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# THE VARIATION OF ADHESIVE QUANTITY ON PARTICLE BOARDS FROM ARECA NUT SHELL AND MAHANG WOOD POWDER

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**ABSTRACT**

Particle boards are the solution to the productivity problems of the timber industry which deficiency of raw materials. The manufacture of particle boards from Areca nut shell and Mahang wood powder is an effort to develop existing types of particle boards as well as efforts to utilize areca nut waste and increase the economic value of local wood (Mahang wood). The aim of this study was to determine the effect of quantity variations of adhesive to the composition of the mixture. There are four types of particle board variations are made with the same composition of areca nut and powder but different quantity of adhesive. The determination of physical properties and mechanical properties of particle boards based on JIS A 5908 2003 or SNI 03-2105-2006. The result was an increase in physical and mechanical properties on the particle board whose content of adhesive was greater. The other sides, the mechanical properties of all variations of particle board do not fulfill the existing standards.

Keywords: Areca nut particle board, Mahang wood powder particle board, adhesive content

## 1. INTRODUCTION

Currently the availability of raw materials for the timber industry is always a problem because the number of wood available in the forest is limited. This has an impact on the productivity of the particle board industry which has hard to finding solid wood with good quality. Some types of products that have been developed as a solution to the problem are fiberboard and particle board. The product uses basic materials from wood scraps, utilizes low quality wood or utilizes lignocellulose material that can be used as an alternative substitution for wood raw materials such as agricultural or plantation waste. One of alternative raw material that can be utilized is areca nut and sawdust.

In Bengkalis district, based on data from the Bengkalis District Statistical Center in 2015, there were 952 ha of harvest area for Areca nut plant. The benefits of areca nuts are in the seeds and stems. Currently Areca nuts have become a trading commodity to be exported to couple of countries. However, the shell of Areca nuts cannot be utilized optimally, thus increasing the amount of organic waste in the form of shell.

The making of particle boards made from areca nut shell and Mahang wood powder that mixed with urea formaldehyde (UF) adhesives was considered for resolve the increasing problem of wood used. On the other hand, it can also make areca waste more useful and economically valuable. The selection of Mahang wood powder because it was widely found in Bengkalis area, has a low selling value and includes low quality wood with E5 grade. However, Mahang wood has good tensile strength and flexural strength (Puluhulawa, I. et al 2018).

Furthermore, the composition of the urea formaldehyde (UF) adhesive to be used must be planned so that it can be produced with quality particle of Areca nut and wood powder of Mahang which suitable the quality standards of JIS A 5908 or SNI 03-2105-2006.

The main objective of the study funded by PNBP Politeknik Negeri Bengkalis in 2018 was to find out the effect of the use of variations in the quantity of adhesives on the composition of the mixture and to know the physical and mechanical properties of the particles of Areca shell and Mahang wood powder.

## 2. LITERATURE REVIEW

### a. Areca nut

Areca (Areca catechu) is a plant that is family and coconut. One type of monocot plant is classified as palm trees. Areca nut has many uses, including for consumption, cosmetics, health, and coloring materials in the textile industry. The shape of Areca is ovate, coloring red-orange and length 3.5-7 cm. This plant has fibrous in the fruit walls and slippery surface. Because of the areca are stringy so that these fibers are considered suitable to be used as raw material for particle boards. Besides that, on Bengkalis island areca shell is only a waste that is not utilized.

### b. Mahang wood

Mahang wood (Macaranga gigantea Mull. Arg.) is family of Euphorbiaceae. The general characteristics of mahang trees have a tall of trees available to 25 m and a diameter of 55 cm. The stems are straight, round, smooth-skinned with gray-brown color. Mahang wood is a relatively light type of wood, which has a relatively low durability and has a density between 0.34-0.38 (Puluhulawa, 2018). The use of this wood on Bengkalis island is only for non-structural wood because it includes light wood types.

### c. Adhesive

Adhesives are substances that have the ability to unite similar types or not through their surface bonds. The factors that influence the success of adhesion include adhesive penetration into wood, the level of surface hardness, and the multi-polymer composition and diversity of types of material glued (Putra, 2011).

Urea formaldehyde (UF) is a synthetic adhesive which is the result of condensation of urea and formaldehyde with a molar ratio of 1: (1.2-2). In general, the resin used in making particleboard has a 1.4 - 1.6 : 1 molar ratio. The adhesives of urea formaldehyde include resins that have the highest amino content and are generally used for plywood and particle board (interior) (Putra, 2011).

### d. Particle Board

Particle boards have couple advantages rather than their original wood, i.e. particle boards free of wood eyes (knot), broken and cracked. The size and density of particle board can be adjusted to the needs, thickness and density are uniform and easy to do. The others, it is have isotropic properties, properties and qualities can be adjusted. The weakness of the particle board is its low dimensional stability (Putra, 2011).

Particle board is one type of composite product or wood panel made of wood particles, or other lignocellulose materials which are bound by adhesive or other binding material then pressed hot (Maloney 1993, in Fuadi 2009).

Physical and mechanical properties according to JIS A 5908 2003 standards for particle boards can be seen in the table 1:

**Table 1.** Physical and mechanical properties of particle boards according to JIS A 5908 2003

| No | Physical and mechanical properties parameters | Standard |
|---|---|---|
| 1 | Density ($g/cm^3$) | 0.4 – 0.9 |
| 2 | Water content (%) | 5 - 13 |
| 3 | Water absorption (%) | - |
| 4 | Thick development (%) | Maks 12 |
| 5 | Modulus of Rupture (MOR) ($kg/cm^2$) | Min 82 |
| 6 | Modulus of Elastic (MOE) ($kg/cm^2$) | Min 20400 |

## 3. RESEARCH METHODS

The materials used in this study included areca nut skin from several sub-districts on Bengkalis island, Mahang wood, and urea formaldehyde (UF) adhesives. The equipment used included oven, areca shell chopper, particle board mold measuring 20x20 cm2 made of steel, Vernier caliper and Universal testing machine and clamp made of steel. The steps taken are as follows:

### a. Mixing of material

Firstly, ensure that the raw material to be used was at the standard water content < 10%. The next, collected the Areca skin until the size was smaller than 1 cm and cutting Mahang wood by cutting machine to produce wood powder. To produce fine and clean wood powder from a mixture of other materials, Mahang wood powder must be filtered by filter No. 4 (4.75 mm).

The ratio between adhesive and water was 2:1, the comparison of adhesive used for making particle board was 1:2 and 1:4 for Areca nut shell and Mahang wood powder. This adhesive can dry in 1 hour at 30˚C and harden within 5-8 hours at the same temperature. After all of the raw materials are available then mixing for one time particle board manufacture.


**Figure 1.** Particle board materials

### b. Making particle board sheets

There are four variations of the mixture used to make particle board, i.e. P200L50 and P200L100 that means areca shell compared to urea formaldehyde adhesive which are 4:1 and 4:2, the others variations are S200L50 and S200L100, it was means Mahang wood powder compared to urea formaldehyde adhesive which are 4:1 and 2:1. The comparison used was the weight ratio.

The process of making particle boards begins by mixing areca shell with wood powder into one unit evenly. Then, mixing the material with adhesive and put into a mold 20x20 $cm^2$.

### c. Pressing and Conditioning

Cold pressing was carried out for 15 minutes at a pressure of 25 kg /cm2. After that the particle board was left at room temperature while still clamped for 5 days. Next the particle board was cut according to the sample size for each test. The test results compared with the JIS A 5908 standard or SNI 03-2105-2006.

**Figure 2.** The process of pressing and conditioning of particle board

#### d. Physical and mechanical properties testing

Tests carried out based on JIS A 5908 or SNI 03-2105-2006 standards include testing of physical and mechanical properties. The type of testing, the size of specimen and the equation used can be seen in table 2 below.

**Table 2.** Types of particle board testing based on JIS A 5908 2003 and SNI 03-2105-2006

| No | Type of test | Specimens (cm$^{3}$) | Equations |
|---|---|---|---|
| 1 | Water content | 10x10x1 | $KA\ (\%) = \frac{m_1 - m_2}{m_2} \times 100\%$ |
| 2 | Density | 10x10x1 | $\rho = \frac{m}{V}$ |
| 3 | Water absorption (%) | 5x5x1 | $DSA\ (\%) = \frac{m_2 - m_1}{m_1} \times 100\%$ |
| 4 | Thick development (%) | 5x5x1 | $PT\ (\%) = \frac{t_2 - t_1}{t_1} \times 100\%$ |
| 5 | (MOR) (kg/cm$^2$) | 20x5x1 | $MOR = \frac{3PL}{2bh^2}$ |
| 6 | (MOE) (kg/cm$^2$) | Using MOR specimens | $\mathbf{MOE} = \frac{\Delta PL^3}{4\Delta ybh^3}$ |

## 4. RESULTS AND DISCUSSION

One of the factors that affect the particle board water content was the moisture content of the material, in this case areca nut and Mahang wood powder. Consequently, a preliminary testing of the moisture content of areca nut and Mahang wood powder were carried out before making particle board. As a result, water content of 3.1% and 2.3% has been obtained for Areca nut shell and Mahang wood powder.


**Figure 3.** Particle board areca nut and Mahang wood powder

**a. Test results for particle board physical properties**

**1. Water content**

According to Widarmana (1977) the water content of the particle board will be lower with increasing temperatures and quantity of adhesives used because the bonds between particles will get stronger so that water is hard to enter into the particle board.

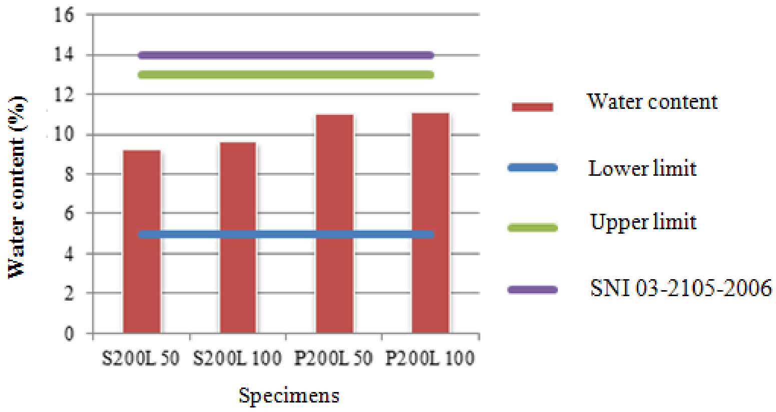


**Figure 4.** Test results for particle board water content

Figure 4 has shown that the average value of particle board water content ranges from 9.23% to 11.15%. The average value of these four particle board variations was still large because the value of the composer particles was lower, this because the adhesive used contains more water and the pressing process that uses cold press, so that the water in the adhesive material was detained in the particles composer of particle board. This average value has been included in the JIS A 5809-2003 standard which requires the particle board water content to range from 5-13% and SNI 03-2105-2006 requires less than 14%.

**2. Density**

Density is defined as mass or weight per unit volume. The density of particle board is very dependent on the density of the material to be used as well as the pressure given during the pressing process (Haygreen and Bowyer 1989). Figure 5 has been shown that the density value increases with the increase in the number of areca shells.

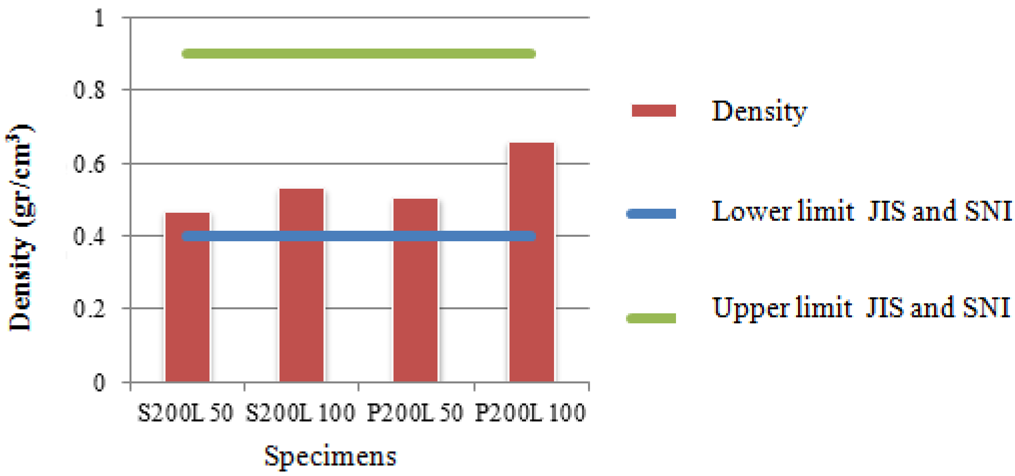


**Figure 5**. Test results for particle board density

The results of the density testing of particle boards of areca shell and Mahang wood powder have been obtained with an average value ranging from 0.47 to 0.66 gr /cm3. This value fulfill the requirements of the Indonesian National standard (SNI 03-2105-2006) or Japanese industrial standards (JIS A 5908 2003) which requires particle board density between 0.4 - 0.9 gr / cm3.

Sulastiningsih (2009) states that particle board density values are related to the concentration of adhesive used. The higher of the concentration of the adhesive will be produced the better of density.

### 3. Water absorption

Water absorption is defined as the ability of the material to absorb water. In general, the higher the thickness of development will make the higher the absorption of water, and vice versa. (Subiyanto, 2003).

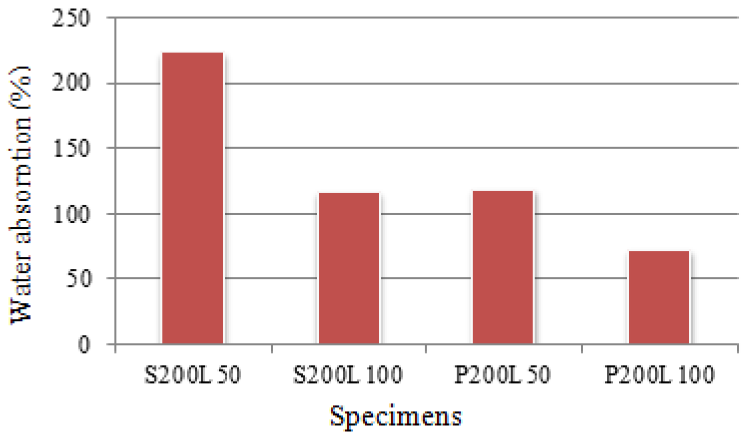


**Figure 6.** Test results for particle board water absorption

Figure 6 has shown that the average of water absorption ranges from 71.96% to 223.93%. The highest average absorptive was in the S200L50 variation of 223.93%. The particle board water absorption was not required in the standards of SNI 03-2105-2006 or JIS A 5908 2003, but the quantity of water absorption must be known because it can affect to the quality of the particle board produced.

### 4. Thick development

According to Sumardi (2004), the development of thickness has correlated with water absorption, where the higher the absorption of water cause thick development to increase. The large particles absorb more water which affects the development of the particle board produced.

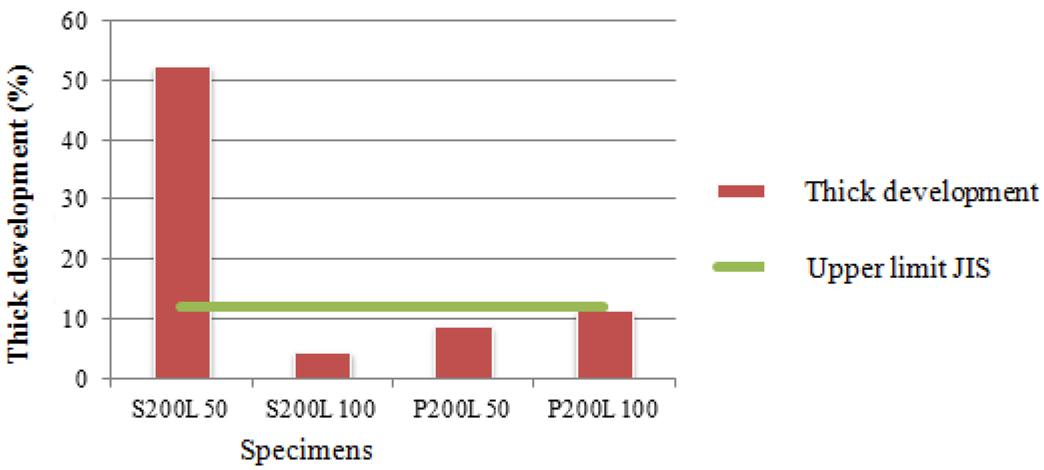


**Figure 7.** Thick development test results

Figure 7 has shown that the average development thick of particle board ranges from 4.4% - 52.48%. The S200L50 particle board has the highest thick development of 52.48% and is not fulfill the standard JIS A 5809-2003. This happens because of the minimum of the quantity of adhesive used. In addition, the shape of the composer material in the form of powder has caused the composer material not to bind to one another.

Wahyuningsih (2011) states that there was a relationship between development thick which decreases with increasing levels of resin. Thick development was influenced by factors in the number of compression given to the product during the board making process. The higher of adhesive level, the lower the thickness development. This was caused by the increasing number of adhesives using, the bonds between particles become more compact so that water was difficult to penetrate.

From Figure 5 and Figure 7 it can be said that the relationship between density and development was inversely proportional, meaning that the higher the density, the thicker the development will be lower and vice versa. This was due to the expansion of fiber cell walls of the composer material when absorbing water. Particle board with a small density causes a large amount of absorbed water because the cavities in the composer particles are not bound by the adhesive. According to Iswanto (2005) this happens because the fiber cavity that shrinks when pressing was easy to return to original size because the adhesive cannot enter the fiber cavity and binds it well.

**b. The results of testing the mechanical properties of particle boards**

**1. Modulus of rupture (MOR)**

Wahyuningsih (2011) states that MOR (Modulus of Rupture) is the ability of the specimen to resist the load to the maximum limit (fracture strength).

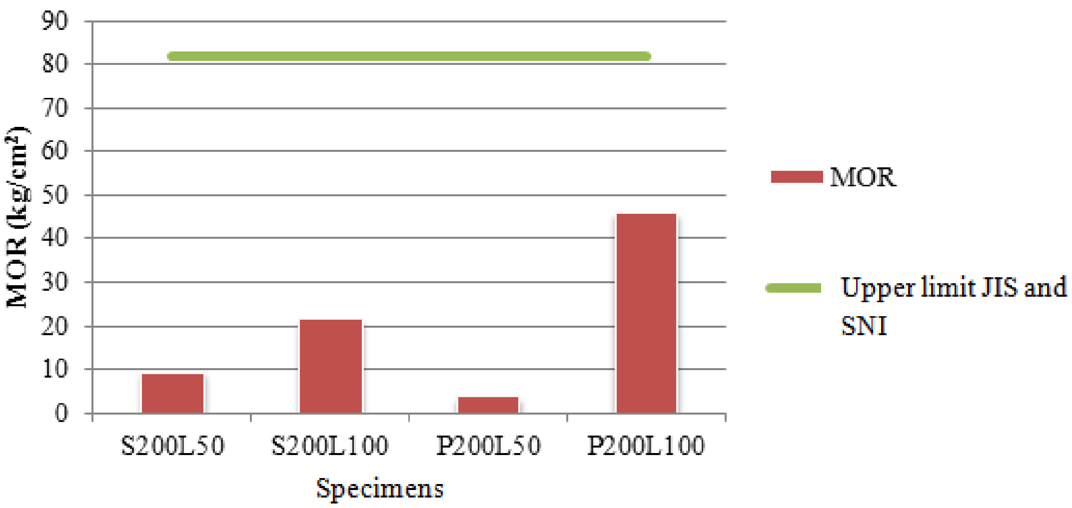


**Figure 8**. MOR test results for 4 specimens

Figure 8 has shown that the average MOR ranges from 3.56 kg/cm2 - 45.79 kg/cm2. The highest MOR was found in P200L100 specimen of 45.79 kg/cm2 and the lowest was in P200L50 specimen of 3.56 kg/cm2. The MOR result was langthy from the limit required by JIS A 5908 2003, which must be greater than 82 kg/cm2. This was caused by several factors such as the press process carried out in cold conditions, wood type, particle shape and size. Furthermore, the factors that affect the fracture persistence of particle board are wood specific gravity, particle geometry, adhesive content, water content and press procedure (Nurmawan 2007 in Putra 2011).

On the other hand, Figure 8 has also shown that the same quantity of adhesive (P200L100 and S200L100), areca shell particle board (P200L100) has a MOR value of two times that of Mahang wood powder particle board (S200L100). This shows that the use of areca shell as a composer material for particleboard can increase the value of MOR. Because areca nut shell contains hemicellulose which functions as an adhesive, so that it can increase bonding between raw materials become stronger.

According to Husin et al (2002) in Ariyani (2009) that raw materials also determine the quality of the mechanical properties of particle boards. Powdered particles will require a higher adhesive content than wood particles. Even though a higher adhesive content was used, it was possible that the mechanical properties obtained are still lower than the standard, due to the shape of the particles in the form of powder. So that even though the areca nut particle board and Mahang wood powder use the same quantity of adhesive, the mechanical properties are different and still do not fulfill the standards.

## 2. Modulus of elasticity (MOE)

The standard of MOE based on JIS A 5908 2003 and SNI 03-2105-2006 must be greater than 20400 kg/cm2.

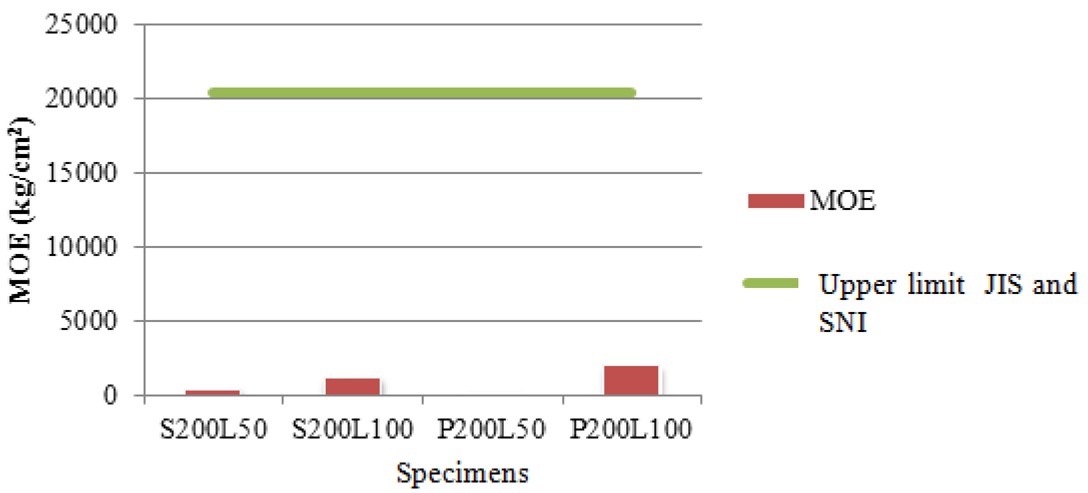


**Figure 9.** MOE test results for 4 specimens

Figure 9 shows the results of MOE testing for four particle board variations. MOE values obtained averaged between 24.7 kg/cm2 - 1914.67 kg/cm2. The highest average MOE value was found in P200L100 of 1914.67 kg/cm2 and the lowest in P200L50 was 24.7 kg/cm2. The overall of MOE has not met the limits of the standard.

In addition, it has been known that the small adhesive content produces particle boards with a low MOE value. This shows that the adhesive content can affect the quality of the particle board.

According to Putra (2011) the size of various compiler particles can reduce the modulus of elasticity of particle board, this occurs because of the high dust content caused by these variations. The impact was that the adhesive distribution was uneven and most of adhesive covered the surface of the dust so that the bond between the particles was less compact.

## 5. CONCLUSION

a. The use of larger levels of adhesives on the particle board can improve physical and mechanical properties.
b. The physical properties of particle boards of areca nut shell and Mahang wood powder have met the existing standards, unless in the sample of S200L50 the thick physical development properties did not meet the standards. The others, mechanical properties of all specimens did not fulfill the standards.

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