3	4	5
1.	0	0	0	0	0
2.	0.1	0	0.1	0	0
3.	0	0.1	0.1	0.1	0.2
4.	0.2	0.3	0.4	0.3	0.2
5.	0.3	0.2	0.3	0.4	0.5
6.	0.4	0.6	0.5	0.4	0.6
7.	1.2	1.0	1.1	1.0	1.1
8.	0.9	0.8	0.9	0.8	0.9
9.	0.8	0.7	0.7	0.8	0.7
10.	0.4	0.5	0.3	0.4	0.3
11.	0.2	0.2	0.2	0.2	0.2
12.	0.2	0.2	0.2	0.2	0.2
Sum	4.7	4.6	4.8	4.6	4.9

Table 2 indicated that the average of subsidence acceleration caused by logging was 4.72 cm/year similar in 23.75 cm/5 years. This value was smaller than the number mentioned in PP No. 150 year 2000 about standard criteria of soil damage for biomass production (35 cm/5 years for peat depth of ≥ 3 m or 10%/5 years for peat depth < 3 m). However, an uncontrolled logging could accelerate the subsidence. Subsidence could decrease peat water holding power. If a peat cupola had decreased about 1 m, peat land could loss water holding power of 90 cm similar in 9,000 m³/ha. In a word, the area could accept water 9,000 m³ more than normal in hard rain. In contrast, because of a little water reserved in rainy season, the area which accepted water reserved is lesser and would be vulnerable and tend to dry in dry season (Agus & Made, 2009).

Soil Water Fluctuation

The result of soil water fluctuation was presented in Table 3.

Table 3. Fluctuation of soil water

Plot	Water table/WT (cm)						WL (cm)
Month	1	2	3	4	5	Rata-rata	
1.	70	70	60	56	60	63.2	63
2.	71	69	68	68	68	68.8	65
3.	70	68	68	68	69	68.6	65
4.	71	71	70	69	70	70.2	67
5.	72	72	72	71	71	71.6	62
6.	60	60	59	59	60	59.6	62
7.	61	60	60	59	60	60.0	65
8.	62	61	61	60	61	61.0	65
9.	61	60	61	60	61	60.6	62
10.	60	61	60	60	61	60.4	63
11.	62	61	60	59	60	60.4	63
12.	61	62	61	60	60,5	60.9	64
Rata-rata	65.08	64.58	63.33	62.42	63.46	63.77	63.84

Remarks: WL =Water level/ water depth in channel, Water table/ water depth in felling site.

Table 3 showed that the average of water table (WT) and water level (WL) each were 63.77 cm and 63.84 cm. Decreasing land cover caused by logging become effective rainfall (that entered into a soil) was increased. Rainfall that entered into the soil is an input to WT/WL changing. The bigger rainfall that entered Into a soil, the bigger changing

of WT/WL. The land with low crown cover could pass through more rainfall into soil. The situation could increase a WT/WL and soil condition more saturated (Hidayah, 2004). A WT/WL is a main factor of subsidence acceleration.

If this result compared by Driessen (1978) on virgin peat swamp forest, where as WT fluctuation in a peat dome centre of 19 cm eventhough in dome side of 10 cm, so this result in after logging had more fluctuated. The bigger soil water fluctuation, less water caught in peat. Consequently, in dry season, peat would be difficult to release the water catchment. This condition could be a trigger for a forest fire.

CO₂ and CH₄ Release

Land clearing in peat forest as channel caused subsidence that potencially get around area relapse to overflow and fire. Therefore, it's better to avoid peat land using which is increasing green house gas (GHG) emission method. The results of CO₂ and CH₄ release were presented in Table 4 and 5.

Table 4. CO₂ dan CH₄ content, before and after logging

Sample	Gas content (%)	
	CO ₂	CH ₄
A1	1.29	0.94
A2	1.17	0.66
B1	1.13	0.17
B2	1.00	0.16

Remarks: A = Before logging; B = After logging.

Based on Table 1,2 and 4 could be calculated CO₂ dan CH₄ release by subsidence x BD x gas content x 10,000 was presented in Table 5.

Table 5. Gas release of CO₂ and CH₄ , before and after logging

Kind of gas	Gas release (tonnes/ha/year)									
	A ₁					A ₂				
	1	2	3	4	5	1	2	3	4	5
CO ₂	1.031	1.009	1.053	1.009	1.075	0.880	0.861	0.899	0.861	0.917
CH ₄	0.751	0.735	0.767	0.735	0.783	0.496	0.486	0.507	0.486	0.517
	B ₁					B ₂				
	1	2	3	4	5	1	2	3	4	5
	1	2	3	4	5	1	2	3	4	5
CO ₂	0.744	0.728	0.759	0.728	0.775	0.846	0.828	0.864	0.828	0.882
CH ₄	0.112	0.110	0.114	0.110	0.117	0.135	0.133	0.138	0.133	0.141

Remarks: A = Before logging; B = After logging.

Based on table 4 and 5, there was a difference of the average of CO₂ and CH₄ release between before and after logging, i.e. 0.9595 tone/ha/year (CO₂), 0.6263 tone/ha/year (CH₄) in before logging area, and in after logging area about 0.7982 tone/ha/year (CO₂), 0.1243 tone/ha/year (CH₄). Data indicated that the average of CO₂ that was produced before logging is bigger than after logging. The average of CO₂ content is 1.23% (before logging) is bigger than after logging (1.065%). This condition caused by tree root respiration and peat material decomposition that was produced from vegetation on peat layer. Land condition before logging has big number of vegetation (tree density between 600-800 trees/ha for diameter of 10 cm and up, the undergrowth in average had rare density). Hence, tree root respiration become bigger. CO₂ production in peat land affected by temperature, O₂ supply in soil, MC, and peat material chemys characteristics (Moore & Dalva, 1997).

The average of CH₄ release before logging is (0.6263 tone/ha/year) bigger than after logging (0.1243 tone/ha/year). It was because the area temperature before logging (30,4°C) is higher than after logging (30°C). CH₄ production in a peat land depends on temperature, un-aerob condition, substrat quality, and microb community (Moore & dalva, 1997). CO₂ and CH₄ production in peat land are determined by temperature. Its equilibrium aims to CH₄ production when the temperature was increasing (Kyuma, 1987).

The Efforts to Reduce a Peat Land Damaged Caused by Logging

In previous chapter, it had been stated that logging affected the changing of peat land, i.e.: (1) reducing BD value, this condition is not good, because of low BD would increase peat land drying, so a peat could be subsidence; (2) the average of MC after logging is higher than before logging, this indicated that a higher MC in peat land caused low BD, weak peat and low power of resistance; (3) uncontrolled logging could increase subsidence, decreased peat

top, and decreased peat water power of resistance; and (4) WT dan WL each are 63.77 and 63.84 cm. Land cover decrease caused by logging affected effective rainfall (that enter into the soil) increase. Logging is carried out, up to now, to fulfill consumptive needs, following economic changing for financial efficiency and tend to ignore negative effects to environment.

Logging technique in peat land forest plantation required more considerations, because the forest type is easily damaged and fragile. Hence, reduce impact logging (RIL) technique should be implemented. Felling in a peat swamp forest should consider land condition and characteristic of the growing major trees, i.e. small tree diameter or less than 50 cm with the soft to hard stem. Furthermore, it required a suitable chainsaw. Muhdi (2002) stated that felling a not too big tree (diameter less than 100 cm), is because strength of skidding road is limited. Samingan (1971) stated that generally, the vegetations are mix trees and has climber species, crown shape in layers, big buttress up to 1 m, log diameter is relatively small. Skidding by manual is called "kuda-kuda" system and mechanized system by using excavator. Transportation in peat land using lorries. Meanwhile loading and unloading is manual by man power.

According to a peat swamp natural forest condition that always wet, log transportation in swamp forest is using lorries. This system consist of 2 methods, i.e. using lorries that pulled by man power, and using lorries pulled by locomotive. Usually, this transportation through dry road then followed by rafting system through water road (Muhdi, 1998).

Conclusions and Suggestion

1. Logging activities in this area could reduced BD value and become subsidence.
2. The higher MC in peat land, the lower BD, peat become weak, and have low power to hold the weight.
3. The average of subsidence acceleration caused by logging is 4.72 cm/year similar in 23.75 cm/5 years. This value was smaller than the number mentioned in PP No. 150 year 2000 about standard criteria of soil damage for biomass production (35 cm/5 years for peat depth of ≥ 3 m or 10%/5 years for peat depth < 3 m).
4. The average of WT and WL each were 63.77 and 63.84 cm. Reduction of land cover caused by logging could increase the effective rainfall.
5. The average of CO₂ and CH₄ release in before logging area were 0.9595 tone/ha/year (CO₂), 0.6263 tone/ha/year (CH₄), meanwhile in after logging area about 0,7982 tone/ha/year (CO₂), 0,1243 tone/ha/year (CH₄).
6. In order to reduce negative impact of logging it shold be implemented RIL technique.

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