

Oriented particleboard made from tali bamboo (*Gigantochloa Apus*): effect of particle length on physical and mechanical properties

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Abstract. Strength properties are one of the problems of particleboard. The objective of this research was to analyze the effect of particle length on physical and mechanical properties oriented particleboard (OPB). The variation particle length size in this experiment namely 3, 5, and 7 cm. The width and thickness size of all bamboo particles were 1 and 0.1 cm respectively. 12% mixed resin of UF and MDI (70/30 %w/w) used for binding. Board size fabricated in 25 by 25 cm² with thickness and density target of 1 cm and 0.75 gcm⁻³. The OPB layers for face and back layers aligned perpendicular to the core layer. The weight ratio of the face-to-core-to-back layers were set at 1:2:1. Mat was pressed at 160 °C under 30 kgcm⁻² as the pressure for 10 minutes. The results showed that 7 cm length particle produced of the best strength and dimensional stability. The increase of particle length resulted in increasing of strength properties. Over all the parameters of physical and mechanical properties fulfill requirements of JIS A 5908 (2003) excepted of thickness swelling and modulus of elasticity.

1. Introduction

Forest degradation in Indonesia resulted in the lack of timber materials for wood industry. Therefore, it is necessary to find alternative materials like non-wood materials to substituting of wood. Bamboo is a non-wood raw material that is often found and used by the community. One type of bamboo that can utilized is bamboo Tali (*Gigantochloa apus* J.A & J.H. Schult.Kalz).

The type of bamboo that is widely used for building materials is bamboo Tali or bamboo apus (*G. apus*) because it has better physical and mechanical properties than other types [1]. Bamboo Tali has a diameter 4 - 8 cm, stem length 6 - 13 m, and very elastic. The price of bamboo Tali is quite low compared to wood or with other types of bamboo. According to that, bamboo Tali could be considered as raw material of particleboard.

Maloney [2] stated that the preparation and orientation of particle direction as one of the factors that affected of particleboard quality. Ordinary particleboard using UF resin has a low dimensional stability [3] and strength properties [4]. Through the orientation of perpendicular crossed on oriented particleboard (OPB) was expected to minimize the weakness of dimensional stabilization and particle board strength.



2. Materials and methods

2.1. Materials

The materials used in this research included of Bamboo Tali, Urea Formaldehyde (UF) resin, and Isocyanate.

2.2. Methods

2.2.1. Particle preparation

Bamboo converted to be particle in size of 3, 5, dan 7 cm (length), 1 cm (width), dan 0,1 cm (thickness). Therefore, the particle was dried at 103°C temperature for 24 hours up to 5% moisture content.

2.2.2. Manufacturing of board

OPB was produced in size of 25 by 25 cm² with the density and thickness target were 0.75 gcm⁻³ and 1 cm respectively. Therefore particle and UF/Isocyanate (70/30 %w/w) at 12% level were blended using the rotary bending machine. After that, the particle was placed into mat former. The next step is hot pressing process at 160°C temperature and 30 kgcm⁻² pressure for ten minute. After board conditioning for seven days, OPB evaluated that refers to JIS A 5908 (2003).

3. Result and discussions

3.1. Density

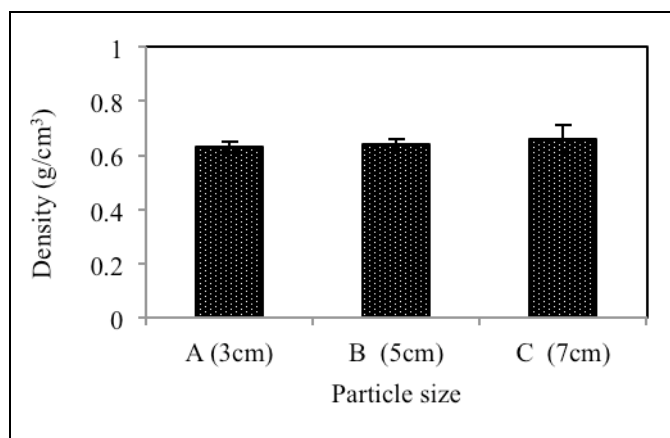


Figure 1. Density of oriented particleboard

The target density has not achieved because of the spring back effect. In the other hand, it was also caused by the loss of particle weight during the blending process. Bufalino et al. [5] stated that board density values lower than the target because of the loss of particles during the manufacturing process. Kelley [6] reported that several factors affecting board density include of wood species, pressure in the pressing process, particle quantity, type and quantity of adhesives. Over all, The OPB produced meets the JIS A 5908-2003 standards [7] that requirement of the density values ranges between of 0.40 to 0.90 gcm⁻³.

3.2. Thickness swelling (TS) and water absorption (WA)

The highest and lowest of TS values were produced by particles of 3 and 7 cm in size respectively (Fig.2). Bektas et al. [8] stated that the TS of the panel depends on several factors such as the amount of adhesive content and its spread, furnish moisture, furnish compatibility and adhesive, the chemical composition of the furnish, etc. Therefore, Garay et al. [9] stated that the particles which are resistant

to moisture content were able to produce of boards with good dimensional stabilization. The TS value in this research had not met the JIS A 5908-2003 standards [7] which require a TS value of less than 12%.

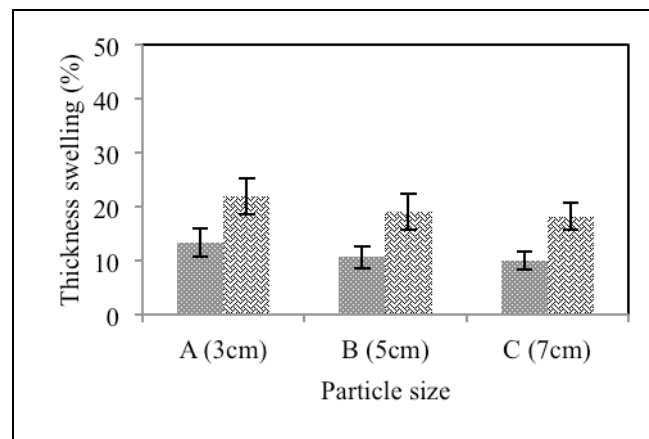


Figure 2. Thickness swelling of oriented particleboard

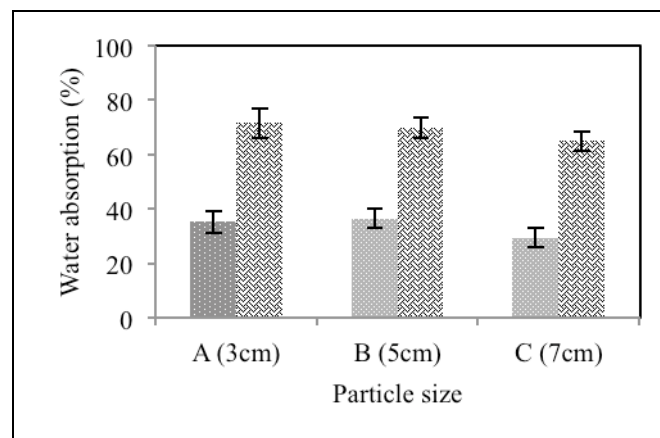


Figure 3. Water absorption of oriented particleboard

The highest and lowest WA values were produced by particles of 3 and 7 cm in size respectively (Fig. 3). WA is not required in JIS standards. OPB with 3 cm particle absorbs more water than particles length 5 and 7 cm. WA produced is still high because in the manufacture of the board did not utilize of water repellent additives. In the other hand according to Rowell [10] that hemicellulose is most responsible for water absorption, however, cellulose, lignin and the surface of crystalline cellulose also affect.

3.3. Internal bond (IB)

The average value of IB presented in Figure 4. The highest and lowest IB values were produced by particles of 3 and 5 cm in size respectively. The high-value IB of OPB was caused the presence of an isocyanate adhesive wherein the isocyanate adhesive has a highly reactive chemical group, that is $\text{R-N}=\text{C}=\text{O}$ [11].

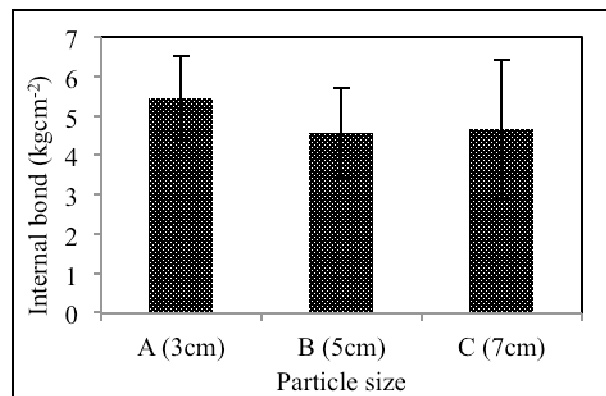


Figure 4. Internal bond of oriented particleboard

IB decreased with increasing of slenderness ratio (SR) particle. In this study, SR values for particle 3, 5, and 7 cm length were 27.60, 49.01, and 62.72, respectively. Lin et al. [12] state that the increasing of SR causes the percentage of cavity area larger than the resin closing area so that it has a negative effect on IB. Likewise, the increasing size of length and width causes the uneven resin distribution on the surface. All of the resulting particle board meets the JIS A 5908-2003 standards [7] was requiring an IB minimum of 1.50 kgcm⁻².

3.4. Modulus of rupture (MOR)

A 7 cm length produced a higher MOR value than another size. These were supported by the highest value of slenderness ratio and aspect ratio of 7 cm particle in length size. Arabi et al. [13] stated that large particle size increases the mechanical strength of particleboard over small particles. Maloney [14]; Sun and Arima [15] suggest that particles with the bigger surface area have larger resin closures and this leads to an increase in mechanical strength. All of the resulting particleboard meets the JIS A 5908-2003 standards [7] was requiring a minimum MOR value of 82 kgcm⁻².

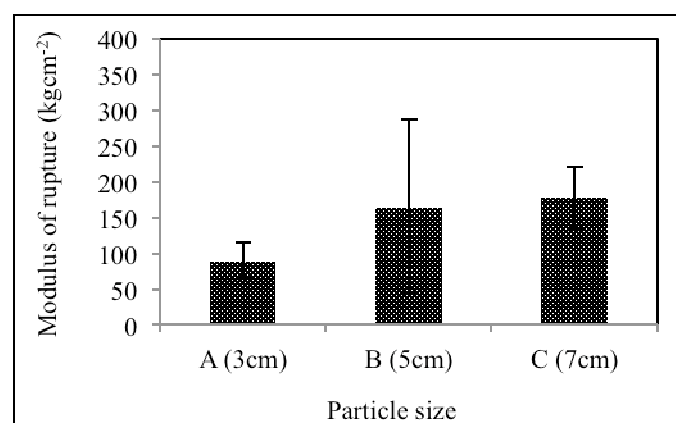


Figure 5. Modulus of rupture of oriented particleboard

3.5. Modulus of elasticity (MOE)

The highest and lowest MOE values were produced by particles of 7 and 3 cm in size respectively.

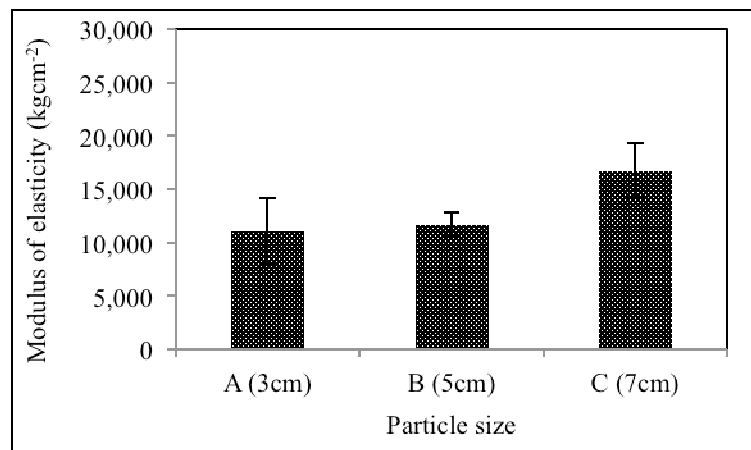


Figure 6. Modulus of elasticity of oriented particleboard

Particles with a length of 7 cm yield the highest MoE value because the particle had the highest SR value, high SR will be easier to orientate so that the strength will increase and it requires a little surface gluing adhesive to bind the particles. According to Maloney [2], SR's ideal value for flake particles is 150. Overall results show that the resulting of MOE value had not met the JIS A 5908-2003 standards [7] was requiring a minimum MOE value of 20,400 kgcm⁻².

4. Conclusion

The particle size had a significant effect on MOE parameters. The treatment of particle size produced of density, IB, and MOR parameters had complied with JIS A 5908 (2003) standard. While the parameters TS and MOE had not met the JIS A 5908 (2003). Over all the particle of 7 cm was the best length to produced of OPB.

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