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ANATOMICAL PROPERTIES AND QUALITY OF AFRICAN WOOD FIBER AS A RAW MATERIAL FOR PULP AND PAPER

Sifat Anatomi dan Kualitas Serat Kayu Afrika sebagai Bahan Baku Pulp dan Kertas

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ABSTRACT

Nowadays, there is growing interest in the development of African wood utilization. Afrika wood is one fast-growing species from plantation forests. This research aimed to evaluate the characterization of African fiber for pulp and paper production. The anatomical properties of African wood were also investigated. Determination of characterization of fiber dimension was conducted based on Tappi (1989). The results showed that African wood has types of porous, namely solitary and radial multiple porous. The parenchyma and ray characters were paratracheal parenchyma confluent and multiseriate types. For fiber characteristics obtained by fiber length, fiber diameter, lumen diameter, and cell wall thickness were 935.33 μm, 28.52 μm, 21.29 μm, and 3.62 μm respectively. The derived value of African fibers obtained by runkel ratio, felting power, muhlsteph ratio, coefficient of rigidity, coefficient of flexibility, and fiber length were 0.43, 35.02, 20.51, 0.12, 0.76, and 935.33 μm respectively. Based on the derived value of African fibers, it qualifies as Grade II material for pulp and paper production. Afrika wood can be used as raw material for pulp and paper production.

Keywords: African wood; anatomical properties; fiber quality; pulp and paper

A. INTRODUCTION

African wood is a fast-growing *species* from the Rhamnaceae family from plantation forests. African wood is widely used for various purposes, such as raw materials for laminated boards, oriented strand board, light construction wood, containers, veneer, and plywood (Muslich *et al.,* 2013; Baskara *et al.,* 2022; Lestari *et al.,* 2023). Fast-growing wood has several characteristics, including small diameter, low quality, contains more juvenile wood, and produces wood in smaller quantities. African wood is inferior with a medium density of 0.37, strong class IV, durable class V against subterranean termite attacks, and durability class III against drywood termite attacks (Febrianto *et al.,* 2013; Karlinasari *et al.,* 2012). This property is less profitable if applied for exterior purposes.

Improving the quality or increasing the added value of using African wood must continue to be carried out. Previous research shows that OSB made from African wood and 7% PF adhesive has good physical and mechanical properties (Baskara *et al.,* 2022). Another alternative use is African wood as raw material for pulp and paper. Pulp and paper products are no less interesting than other products. In Indonesia, demand for pulp and paper products continues to increase (Ministry of Industry of the Republic of Indonesia, 2021). African wood is identified as a potential alternative because it dominates plantation forests.

For this reason, testing the suitability of using African wood as raw material for pulp and paper must be carried out. This research aims to identify the anatomical properties of African wood and the quality of African wood fiber as an alternative raw material for pulp and paper.

B. METHODS

Materials and Tools

The primary material for this research is African wood obtained from the Dramaga Bogor Campus. The wood samples used are defect-free. The tools include a microtome, light microscope, and Image J software.

Procedure

1. Observation of Wood Anatomy and Fiber Quality

The anatomical characteristics of wood were observed by observing microtome incisions on three wood sections: cross-section, radial, and tangential. The sample is boiled in water until it softens and then sliced using a microtome. The sections were stained with safranin, left for 8 hours, and washed with distilled water. The slices were dehydrated in stages with 50, 70, and 90% ethanol for 5 minutes each. The resulting slices are then placed in an

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object glass and covered with a cover glass. The preparations were observed and documented under a microscope using ImageJ software. The anatomical characteristics observed include growth rings, pores, parenchymal arrangement, rays, and intercellular pathways DJK (1976) in (Lempang, 2016). Fiber quality was assessed using maceration techniques based on TAPPI standards (1989) for testing parameters. The test sample used is a core sample. African wood fiber was dyed with 2% safranin dye for 8 hours. After dyeing, the fiber was dehydrated in stages with 50, 70, and 90% ethanol solution. The fiber is placed in a glass object and observed under a light microscope. The parameters measured to measure fiber dimensions are fiber length, fiber diameter, lumen diameter, and fiber wall thickness. The results of the fiber dimension measurements are used to measure the derivative fiber dimensions. The derived fiber dimension values sought are the runkel ratio, weaving power, muhlsteph ratio, rigidity coefficient, and flexibility coefficient.

2. Data analysis

This research is qualitative and quantitative. Qualitative research is presented in the form of described images. For quantitative research, the average number and standard deviation are calculated using Microsoft Excel (Augustina *et al.,* 2020).

C. RESULTS AND DISCUSSION

Anatomical Characteristics of African Wood

The anatomical characteristics of African wood are carried out by observing the wood structure in 3 planes of wood orientation (Figure 1).

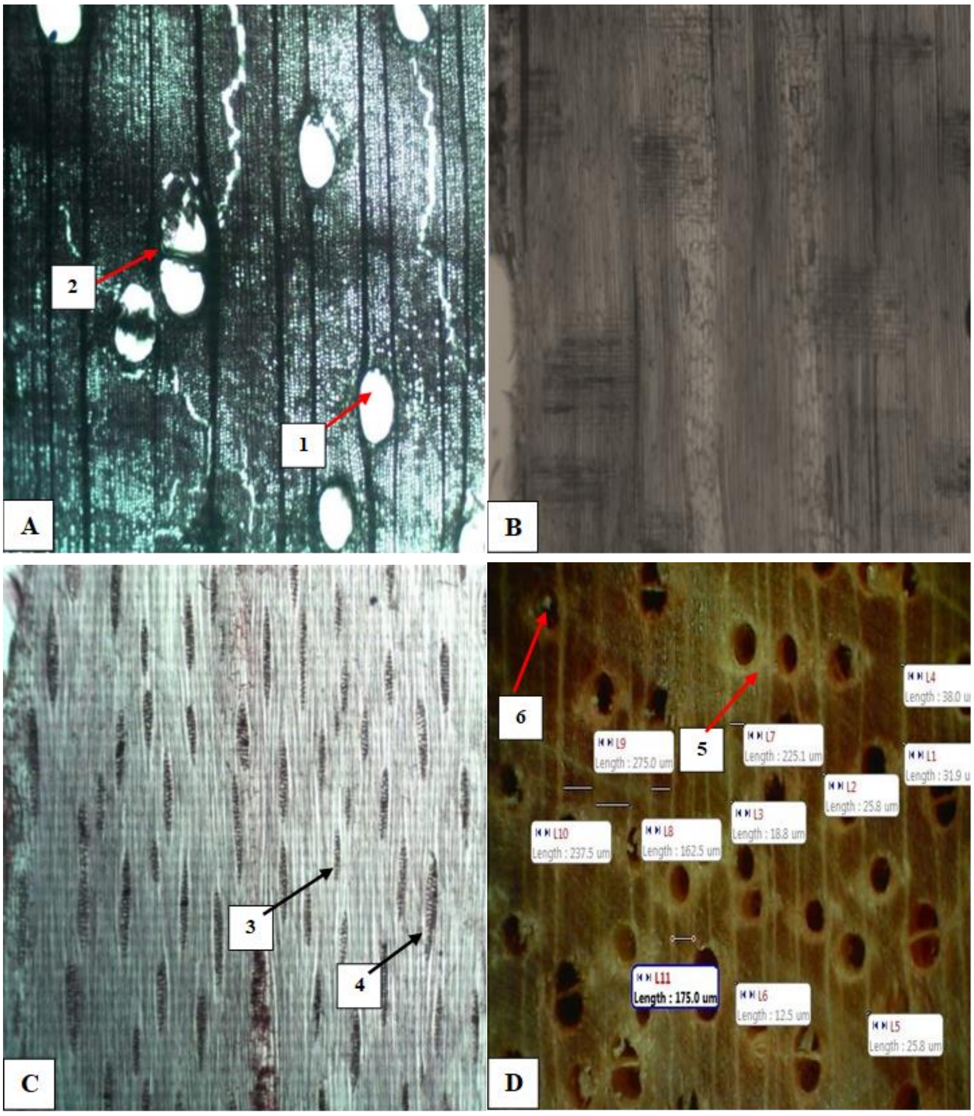

Figure 1. Cross section of African wood in cross-section (A & D), radial (B), and tangential (C). Solitary type pores (1), radial multiple-type pores (2), two-series multiseriate rays (3), three-series multiseriate rays (4), confluent paratracheal parenchyma (5), and tylosis (6)

Fiber Quality

African wood has a fiber length of 953.33 ± 200.44 µm. The fiber length of African wood is shorter than that of *Acacia mangium* wood, which is currently most widely used in the pulp and paper industry. The *Acacia mangium* wood type has a fiber length of 1593.68 µm (Mutiar *et al.,* 2020). African wood has a lumen diameter of 21.29 ± 6.4 µm and a wall thickness of 3.62 ± 2.83 µm. If a fiber with a lumen diameter is three times or more than twice the thickness of the fiber wall, the fiber is classified as having a skinny wall thickness (Lempang, 2014). African wood has a fiber lumen diameter over three times the fiber wall thickness, so African wood has thin cell walls. Fiber dimensional values and derivatives are essential for estimating pulp and paper quality (Syafii and Siregar, 2006). The value of each fiber dimension derivative parameter will determine the quality of the pulp and paper class produced.

Table 1 Fiber dimensions

Parameter	Average	Value range
Long	953.33±200.44	640-1640
Diameter	28.52±6.43	15.5-45
Lumen diameter	21.29±6.4	9.3-40.3
Wall thickness	3.62±2.83	1.55-13.95

Table 2 Derived values of fiber dimensions

Fiber derived parameters	Average	Score
*Runkel ratio*s	0.43	75
Weaving Power	35.02	25
Muhlstep ratio	20.51	100
Coefficient of Rigidity	0.12	75
Flexibility Ratio	0.76	75
Fiber length	935.33	50
Total		400 (Class II)

Runkel Ratio

The runkel ratio is a parameter used to determine whether a raw material is suitable to be used as raw material for pulp and paper. If the wood has a runkel ratio of more than 1, the wood fibers are stiff, less flexible, and have weak bonds between fibers (San *et al.,* 2016). On the other hand, if the value is less than 1, it will produce good-quality pulp and paper. African wood fiber has a runkel ratio of 0.43, less than 1. Based on Ferdous *et al.,* (2021), a runkel ratio value of less than one indicates that the wood fiber has thin cell walls so that the fibers fold easily and form a paper sheet with a large bond area between the fibers.

Weaving Strength

Weaving power is an important parameter that positively contributes to the paper's physical strength, such as tear strength, tensile strength, and breaking strength of paper (*Tutuş et al.,* 2015). The woven power value of African wood fiber is close to the woven power value of hardwood fiber (40-80), namely 35.02, so the woven power value of African fiber is expected to produce paper with better tearing, breaking, and tensile strength (Main et al., *2014)*.

Muhlsthep Ratio

The muhlshtep *ratio* is the ratio between the cell wall's cross-sectional area and the fiber's cross-sectional area. The muhlstep ratio value depends on the thickness of the cell walls and affects the tear strength, tensile strength, and density of the resulting pulp (Sumardi *et al.,* 2020). Thin fibers are more accessible to crush during the paper production process and have a good effect on the density and durability of the paper (Akgul and Tozluoglu, 2009; Tutuş *et al.* 2015). Mulhsteph value African wood *ratio* is 20.51. Based on Anonymous (1976) in (Aprianis and Rahmayanti, 2008), the mulhsteph ratio value for African wood is classified as class I quality (≤30).

Coefficient of Rigidity

The coefficient of rigidity is a parameter that determines the stiffness of the paper produced. The *coefficient of rigidity* value is obtained by comparing the cell wall thickness with the fiber diameter. The higher the *coefficient of rigidity value,* the stiffer the paper will be (Herlina *et al.,* 2018). The value of *the coefficient of rigidity* is opposite to the tensile strength of the paper, which states that the lower the value, the better the tensile strength of the paper produced. *The coefficient of rigidity* value for African wood fiber is 0.12, so it is classified as class II pulp quality (0.10-0.15).

Coefficient of Flexibility

The coefficient of flexibility value is expressed in percentages obtained from the ratio of the lumen diameter to the diameter, which determines the elasticity and stiffness properties of the fiber (Nagarajaganesh *et al.,* 2023). The coefficient of flexibility value for African wood is 0.76, and it is a very plastic fiber because the value is more than 75%. Fibers with a *coefficient of flexibility value* of more than 75% are categorized as highly plastic fibers (Syed *et al.,* 2016; Afrifah *et al.,* 2022). Next, the *coefficient value of* High *flexibility* produces a larger adhesive surface area, resulting in better fiber bonding and producing pulp sheets with good strength (Ashori and Nourbakhsh 2009). Based on the sum of the parameters of the derived dimensional values, African wood can be used as raw material for pulp and paper. The total score is 400, so African wood fiber falls into the Class II quality category.

D. CONCLUSION

African wood has solitary and multiple radial-type pores, confluent paratracheal-type parenchyma, and multiseriate-type rays. Based on the dimensional values of the fiber and its dimensional derivatives, African wood fiber is suitable as raw material for pulp and paper and is classified as Class II quality.

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