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FABRICATION AND CHARACTERIZATION OF COMPOSITE FROM CASSAVA STEMS AND SUGARCANE BAGASSE FIBERS AS PARTICLEBOARD MATERIAL

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ABSTRACT
Composite particle boards mixed with cassava stems and bagasse has been successfully fabricated. The purpose of this study was to find out the effect of cassava stem powder and bagasse fiber powder can be used to produce particle board, the effect of plastic waste as particle board adhesive, particle boards from cassava stem powder waste and bagasse fiber powder can meet SNI standards. Composition particle of 70:30, 60:40, 50:50, 40:60, 30:70, with variations of plastic adhesive 10%, 15%, 25%. The characterization results of physical properties and mechanical properties of the most optimal particleboard produced at 70:30, 60:40, 50:50 with 25% plastic adhesive variation composition has a density value of 0.44 g/cm^3, 0.43 g/cm^3, 0.40 g/cm^3, 0.36 g/cm^3 and 0.36 g/cm^3. The moisture content values are 4.44%, 4.44%, 6.52%, 4.76% and 4.65%. The water absorption values were 72.72%, 109.09%, 115.38%, 125% and 154.54%. Flexural strength values (MOE) of 699.87 kgf/cm^2, 646.77 kgf/cm^2, 667.25 kgf/cm^2, 576.65 kgf/cm^2 and 615.51 kgf/cm^2. The fracture toughness values (MOR) were 232.23 kgf/cm^2, 218.07 kgf/cm^2, 186.55 kgf/cm^2, 155.95 kgf/cm^2 and 199.03 kgf/cm^2. The obtained values of density, moisture content, and fracture toughness have met SNI standards, while water absorption and flexural toughness have not met SNI standards.

Keyword: Cassava Stem, Particle Board, Bagasse Fiber, Plastic Adhes.

INTRODUCTION

Wood as a raw material is a continuously increasing human need. However, relying on wood from forests leads to a decline in forest production capacity. Therefore, alternative wood substitutes with better quality and abundant availability are being sought (Armaya et al., 2013). The growing demand for wood contrasts with the forest's capacity to produce it, resulting in a decrease in production (Widodo, 2020).

The large amount of plastic waste can be utilized to create more useful products. Composite boards made from mixed plastic waste can serve as an alternative to waste management. In addition to reducing the amount of polluted waste, composite boards can also meet industrial needs at a low cost (Jonoko et al., 2021).

Indonesia also imports around 2.3 million tons of cassava stem waste, with a ratio of 10:1 between cassava roots and stems. About 10% of the cassava stems are used as seeds, while 90% become waste. Cassava stem waste is utilized as a raw material for particleboard because it contains 56.82% alpha-cellulose (Widodo et al., 2012).

Sugarcane bagasse is a byproduct of sugarcane processing in the sugar industry, and its utilization remains suboptimal. The waste generated during sugarcane processing accounts for approximately 32% of the total weight of milled sugarcane. Up to 60% of the bagasse is used as fuel, raw material for the pulp/paper industry, and herbal medicine production, while the remaining 40% is still unused (Subroto, 2017).

Particleboard is a product made from composite materials using a hot press, utilizing lignocellulosic materials and horizontal pressing of a mixture of organic and other adhesives between two flat plates (Roza et al., 2015). It offers several advantages over natural wood, such as customizable size and density, absence of knots, uniform thickness, ease of processing, isotropic properties, and adjustable quality and characteristics (Mikael et al., 2015).

RESEARCH METHOD

The materials used include cassava stem powder, sugarcane bagasse fiber powder, and plastic powder as an adhesive. The particles are dried in an oven for 24 hours at 80ºC until the moisture content reaches approximately 5%. The particleboard compositions are 70:30, 40:60, 50:50, 40:60, and 30:70. The particleboard is produced using a blending method with variations of plastic powder adhesive at 10%, 15%, and 25%, along with a mixture of polyester resin and catalyst in a 100:1 ml ratio, molded into dimensions of 25 × 25 × 1 cm³.

Hot pressing is performed using a hot press machine at a pressure of 25 kgf/cm² and a temperature of 190ºC for 10 minutes. The particleboard is conditioned for 14 days at room temperature. The obtained boards are characterized for their physical properties—such as density, moisture content, and water absorption—and mechanical properties, including the Modulus of Elasticity (MOE) and Modulus of Rupture (MOR), ensuring compliance with the SNI 03-2105-2006 standard.

Flowchart of Particleboard Production and Testing.

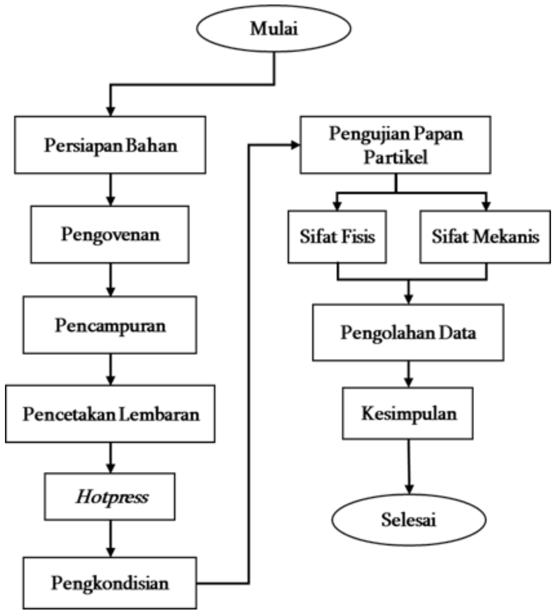

Figure 1. Research Flowchart

RESULT AND DISCUSSION

1. Result

A. Formation of Particleboard from Cassava Stems and Sugarcane Bagasse

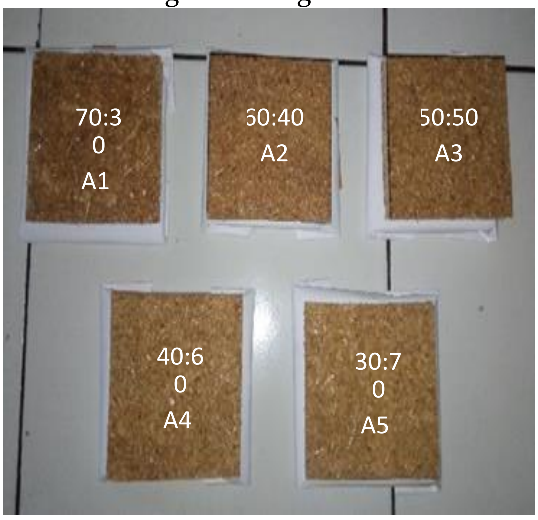

Figure 2. Particleboard with 10% adhesive

Figure 3. Particleboard with 15% adhesive

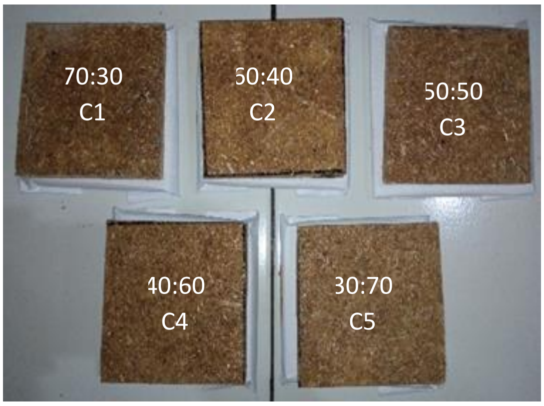

Figure 4. Particleboard with 25% adhesive

2. Physical Properties of Particleboard Made from Cassava Stems and Sugarcane Bagasse

A. Density

The density of the particleboard for sample A ranged from 0.24 to 0.30 g/cm³, with sample A1 achieving the highest density of 0.30 g/cm³, while sample A5 had the lowest density at 0.24 g/cm³. The values obtained for sample B ranged from 0.27 to 0.33 g/cm³, where samples B1 and B2 both had a value of 0.33 g/cm³, while sample B4 recorded the lowest density at 0.27 g/cm³. Additionally, sample C had a density ranging from 0.36 to 0.44 g/cm³, with the highest value for sample C1 at 0.44 g/cm³, and the lowest value for sample C5 at 0.36 g/cm³.

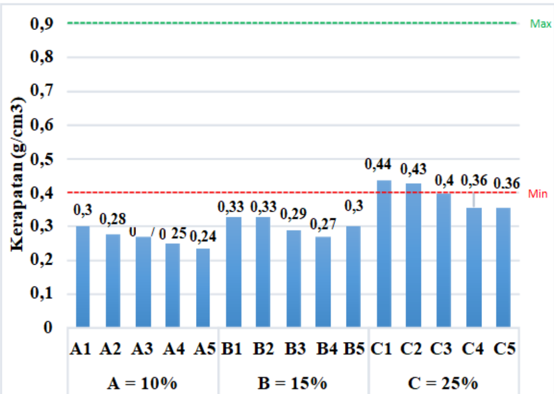

Figure 5. Density of particleboard

Figure 5 shows that the density values increase as the amount of plastic adhesive increases. The influence of cassava stems and sugarcane bagasse fibers on density can be observed based on the composition of cassava stems, where a higher amount leads to increased density due to the larger number of particles. Conversely, an increased amount of sugarcane bagasse particles results in a lower density. According to previous research by Mikael, I (2015), a higher adhesive content leads to an increase in the mass of the raw materials and enhances the bonding between particles, which impacts the density of the particleboard. This indicates that the density of the particleboard will increase with the amount of adhesive used.

B. Moisture Content

The moisture content of sample A ranges from 3.22% to 11.11%, with the lowest value recorded in sample A3 at 3.22%, while the highest value is found in sample A5 at 11.11%. Sample B shows a moisture content ranging from 2.85% to 6.66%, with the lowest value in sample B1 at 2.85% and the highest in sample B5 at 6.66%. Sample C has a moisture content ranging from 4.44% to 6.52%, with the lowest value in sample C1 at 4.44% and the highest in sample C3 at 6.52%.

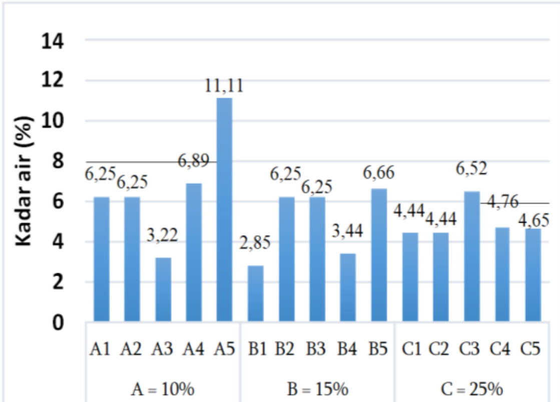

Figure 6. Moisture content of particles

Figure 6 shows that as the amount of adhesive increases, the moisture content decreases, and the difference in the composition of cassava stems and sugarcane bagasse affects the moisture content, leading to compliance with the SNI percentage. According to previous research by Purwanto, D (2016), it was stated that during conditioning, the mixture of particles exhibits hygroscopic properties, meaning that the particles easily absorb or release moisture from their surrounding environment through a conditioning process in a relatively high humidity space. This causes the particleboard to readily absorb water vapor and fill the voids between the particles.

C. Water Absorption Capacity

The water absorption capacity for the samples was tested by soaking them in water for 24 hours. For sample A, the water absorption capacity ranged from 90% to 125%. Sample A2 had the lowest value at 90%, while sample A3 had the highest value at 125%. For sample B, the water absorption capacity ranged from 100% to 162.5%, with sample B3 having the lowest value at 100% and sample B4 having the highest at 162.5%. Sample C showed a water absorption capacity of 72.72% to 154.54%, with the lowest value in sample C1 at 72.72% and the highest value in sample C5 at 154.54%.

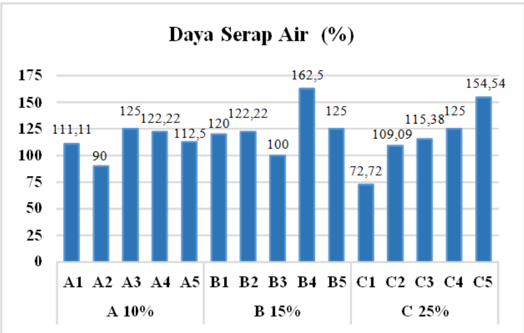

Figure 7. Water absorption capacity of particleboard

Figure 7 shows that the moisture content in particleboard increases with prolonged soaking time. This is due to its hygroscopic nature, where particleboard easily absorbs water during extended immersion. According to previous research by Mikael, I (2015), the high level of water absorption is attributed to the hygroscopic properties of lignin and cellulose, which readily release or absorb water. The water absorption capacity is influenced by the amount of pith produced from cassava stems and sugarcane bagasse fibers. Pith is a material that absorbs water easily and can weigh up to seven times its dry weight when submerged in water.

3. Mechanical Properties of Particleboard Made from Cassava Stems and Sugarcane Bagasse

A. Modulus of Elascity (MOE)

The flexural strength of the particleboard for sample A ranged from 461.71 to 905.40 kgf/cm², with the lowest value recorded in sample A_4 and the highest value in sample A_2. For sample B, the flexural strength ranged from 465.13 to 860.53 kgf/cm², where sample B_3 had the lowest value and sample B2 had the highest. Sample C exhibited a flexural strength ranging from 576.64 to 699.86 kgf/cm², with the lowest value in sample C_4 and the highest value in sample C_1.

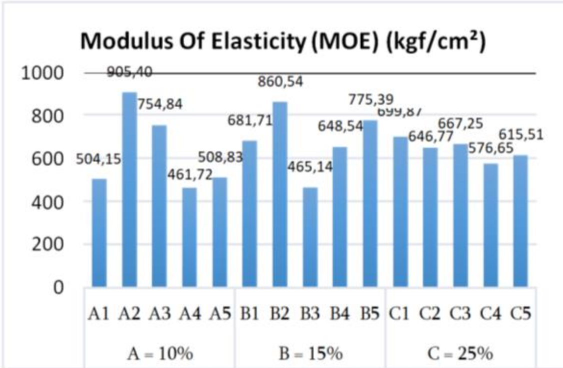

Figure 8. MOE of Particleboard

Figure 8 shows that the lowest value was recorded in sample A3 at 461.72 kg/cm², while the highest Modulus of Elasticity (MOE) was found in sample A2 at 905.40 kgf/cm². According to previous research by Purwanto, D (2016), flexural strength has a linear relationship with the modulus of rupture. Particleboard with low flexural strength also exhibits low modulus of rupture. Increasing the amount of powder will enhance the flexural strength, although it still may not meet the SNI standards.

B. Modulus of Rupture (MOR)

The modulus of rupture values for the particleboard in sample A ranged from 151.38 to 236.03 kgf/cm², while sample B showed values ranging from 142.07 to 255.50 kgf/cm², and sample C had values ranging from 155.95 to 232.32 kgf/cm². The modulus of rupture for samples A, B, and C meets the SNI standards.

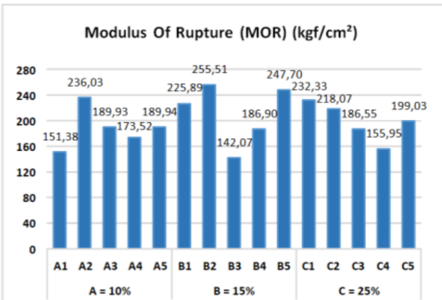

Figure 9. Modulus of Rupture of Particleboard

Figure 9 shows that the modulus of rupture of the particleboard with a composition of cassava stems and sugarcane bagasse fibers has increased. The lowest modulus of rupture value was found in sample

B3 at 142.07 kgf/cm², while the highest value was recorded in sample B2 at 255.51 kgf/cm². According to previous research by Mikael, I (2016), an increase in the density of the particleboard correlates with an increase in the modulus of rupture. The tighter arrangement of the particle interface results in a stronger sheet.

4. Discussion

Based on the test results, the particleboard can meet the Indonesian National Standards with a mixture of cassava stems and sugarcane bagasse fibers, achieving values for physical properties such as density, moisture content, and water absorption capacity. However, the water absorption capacity has not yet met the SNI standards. Meanwhile, the mechanical property testing, specifically the modulus of rupture (MOR), has met the SNI standards, while the modulus of elasticity (MOE) has not yet met the standards.

The density values of the particleboard samples ranged from 0.24 g/cm³ to 0.44 g/cm³, with samples C1, C2, and C3 meeting the SNI standards at densities of 0.44 g/cm³, 0.43 g/cm³, and 0.40 g/cm³, respectively. As the composition of cassava stem powder increases, higher density values are achieved. However, an increase in the composition of sugarcane bagasse powder results in lower density values, and a higher amount of plastic adhesive leads to increased density.

The moisture content values of the particleboard samples ranged from 2.85% to 11.11% and met the SNI standards. As the amount of adhesive used increases, the moisture content decreases. Higher compositions of cassava stem powder result in increased moisture content, while higher compositions of sugarcane bagasse powder lead to lower moisture content.

The water absorption capacity values of the particleboard samples ranged from 72.72% to 162.5% and have not yet met the SNI standards. In this case, the particleboard made from cassava stems and sugarcane bagasse fibers exhibits hygroscopic properties, where the moisture content increases with prolonged immersion. The high moisture content is attributed to the hygroscopicity of the particleboard due to the presence of lignin and cellulose.

The flexural strength or Modulus of Elasticity (MOE) values for the particleboard samples ranged from 461.72 to 905.40 kgf/cm² and do not meet the SNI standards. This is due to the low particle bonding between cassava stem powder, sugarcane bagasse powder, and the amount of plastic adhesive used.

The modulus of rupture (MOR) values for the particleboard ranged from 142.07 to 255.51 kgf/cm² and have met the SNI standards. This is because the composition of the mixture of cassava stems and sugarcane bagasse fibers affects the plastic adhesive, resulting in a higher modulus of rupture. As the density increases, the modulus of rupture of the particleboard also increases.

CONCLUSION

Cassava stem waste and sugarcane bagasse fibers can be used to produce particleboard with particle compositions of 70:30, 60:40, 50:50, 40:60, and 30:70, along with adhesive variations of 10%, 15%, and 25%. The characterization results for the particleboard made from cassava stem powder and sugarcane bagasse powder indicate that the optimal density value is 0.44 g/cm³. The moisture content is 44.4%. The water absorption capacity is 72.72%. The flexural strength is 699.87 kgf/cm², and the modulus of rupture is 232.33 kgf/cm². Based on the results, the density, moisture content, and modulus of rupture (MOR) meet the SNI standards, while the water absorption capacity and modulus of elasticity (MOE) have not yet met the SNI standards.

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