Characterization of Physical Fibers Bamboo Properties in 6 Types of Bamboo Fibers from Jambi Province Based on Differences in Stem Position

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Abstract

Jambi Province has a considerable diversity of bamboo species, types of bamboo include worm bamboo (*Gigantochloa apus*), seric bamboo (*Gigantochloa serik*), bamboo gutters (*Schizostachyum brachycladum*), ampelous bamboo (*Bambusa vulgaris*), thorn bamboo (*Bambusa blumeana*) and temiang bamboo (*Schizostachyum blumei* Nees). The use of bamboo as a textile, it is important to know the strength of bamboo fiber as a source of fiber. Based on the value of fiber dimensions and derivatives of fiber dimensions, worm bamboo and guttering bamboo include quality I. Bamboo serik, ampelous, thorn and temiang bamboo are included in quality class II. The highest fiber moisture content in seric bamboo species and the lowest in thorn bamboo species. The moisture content value of bamboo fiber of the six types shows the increased moisture content value of the base, middle and end. The highest fiber moisture content value at the end of the stem. The density value of the six bamboo fibers is included in the criteria for less for the pulping process because it has a density above ($\rho \geq 0.600$), but for the manufacture of composite products it is included in the good criteria.

Keywords: *bamboo, physical fiber*

Introduction

One source of natural fiber that is abundant and includes long fiber but has not been optimally utilized, one of which is bamboo. Bamboo is a plant that belongs to the gramineae family with efficient and fast-growing photosynthesis ability (Fatriasari 2022) and can mature at the age of 3-4 years so that it has the potential to replace wood because of its fast cycle (Hartono et al. 2022). National production of bamboo reached 17 million sticks per year in 2019 (Forestry 2019). Indonesia is estimated to have 172 species of bamboo which is more than 16% of bamboo species in the world. Bamboo species in the world are estimated to consist of 1642 types (Widjaja 2019).

Bamboo has been widely utilized for various bioproducts such as biocomposites, pulp and paper, construction, furniture, medicine (Hartono et al. 2022), textiles (Marpaung 2020). Bamboo includes long fibers with fiber lengths of more than 2 mm (Fatriasari and Hermiati 2008) so that it has the opportunity to be used as a source of viscose or rayon raw materials for textile products which are reported to be more attractive than conventional viscose (Marpaung 2020). To be used as a textile, it is important to know the strength of bamboo fiber as a source of fiber.

The diversity and endemic species of bamboo are among the highest in Indonesia found on the island of Sumatra, namely there are 75 species and 34 species are endemic (Suriani 2017). Jambi Province on the island of Sumatra has a considerable diversity of bamboo species and some types of bamboo are included in the types that are endemic to Jambi. In this study, 6 species of banbu that grow in Jambi Province were selected with relatively large numbers, namely serik bamboo (*Gigantochola serik*), worm bamboo (*Gigantochloa apus*), guttering bamboo (*Schizostachyum brachycaldum*), thorn bamboo (*Bambusa blumeana*), temiang bamboo (*Schizostachyum blumei*) and ampelous bamboo (*Bambusa vulgaris*).

As in wood, bamboo has variations in physical properties. Huang et al. (2018) mentioned that bamboo will be denser than the rootstock to the top because of the increase in vascular bundle from the rootstock to the top. In addition, the moisture content of bamboo stems decreases from the lower stem to the top (Adam and Jusoh 2019) which is associated with fewer parenchyma on the rootstock compared to the top.

Physical properties such as specific gravity and moisture content are related to their mechanical properties (Hartono et al. 2022). Abdullah et al. (2017) reported that the mechanical properties of bamboo are influenced by its specific gravity. In addition, the mechanical physical properties of bamboo are also influenced by its axial position, where the upper stem has higher compressive strength than the middle and bottom. The mechanical properties of bamboo stems is also influenced by specific gravity and moisture content (Awalluddin et al. 2017; Wakchaure and Kute 2012). Like other natural fibers, the variability of bamboo's basic properties is influenced by where it grows (Karimah et al. 2021; Praptoyo and Wathoni 2013). Variations in this trait are also found in one family of natural fibers such as banana fibers (Fatriasari et al. 2022).

Based on the results of previous publications, many have reported the basic characteristics of bamboo including the physical properties of various bamboo species in various locations where it grows. Observations of the physical characteristics of bamboo at various axial positions were reported on bamboo stems, but no observation of these properties has been found in a single fiber of bamboo.

Materials and Methods

1.1. Materials

The materials used in this study were serik bamboo, thorn bamboo, temiang bamboo, guttering bamboo, black bamboo and ampelous bamboo with an age ranging from 3-5 years, having a circumference of 20 cm, diameter of 6.5 cm, height of 9 m, pins, foam cork and kerosene.

1.2. Methods

2.2.1 Preparation of Raw Materials

The six types of bamboo were cut down and then cut the bamboo parts into 3 parts (base, middle and end) to become test samples. Bamboo fiber preparation is done by taking bamboo fiber in a wet or fresh state manually using a cutter and the fiber taken is a single fiber with a length of 8-10 cm.

(a) (b)

Fig. 1. (a) Bamboo fiber, and (b) single fiber

2.2.2 Physical Properties of Fiber Moisture Content

The method of measuring water content is carried out based on (TAPPI, 1997). The test begins by preparing an empty glass container to store the dried sample in a 105°C oven for at least 4 hours. Then cooled in a desiccator for 30 minutes. Empty glass containers weighed dry weight ovens. The sample is weighed as much as 2 g and put the sample into a glass container, record the weight of the sample weighed. Samples are dried in a 105°C oven for 24 hours. Then cooled in a desiccator for 30 minutes The sample along with the glass container is weighed and the final weight is recorded.

2.2.3 Physical Properties of Fiber Density

Density testing or measuring fiber density by means of a crimped sample is associated with a pin pin. The pin needles are already assembled and connected with cork foam and thread. Cork foam is inserted into analytical balances and inlaid. The glass beaker is filled with kerosene and placed under a pin that has been associated with the sample and the cork foam circuit. Furthermore, the weight recorded on the analytical balance is recorded the final result. Fiber density is measured following the kerosene displacement method. After obtaining the weight and volume of air-dried fibers, the fiber density is then calculated according to ASTM 3800 standards. The density of the sample is calculated using the following equation:

$$\rho = \frac{\mathrm{m}}{\mathrm{V}}$$

where m is the mass of an object which is the measure of many substances contained in an object. While density or density (ρ) is a quantity that shows the ratio between mass and volume of an object and V is the volume of the object.

2. Result and Discussion

2.1. Moisture Content of Bamboo Fiber

Fiber is a small filament of natural or synthetic material that has a minimum aspect ratio of 100 times and has flexible and strong properties. Fibers can be grouped as natural fibers, semisynthetic fibers and synthetic fibers. Natural fibers are used to produce various products through appropriate processing processes (Examples of natural fibers are cotton, hemp, silk, wool, and asbestos fibers. Natural fiber has various advantages and has long been used in meeting human needs and various industries. Natural fibers are used in the textile, paper, handicraft, accessories, decoration and biocomposite materials industries. Natural fibers produced in Indonesia are vegetable fibers, namely cotton, hemp, sisal, coconut husk, jute, kenaf, pineapple leaves, banana fiber, and bamboo.

Bamboo (*Phyllostachys* sp.) has a high content of cellulose and lignin, as well as a short ripening period. Easy to grow in forests or plantations. There are many types of bamboo, and the price is cheap enough to meet the extensive needs for board manufacturing (Tajuddin et al., 2016). Bamboo fiber is already used for raw materials for paper, textiles, socks, and shoes. Bahari et al. (2008) succeeded in making bamboo fiberboard without adhesive through the digesting process.

The results of testing the moisture content values of six types of bamboo fiber based on the position of the stem are presented in Figure 3. The test results show the smallest bamboo fiber moisture content value at the base position and rising towards the end of the bamboo stem. This can happen because at the base position the growth process begins at the bottom position (base) and the development of plants is already an adult phase that has formed substances needed by a stem, causing less water content at the base position than in the middle and end positions where in this position is still carrying out growth and development processes that require water as one of the elements in plant photosynthesis.

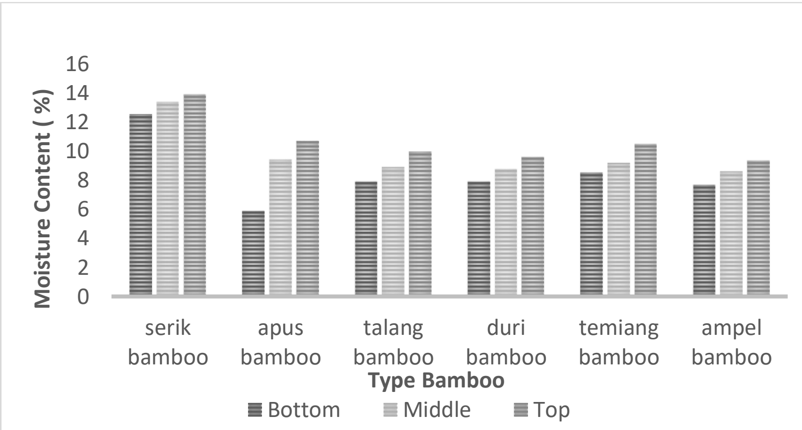

Fig. 2. Moisture content of fibers from six types of bamboo based on the position of the stem

The results of fiber moisture content testing of the six types of bamboo studied are as presented in Figure 3. shows the highest moisture content value in serik bamboo types and the lowest in thorn bamboo species, meaning that fiber from serik bamboo requires a longer time during the process of decreasing water content than other types of bamboo before bamboo fiber is processed to be used as the desired product.

2.2. Bamboo Fiber Density

Natural fiber has advantages including its light weight, nonabrasive, burnable, toxin-free, similar specific properties, cheap, abundant in nature and easily decomposed in nature. This makes natural fiber very potential as a candidate for composite product materials. This makes petrochemical-based composite reinforcement fibers such as glass fiber and carbon begin to be displaced by biological fibers. Research Wang et al. (2014) quoted from Osorio (2011) shows that bamboo fiber has strength that is almost similar to glass fiber.

The current trend of green development has made biofibers the main focus as polymer composite reinforcement. The low density of biological fibers compared to synthetic fibers gives advantages to green composites in terms of using natural fibers. That is, to get the same composite strength, the portion of environmentally friendly biofibers will be greater than the pollutive synthetic matrix. The light weight makes biofiber-reinforced composites more competitive for energy savings in the automotive sector.

Bamboo is one potential source for biological fiber. The types of bamboo in the world are around 1200-1300 species and 11.9% of them are in Indonesia (Abdul Khalil et al. 2012). According to Nasendi 1995 in Herliyana et al. (2005), bamboo is one of the lignocellulose materials that produces cellulose per ha 2-6 times greater than pine. The increase in bamboo biomass per day is 10-30%, while the increase in wood tree biomass is only 2,5%. Bamboo can be harvested in 4 years, shorter than 8-20 years for fast-growing woody tree species.

Bamboo over the age of 1 year (adult bamboo) provides uniform results and optimal physical strength. Bamboo is thought to have suitability as a raw material for pulp and paper in terms of anatomical and chemical composition because it has long fibers (3-4 mm) (Kadarisman and Silitonga 1976). In addition, the pulp quality of bamboo is between wood and grasses, and judging from the ratio between fiber length and width, bamboo is the highest value among the three raw materials (bamboo, wood, grasses) (Maoyi 2006). The length of bamboo fiber is equivalent to red spruce wood and longer than pine (Andtbacka, 2006).

Observation of the density of bamboo fiber is needed to criterion the quality of fiber as pulp raw material based on criteria (FAO 1980 in Wardany 2002). In addition, fiber density measurements based on (SNI 0264: 2015) are carried out to determine the physical properties of composites and in order to determine fiber weight according to the amount of the targeted fiber volume fraction. The results of the analysis of the physical properties of fiber densities of six types of bamboo are presented in Figure 4.

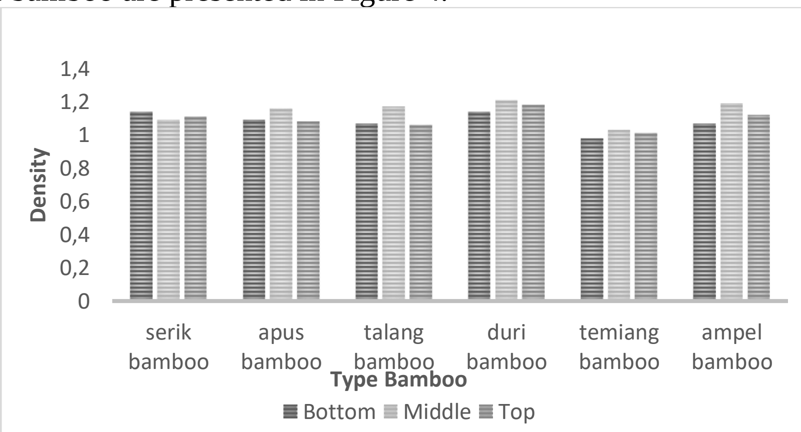

Fig. 3. Density of fibers from six types of bamboo based on the position of the stem

Based on the specific gravity of raw materials, pulp quality is divided into 3 categories, namely good, sufficient and less (FAO 1980 in Wardany 2002). Bamboo which belongs to the category both in terms of specific gravity (ρ) (smallest) ($\rho \leq 0.501$), belongs to the sufficient category ($\rho = 0.501$-0.600) and belongs to the category less ($\rho \geq 0.600$).

The six types of bamboo studied were all included in the category of lacking in all parts of the stem position, namely with a density of $\rho \geq 0.600$. The six types of bamboo studied were all included in the category of lacking in all parts of the stem position, namely with a density of $\rho \geq 0.600$. Raw materials that have a high specific gravity require harsher cooking conditions. As a result first, the fiber is more difficult to grind, the fiber wall is thick, the tear strength is high, while the tensile, cracking strength and folding resistance are low. Second, the difficulty in fibrilisation causes the quality of the paper produced to be low. Third, cooking chemicals are not held long enough in the fiber. Visual color observation of the six types of bamboo tested showed that all of them were white to yellow so they were predicted to produce good pulp quality.

3. Conclusions

The moisture content value of bamboo fiber of the six types shows the increased moisture content value of the base, middle and end. The highest fiber moisture content value at the end of the stem. The density value of the six bamboo fibers is included in the criteria for less for the pulping process because it has a density above ($\rho \geq 0.600$), but for the manufacture of composite products it is included in the good criteria.

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