ANATOMICAL CHARACTERISTICS AND CHEMICAL PROPERTIES OF THE BRANCH-WOOD OF *Schizolobium amazonicum* DUCKE SPECIES AND ITS POTENTIAL USES

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ABSTRACT

The scale of forest degradation and deforestation in Indonesia has inspired the use of lesser-known wood species, which are potentially abundant and so far has not much been utilized. Utilization of these woods should be imposed not only of the stem wood but also of the branch-wood portions. *Schizolobiumamazonicum* Ducke treeis one of those lesser-known species, and growing fast with an MAIof3.68 cm/year.In Indonesia this species is only found in the Purwodadi Botanical Garden. A research was conducted to study the basic characteristics (anatomical aspects and chemical properties) of the branch-wood portion of this species. The branch-wood materials were obtained from the Purwodadi Botanical Garden situated in Pasuruan (East Java). The specimens used were the first branch of the trunk (stem) of nine-year old *S. amazonicum* tree (= 29.46 cm). The branch-wood samples were then examined for the anatomical aspects (macroscopic and microscopic characteristics) and chemical properties (chemical composition). Results revealed that the anatomical properties of *S.amazonicum* branch-wood exhibited close similarities to those of sengon wood; it was light in appearance and white in color. Its fiber averaged about 1500 μm, and based on the fiber dimension's derived values the branch-wood fiber of this species was categorized into first-class quality for pulp and paper manufacture. Further, the chemical composition of this branch-wood compared favorably with that of sengon and mangium wood. The composition of extractive content that soluble in alcohol-benzene; lignin; holocellulose; and α-cellulose of this branch-wood were 2.46; 28.71; 80.64; and 50.47%, respectively. The overall assessment implied that the branch-wood portion of *S.amazonicum* tree affords favorable potential to be developed as raw material for pulp and paper manufacture. Also, considering that both sengon and mangium woods were already used in the pulp and paper industries as well as the trees are used for the establishment of industrial plantation forests (HTI), therefore *S.amazonicum* trees, as fast-growing species,are also promising for the establishment of pulp/paper-HTI for their branch-wood.

Keywords: *Schizolobium amazonicum* Ducke, fast-growing species, branch-wood,anatomical properties, chemical component

I. INTRODUCTION

Rapid population growth and development of wood industries have increased wood consumption. Unfortunately communities and industries are still utilizing commercial woods, whereas the availability of those woods nowadays is decreasingdue to high degradation and deforestation of natural forests, which istheir habitat. Currently about 60% of the logsare produced from plantation forest, natural forests contribute about 10 million m^3 only. On the contrary, the lesser known species, which are abundantbuthas not yet been much studied, seem to have a good potential for being used as an alternative wood resource in the future.

The commercial fast growing wood species, e.g. sengon wood (*Paraserianthesfalcataria*) and

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acacia, are exotic species. Previous studies have shown that woods from those species have favorable characteristics (Marsoem, 2004). Therefore, they became commercial species, being used and developed by communities as well as by many wood industries, e.g. sengon wood was developed by PT. Albizia Parahyangan and PT. Bina Kayu Lestari in West Java, while *Acacia mangium* was developed by PT. Musi Hutan Persada, PT. Sinar Mas Forestry, etc.

One of the lesser-known species in Indonesia is *Schizolobium amazonicum* Ducke, which has rarely been studied. This species is originating from Cuba. In Indonesia it is only found in the Purwodadi Botanical Garden. The new paradigm of the Botanical Garden will essentially transform this scarce wood species into the breeding center of potential species, which is expected to support the development of this wood in the future.

S. amazonicum is one of the species used for reforestation in the tropical forest of Perú-Amazon (Maruyama and Ugamoto, 1989). This species belongs to the fast growing treesthat have a favorable prospect for development of community forest and/or industrial plantation forest. Mean annual increment (MAI) of this wood in Purwodadi Botanical Garden is about 3.68 cm/year for aneight year old tree (Amin *et al*., 2008). Mean while in Brazil, the MAI reaches 2.9 cm in 4 years, which is higher than the 2.4 cm of *Acacia mangium* of the same age (Rossi *et al*., 2003).

However, more studies in basic properties of this wood and also its silviculture technique are necessary to be carried out before developing this species for plantation at a commercial scale. Therefore, the objective of this research was to study the basic characteristics (anatomical and chemical properties) of *S. amazonicum*; and it is expected that the research would be providing information of its utilizationpotential.

II. MATERIAL AND METHOD

The material for this study was the branch wood of *Schizolobiumamazonicum* Ducke (=10 cm) obtained from the Purwodadi Botanical Garden, Pasuruan, East Java. This tree belongs to one of the lesser-known collection plants. The chemical composition analysis was done at the Research and Development Unit for Biomaterials, Indonesian Institute of Sciences, while the observation of anatomical properties was done atthe Plant Anatomy Laboratory, Forest Products Research and Development Center, Ministry of Forestry of Indonesia.

The specimens used were the first branch of the trunk (stem) of a nine-year old *S.amazonicum* tree (= 29.46 cm). The branch was then cut into lengths of 50 cm and converted into sawdust that passed through a No. 40 sieve but was retained by a No. 60 sieve. Chemical content of branch wood with respect to the relative amounts (percentages) of extractives soluble in alcohol-benzene, holocellulose, α-cellulose, and lignin, was quantitatively analyzed by using Mokushitsu Kagaku Jiken Manual (2000).

The observationof wood anatomical properties consisted of (1) the macroscopic (general) characteristics, i.e. color, texture, grain orientation, lustre, and appearance of wood surface, as well as the odor (Mandang and Pandit, 2002); and (2) the microscopic characteristics. The latter was observed from the branch-wood specimen of cross, radial, and tangential sections 15 25 μmin thickness by using a microtome. The dehydration process was done simultaneously by using alcohol with 30%, 50%, 70% and an absolute concentration. The dehydrated specimens were then immersed for a while in carboxyl and toluene to obtain transparent specimen and then mounted on the object glass (Sass, 1961). The anatomical properties as observed were compared with the standard of the International Association of Wood Anatomist (IAWA) (Wheeler *et al*., 1989).

The maceration was also made for evaluating fiber qualities through the observation of their quantitative characteristic (fiber dimensions). Small wood sticks were put inside the tube then solution of hydrogen peroxide (H_2O_2) and acetic anhydride glacial (1 : 1) were added, and then heated using a water bath (Tesoro, 1989).

The quantitative characteristics were observed using 1025 measurements (n) per sample, which depended on the variables such as (1) vessel diameter, n=25,(2) vessel frequency per mm^2, n=10, (3) rays frequency, n=10,(4) rays height, n=25, (5) fiber length, n=25, (6) fiber diameter and cell wall thickness, n=15. The fiber morphology/dimensions as obtained (e.g. fiber length, fiber diameter, cell wall thickness) were then used to determine theirderived values as the parameter to classify the quality offiber based on RachmanandSiagian (1976).

III. RESULT AND DISCUSSION

A. Anatomical Properties of *Schizolobium amazonicum* Branch-wood

- Macroscopicfeatures

Color: white (sapwood and heartwood). Pattern: figured. Texture: fine. Grain: straight to interlocked. Luster: glossy. The appearance of wood surface: fine. Hardness: soft-hard, light. Odor: no special odor.

- Microscopic Features

Growth rings: distinct (Figure 1), since the latewood has thick cell wall and radially compared to that of the early wood (characteristic number 1). Vessel cell: diffuse_(5)._Vessel diameter was 128.35 - 215.55 µm (average value is 154 µm). Vessels are almost solitary_(9) with simple perforation plates (13). Alternate intervessel pits were polygonal; the pits between vessel and ray are distinct, similar to intervessel pits in size and shape (30). There is no tylosis. Axial parenchyma: vasicentric to aliform (Figure 2); 3-4 cells per strand (92). Rays: 1-3 cells wide (97). It was also found that the wood has two sizes of ray. Therefore, further research is needed since the existence of the wide rays would result in the decrease of the mechanical property and difficulty in the drying process. In general, the_ray composed of procumbent cell. However, one row of upright and/or square cells was also found in a limited frequency(104 and 106). Fibers: fibers length was about 1500 µm, non septate. The cell wall was very thin and the pits are simple to very small of bordered pit (61, 66, 68, and 72). Material inclusion: prismatic crystals were found inside the axial parenchyma chamber(136 and 142) (Figure 3). Other information: the wood was susceptible to fungi. From the observation, it was shown that the hypha was found inside the vessel and the entire rays (Figure 4). Figures 5 and 6 show the fibers, vessels, and parenchyma of *S. amazonicum*.

- Fiber dimensions and their derived values

Results of the measurement of fiber dimensions and calculation of their derived values are presented in Table 1. Table 1 also showsthe comparison between fiber quality of *S. amazonicum* (present study) and that of sengon wood (Martawijaya *et al.,* 1989).

Table 1 shows that fiber quality of *S. amazonicum* branch-woo disalmost similar to that of sengon wood, although its felting power value is higher than that of sengon wood. Further, *S. amazonicum* fibers were longer than that of sengon wood. This longer fiber would affect the tear strength of a corresponding paper (Haygreen and Bowyer, 1996). Both sengon wood and *S. amazonicum* branch-wood exhibiteda fiber quality value that could becatagorized as first class. Therefore, with regard to thederived values of fibers, those two woods would beexcellent to be used as raw material in pulp and paper industry. Paper made from *S.amazonicum* fiber would have greater fiber to fiber contact during the paper sheet forming because of the high value of its Runkel ratio. Such paper would also be flexible to tensile force, not easily torn off due to traction, smooth, and strong (Haygreen and Bowyer, 1996). Haygreen and Bowyer1996, felting power indicated the silkiness grade of the paper. Table 1 shows that based on the felting power value, *S. amazonicum* fiber could be catagorized into class III. Hence the paper produced from this wood was not smooth enough, however it tended tobe silkier than a paper made from sengon wood.

The observation of anatomical properties showed that *S. amazonicum* branch wood characteristics were almost similar to those of sengon wood (Martawijaya *et al.*, 1989), i.e. the color of both wood is white and light.Referring to the growth rate, this wood belongs to the species with faster growth rate.

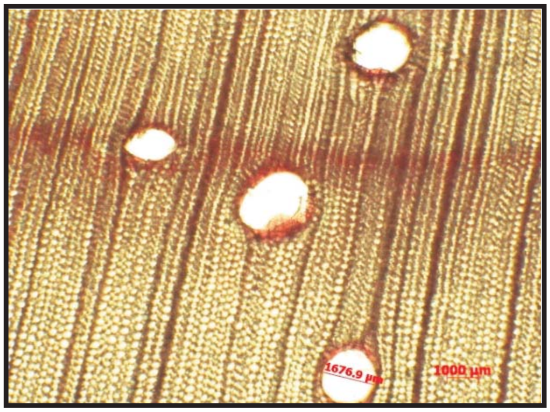

Figure 1. Cross section of *S. amazonicum* branch wood. Growth rings were distinct(microscopy)

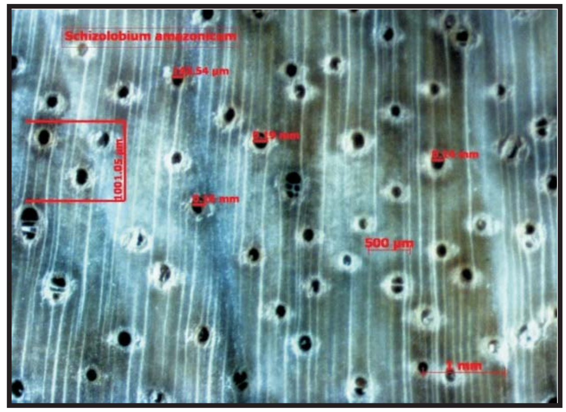

Figure 2. Cross section of *S. amazonicum* branch wood (macroscopy)

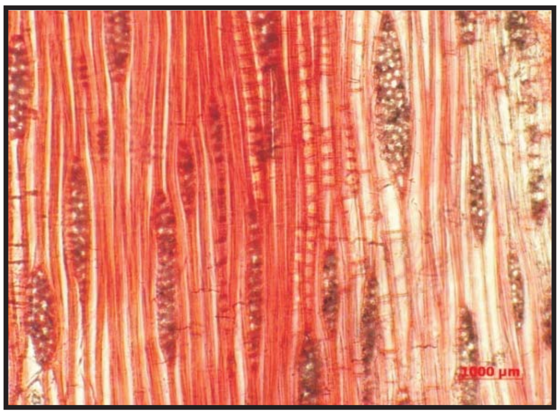

Figure 3. Tangential section of *S. amazonicum* branch wood. Prismatic crystal was found inside the parenchyma cells.

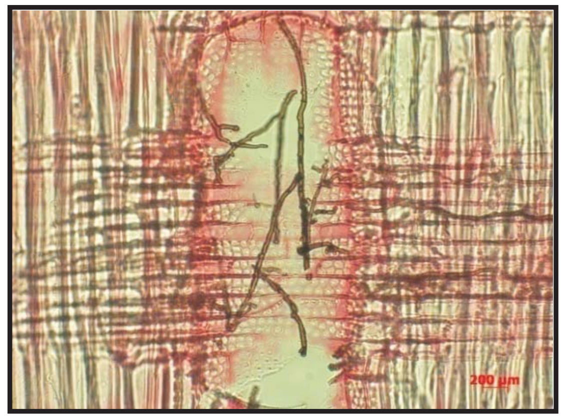

Figure 4. Radial section of *S. amazonicum* branch wood. Fungi hypha was found insidethe vessels and rays cells.)

Figure 5. Fiber cells of *S. amazonicum*.

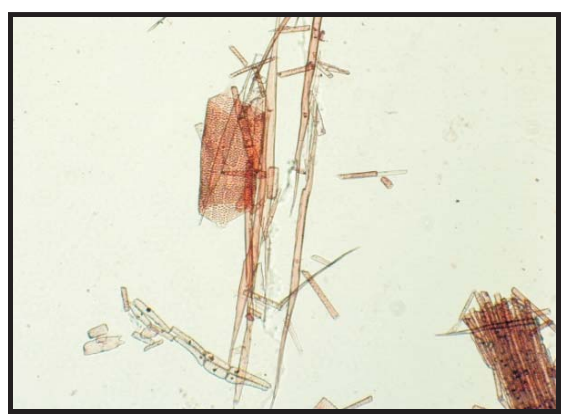

Figure 6. Vessel and parenchyma cells of *S. amazonicum*

Table1. Comparison of fiber quality between *S. amazonicum* branch-wood and *P. falcataria* Nielsen wood

Species	Fiber Dimensions (µm)				Derived Values of Fiber Dimensions				
	L	d	l	w	Runkel Ratio	Felting Power	Flexibility Ratio	Coef. of Rigidity	MultshepR atio
S. amazonicum (branch-wood)	1507	33	29	2.2	0.04	45	0.87	0.07	24.5
Quality class					I	III	I	I	I
Paraserianthes falcataria)*	1242	46	39	3.3	0.14	27	0.86	0.07	26.6
Quality class					I	IV	I	I	I

**) Martawijaya et.al. (1989)*

Notes:

L = fiber length	Runkel ratio	= 2w/l
d = fiber diameter	Felting power	= L/d
w = cell wall thickness	Flexibility ratio	= l/d
l = lumen diameter	Coefficient of rigidity	= w/d
(l = d - 2w)	Multsteph ratio	= $\frac{(d^2-l^2)}{d^2}$ x 100 %

A. Chemical Properties of *S.amazonicum* Branch-wood

Table 2 shows the chemical composition of *S. amazonicum* branch wood, while Table 3 discloses the chemical composition of sengon and mangium woodswhichare commonly used in the pulp and paper industry, as well as for construction and in the furniture industries.

Table 2. Chemical composition of *S.amazonicum* branch wood*)

No.	Compounds	Percentage (%)**)
1.	Extractive soluble in alcohol-benzene	2.46
2.	Lignin	28.71
3.	Holocellulose	80.64
4.	α-cellulose	50.47

*)Sample moisture content: 2.75%
**)Corrected for moisture-free wood

Table 3. Chemical composition of sengon and mangium woods

Wood	Position	Percentage (%)			
		Extractive	Lignin	Holocellulose	Cellulose
P. falcataria (sengon)	Stem wood(a)	3.40	26.80	-	49.40
A. mangium	Stem wood(b)	2.9 – 5.6	19.7 – 27.3	73.16 – 81.75	44.0-47.2
A. mangium	Stem wood without bark(c)	3.87	30	88.86	-
A. mangium	Branch wood without bark (= 6-8 cm) (c)	2.43	27.33	88.95	-

(a) Martawijaya *et.al.* (1989)
(b) Law and Wan Daud, 1998; Valadeand Law, 1998; in Marsoem, 2004
(c) Yahya, 2004

Table 2 and 3 show that holocellulose content of *S. amazonicum* branch wood was slightly lower than thatof mangium wood, although the difference seemed insignificant. Such difference was caused by the variation in characteristics between branch wood and stem wood (Haygreen and Bowyer, 1996). Generally, branch wood from hardwood had more vessel and ray components, but the portion of fiber cells was low. The lower the fiber portion, then usually,the loweralso the holocellulose content, particularly cellulose content. As shown previously, the holocellulose content of *S. amazonicum* in this research was in fact lower than that ofmangium wood.

Table 2 also shows that holocellulose content in *S. amazonicum* was quite high. According to Ritter and Kurth (1993) in Fengel and Wegener (1995), holocellulose consists of cellulose and hemicelluloses. Holocellulose serves as essential compound in the production of pulp and paper since it affects the pulp yield and physical/ strength properties of paper. Tables 2 and 3 show that the cellulose content in *S. amazonicum* was also higher than that of sengon and mangium woods. Therefore, the pulping of *S. amazonicum* branch wood would expectedly result in pulp with high yield and paper with favorable physical/strength properties. It could be explained that the more the content of α-cellulose in the wood, themore intensive the hydrogen bonding in theresulting paper. Considerable number of free hydroxyl group in α-cellulose would enhance the lateral linking between fibers, thereby rendering the fiber-to-fiber bond stronger in the resulting paper sheet.

Lignin on the other hand accounts for the fiber rigidity and serves as adhesive (binding agent) between fibers in the original woods or other ligno-cellulose fibrous stuffs, and therefore should be removed in the pulping and bleaching process. Tables 2 and 3 show the lignin content of*S. amazonicum* branch wood compared with that of sengon and mangium woods. From those tables, it can be seen that the branch wood of *S. amazonicum* contained higher lignin than both thesengon and mangium woods. Hence, more intensive treatment (e.g. use of stronger selective chemical agent) is needed to remove the lignin and leave holocellulose practically intact, thereby enabling the branch wood to produce paper with good strength. The lignin that still exists in the pulp would decrease the tear and burst strength of the resulting paper. This is because the lignin as such could interfere with fiber-to-fiber bonds through the OH groups (Bierman, 1996; Marsoem, 2005). Furthermore, the lignin being inherently rigid would render the fibers less flexible (less collapsible) and therefore forming rough and thick paper sheet (Haygreen and Bowyer, 1996).

In general, the anatomical characteristics of *S. amazonicum* branch wood were almost similar to those of sengon wood, and its chemical characteristics compared favorably with those of sengon and mangium woods. Those two woods are commonly used as raw material in the pulp and paper industries as well as for construction and in the furniture industries. Both wood species are also intensively used for the establishment of HTI (industrial plantation forests). Therefore, the much similarities between the former (*S. amazonicum* branch wood)and the latter (sengon as well as mangium woods) render *S. amazonicum* indicatively as a good prospect for the pulp and paper industry, as well as for construction or furniture industries. However, further in-depth studies with respect to especially sylvicultural techniques are urgently needed before using*S. amazonicum* for HTI establishment on a commercial scale.

IV. CONCLUSION

The results showed that the anatomical characteristics of *Shizolobium amazonicum* Duckebranch wood exhibited similarity to those of sengon wood. Its chemical components were also similar to those of sengon and mangium woods, which are commonly used as raw material in the pulp and paper industry. The branch wood fibers are indicatively suitable as raw material for pulp and paper manufacturing, since the fiber quality belonged to the first quality class for pulp and paper. Further, *Shizolobium amazonicum* treesareone of the fast growing species, therefor etheutilization of their branch wood for pulp and paper is looking promising in the future.

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