Particle Board Made From Areca Fiber With Tapioca Adhesive

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Abstract. The development of engineering materials, has increased its use in various fields. Engineering material which is a combination of various materials that can be made into a product, namely particle board. Areca nut has the potential to be engineered material. Development of various technological processes in the use of areca fiber waste into particles Development of particle board made from areca fiber as an interior material that has the ability and light weight as a substitute for wood. In making this particle board, areca fiber is made of particles and combined with tapioca adhesive. Optimizing the concentration of a mixture of particles and adhesives used to obtain the characteristics of newly developed materials. The results of particle board testing made from areca fiber with tapioca adhesive are valued for characteristics that meet JIS A 5908-2003 and SNI 03-2105-2006 quality standards. So that the areca fiber reinforced particle board can be used as raw material for furniture making as needed as a substitute for wood.

1. Introduction

The development of engineering materials causes its use to increase so it takes engineering materials into a product that is particle board. Particle board from lignocellulosic materials obtained from various non-wood plant wastes and given an adhesive then pressed so that it has the ability like wood. According to SNI [1], particle boards are the result of a mixture of hot compressed wood particles or other lignocellulose materials with organic adhesives. Plants that contain lignocellulosic material derived from non-wood namely areca catechu which have not been used maximally and are very potential to be used as engineering material. Areca palm is a palm plant as a commodity with many benefits that have fiber and seeds contained therein. Utilization of areca nut plants is only limited to betel nuts, namely as ingredients for medicines, cosmetics, coloring, and so on. The rest of the extraction of betel nuts in the form of fiber will be wasted and untapped waste. So that in areca-producing areas, this has an impact on environmental pollution and when burned impacts on air pollution. The areca fiber waste is very possible to be used as engineering raw material. Can be imagined during the harvest season, betel nuts that have separated seeds and fiber will leave an abundant waste to be destroyed. The impact of the existence of waste which causes problems to the environment thus encouraging engineers to recycle the waste again. The existence of this engineering material encourages engineers to deepen it so that it can be mass produced as needed by utilizing agricultural crop waste which has been a problem also in the environment in the community. With this basis the utilization of areca fiber waste can be developed in the technological process so that there is a diversification of the utilization of waste into engineered material in the form of particle boards.

Particle board engineering innovation is due to its renewable features that can reduce the impact of environmental disturbances. Through the improvement of process technology and potential plant waste production so as to obtain advanced materials that have benefits. Innovation of engineering
materials in the form of particle boards made from areca fiber waste as a substitute for wood furniture is very possible. The process of making particle board uses a compacting system with optimization of the composition of the mass fraction in an effort to obtain new material as an engineering material.

Research on the use of plant waste has been carried out. Research on tea leaf waste can be used as an alternative material either alone or in combination with wood particles for the manufacture of particle boards [2]. One of the most important reasons for the increasing trend in the production of natural fiber composite is due to easy economical disposal of the wastes [3]. The composite board of bagasse waste has good and potential strength and deflection behavior as a substitute for wood on interior furniture [4]. The bagasse waste-based composite board obtained density characteristics of 0.41 gr/cm$^3$, 2.1% water absorption with the development of a thickness of 9.09% while drawing composite particle boards that met standard quality [5]. Development of further research on bagasse fiber-based particle composite boards using resin adhesives which yield tensile strength of 1.81 MPa, with strain 13.52% [6]. The characteristics obtained are recommendations for furniture manufacturers as the development of furniture materials in accordance with SNI standards [1].

Development of particle board based on areca fiber waste which is produced further so that sustainable research is needed at a more specific stage. This study aims to obtain a particle board model based on areca fiber waste as an interior furniture raw material which has quality characteristics according to the standards of JIS A 5908 (2003) [7] and SNI 03-2105-2006 [1]. In obtaining particle board products according to quality, a manufacturing method is required using a hot press (compacting) system with the feasibility of production capacity. Areca-fiber waste particle board based on the development of a new material model as the main material for interior furniture can be applied to the wider community.

2. Research Methods
The research carried out, focused on experiments in obtaining particle board characteristics related to the quality test of the resulting particle board. Experiments carried out to find out and get observational data. The method of implementing particle board manufacturing begins with preparing areca nut shell waste (Figure 1) that has dried. Areca nut shells are then chopped and made into particles or grains (mesh) measuring ± 0.6 mm (Figure 2) using a disk mill machine.

Figure 1. Areca Nut Skin
Figure 2. Areca Fiber Particles

Figure 3. Tapioca
In the manufactured of particle board, the adhesive used is tapioca (Figure 3). The use of variations in the volume fraction ratio of areca nut particles with concentrations of 90%, 80%, 70%, and 60%. Areca fibre particles and tapioca are mixed in a container which is then stirred with the addition ± 250 ml of water. Stirring the mixture is done manually until evenly distributed. Then the mixture is transferred to a 250mm x 250mm x 12mm mold which is coated with aluminum foil. The printing process is then compressed with a pressure of 100kg/cm$^2$ with a holding time of 60 minutes so as to get a particle board model for interior furniture. The removal of the product is continued by heating the particle board to the oven at a temperature of 120 °C for 60 minutes. The particle board that has finished heating is followed by the drying process with sun drying for 4 days (Figure 4).

![Figure 4. Particle board produced](image)

The next step, cutting the particle board as a test sample in accordance with standard [7] as shown in Figure 5. The tests carried out in this study were in the form of measuring the characteristics of the particle boards produced so that were expected to be close to the standard values of the particle boards. The particle board characteristic test parameters include the development of particle board density, thickness on water absorption, thickness development, modulus of elasticity (MoE), modulus of rupture (MoR), strong screw hold in accordance with standards JIS A 5908-2003 [7] and SNI 03-2105-2006 [1]. Description of the test carried out in the form of data results by means of measurement and testing. Next do the calculation analysis and tabulate the test results.

![Figure 5. Cutting pattern of test sample](image)

Caption:
A. Examples of density tests
B. Example of water content test.
C. Examples of air absorbency and thick development tests.
D. Example of screw holding strength test.
E. Examples of Modulus of Elasticity (MoE)
F. Examples of Modulus of Rupture (MoR).
The method of processing the test data is done by statistical analysis and mathematical analytical calculations that apply several equations. The theoretically calculated mathematically generated can be expressed as a statement of the various characteristics of the particle board of the test object.

3. Result And Discussion

In this research the process of making particle board as many raw materials as possible is prepared. The need for raw materials in the form of areca fiber particles is calculated by predicting the large number of variations of made particle boards. Variation of mixture mixture between areca fiber particles and tapioca adhesive is prepared in large quantities so that the test data is more significant. In addition, it is intended to make it easier to describe and find the optimum variation produced as a particle board prototype model that can be further analyzed. In the manufacture of particle boards obtained several physical prototypes as development products. From the analysis conducted on particle board made from areca fiber raw, several characteristics were obtained according to quality standards. The characteristics of the particle board are shown in Table 1.

| Particle Board | Density (gr/cm³) | Water Content (%) | Water Absorption (%) | Thickness Development (%) | Modulus of Rupture (MoR) (kg/cm²) | Modulus of Elasticity (MoE) (kg/cm²) | Strong Screw Hold (kg) |
|---------------|------------------|-------------------|----------------------|--------------------------|-----------------------------------|-------------------------------------|-----------------------|
| Areca Fiber   | Tapioca          |                   |                      |                          |                                   |                                     |                       |
| (%)           | (%)              |                   | (%)                  | (%)                      | (%)                               | (%)                                 | (%)                   |
| 90            | 10               | 0.38              | 9.58                 | 168.02                   | 13.97                            | 3.92                                | 552.29                | 1.19                  |
| 80            | 20               | 0.45              | 8.97                 | 121.66                   | 11.70                            | 18.20                               | 1837.44               | 3.68                  |
| 70            | 30               | 0.57              | 8.55                 | 71.98                    | 8.04                             | 40.61                               | 3475.39               | 7.19                  |
| 60            | 40               | 0.71              | 8.05                 | 51.19                    | 5.78                             | 73.31                               | 4761.68               | 12.88                 |

The results of tests conducted on the particle board produced, the average density value of 0.38 to 0.71 gr/cm³ was obtained. This refers to the standards of JIS A 5908-2003 and SNI 03-2105-2016 namely the particle board density standard is 0.4 - 0.9 gr/cm³. The highest particle board density values were obtained in the composition of the variation of the concentration of areca fiber particles of 60%. Particle board that has this density value uses 40% tapioca adhesive concentration so that it affects the adhesion between the particles. The more adhesive content on the particle board, the higher the density value it has. According to Saddikin, 2019 [8] in his research stated that the more adhesives used were the higher the strength and density of the particle board. This happens because the use of adhesives causes maximum bonding between particles and adhesives. The compacting process in particle board manufacturing has an impact on the strengthening of bonds between particles so that the particle and the adhesive get closer together. This is reinforced by the statement of Sutigno, 2000 [9] that the amount of material, the state of the material, and the compression technique affect the results of the particle board density. In addition, the use of the type of adhesive in the process of making composite boards greatly affects the density value of the resulting particle composite board [10].

Another parameter is the value of water content at the concentration of areca fiber 60% obtained 8.05%, with a thick development value of 5.78% as shown in Table 1. The results obtained have met the quality standards set by JIS A 5908-2003 namely levels water 5 to 13% and SNI 03-2105-2006 i.e. <14%, and thickness development of 12%. From the results of the test analysis (Table 1) shows the higher the concentration of the adhesive used, the lower the water content value and the thick development of the resulting particle board. This is in accordance with Mawardi's statement, 2010 [11] that particle board with a minimum adhesive composition has a much higher application value compared to more adhesive compositions. In addition, the nature of thick development correlates with the nature of water absorption, where the higher the water absorption capacity the thick development is increasing [12]. Large particles are easier and absorb more water, thereby affecting the development of the resulting particle board.
In the measurement of the Modulus of Rupture (MoR) value of the areca nut fiber concentration of 60%, a value of 73.31 kg/cm² was obtained. This when compared with the concentration of other areca fiber particles, a concentration of 60% can be recommended. These results approach the value of JIS A 5908-2003 quality standards. From the analysis conducted shows the level of adhesive use can affect the strength of particle board the higher the adhesive level used, the higher the modulus of rupture value. The concentration of the use of adhesives in the manufacture of particle board is directly proportional to the modulus of rupture, so the higher the adhesive content the greater the modulus of rupture of the particle board [13].

The Modulus of Elasticity (MoE) value of all concentrations in particle board manufacturing obtained an average value of 4761.68 kg/cm² at a concentration of 60% fiber particles. So that the particle board's ability to experience elastic deformation when the force is applied to the particle board at a threshold according to the value obtained. This result also shows the particle board rigidity is very good so that the static load that can be applied to the surface of the particle board is also large. From this picture, it can be seen that what affects the wet MoE value is the adhesive resistance to water. The type of adhesive used in making particleboard can have a very significant effect on the mechanical properties of particle board while the type of wood (plant) is not real [14].

The mechanical properties of particle board that shows the strength of the board in holding the screw against the pull force from the outside is the screw holding strength. The mean value of holding strength of particle board screws produced with varying concentrations of fiber particles was obtained from 1.19 to 12.88 kg. The test results obtained from particle board testing made from areca fiber and tapioca adhesive where the mechanical properties of the particle board close to the suitability of the particle board quality standards. The strength of holding screws is determined by the density of the board, the higher the density of the board, the higher the holding strength of the screw [15]. Particle board density is affected by the concentration of the adhesive used which can make the bond stronger between the particles so that the screw holding value increases.

Based on the measurement and analysis of test data on the characteristics of particle boards made from areca fiber already meet the quality standards of JIS A 5908-2003 and SNI 03-2105-2006. So that the areca fiber reinforced particle board can be recommended as a raw material for making furniture in (interior furniture) that is not directly exposed to water and is in a dry room.

4. Conclusion
The conclusions of the study obtained the results that stated the average particle board characteristics meet the standards of JIS A 5908-2003 and SNI 03-2105-2006 where the particle board has a density value of 0.71 gr/cm³, with a moisture content of 8.05%, water absorption 51.19% and thick development 5.78%. As for the Modulus of Rupture (MoR) average of 73.31 kg/cm² with a Modulus of Elasticity (MoE) value of an average of 4761.68 kg/cm² and a screw holding value of 12.88 kg. The characteristics of this particle board are produced in a variation of 60% concentration of areca fiber particles and a variation in the concentration of 40% tapioca adhesive.

The concentration of tapioca adhesive used in the manufacture of particle board has a significant influence on the physical and mechanical properties of the resulting particle board. Particle boards with higher adhesive content have better physical and mechanical properties than particle boards with lower adhesive content.

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