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Dimensions and Fiber Quality Values of Api-api Wood (*Avicennia alba* Blume)

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KEY W O R D S
Fiber dimension, Fiber derivatives value, *Avicennia alba* Blume

A B S T R A C T
The aim of this resarch is to determine the fiber dimensions and the fiber quality of api-api woo (*Avicennia alba* Blume). Samples were taken from Tanjung Limau village, Muara Badak district and cut in form of disk at the base, middle and top of the tree. The maceration process (fiber separation) using schultze method, while observations and fiber measurements using laboratory standard method with research microscope Nikon E400. The results showed that the longest average values of wood fiber is in the middle of the trunk (1584, 75 µm) and the widest of the fiber diameter (18,70 µm) is in the middle as well. The biggest average values of lumina is in the base (10,06 µm) and the wallthickness (4,40 µm) is in the middle of the trunk. The results of the fiber derivative values of *Avicennia alba* Blume are as follows, the runkel ratio with an average value of 0.77 at the base, 0.92 in the middle and 0.78 at the top. Felting power with an average value of 84.55 at the base, 84.86 in the middle and 79.37 at the top. Flexibility ratio with an average value of 0.56 at the base, 0.5275 in the middle and 0.55 at the top. Coefficient of rigidy with an average value at the base 0.21, the middle 0.23 and the top 0.212. Muhlsteph ratio with an average value of 33.2% at the base, 35.28% in the middle and 32.71% at the top. Overall, the fiber quality value of Api-api (*Avicennia alba* Blume) is included in quality class II with the total value 350.

1. INTRODUCTION

According to Soerianegara (1976), mangrove forests are forests that grow on alluvial mud in coastal areas and river estuaries and their existence is always influenced by tidal waters. Mangrove forests consist of various types of plants from the genera *Avicennia, Sonneratia, Rhizophora, Bruguiera, Ceriops, Lumnitzera, Excoecaria, Xylocarpus, Scyphyphora and Nypa*. Mangrove forests are transitional ecosystems between land and sea that are always or regularly inundated by sea water. Because of their location on the coast, these mangrove forests also have a strategic

dual function that must be developed, namely as coastal environmental conservation, and at the same time are also required to be able to provide economic benefits, especially for communities around the coast. Soerianegara and Indrawan, (1998).

Wood, besides its commercial use, is also used as a raw material for the pulp and paper industry. However, the production process often encounters challenges because not all types of wood meet the requirements for papermaking. Wood, as a raw material for pulp and paper, must meet certain requirements, including the properties of the fiber and its derivative value. A type of wood can be made into paper after pulping, but this process is expensive and time-consuming. An easy way to assess the suitability of wood for papermaking is by examining the fiber dimensions and calculating its derivative value.

The quality of wood as a raw material for pulp and paper in the laboratory generally uses the maceration method (fiber separation) and fiber dimension measurement with the aid of a microscope. A description of the condition of fiber dimensions and the possibility of using wood species from mangrove areas as raw materials for pulp and paper has not been widely carried out, therefore research was conducted on the type of api-api wood (*Avicennia alba* Blume).

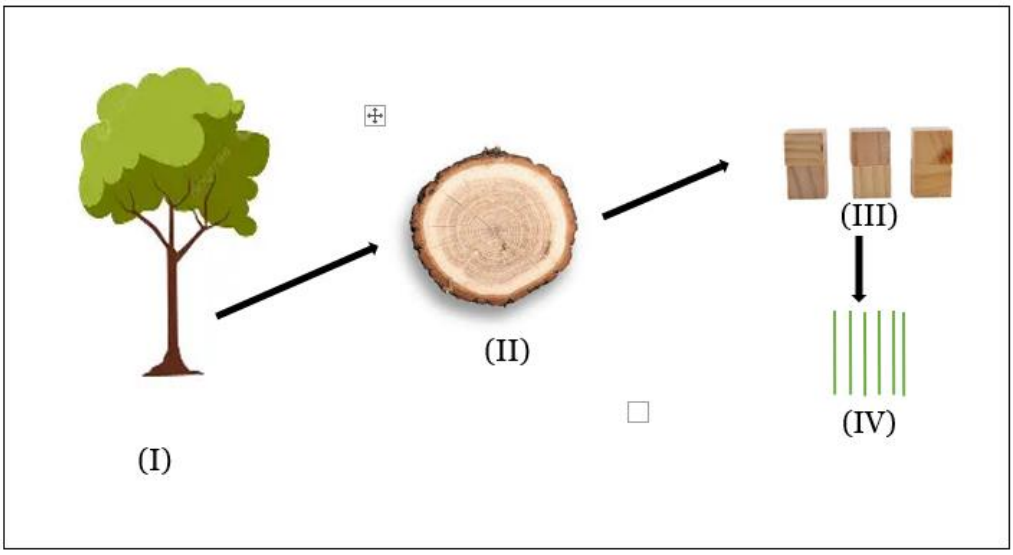
2. METHODS

Research Materials and Tools

The materials used in this study were api-api wood (*Avicennia alba* Blume) comes from Tanjung Limau Village, Muara Badak District, Kutai Kertanegara, with a diameter of 25 cm and a height of 7 meters. Samples were taken in the form of 3 cm thick plates from the base, middle, and top of the stem. Chemicals include *Nitric acid* solution (NHO3), *Potassium chlorate* (KClO3), 50%, 70%, 90% alcohol, and ethanol solution. The equipment used in the study was a Nikon E400 research microscope, object glass, cover glass, pipette, cutter, tweezers, filter, clamping forceps, tissue, heater, funnel, photo tube, test tube, calculator, and stationery.

Sampling Method:

The samples taken from Tanjung Limau Village, Muara Badak District, are shown in the following image:



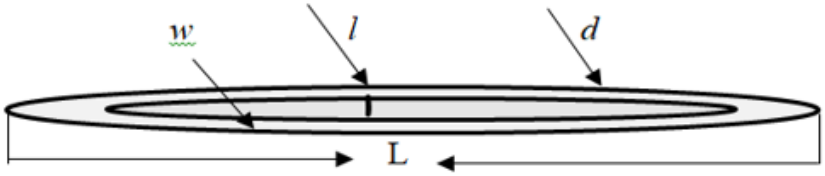
I. Trees taken as samples
II. Cutting the sample 3 cm in size of disk
III. Sample size 2cmxcmx2cm
IV. Sample for maceration process

Figure 1. Sampling Method

Research Procedures

Samples were taken from three parts of the stem, namely the base, middle, and top, and were cut into several pieces to measure 2mmx2mmx10mm, or the size of a matchstick. The fiber separation process (maceration) used the Schultze method (Husien, 1989), and the fiber dimensions were measured by using laboratory standards (Budiarso, 1988). Observation and measurement of fiber dimensions using a Nikon E400 research microscope with a magnification of 100x, namely for measuring fiber length, and magnification (400x) for fiber diameter and lumen diameter. Measurement of fiber wall thickness obtained from the calculation of fiber diameter minus lumen diameter divided by two, then the entire calculation result is converted into microns (μm).

The parts of the fiber that were measured are listed in the following image:



L : Fiber length w : Fiber wall thickness

d: Fiber diameter l : Lumen diameter

Figure 2. Measured fiber cross-section

The calculated fiber derivative values include: runkel ratio, felting power, flexibility ratio, coefficient of rigidity and muhlsteph ratio, determined using the following formula:

Runkel ratio: 2w / l

Felting power : L / d

Flexibility ratio: l / d

Coefficient of rigidity: w/d

Muhlsteph ratio: $MR = \frac{d^2 - l^2}{d^2} \times 100\%$

Data analysis

Data analysis was carried out using simple statistical tests, namely by determining the mean value, standard deviation and coefficient of variation, then presented in the form of tables and graphs. The data was then analyzed comparing the obtained value with the table value of fiber requirements as a raw material for paper to determine the fiber quality value.

3. RESULTS AND DISCUSSION

Fiber Dimensions

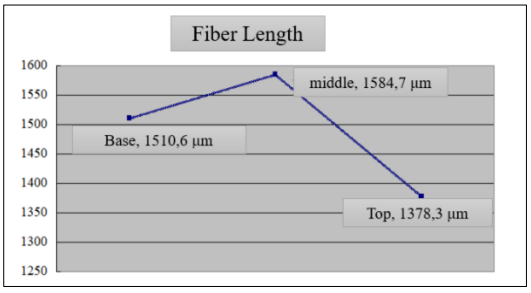
Measurement of fiber dimensions other than directly related to the use of wood as a raw material for pulp and paper as well as to determine other uses, because wood fiber is one of the main components in wood. The average value of the dimensions of Api-api wood fiber (*Avicennia alba* Blume), the results of the calculation of the average section, base, middle and top which include fiber length, fiber diameter, lumen diameter and fiber wall thickness, are presented in the following table:

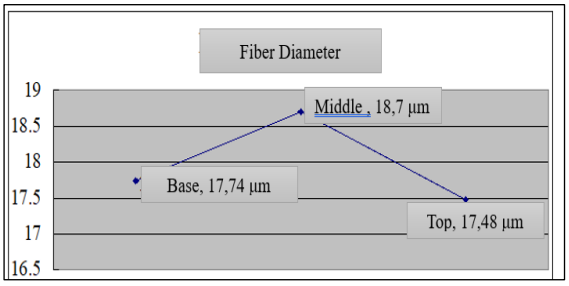
Table1. Average Fiber Dimensions of the Base, Middle and Top of Api-Api wood (*Avicennia alba* Blume).

Tree parts	Code	Fiber length (µm)	Fiber diameter (µm)	Lumen diameter (µm)	Fiber wall thickness (µm)
Base	A1	1230.00	17.46	11.69	2.89
	B1	1224.00	15.54	9.03	3.26
	A2	1742.40	18.72	9.18	4.77
	B2	1846.20	19.24	10.36	4.44
Base average		1510.60	17.74	10.06	3.84
Middle	A1	1515.00	19.69	9.25	5.22
	B1	1525.20	18.50	8.14	5.18
	A2	1701.60	18.50	10.21	4.14
	B2	1597.20	18.13	11.99	3.07
Middle Average		1584.70	18.70	9.90	4.40
Top	A1	1046.40	15.83	8.88	3.47
	B1	1348.20	16.13	8.73	3.70
	A2	1477.80	15.68	9.25	3.21
	B2	1641.00	22.27	12.21	5.03
Top average		1378.30	17.48	9.77	3.86
Total value		1491.20	17.97	9.64	4.03
Average		104.50	0.64	0.49	0.31
Coefficient of Variation (CV)		7.00	3.57	5.16	7.87

Information :
(A = left, B = right, 1 = near the pith, 2 = near the bark)

The average fiber dimensions of *Avicennia alba* Blume are as follows: fiber length 1491.20 µm, fiber diameter 17.94 µm, lumen diameter 9.64 µm and wall thickness 4.03 µm. More clearly, the average fiber dimensions of the base, middle and top of the api-api tree can be seen in the following image:





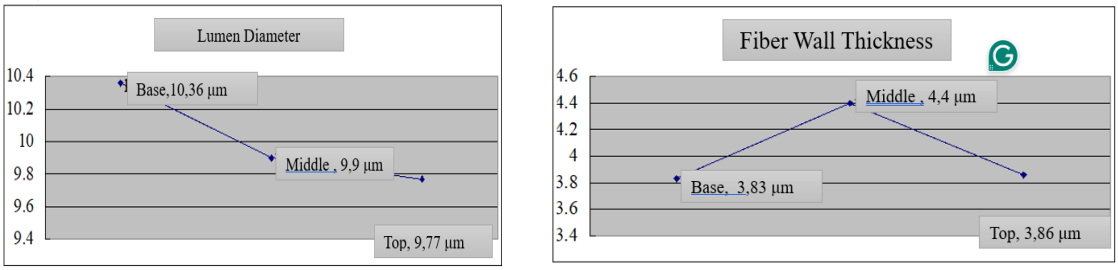


Figure 3. Average Fiber Dimensions at the Base, Middle and Top of the Stem

Fiber Length

The fiber length in Figure 3 shows an increase towards the center of the rod and then decreases towards the top, as does the fiber diameter and fiber wall thickness. This is different from the average value of the lumen diameter which tends to decrease from the base to the top of the rod. According to Casey (1960), fiber length, fiber diameter, and fiber thickness vary greatly depending on the type and position of the fiber in the trunk and where it grows. Meulenhoff and Wiratmoko (1965) stated that as the tree ages, the fiber length also increases, and variations in fiber length are also determined by where the tree grows and the inherited traits. Based on classification Wegenfuehr (1984) quoted by Hernandi (1996) The length of the fiber at the base and middle of the Api-api tree is included in the “medium” fiber category (1500-2000 µm), while the top is included in the “short to medium” fiber category (1000-1500 µm).

Fiber Diameter

Figure 3 shows that the average value of the largest fiber diameter is located in the middle of the tree, 18.7 µm, then at the base 17.74 µm and at the top 17.78 µm. According to classification Klemm (1928) in Sumiati (2001), the diameter of the firewood fibers at the base is included in the category of fibers with a "medium" diameter (10 - 24 µm), also based on the classification Wagenfuehr (1984) In Hernandi (1996) the diameter of the fibers in the middle of the Api-Api tree is included in the "medium" category (10-24 µm).

Lumen Diameter

Figure 3 shows the average largest lumen diameter is located at the base of the tree 10.36 µm then the middle 9.9 µm and the top 9.77 µm. Based on the classification of Wegenfuehr (1984) in Hernandi (1996) the lumen diameter of the Api-api tree is included in the category of "small" (5-10 µm) and "medium" (10-15 µm).

Fiber Wall Thickness

The average fiber wall thickness in Figure 3 shows a decrease in value from the base to the top of the stem. The average fiber wall thickness is greatest in the middle, namely 4.4 µm, followed by the base at 3.83 µm, and the top at 3.86 µm. According to the Wagenfuehr (1984) classification, the average fiber wall thickness obtained at the base and top of Api-api wood is included in the very thin-walled category (<4µm). Meanwhile, the middle part of the Api Api tree trunk has thin walls (4 - 6µm). Soenardi (1976) stated that thin-walled fibers undergo a change in shape (collapse) and become flat, thus providing a large surface area between the bonds, resulting in high tensile, breaking, and folding strengths. The image of Api-api wood fiber is presented in Figure 4 below:

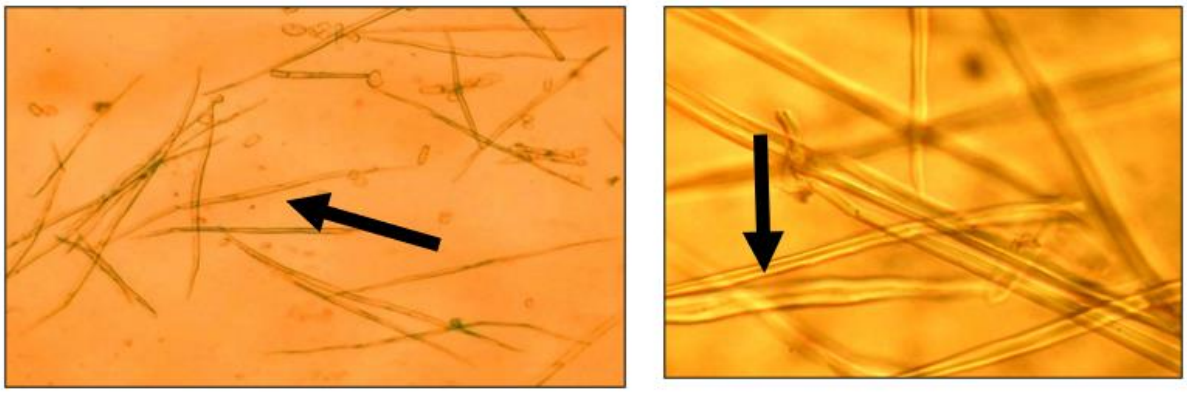


Figure 4. Fiber length (100x) and Fiber wall thickness (400x) of Api-api wood (*Avicennia alba* Blume)

Fiber Derivative Value

The fiber derivative value was calculated to determine the potential use of api-api wood as a raw material for pulp and paper. The average fiber derivative values at the base, middle, and top of api-api trees are listed in the following table.

Table. 2. Average Fiber Derivative Value of the Base of *Avicennia alba* Blume.

Code Sample	Runkel Ratio	Felting Power	Flexibility Ratio	Coefficient of Rigidity	Muhlsteph Ratio%
UA 1	0.49	70.43	0.66	0.16	32.25
UA 2	1.04	93.06	0.49	0.25	35.48
UB 1	0.72	78.76	0.58	0.20	28.75
UB 2	0.85	95.95	0.53	0.23	36.32
Average	0.77	84.55	0.56	0.21	33.20

The table above presents the results of the calculation of the average value of the derivative fiber of the Api-api tree, at the base, namely: the average value

of the runkel ratio is 0.77, felting power is 84.55, flexibility ratio is 0.56, coefficient of rigidity is 0.21 and muhlsteph ratio is 33.20%.

Table.3 Average Fiber Derivative Values in the Middle Part of *Avicennia alba* Blume.

Code Sample	Runkel Ratio	Felting Power	Flexibility Ratio	Coefficient of Rigidity	Muhlsteph Ratio%
UA 1	1.12	76.96	0.46	0.26	37.48
UA 2	0.81	91.97	0.55	0.22	34.79
UB 1	1.27	82.44	0.44	0.28	35.24
UB 2	0.51	88.09	0.66	0.16	33.61
Average	0.92	84.86	0.52	0.23	35.28

The average value of the fiber derivatives of the middle part of the Api-api tree, namely: runkel ratio 0.92, felting power 84.86, flexibility ratio 0.52, coefficient of rigidity 0.23 and muhlsteph ratio 35.28%.

Table 4. The Average Result of Fiber Derivative Values at the Top Section

Code Sample	Runkel Ratio	Felting Power	Flexibility Ratio	Coefficient of Rigidity	Muhlsteph Ratio%
UA 1	0.78	66.07	0.56	0.21	29.42
UA 2	0.69	94.19	0.58	0.20	29.01
UB 1	0.84	83.57	0.54	0.22	30.09
UB 2	0.82	73.67	0.54	0.22	42.35
Average	0.78	79.37	0.55	0.21	32.71

The average value of fiber derivatives at the end of the api-api tree, namely the average value of the runkel ratio is 0.78, felting power is 79.37, flexibility ratio is 0.55, coefficient of rigidity is 0.21 and the average value of the muhlsteph ratio is 33.71%.

Fiber Quality Value

Overview of the possibilities the use of Api-api wood (*Avicennia alba* Blume) as a raw material for making pulp and paper can be seen in the table below.

Table 4. Fiber Quality Values at the Base, Middle and Top of *Avicennia alba* Blume.

Parameter	Base		Middle		Top	
	Average	Score	Average	Score	Average	Score
Fiber Length (μm)	1510.65	50	1584.75	50	1378.35	50
Runkel Ratio	0.77	50	0.93	50	0.78	50
Felting Power	84.55	75	84.87	75	79.38	75

Flexibility Ratio	0.56	50	0.52	50	0.56	50
Coefficient of Rigidity	0.21	50	0.23	50	0.21	50
Muhlsteph Ratio (%)	33.2	75	35.28	75	32.72	75
Total		350		350		350
Class Fiber quality	Class II		Class II		Class II	

The quality value of fiber as a raw material for pulp and paper is not only determined by the dimensional value and the value of the fiber derivatives, but also based on the provisions of the requirements and the value of the wood fiber. Based on the average value in tables 3, 4, 5 and the requirements for calculating fiber quality, it is known that the quality class of the api-api tree fiber (*Avicennia alba* Blume) included in quality class II with an average value at the base of 350, middle 350 and top 350. Rahman and Siagian (1976 in KLHK 2020), stated that the average fiber quality value between 301 and 450 is included in fiber quality class II. Fibers in this class usually have medium to long fibers, thin walls and a fairly wide lumen. The fibers will easily flatten when milled and the fiber bond is good. This type of fiber can produce paper sheets with moderate tear, crack and tensile strength.

4. CONCLUSION

1. Average fiber length valueAvicennia alba Blume Firewood. Based on Wegenfuehr's classification, it is included in the "short to medium" fiber category and average fiber diameter value it is included in the “medium” diameter fiber category (10 – 24 μm). The average lumen diameter value is included in the “medium” category (< 15 μm). The fiber wall thickness is included in the “very thin” (< 4 μm) and thin (4-6 μm) categories.
2. Based on the calculation of fiber quality values, Api-api wood (*Avicenia alba* Blume) including in quality class II, with a value between 300 and 450, and can be used as raw material for paper

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