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The Use of Mushroom Growing Media Waste for Making Composite Particle Board

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Abstract. One of the agricultural waste is mushroom growing media, where the number of this waste is huge and accumulated after mushroom harvest. This accumulation is caused by using the new planting medias. Meanwhile, the old planting medias have thrown out and been as solid matter to widen the slope of cliff area. Therefore, this research aims to use mushroom growing media waste (MGMW) as a composite particle board added by polyester resin and mekpo (methyl ethyl ketone peroxides) as catalys. Some physical and mechanic tests which are done, namely: density, moisture content, thickness swelling after immersion in water, strength of absorption water, internal bonding, modulus of elasticity, modulus of rupture and screw holding power. The composition of 75% MGMW + 24% polyester resin + 1% catalyst mekpo suitable to the physical and mechanic tests and accordance with SNI 03-2105-2006 and JIS A 5908-2003.

1. Introduction

Composite particle board is a part of particle board, until now, the basic material for making particle board is still wood, either wood fickle or wood waste, such as sawdust. Meanwhile, the stock of wood in the forest is limited. In the period of eight years later, the use of wood as raw material in the timber industry is descending. In 2005-2013, the fullfilment of raw material from natural forest decreased from 20.5 million m³ to 5.54 million m³. On the other side, the increasing of wood material from planting forests, including the industrial planting forest and public forest is from 11.22 million m³ to 39.8 million m³. Thus, it makes the condition of forest in Indonesia is getting worse [1].

One of the agricultural waste is Mushroom Growing Media Waste (MGMW) where the number of this waste is huge and accumulated after mushroom harvest. This accumulation is caused by using the new planting medias. Meanwhile, the old planting medias have thrown out and been as solid matter to widen the slope of cliff area. This research aims to use MGMW as a composite particle board must be in accordance with the Standart. The application will be used for audio equipment such as the manufacture of box speakers.

2. Experimental Studies

The basic ingredients used in producing composite particle board are MGMW mixed by polyester resin and added by catalyst mekpo (methyl ethyl ketone peroxides). A composite particle board is made from the three compositions, namely: (1) Sample A: 80% MGMW + 19% polyester resin + 1%



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catalyst mekpo, (2) Sample B: 75% MGMW + 24% polyester resin + 1% catalyst mekpo, and (3) Sample C: 70% MGMW + 29% polyester resin + 1% catalyst mekpo. The first is drying the MGMW under the sunray for about two days and then it will be sieved by size 1.5 mm. The second step is the MGMW is dried again in the oven at temperature of 90°C for six hours. If the the MGMW is really dry (free from the humidity), it can be mixed with polyester resin and catalys, and poured into a mold length x width x height (40 x 40 x 1.5) cm and then is pressed by the hot press machine with pressure of 50 kg/cm² at 130 °C for 30 minutes. After it reversed and press again for ± 30 minutes at the same temperature. The results of hot press is composite particle board is shown in **Figure 1(a)** and further subdivided to form the sixth section (**Figure 1b**) on physical and mechanical testing on composite particle board according to the JIS standard A 5908-2003 [2] and Standar Nasional Indonesia (SNI) 03-2105-1996 [3] includes some tests, they (for physical testing) are density and moisture content (number 5), internal bonding/IB (number 3), swelling in thickness after immersion in water, and strength of absorbtion water (number 4). Mechanical testing are modulus of elasticity/MOE (number 1), modulus of rupture/MOR (number 2), and strength of screw holding (number 6).



Figure 1(a). Composite particle board.

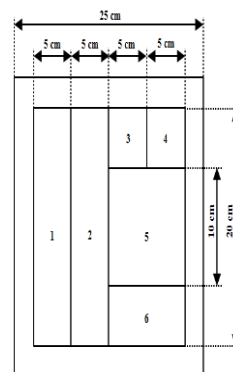


Figure 1(b). Subdivided of composite particle board (JIS A 5908-2003).

3. Result and Discussion

The result of density, moisture content, internal bonding, swelling in thickness after immersion in water, strength of absorbtion water, modulus of elasticity, modulus of rupture, and strength of screw holding for the three compositions: (1) Sample A, (2) Sample B, and (3) Sample C, which can be seen on the **Table 1**.

Table 1. Result of physical and mechanical testing on composite particle board.

Composition Composite Particle Boards	Density (gr/cm ³)	Mois ture Content (%)	Swelling in Thickness after Immersion in Water (%)	Strength of Absorb tion Water (%)	IB (kgf/cm ²)	MOR (kgf/cm ²)	MOE (kgf/cm ²)	Strength of Screw Holding (kgf/cm ²)
Sample A	0.82	5.07	6.09	53.18	2.33	92.00	7740.24	41.95
Sample B	0.87	5.14	5.13	40.24	4.00	123.11	22228.52	62.91
Sample C	0.81	4.81	3.43	39.32	5.67	89.56	12425.88	80.06

Result of physical testing are density, moisture content, swelling in thickness after immersion in water, strength of absorbtion water (**Table 1**) shown that density of all sample (A,B, and C) suitable with SNI 03-2105-2006 and JIS A 5908-2003 and include in high density. Composition of 75%

MGMW + 24% polyester resin + 1% catalyst of composite particle board is the most highest of density with value 0.87 gram/cm^3 . Differences value of density is affected by the number of particles MGMW and adhesive levels in the mix with the same volume. It may be occurred the particles spread unevenly and also become widen in the process of hot compression. This causes the particle mass on each side of composite particle board is not the same, so the pressure and the heat is also different on the whole of sheet surface. The density of particle board is rarely uniform toward its thickness [4].

Composition of 75% MGMW + 24% polyester resin + 1% catalyst of composite particle board is the most highest of moisture content with value 5.14%, The high of moisture content is mean that adhesives used in the making of composite particle board in small quantities. It is not permitted when results of below 5% . Because will be need much more adhesives used. If the adhesive is increasingly being used then the contact between the particles will become tight so that the water would be difficult to enter between in the composite particle board.

All sample (A,B, and C) suitable with SNI 03-2105-2006 and JIS A 5908-2003 for swelling in thickness after immersion in water. Result of swelling in thickness after immersion in water will decrease when adhesive is added. However, the mechanism of thickness swelling after immersion in water of composite particle board is more complex because the particle in the board is bonded with an adhesive that can prevent the thickness swelling. The thickness swelling in the composite particle board is caused by the combination of the potential thickness recovery from the particles densification and destruction of adhesive bond web (the bond strength among particles or the pressure on adhesive bonding). Koch, 1985 [5] also states that the changes of the board dimensions are influenced by the variables of product manufacture itself, such as the density of the raw material, the thickness of the particle, the amount of compression given, adhesive level, and the number of pressure given on the board.

Another physical testing is strength of absorbion water, explain that decrease of it because of adhesive is added. According to Maloney's statement (1993) [6], the longer the time of immersion in the water, the water absorption will be the greater. This is because the water that goes into the composite particle board is increasing as more as the adhesive substituted. Djalal (1984) [5] defines that in addition to the water absorption properties of the raw materials used and the adhesive resistance to the water, there are other factors that influence the increase of moisture content on the particle board. These factors includes the volume of empty space that can accommodate water amongthe particles, the presence of a capillary channel that connects the empty space with each other, the broad of particle surface area, and the broad of particle surface area can not be covered by adhesive. If the process of compression does not run maximally, it will make the particle broad compression is not quite good. So it will cause the water absorb easily in the particle cracks. A high absorption can also be caused by the spread of the particles unevenly and the board compression does not work optimally. It causes the particles will be loose and it will be easier to be placed by the water.

Result of physical testing are internal bonding, modulus of elasticity, modulus of rupture, and strength of screw holding. Composition of 75% MGMW + 24% polyester resin + 1% catalyst is most highest value for MOR (**Figure. 2a**). Maloney (1993) states that the MOR values are influenced by the content and the type of adhesive used, adhesive holding capacity and particle size. Koch (1985) states that the factors that affect the value of MOR is the density of the wood particle board, particle geometry, adhesive level, moisture content of the board, and the process of compression. If the density is too high, it will cause the difficulties in processing adhesiveness. Because of the thickness of the cell wall and the small amount of cavity volume. Thus, it will make the adhesive does not penetrate easily, so the penetrating adhesive will be limitede in the a certain depth.

For MOE, only composition of 75% MGMW + 24% polyester resin + 1% catalyst suitable with SNI 03-2105-2006 and JIS A 5908-2003 with value is $22,228.52 \text{ kgf/cm}^2$ (SNI Minimum $15,000 \text{ kgf/cm}^2$ and JIS Minimum $20,000 \text{ kgf/cm}^2$) (**Figure. 2b**). MOE value is influenced by the content and the type of adhesive used, adhesive holding capacity and particle size. Bowyer et al. (2003) [7] states that in addition to the density and levels of adhesive, the particle geometry is the main feature that determines the result of board properties.

All samples (A,B, and C) suitable with SNI 03-2105-2006 and JIS A 5908-2003 for internal bonding. Djalal (1984) states that the increase of density causes the particle bonding will be stronger.

The higher of density value (in accordance with the standards), the bond internal value that be resulted also getting bigger. Maloney (1993) states that the resin content gives an effect to the internal bonding. If the higher levels of resin in a certain limit, the internal bonding board will increase. This is caused by the greater the amount of the constituent molecules which reacts with wood during the adhesiveness process. However, the increase of density that exceeds the standards will make dissolved particles during compression so that it will produce a weak internal bonding.

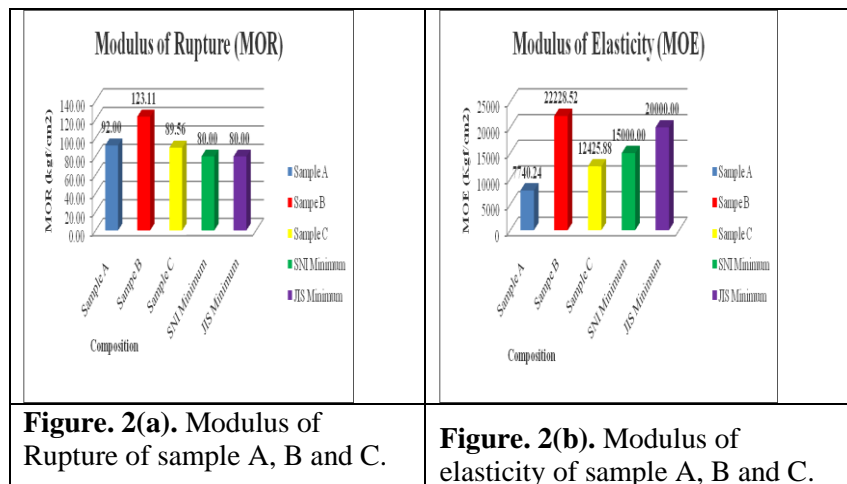


Figure. 2(a). Modulus of Rupture of sample A, B and C.

Figure. 2(b). Modulus of elasticity of sample A, B and C.

Samples A,B, and C suitable with SNI 03-2105-2006 and JIS A 5908-2003 for strength of screw holding. Bowyer et al. (2003) states that the value strength of screw holding is influenced by the density of the particle board, adhesive level, and the spread of adhesive. The high density of particle board will generate a high value of strength of screw holding.

4. Conclusion

From the discussion above, it can be concluded that optimum composition is on the composite particle board which has 75% MGMW + 24% polyester resin + 1% catalyst, suitable with SNI 03-2105-2006 and JIS A 5908-2003, can making composite particle board. The results of physical test and mechanical testing, has been appropriate with standard of JIS A 5908-2003 and Standar Nasional Indonesia (SNI) 03-2105-1996.

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