Characterization of Particleboard from Waste Tea Leaves (*Camellia Sinensis* L) and Meranti Wood (*Shorea* Sp) using Urea-Formaldehyde Adhesive and It's Formaldehyde Emission

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Abstract: The production of particleboard still uses formaldehyde-based adhesives, such as urea formaldehyde (UF) adhesives, although it has been known that the adhesive is harmful to human health in the long term. Therefore, an effort is needed to get adhesive that is relatively safe to use. One of them is by utilizing tea plant waste which can reduce formaldehyde emissions. The purpose of this study was to evaluate the physical and mechanical properties of particleboard, to evaluate the ratio of waste tea leaves (Camellia sinensis L)and meranti wood (*Shorea sp*) particles, and to evaluate the effect of adding waste tea leaves for formaldehyde emissions produced by particleboard. The results showed that the addition of tea leaf particles can improve the physical and mechanical properties of the particleboard.

1 INTRODUCTION

Wood composite products such as particleboard are widely circulating in the community in a variety of uses, such as household furniture, room dividers and others. Particle boards are usually produced using formaldehyde-based adhesives (such as urea formaldehyde/UF resin) which produce formaldehyde emissions. Although formaldehyde-based adhesives are a major source of emissions that are harmful to human health, they are still used because of low prices and good performance (Shi et al., 2006).

Furthermore, many studies were conducted to modify particleboard or UF adhesives in reducing their emissions. One approach taken is to use natural raw materials that can reduce these emissions. Tea leaves fulfill this function because they have phenolic compounds that can react with formaldehyde (Shi et al., 2006; Batiancela et al., 2014).

2 MATERIAL AND METHODS

Waste Tea Leaves (*Camellia Sinensis* L) collected from PTP Nusantara IV Bah Butong, Sumatera Utara. Tea leaf waste (*Cammellia sinensis*) and meranti wood waste are filtered using a 10 mesh filter and then dried and oven until it reaches a moisture content of ± 5%. The composition of tea leaf waste and wood particles used is 0/100, 30/70, 50/50, 70/30 and 100/0 while the adhesive used is Urea Formaldehyde (UF) adhesive with hardener content (NH_4Cl) 7% and 9 %. The particle board is made measuring 25cm x 25cm x 1cm with a target density of 0.8 g/cm^3. Material testing conducted include physical and mechanical properties and formaldehyde emissions, which refer to the JIS A 5908 (2003) standard.

3 RESULT AND DISCUSSION

3.1 Physical and Mechanical Properties of Particleboard

The density of particleboards ranges from 0.71-0.87 g/cm^3 so that it can be classified into medium and high density boards. The density of particleboard produced in this study has met the JIS A 5908-2003 standard which requires particleboard density which is 0.4-0.9 g/cm^3.

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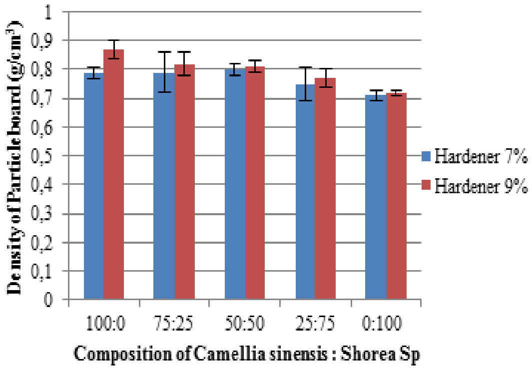

Figure 1: The density of particleboards.

Figure 1 shows that the highest density value is produced by particleboards made from 100% tea leaf waste. This is because tea leaf waste is rich in polyphenols, also called tannins. Some tannins can actively react with formaldehyde. Besides protein and amino acids contained in tea leaf waste can also react with formaldehyde (Shi et al., 2006) so that the urea-formaldehyde adhesive mixed with tea leaf waste at the time of making the board will blend with other particles so that the board the result is high density due to the strong bond between the tea leaf waste and the adhesive provided.

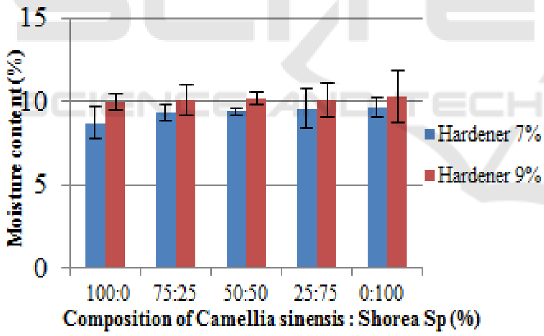

Figure 2: The moisture content of particleboards.

Figure 2 shows that the average value of moisture content produced on particleboards from tea leaf waste and meranti wood ranged from 8.71% - 9.67% on particleboards using 7% hardener and 9.97% -31.3% on particleboards made using 9% hardener.

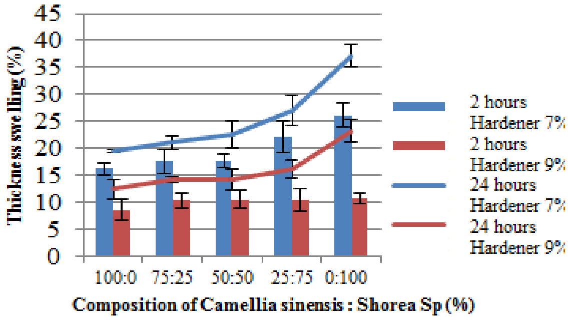

Figure 3: Thickness swelling of particleboards.

Figure 3 shows that the thickness swelling of particle board from tea leaf and meranti wood waste during 2-hour immersion is 16.24% -26.24% and 19.56% -37.21% for 24-hour immersion on boards that use hardener 7 %. The particleboard that uses adhesives with a hardener content of 9% has thickness additions ranging from 8.60% -10.74% at 2-hour immersion and 12.47% -23.19% at 24-hour immersion. Thickness swelling increases with the addition of wood particles.

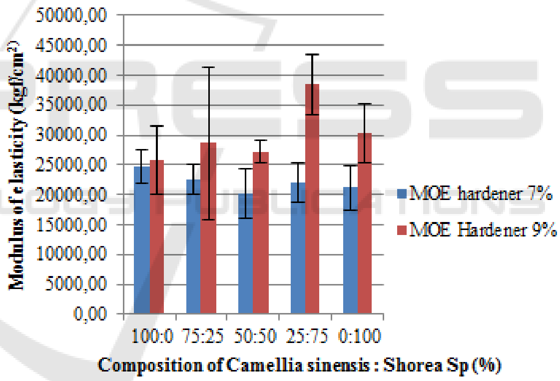

Figure 4: Modulus elasticity of particleboards.

Figure 4 shows that the particleboard made using adhesive with a hardener content of 9% has a modulus of elasticity higher than the particle board produced using an adhesive content of 7% hardener. The highest modulus of elasticity values were found on particleboard from tea leaf waste and meranti wood with a composition of 25:75 on adhesives using 9% hardener which was 36101.48 kgf/cm^2 while the lowest modulus of elasticity value was found on particle board from tea leaf waste and meranti wood with a composition 50:50 on the adhesive using 7% hardener which is 20012.36 kgf / cm^2. According to Firmansyah and Astuti (2013) that tensile strength value will reach the maximum at the addition of hardener volume at a certain content, but further addition of the hardener decreases the tensile strength. This is because there are many small cavities in the material which reduce the mechanical strength of the material. The modulus of elasticity also increases when the tensile strength increases.

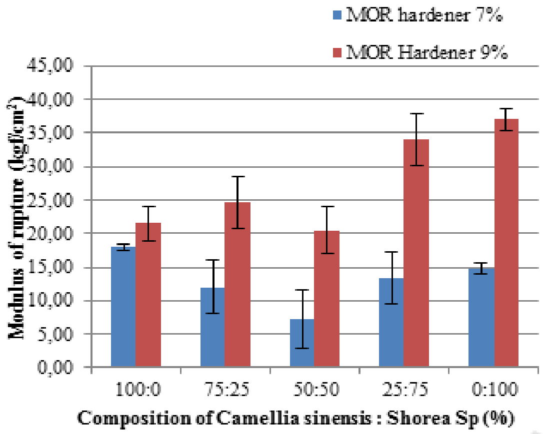

Figure 5: Modulus of rupture of particleboards.

Modulus of rupture values of particleboards ranged from 7.28-41.03 kg/cm2. Figure 5 shows that the highest modulus of rupture is found on particleboards made of 100% meranti wood using an adhesive hardener content of 9%. While the lowest modulus of rupture value is found on the particleboard using adhesive with hardener content of 7%.

The modulus of rupture on the particleboard affected by the particleboard density. The lower the density of the particleboard, the lower the modulus of rupture produced. According to Haygreen and Bowyer (1996) that the factors that affect the low or high of modulus of rupture are influenced by the density of the board, so that the bond between the boards becomes less tight so due to reduce on the modulus of rupture value. Addition of tea leaf waste to the particleboard causes a decrease in the value of modulus of rupture of particleboard (Batiancela et al., 2014). This is due to the low content of chemical compounds in tea leaves in the form of cellulose and hemicellulose so that the mechanical strength produced by particleboards from tea leaf waste powder is also very low (Shi et al., 2006).

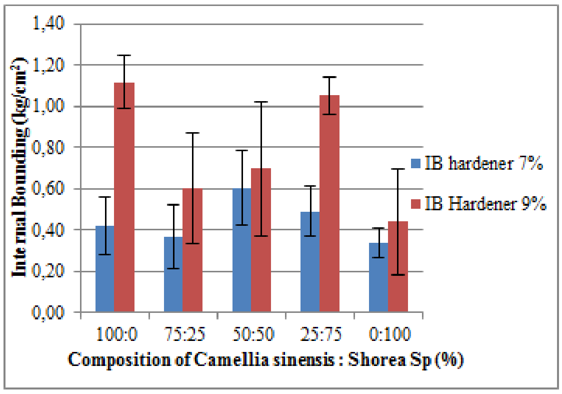

Figure 6: Internal bonding of rupture of particleboards.

Figure 6 shows the average value internal bonding of particleboard ranged from 0.33-1.12 kg/cm^2. The highest value of internal bonding on particleboard from 100% tea leaf waste with hardener content 9% which is 1.12 kg/cm^2 while the lowest on meranti wood particle board 100% at hardener content 7% which is 0.33 kg/cm^2. High content of adhesive with high hardener content can increase the internal bonding value of particleboard. The hardener used in making this particleboard is NH_4CL which can make the acidic condition so that UF adhesives become curing or mature (Nuryawan, 2016).

Internal bonding value of the particleboard from tea leaf waste is higher than the meranti wood particleboard. In accordance with the research of Batiancela et al., (2014) which states that adhesive firmness increased from 148 to 346 kPa with an increase in the proportion of tea leaf waste. Increasing the adherence of adhesion can be attributed to good pressure on the particle board pressing process and the bonding between particles that occurs due to the content of chemical compounds in tea leaf waste. Tea leaf waste contains 4-7% cellulose, 5-6% hemicellulose, and 5-6% lignin.

Table 1 shows the value of formaldehyde emissions on particle boards from tea leaf waste and meranti wood waste ranging from 0.95mg / L-6.045mg / L. The particle board formaldehyde emission using adhesive with a hardener content of 7% higher than the particle board with 9% hardener content. This is because of the variation in density on each board. The average particle board density used for formaldehyde emission testing is in the range of 0.73-0.84g / cm3. The higher the density of the particle board, the lower the formaldehyde emissions released. This is due to the lack of cavities or pores on the particle board so that the emissions released will be smaller (Sutigno and Santoso, 1995). Based on the emission value, it can be seen that the addition of tea leaf waste on the particle board can reduce formaldehyde emissions. In accordance with the statement of Shi et al. (2006) that tea leaf waste can reduce formaldehyde emissions on particleboards.

Table 1: Formaldehyde emissions of particleboard.

Treatment	Emission		Average	JIS A 5908 (2003)
	1	2		
Camellia sinensis : *Shorea* Sp 100 : 0 NH4Cl 7%	1.11	1.11	1.11	F**
Camellia sinensis : *Shorea* Sp 5 : 27 NH4Cl 7%	1.28	1.09	1.185	F**
Camellia sinensis : *Shorea* Sp 0 : 50 NH4Cl 7%	4.46	4.26	4.36	F*
Camellia sinensis : *Shorea* Sp 25 : 75 NH4Cl 7%	5.48	5.48	5.48	F*
Camellia sinensis : *Shorea* Sp 0 : 100 NH4Cl 7%	6.17	5.92	6.045	F*
Camellia sinensis : *Shorea* Sp 100 : 0 NH4Cl 9%	0.75	1.15	0.95	F**
Camellia sinensis : *Shorea* Sp 75 : 25 NH4Cl 9%	1.52	1.52	1.52	F**
Camellia sinensis : *Shorea* Sp 50 : 50 NH4Cl 9%	1.59	1.59	1.59	F**
Camellia sinensis : *Shorea* Sp 25 : 75 NH4Cl 9%	4.94	4.94	4.94	F*
Camellia sinensis : *Shorea* Sp 0 : 100 NH4Cl 9%	5.29	5.29	5.29	F*

4 CONCLUSIONS

The physical properties of particleboards are density and moisture content that have met the JIS A 5908 (2003) standard, while for the thickness swelling and water absorption it has not met the standard. In the mechanical properties only the modulus of elasticity meets the standard while the modulus of rupture and internal bonding of particleboards do not meet the standard. Addition of tea leaf waste can improve the physical and mechanical properties of the particleboard. Addition of tea leaf waste can also reduce formaldehyde emissions. The lowest emissions are produced on particle boards made entirely from tea leaf waste which is 0.95 mg/L.

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