ANATOMICAL PROPERTIES OF *Shorea mujongensis* P.S. Ashton, A CRITICALLY ENDANGERED SPECIES OF DIPTEROCARPS FROM KALIMANTAN

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ABSTRACT

Wood anatomy of *Shorea mujongensis* P.S. Ashton was investigated in order to ensure this species belongs to yellow meranti group. Such study is very important since this species is already listed in the red list of IUCN and classified as critically endangered species. The microscopic slides were prepared according to the Johansen's method, while the anatomical features observed according to the IAWA List. The results show that *S. mujongensis* wood exhibit brown heartwood, light brown sapwood, rough texture, straight grain sometimes interlocked and somewhat rough. The main microscopic characters are growth rings indistinct; vessel diffuse, mostly solitary, rounded to oval; simple perforation plate and alternate intervessel pits; parenchyma scanty paratracheal to thin vasicentric; axial intercellular canals in long tangential line, radial intercellular canal and vasicentric tracheids present; rays uniseriate and multiseriate, prismatic crystal in procumbent cells; fiber length 1,294 μm, diameter 26 μm and wall thickness 4 μm. Macroscopic and microscopic observation of *S. mujongensis* wood confirms the species belongs to yellow meranti group. The assesment on fiber dimensions and derived values of the wood fibers classified the wood into class quality II. It indicates that this species is moderately favorable as raw material for pulp and paper manufacture.

Keywords: *Shorea mujongensis*, critically endangered species, wood anatomy, fiber quality

I. INTRODUCTION

Indonesian tropical rain forests are dominated by Dipterocarpaceae family, especially in Sumatera, Kalimantan, Sulawesi, Maluku and Papua. There are about 500 species growing in South East Asia and 386 species grow in Indonesia (Newman *et al.*, 1999). Dipterocarps species is commercially high, as the tree produces timber and non-timber forest products. Dipterocarps species is usually traded through the name of three groups: red, yellow and white meranti. Within each group there are many species that in the exploitation activities are often solely based on the name of the group. This is caused by the similarities among those features are difficult to differentiate. Often a

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particular species that exists following its severe exploitation is still left unidentified and therefore makes one uncertain what exactly species is. Furthermore, over exploitation caused this wood species becomes extinct.

A total of 384 dipterocarps species in South East Asia have been recorded into the IUCN (International Union for the Conservation of Nature and Natural Resources) and categorized as the red list for the threatened species under the category of vulnerable, endangered, critically endangered, extinct, lower risk/least concern and data deficient (IUCN, 2011). The IUCN's red list presents a list depicting the scarcity of the species status of many living creatures that are classified as endangered by IUCN. *S. mujongensis* represents one of the yellow meranti group of the dipterocarps listed under the category of critically endangered, implying that this species is at risk of extinction. A taxon is critically endangered when it is facing an extremely high risk of extinction in the nature (IUCN, 2001). For this reason, it is necessary to complete identification guidance through particularly anatomy scrutiny on especially wood portion to be available for particular wood species. The data and information of specific anatomical structure of *S. mujongensis* is currently unavailable. Therefore, this research was conducted to study the anatomical structure of *S. mujongensis* for wood identification database and for the evaluation of its suitability as raw material for pulp and paper.

II. MATERIALS AND METHODS

A wood sample of *S. mujongensis* was provided by PT. Hutansanggam Labanan Lestari (HLL) Forest Concession in Berau, East Kalimantan. The microscopic slides were prepared based on Johansen (1940) methods. Wood sample of (2x2x2) cm³ in size was prepared and saturated within distilled water for one night, and then submerged into 50:50 proportion of alcohol and glycerin for 2-3 days. Then, the samples were sliced by a rotary microtome to obtain 15-25 μm thick covering cross, radial and tangential sections. The best specimen were chosen and washed with distilled water. The sliced samples were then stained with safranin, dehydrated with a series of ethanol solutions (30%, 50%, 70% and absolute). Dried sliced pieces were then cleared with carboxylol and toluene simultaneously. The cleared specimens were mounted on a glass object and sticked with entellan before observed under light microscope for anatomical features as listed by IAWA Committee (Wheeler *et al.*, 1989). In order to observe fiber quality, fiber dimensions were examined from macerated samples. *Shorea mujongensis* wood chips were macerated according to the Forest Product Laboratory method, using a mixture of equal parts of 60% glacial acetic acid and hydrogen peroxide (20% by volume), then heated at 80°C for 1-2 days or until the sample became colorless and soft. The macerated chips were washed with flowing tap water until becoming acid free and mostly separated into individuals fibers. The separated fibers were stained with safranin for 3 hours, then washed with distilled water and pippeted on a glass slide. Afterwards,

glycerin were gently dropped on to the separated fibers that has already on the upper glass object. The separated fibers were arranged properly so that the fibers are not pile up one another. Subsequently, a thin glass was set to cover the glass object exactly. Furthermore, the specimens were ready for microscopic examination under a light microscope. Such examination consists of fiber dimensions, conducted on individual fibers, comprising length (n = 25), fiber diameter (n = 15) and lumen diameter (n = 25). The derived values of fiber dimension are calculated using the following formulas:

$$RR = \frac{2w}{l} \qquad MR = \frac{(d^2 - l^2)}{d^2} \times 100\% \qquad CR = \frac{w}{d}$$

$$FP = \frac{L}{d} \qquad FR = \frac{l}{d}$$

where,   RR = Runkel ratio   l = lumen diameter
         FP = Felting power   L = fiber length
         MR = Muhlsteph ratio   d = fiber diameter
         FR = Flexibility ratio   w = wall thickness
         CR = Coefficient of rigidity

Data of fiber dimension and their derived values were utilized to determine the fiber quality criteria following Rahman and Siagian (1976), as described in Table 1.

Table 1. Quality criteria of fibers as raw material for pulp and paper

Criteria	Class I		Class II		Class III	
	Requirement	Score	Requirement	Score	Requirement	Score
Fiber length (µm)	> 2,000	100	1,000-2,000	50	< 1,000	25
Runkel ratio	< 0.25	100	0.25-0.50	50	0.50-1.0	25
Felting power	> 90	100	50-90	50	< 50	25
Muhlsteph ratio (%)	< 30	100	30-60	50	60-80	25
Flexibility ratio	> 0.80	100	0.50-0.80	50	< 0.50	25
Coefficient of Rigidity	< 0.10	100	0.10-0.15	50	> 0.15	25
Interval	450-600		225-449		< 225	

Source: Rachman and Siagian (1976)

III. RESULTS AND DISCUSSION

A. Macroscopic Characteristics

The macroscopic characteristics of *S. mujongensis* are brown heartwood, light brown sapwood, rough texture, straight grain sometimes interlocked and somewhat rough. The color of this wood is not yellow as that of the other member of yellow meranti. Therefore, further in-depth scrutiny on the microscopic characteristics of this wood was needed to ensure what meranti group this wood belongs.
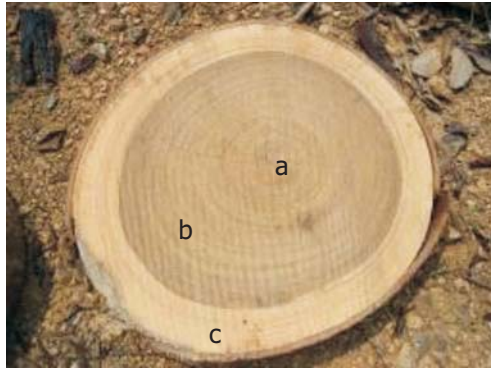
Figure 1. Transversal section of *Shorea mujongensis* wood Remarks: a) pith, b) heartwood, c) sapwood

B. Microscopic Characteristics

Shorea mujongensis has indistinct growth ring. Vessels are diffuse, mostly solitary, rounded to oval and tylosis is present (Figures 2 and 3). In tangential section, intervessel pitting was found alternate. Simple perforation plate and vasicentric tracheids were also observed in radial section. The type of axial parenchyma is scanty paratracheal to thin vasicentric (Figure 2). Axial intercellular canals in long tangential lines are also found (Figure 2).
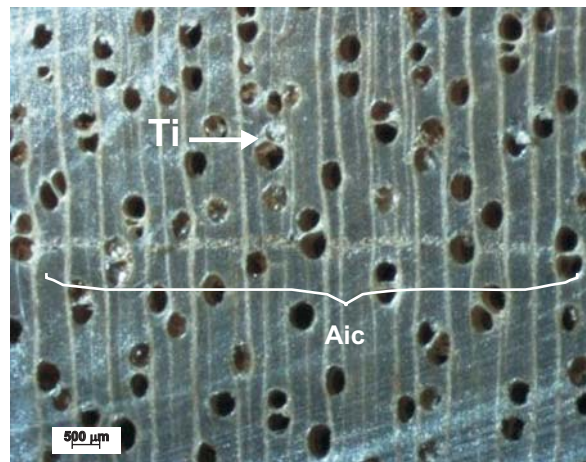

Figure 2. Transverse section of *Shorea mujongensis* wood

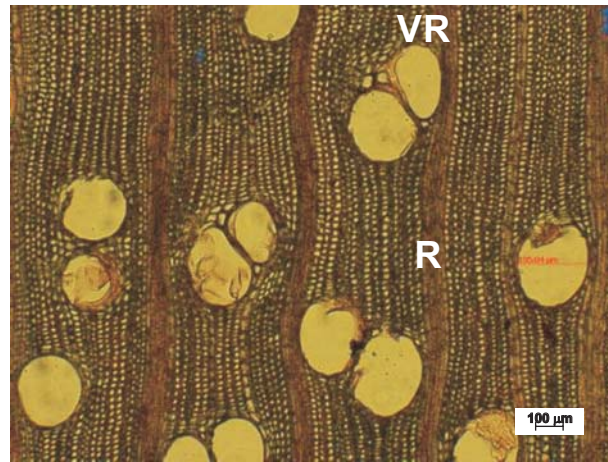Remarks: Ti = Tylosis, Aic = axial intercellular canals in long tangential line (3.75 x magnification)

Figure 3. Transverse section of *Shorea mujongensis* wood
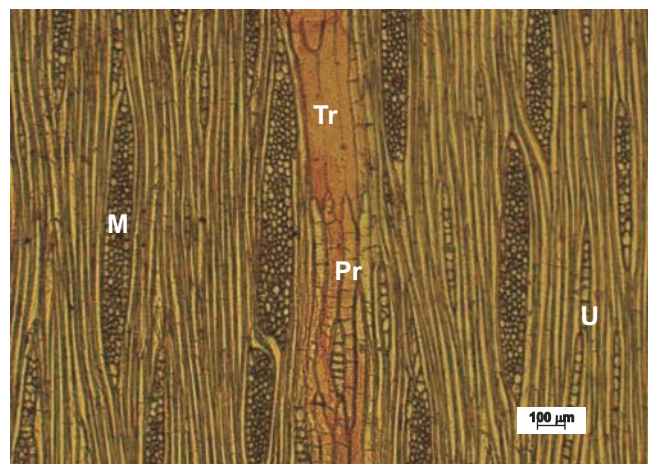
Remarks: R = rays, VR = vessels with rounded shape

Figure 4. Tangential section of *Shorea mujongensis* wood

Remarks: Tr = Vasicentric tracheids, M = Multiseriate rays, U = Uniseriate rays, Pr = 3-6 cells per parenchyma strand

Figure 4 shows that there are 3-6 cells per parenchyma, rays consist of uniseriate and multiseriate rays, larger rays commonly 2-6 seriates. Vasicentric tracheids were also found. Wheeler *et al.* (1989) mentioned that vasicentric tracheids were found in many *Shorea* spp. wood. Fei-Tan (1974) also mentioned that vasicentric tracheids always present in all Dipterocarps in irregular shape and with conspicuous bordered pits. In hardwood, the function of vasicentric tracheids is providing mechanical strength which are always associated with vessels (Pandit and Kurniawan, 2008). Meanwhile, fibers have simple pits and thin wall.

Figure 5 shows that the composition of rays is heterocellular with the body is procumbent cells with mostly 2-5 rows of upright cells. Based on Kribs's (1935) in Takahashi and Suzuki (2003), heterocellular rays with procumbent-body cells and many marginal row of upright and/or square cells (Krib's heterogeneous type I) are the most primitive type; meanwhile, homocellular rays composed of procumbent cells only (Krib's heterogeneous type II and III) is the most advance. Therefore, the rays of *S. mujongensis* are categorized as primitive. Prismatic crystals are also found in procumbent ray cells (Figure 5). According to Fei-Tan (1974), crystals occasionally present in all meranti groups except white meranti.
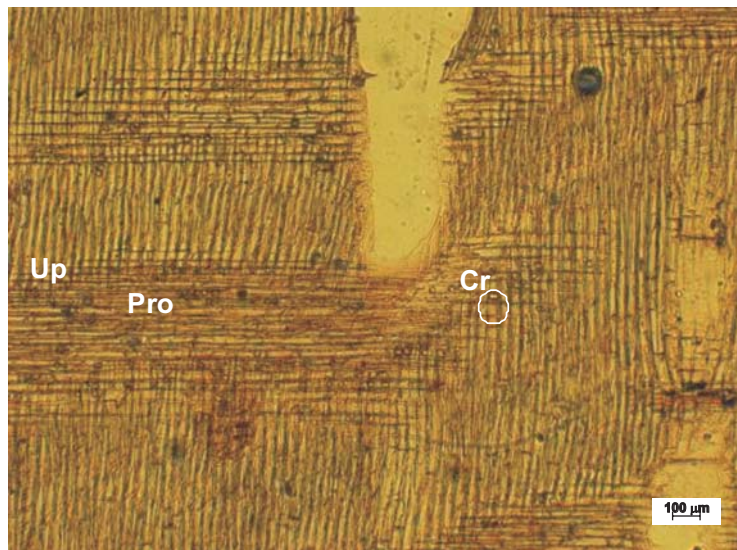

Figure 5. Radial section of *Shorea mujongensis* wood

Remarks: Cr = prismatic crystal in procumbent ray cells; Up = upright cells; Pro = procumbent cells

Radial intercellular canals are also present in tangential section (Figure 6). Radial canals are located in the middle of rays. Sometimes there are two canals in one rays. Fei-Tan (1974) mentioned that radial intercellular canals are always present in all species of yellow meranti and some of red meranti (*Shorea leprosula, S. ovata, S. Parvistipulata, S. scabida,* and *S. teysmanniana*). Sarayar (1976) also revealed that yellow meranti is characterized by the presence of radial canals and calcium oxalate crystals, but the absence of silica deposits. It indicates that radial intercellular canals become the main characteristics of yellow meranti wood species.
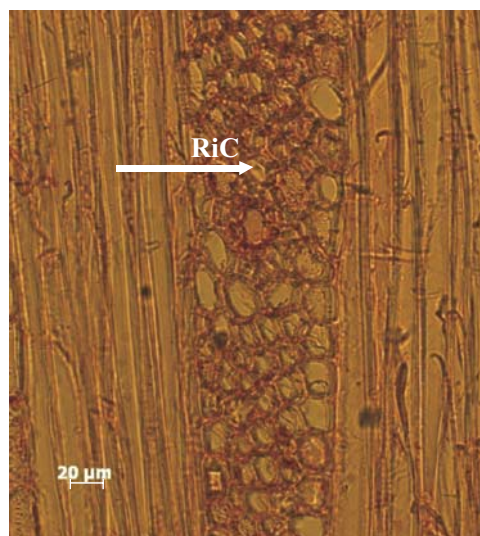

Figure 6. Tangential section of *Shorea mujongensis* wood

Remarks: RiC = Radial intercellular canals

In the following, detailed quantitative of microscopic characteristics of *S. mujongensis* wood are described. *Shorea mujongensis* has vessel diameter of 213 μm in average. Based on Mandang and Pandit (2002), it belonged to rather large size (200 - 300 μm). Meanwhile, the frequency of vessels is rare (4 per mm^2). The ray frequency is categorized also rare (4-5) with a ray width rather wide (>50-100 μm). Ray height belonged to very short (0.5-1 μm). Based on Wheeler *et al*. (1989), vessel length of this species belonged to medium size (350-800 μm) as well as fiber length (900-1600 μm). Wall thickness was thin (4 μm). The percentage of fiber cells was greater (70%) than the percentage of vessel and parenchyma. Greatest proportion of fiber cells than other cells affords strength properties of its corresponding wood. Quantitative microscopic characters of *S. mujongensis* wood presented in Table 2, while the microscopic characters of individual fiber of *S. mujongensis* wood (fiber dimension and their derived values) are presented in Table 3.

Table 2. Quantitative characters of *Shorea mujongensis*

Anatomical Characters	Values
a. Vessel:	
- Diameter (μm)	213
- Vessels per mm²	4
- Mean vessel length (μm)	450
b. Rays:	
- Ray height (μm)	813
- Ray width (μm)	60
- Rays per mm	4
c. Fiber:	
- Fiber length (μm)	1,294
- Fiber diameter (μm)	26
- Lumen diameter (μm)	18
- Wall-thickness (μm)	4
d. Cell percentage (%)	
- Vessel	15
- Parenchyma	15
- Fiber	70

Table 3. The fiber quality of *Shorea mujongensis*

Criteria	Values	Score*
- Fiber length (μm)	1,294	50
- RR	0.44	50
- FP	49.77	25
- MR (%)	52	50
- FR	0.69	50
- CR	0.15	50
Total Score*		275
Quality Class		II

Fiber length is important to provide the sufficient bonding surface to produce good stress distribution in the sheet. Paper made from fibers which are too short will sustain insufficient bonding areas between fibers; as a result there will be points of weakness for stress transfer within the sheet and the paper will be low in strength (Panshin and de Zeeuw, 1980). The fibers with low Runkel ratio indicate a thin wall but wide in lumen diameter. Pulps produced from this fibers are predicted to be more easily

milled (beaten) and afford wider inter-fiber bonding area. Consequently the pulp will be high in bursting strength, tensile strength, and folding endurance as well. According to the criteria of fiber quality by Rachman and Siagian (1976), fiber length and Runkel ratio values of *S. mujongensis* belonged to quality class II.

Felting power affects the tear strength of paper produced. The higher value of felting power, the more flexible the fiber (Tamolang and Wangaard, 1961 *in* Sofyan *et al.,* 1993). Based on the criteria of fiber quality by Rachman and Siagian (1976), felting power of *S. mujongensis* belonged to quality class III. Wood fibers with a high Muhlsteph ratio exhibit a smaller surface area, and therefore the bonding area and contact between the fiber decreases. This causes the lowering of tensile strength and crack resistance of resulting paper. According to the criteria of fiber quality by Rachman and Siagian (1976), Muhlsteph ratio of *S. mujongensis* falls into the quality class II. Flexibility ratio signifies a role in the development of fiber-to-fiber contacts. Fibers with high flexibility ratio resulted in paper sheet with good strength and high density but lower in porosity (Casey, 1980). Fibers with high coefficient of rigidity reflect the higher density. Panshin and de Zeeuw (1980) mentioned that high fiber density correlated positively to pulp yield. In addition, the resulting fiber will also produce a sheet of paper with high opacity, more rugged, larger dimension and high tear strength. Based on the quality criteria by Rachman and Siagian (1976) about flexibility ratio and coefficient of rigidity, the value of *S. mujongensis* belonged to quality class II.

According to the overall analyzed parameters (fiber length, Runkel ratio, felting power, Muhlsteph ratio, flexibility ratio, and coefficient of rigidity), fiber of *S. mujongensis* belonged to quality class II. Fibers with quality class II have moderate in tear resistance, crack resistance, and tensile strength, since they are easily flatened during pulp sheet forming (Rachman and Siagian, 1976). Therefore, this species is recommended to be cultivated as raw material for pulp and paper.

D. CONCLUSION

The main microscopic characters of *S. mujongensis* are growth rings indistinct, vessel diffuse and mostly solitary. Outline of vessels is rounded to oval, simple perforation plate, and intervessel pits alternate. Paratracheal axial parenchyma scanty to thin vasicentric, axial intercellular canals in long tangential lines, radial intercellular canals and vasicentric tracheids present, rays uniseriate and multiseriate, prismatic crystal in procumbent ray cells, fiber length 1294 μm, diameter 26 μm, and wall thickness 4 μm. The occurrence of radial intercellular canals in *S. mujongensis* confirms its grouping under yellow meranti even though it has brown heartwood, not yellow as the other member of yellow meranti. Assesment of microscopic characters on individual fibers of *S.mujongensis* wood (fiber dimension and their derived value) brought out the fiber qualities on class II, which is strongly moderately favorable for pulp and paper manufacture.

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