Mechanical Properties of Coconut Particle Board with Variation of Material Composition

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ABSTRACT

The research carried out is a laboratory experimental research with make particle board from coconut coir, with variations in the composition of fibers and powders used are 100 % - 0%, 90 % - 10 %, 80 % - 20 %, and 70 % - 30 % using urea formaldehyde adhesive in order to determine the mechanical properties, and find a good composition of coconut coir particle board. Sampling was carried out at the Forestry Laboratory of the Muhammadiyah University of West Sumatra. The tests were carried out at the Civil Polytechnic Laboratory of Unand, and at the Agricultural Product Technology Laboratory of Unand. The independent variables in this study were thickness and composition variation. The dependent variable is density, flexural strength or MOR. Control variables are temperature, adhesive content, particleboard thickness, compression pressure, and drying time. Data were taken by repeated measurements of 5 samples. Based on the results of the research that has been carried out, it was found that the use of coconut coir powder particles as an outer coating for particleboard at different percentages has an influence on the mechanical properties of the particle board. From the results of the study, it was found that particleboard with a composition between fiber and coconut coir powder (90% - 10%) was the best result because the less powder used resulted in good mechanical properties with a density of 0.52 g/cm³ and flexural strength or MOR 159, 43 Kg/cm².

Keywords: Particle Board, Urea Formaldehyde, Compressive Strength

INTRODUCTION

The human need for wood makes forest exploitation happen on a large scale (Dewi, I.N., 2018). This problem is a serious problem, especially the Indonesian people who live in West Sumatra. As a result of massive forest exploitation, the forest is deforested. Deforestation is the main factor in the occurrence of disasters, including floods, erosion, and even warmer the problem of global warming. The community's high demand for wood has resulted in high levels of illegal logging or better known as illegal logging (Enjang, S., 2022). Until now, most of the demand for wood is still met from natural forests.

To overcome the shortage of wood as an industrial raw material as the basic material of the boards needed by the community for building construction materials and other equipment is particle board. Particleboard is usually made of sawdust or wood waste which is used as
the base material for making it (Laksoni, A. D., et al, 2021). With the scarcity of wood in West Sumatra, automatically sawdust is difficult to obtain. To overcome this, it is necessary to think about making a new type of particle board by replacing the basic material of the particle board using coconut fiber. Irfandi (2018) in his research stated that coconut powder particle board can be used as an alternative raw material for composites to replace wood.

Coconut coir has also been developed for the manufacture of particle board, but there are still obstacles such as the size of the coconut coir which is still rough and the surface of the resulting particle board is uneven (Ilyas, M., & Hernawati, H., 2019). To overcome this, one way that can be done is to coat the outer layer with coconut coir particle board with powder particles from the coconut coir. The function of the outer layer of the particle board is to improve the surface so that the surface of the particle board is smoother so that when coated with mica the mica will stick evenly and not easily come off, besides that it is expected to further increase the strength of the mechanical properties of the particle board (Bangun, E., 2021).

In this study, a particle board was made using Urea Formaldehyde (UF) as an adhesive. Sutiawan, J., et al (2020) in their research found that the best mechanical properties were owned by boards made with Urea Formaldehyde (UF) adhesive. Urea Formaldehyde (UF) has an effect on thickness expansion, water absorption, increasing fracture modulus, and increasing elastic modulus (Hardiyanti, N., et al., 2019). According to the results of Suryadi, I (2010) research using Surian wood sawdust particles with a bond content of 22% for powder and 18% for fiber, with this level of attachment the particles are not easily separated, therefore the researchers used adhesive levels according to the results of previous studies, while the composition ratio used is 100% - 0%, 90% - 10%, 80% - 20%, and 70% - 30%. Based on the above background, a research entitled Mechanical and Physical Properties of Coconut Coir Particle Board with Variation in Material Composition was conducted.

**Problem of Research**

Based on the background of the research above, a problem can be formulated, namely How is the flexural strength and density of particle board made from coconut fiber with variations in the composition of fiber and powder.

**Research Focus**

1. To find out the flexural strength or MOR coconut coir particle board with various compositions between fiber and powder.
2. To determine the density of coconut coir particle board with variations in the composition between fiber and powder.
METHODOLOGY OF RESEARCH

General Background of Research
The research is a laboratory experimental research. In this experiment, a sample of particleboard was made with coconut coir as a base material by mixing fiber, powder with adhesive, after the sample was ready for the next process to collect data, the data was taken in the form of testing the flexural strength and density of coconut coir particle board, then analyzed the data, drawing conclusions. and compiling reports on the results of research conducted.

Subject of Research
Research takes place at the Faculty of Forestry Laboratory of Muhammadiyah University of West Sumatra (UMSB), in the form of making a particle board sample with a thickness of 1 cm, using urea formaldehyde as an adhesive. The place for testing mechanical properties is carried out in the Civil Polytechnic Laboratory of Andalas University.

Instrument and Procedures
Before conducting research, it is better to prepare the materials that will be used when conducting research. The material used is coconut coir, in the form of fiber and coconut coir powder with a separation process produced by PT. Tata Coco Fiber, after the separation is carried out, weigh the material with the ratio of fiber and powder as:

a. Comparison of fiber and coconut coir powder.
Comparison of the composition used in the study between fiber and powder as follows:
A= 100% coconut fiber 0% coconut powder
B= 90% coconut fiber 10% coconut powder
C= 80% coconut fiber 20% coconut powder
D= 70% coconut fiber 30% coconut powder

b. The content of the bond used in this study was 22% for powder and 18% for fiber.
The additional material used is NH4Cl as much as 1% by weight of Urea Formaldehyde adhesive. The addition of NH4Cl so that the drying process on the particle board is fast.

Particleboard Manufacturing Process
According to Kollmann (2012), the principle of making particleboard is by mixing the adhesive and coconut fiber in the form of fiber and powder or other lignocellulosic fibers. Meanwhile, according to Haygreen and Bowyer (1989) added, the process of making particleboard is: particle preparation, particle drying, mixing, forming, pressing and refinement. Particle preparation is carried out by cleaning the particles, after which it is continued by drying the particles to a moisture content of 2-5%. The dried particles are then mixed with adhesive, then formed. The material that has been formed is then pressed and then refined in the form of cooling or curing for 7 to 14 days in order to avoid damaging the
adhesive. In the process of making particleboard, researchers carried out the same process according to Haygreen and Bowyer, so that the results of particleboard met the Indonesian National Standard.

**Table 1. Material Composition**

| No | Ingredients (%) | Material Weight (grams) | Urea Formaldehyde Adhesive (UF) (grams) | Ammonium Chloride (NH4Cl) (grams) |
|----|-----------------|-------------------------|------------------------------------------|----------------------------------|
|    | Fiber Powder    | Fiber Powder            | 18% fiber 22% Powder 1%                 |
| 1  | 100 0           | 814.93 0                | 146.69 0                                 | 1.46                             |
| 2  | 90 10           | 733.32 81.49            | 132 19.55                                | 1.51                             |
| 3  | 80 20           | 651.94 162.98           | 117.35 39.11                             | 1.56                             |
| 4  | 70 30           | 570.45 244.48           | 102.68 58.67                             | 2.41                             |

Table 1 is the result of calculations in making particle board from coconut fiber with various variations and the use of the adhesive used and in accordance with the chart below:

**Figure 1. Experimental Procedure Diagram**
Data Analysis

Data analysis begins by making a description of the Experiment data. From the description of the data, a table of values for density, flexural strength or MOR (Modulus of Rupture) can be made. Data analysis by looking at the average results of testing the mechanical properties of coconut coir particle board.

RESULTS AND DISCUSSION

Particleboard according to Maloney (1993) is a type of composite product or wood panel made of wood particles or other lignocellulosic materials, which are bonded with adhesives or other binding materials and then pressed. Based on their density, particleboard can be divided into several groups, namely (Ministry of Forestry, 1997):

a. Low Density Particleboard, ie the board has a density of less than 0.4 g/cm$^3$. This particle board has properties as an insulator against heat and sound, and can be used for furniture that does not require high strength.

b. Medium Density Particleboard, namely particleboard with a density between 0.4-0.8 g/cm$^3$. These boards are mainly used for panels and furniture. Judging from the point of view of its strength and the use of adhesive materials, this type of board is good and widely produced.

c. High Density Particleboard, namely particleboard that has a density of more than 0.8 g/cm. This board is mainly used for panels that require high strength.

From the distribution of particleboard density values, researchers can find out the properties of particleboard and the uses of the particleboard. The density value will affect the mechanical properties and physical properties of the particleboard. The density value to be achieved in the study is the medium density value.

In the manufacture of particle board is very important because it is to overcome the scarcity of wood. More and more wood is cut down causing environmental damage so that it will disrupt the ecosystem. In this case, it is necessary to use agricultural waste that is no longer used to become useful material for the community.

The Indonesian National Standard (SNI 03-2105-2006) stipulates the quality requirements of particle board which can be seen in Table 2

| Physical-mechanical properties of particleboard |
|-----------------------------------------------|
| **Sifat Fisik-Mekanis Papan Partikel** | **JIS A 5908** | **SNI 03-2105** |
| Water content (%) | 5 - 13 | < 14 % |
| Density (g/cm$^3$) | 0.4 – 0.9 | 0.5 – 0.9 |
| Thick development (%) | Max 12 | Max 12 |
| Flexural strength (kgf/cm$^2$) | Max 82 | Max 80 |
| Elastic Modulus (kgf/cm$^2$) | Min 2.04 x 10$^4$ | Min 1.5 x 10$^4$ |
| Tensile strength perpendicular to the surface(Kgf/m$^2$) | Min 1.5 | Min 1.5 |
| Hold the screw firmly (kg) | 31-51 | 30-50 |
According to Achmadi (1973) cit Harmi (2006), some of the advantages of particle board compared to ordinary particle board are that the length and width directions are not different, have a hard and strong surface, are not easily broken or damaged, do not contain defects such as those caused by fungi. good acoustic properties, as a good insulator and easy to shape and bend. The properties of the coconut coir particle board are different from the properties of other particle boards, therefore the coconut coir particle board is durable and strong.

According to Haryanti, N., et al (2019) coconut fiber consists of fibers and the cork that connects one fiber to another is a valuable part of the coir. Each coconut contains 525 grams of fiber (75% of coir), and 175 grams of cork (25% of coir).

According to Eddi and Shinagawa (1982) cit Siburian (2009), old coconut fiber has 33.74% alpha cellulose, 37.80% lignin and 4.49% ash. Rizal (2002), added that coconut husks contain 33.06% lignin and 38.91% alpha cellulose and for hybrid coconuts it contains 33.35% lignin and 36.68% alpha cellulose.

According to Novizar (1988), adding urea adhesive is included in the thermosetting adhesive, meaning that the adhesive material can harden when heated at high temperatures but after hardening cannot melt when heated again.

According to Reymon (1974) and Laksono, A. D., et al (2021), the characteristics of urea formaldehyde resins are: it has a distinctive urea odor, the color of the liquid is milky white, the specific gravity at a temperature of 30˚C is 1.18 to 1.20, the pH is 6.8 to 7.5, the viscosity is at a temperature of 1.18 to 1.20. 30˚C and can be stored up to 720 hours or ± 30 days at 30˚C.

According to a technical report at the end of 2006. UPT BPP biometal-LIPI, the use of urea formaldehyde adhesive was chosen, because based on research on particleboard using urea formaldehyde adhesive, its mechanical strength is better than phenol formaldehyde adhesive, besides that the price of the adhesive is cheaper than the adhesive phenol formaldehyde.

1. Mechanical Properties Test Results Data

The test data for the mechanical properties of particleboard is the flexural strength or MOR, (Modulus of Rupture)will be explained as follows:

a. Flexural Strength Test or MOR (Modulus of Rupture)

MOR (Modulus of Rupture) shows the strength of the wood to withstand the load. The results of the analysis showed that the variation in the composition of the fiber and coco powder had an effect on the flexural strength or MOR (Modulus of Rupture) of the particle board. To see the effect of composition variations with the average MOR (Modulus of Rupture) of particleboard, see Table 3.
Table 3 shows that the higher the powder used in the manufacture of particle board, the lower the MOR (Modulus of Rupture) results, because coconut fiber powder does not have a strong binding capacity. The MOR value ranges from 111.07 kg/cm² up to 159.43 kg/cm².

Based on the table above, the more powder, the flexural strength or MOR will decrease and the more fiber used, the value of flexural strength or MOR, the stronger. This is because the function of the fiber in the sample is as a reinforcement, while the powder acts as a surface lubricant for particleboard. Flexural strength also increases with increasing density of the resulting particle board. Suryani, R., et al (2019) in their research found that the value of the flexural strength of particleboard is directly proportional to the density value. This is in accordance with the theory presented by Haygreen and Bowyer (1989). In addition, the use of fine coco powder for the outer layer makes the bonds between particles even more compact. This is in accordance with the opinion of Haygreen and Bowyer (1989), that smaller particles are the best for the surface layer when good strength and a smooth surface are required.

Coconut coir has several properties, namely durable, strong against friction and not easily broken, resistant to water (not easy to rot), resistant to fungi and pests and not inhabited by termites and rats, besides that it also has heat-resistant properties and a strong test. Indirect tensile, its strength is comparable to steel (Hadari, 1994; Ilham, I., et al, 2019).

b. Density

Based on the test results, the results showed that the density of particleboard with variations in the composition of powder and coco fiber had no significant effect on the density of particleboard. Density data for each treatment can be seen in Table 4.
From table 4 above, it can be seen that the density value of particleboard ranges from 0.52 g/cm³ to 0.55 g/cm³. According to the Ministry of Forestry (1997), this particle board includes medium density particleboard because its value ranges from 0.4 g/cm³ to 0.8 g/cm³. The results of the density of the particle board being medium density, the particle board from coconut fiber can be used for furniture or study tables. The more powder used, the lower the density value. This is because the more powder, the larger the volume, so the density is small. According to Haygreen and Bowyer (1989) Density affects the physical and mechanical properties of particleboard, the higher the density of particleboard the higher its strength, but the properties of particleboard such as dimensional stability decrease with increasing density. According to Rahmadhanti, D., & Susilowati, A. (2019), increasing density will result in an increase in other properties. In general, it can be concluded that the higher the density value, the higher the strength of the particle board.

2. Flexural Strength Data Analysis or MOR

In the test results, the average flexural strength or MOR can be seen that the smaller the ratio of powders used, the higher the MOR test results. It can be seen in the graph of the relationship between variations in the composition of fiber and coconut coir powder on the MOR of particleboard for each comparison, which can be seen in Figure 2.

![Graph of Relationship Between Flexural Strength or MOR of Particle Board on Percentage of Variation in Composition of Powder and Coir Fiber.](image_url)

**Figure 2.** Graph of Relationship Between Flexural Strength or MOR of Particle Board on Percentage of Variation in Composition of Powder and Coir Fiber.

In Figure 2 it can be seen the relationship between composition variations between fiber and powder with the average MOR of each composition producing different values or the more powder used, the lower the flexural strength or MOR.
3. Density Data Analysis

Based on the data from the test results of the density value of the coconut coir particle board in Table 4, the results can be seen in the graph of the relationship between variations in the composition of fiber and coconut coir powder on the density of particleboard for each treatment can be seen in Figure 3.

![Graph of Relationship Between Particle Board Density on Percentage of Variation in Composition of Powder and Coir Fiber.](image)

**Figure 3.** Graph of Relationship Between Particle Board Density on Percentage of Variation in Composition of Powder and Coir Fiber.

In Figure 3 the value of particleboard density for each composition variation between fiber and powder decreases. The more use of powder, the density value will decrease. This is following the results of research conducted by Rahmadhani, D & Susilowati, A (2019) that the more content of coco fiber added, the smaller the density value produced. The results of the density of the particle board being medium density, the particle board from coconut fiber can be used for furniture or study tables according to research (Harmi 2006).

**CONCLUSIONS**

Based on the research that has been done, it can be concluded that flexural strength or MOR of coconut coir particle board with composition variations between fiber and powder ranging from 111.07Kg/cm² up to 159.43Kg/cm². The MOR value of the coconut coir particle board has complied with SNI 03-2105-2006. The more powder ratios, the lower the flexural strength or MOR. The density of coconut coir particleboard with various compositions between fiber and powder ranges from 0.52 g/cm³ to 0.55 g/cm³. The density value of the coir particle board produced has met the Indonesian national standard SNI 03-2105-2006. The more powder, the lower the density.

From the conclusions above, the manufacture of particle board is very possible to make a table made of wood and the results are relevant and in accordance with the theory in the
discussion. Based on the research that has been done, there are still many mistakes and shortcomings in the research. Therefore, it is recommended to continue this research on the composition of coco fiber and the optimal use of adhesive for the outer layer (coconut coir powder) and variations in adhesive composition.

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