Modifying Of Particle Boards From Rice Husk and Pinus Merkusii Sawdust And Using Soybean Waste Waters Based Adhesive.

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Abstract. Research of modifying particle board has been prepared by mixing of pinus merkusii sawdust and rice husk, where used of adhesive base on Boiled Soybean Water (BSW) has been done. The research utilize the rice husk and sawdust pines mixed, and used of a renewable and environmental adhesive to replace the toxic and carcinogenic one. The testing of adhesive included are; colour, pH, solid contain, gelatination time, density and viscosity. Result showed yellowish colour, 10 of pH, 44.70 % of solid contained, 56.29 minutes of gelatination time, and 1.1656 g/cm³ and 182.4387 cP of viscosity respectively. While the particle boards testing include are density, moisture, immersion, thickness, Modulus of Rapture (MOR) and Modulus of Elasticity (MOE). The particle board best ratio it was 1:4 (Rice husk: pinus merkusii sawdust). Result of each parameter are, 0.7735 g/cm³ of density, 5.79 % of moisture, however the immersion for 2 hours is 26.90 % and immersion for 24 hours is 39.77 %, 101.1592 kg/cm² of MOR and 18,248.3063 kg/cm² of MOE.

The summery, the adhesive based on SNI 06-4567-1998 and the particle board based on SNI 03-2105-1996

1. Introduction
Indonesia is well-known as one of the forest areas in the world, but lowest supplier of furniture compare with Italia and China. The furniture productions in Indonesia has not optimal to supply necessary of world markets yet. Whereas, Italia and china has little raw material, but they can be supply necessary of world markets [1].

Based on the forestry of statistics in 2011, the progress of export products of forest in last five years, especially particle board, be through a fluctuating production. It is caused by many factors, dominated by particle board low quality which produced by woods industries in Indonesia [2].

In Indonesia the particle board generally has produced with using of formaldehyde based woods adhesives, like Urea-Formaldehyde (UF) and Phenol-Formaldehyde (PF). Whereas, they are carcinogenic for human [3]. The formaldehyde emission which carcinogenic, it is require to develop an environmental friendly and renewable adhesive [4].

Therefore, many scientists looking for an non carsinogenic adhesive. An example, Liu 2014 who has modifying soy protein become good and waterproof wood adhesives [4].
The others alternative, where using waste liquids from industries of tofu and tempe that contains percentage of protein is high sufficiently. It has not utilized by people, so that can be contaminate environment in the industrial area. Because industries of tempe and tempe just the little industry, so that it has not water treatments [5]. In this research were used Boiled Soybean Water (BSW), to make efficient in making process of particle board which according of Indonesia National Standards (SNI).

On the other hand, waste of rice husk and sawdust has not been utilized optimally by people. So that, economic value has not been increased yet. Based on the Statistic Centre Institution (BPS), production of rice plant in 2010 reaches 64.90 million tons rice husk. Process of rice plant milling produced rice husk between 20-30 %, husk between 8-12 % and rice between 50-63.5 % [6]. Therefore, we can see the most waste is rice husk in each year. So that, this research utilized it as one of the raw material in particle board.

Similarly rice husk, sawdust has taken from sawmill waste, was pinus merkusii, in PT Nelly Jaya Pratama, Tana Toraja. According of survey which has done in the PT Nelly Jaya Pratama, veneer s has produced as 72 % from raw material and sawdust as 28 % from raw material. It was not utilized by that industry although people in the industrial area [7]. Therefore, this research utilized it as raw material also. Besides base material from soybean which environmental and used waste rice husk and sawdust as raw materials for increasing economic value it.

2. Materials and Methods
2.1 Materials
The materials used in this research include: soybeans, rice husk, pinus merkusii sawdust, aquadest, sodium hydorxide 40 %, glycerin, gelatine, SiO2 solution, acetic acid 5 %, pine latex, tissue roll and detergent.
2.2 Apparatus
The apparatus used are, analytical balance model NO AP 110, pycnometer 25 mL, stopwatch, viscometer ostwald canon 400, bulb, pumpkin spray, hot plate, grinder, oven, pH universal, FT-IR model SHIMADZU 820 1PC, UTM (Universal Testing Machine), SEM-EDX Tescan Vega3SB and glass tools which are generally used in the laboratory.
2.3 Procedures
2.3.1 Preparation of Adhesive Based Boiled Soybean Water
Soybean weighed as 40 g, added aquadest to 300 mL, and then boiled for 30 minutes and filtered. Filtrate that soybean taken as 60 mL and boiled. And then, gelatine was added as 20 g and homogenized to soluble. Glycerin was added as 25 mL while homogenized to coagulate. Acetic acid 5 % was added as 12 mL. Latex of Pinus merkusii was added as 33 g while homogenized. Sodium hydroxide 40 % was added dropwise as 8.5 mL while homogenized to coagulate. SiO2 solution was added as 4.5 mL to homogen. Each addition of reagent analyzed interact happen using FT-IR model SHIMADZU 820 1PC.
2.3.2 Test of Adhesive Based Boiled Soybean Water
The test of quality the adhesive based Boiled Soybean Water according of SNI 06-4567-1998. Parameter of testing are appearing colour, pH, solid contain, gelatination time, density and viscosity.
2.3.3 Preparation of Particle board Raw Materials
Rice husk immersed for 24 hours and then boiled for 2 hours. Rice husk dried at room temperature and grinded using grinder. Moisture contain determined for working-out raw material that used in manufacture of particle board.
Sawdust dried at room temperature. Moisture contain determined for working-out raw material that used in manufacture of particle board.
2.3.4 Determined Ratio of Rice Husk and Sawdust as Particle board materials
Respectively rice husk and sawdust weighed with ratio 0:1; 1:4; 1:2; 1:1; 2:1; 4:1 and 1:0 with total both of them as 491.07 g based on oven dry weight. Respectively of ratio was homogenized, and then mixed with adhesive has been made and homogenized. It put into block sized 25 x 25 x 1 cm. And then, it made the process of pressing, conditioning and cutting the sample test.
2.3.5 Test of Physical and Mechanical Properties
Test of quality the particle board according of SNI 03-2105-1996. Parameter of testing are density, moisture contain, thickness, immersion, Modulus of Rapture (MOR) and Modulus of Elasticity (MOE).

2.3.6 Data Analysis
Data was obtained, be treated using descriptive method, qualitative and quantitative. Manufacture of adhesive and particle board were analyzed interact that happen using FT-IR model SHIMADZU 820 1PC. Morphology of the best ratio particle board was analyzed using SEM-EDX Tescan Vega3SB.

2.4 Scheme of Particle Board preparations

![Figure 1. Scheme of Particle Board Processing.](image)

3. Results and Discussions

3.1 Test of Adhesive Based Boiled Soybean Water
Test of adhesive based Boiled Soybean Water has been done, tested the quality according of the adhesive Urea-Formaldehyde Adhesive SNI 06-4567-1998. The result were appearing colour is yellowish, pH of 10, solid contain of 44.70 %, gelatination time of 56 minutes 29.71 seconds, density of 1.1656 g/cm$^3$ and viscosity of 182.4387 cP.

That result has statisfied SNI 06-4567-1998 about adhesive Urea-Formaldehyde (UF) standard. So that can be said that adhesion of adhesive based Boiled Soybean Water same with adhesion of Urea-Formaldehyde adhesive.

3.2 Test of Physical and Mechanical Properties
Test of physical and mechanical properties with various ratio between ricehusk and sawdust are 0:1; 1:2; 1:4; 1:1; 2:1; 4:1 dan 1:0 based on SNI 03-2105-1996.

Histogram on figure 2 was shown that density of particle board from all ratio have statisfied SNI 03-2105-1996. The highest density value seen on 1:2 ratio of 0.7804 g/cm$^3$. Whereas the lowest density value seen on 1:0 ratio of 0.6943 g/cm$^3$.

![Figure 2. Density of Particle board.](image)

3.3 Results and Discussions

Histogram was shown on figure 3 that particle board with 0:1 ratio has the lowest moisture contain of 5.49 %. Whereas the particle board with 4:1 has the highest moisture contain of 7.45 %. Although from all the ratio have moisture contain statisfied SNI 03-2105-1996. Based on figure 2 has shown that moisture contain of particle board affected by density from particle board, eventhough that effet has not significant.
Figure 3. Particle board Moisture Contain.

The water immersed value it is shown on figure 4, it was founded that the 1:0 particle board ratios has the highest immersion, is 47.12 % for 2 hours immersed, and 83.00 % for 24 hours immersed. Whereas the particle board with 0:1 ratio has the lowest immersion of 26.52 % for 2 hours and 38.64 % for 24 hours immersed, it was caused by density of particle board which high fairly for 0:1 ratios.

Histgram was shown on figure 5 that value of thickness was varying. Particle board thickness satisfied SNI 03-2105-1996 were particle board with 0:1, 1:4, 1:2, 1:1, and 2:1 (2 hours) ratio. If that ratio was observed, then ricehusk increasing, thickness will be increasing. Thickness and immersion of particle board were directly proportional. Therefore, the same factor affected.

Histgram was shown on figure 6 that sawdust increasing in specific ratio can be increased modulus of rapture (MOR). MOR was affected by many factors are contain and kind of adhesive that used, power tie adhesion, amount of adhesive was added, and particle size [8].

Histgram on figure 7 was shown that the highest of particle board MOE 1:4 ratio with 18248,3063 kg/cm². Whereas, the lowest of particle board MOE 4:1 ratio with 5315,6268 kg/cm². Ratio of rice husk and sawdust gave effect to the MOE. The 1:4 ratio was the highest of particle board MOE. It was caused rice husk can be increasing the elasticity of particle board. The rice husk with adhesive act as the bridge. It resulting in the highest of MOE.
From the various parameters were tested, the particle board ratio that has the best quality was 1:4 ratio. Therefore, can be known with mixed sawdust and ricehusk of specific ratio resulting particle board quality was the best.

3.3 Analys of Adhesive and Particle boards Interactions by Using Infra-Red Spectroscopy
3.3.1 Interact Adhesive Analysis
- Boiled Soybean Water (BSW)

The Infra Red spectrum showed on figure 8 indicated that broadband on 3383.14 cm\(^{-1}\) area is O-H group. The area of 3732.6 cm\(^{-1}\) with weak intensity indicated as N-H group, where supported by double band in 2356.94 cm\(^{-1}\) and 2326.15 cm\(^{-1}\) shows as \(\text{–NH}_2\). The area of 2929.87 cm\(^{-1}\) with medium intensity is C-H aliphatic. The area of 1597.06 cm\(^{-1}\) with strong intensity is C=O from carboxylic functional groups. The area of 1055.06 cm\(^{-1}\) is C-O that was supported by strong intensity band in 923.90 cm\(^{-1}\) as C-O-H deformation.
The Infra Red spectrum on figure 9 indicated that broadband on $3442.92 \, \text{cm}^{-1}$ is O-H group area. While the area of $2927.94 \, \text{cm}^{-1}$ is C-H aliphatic. There was N-H group with weak intensity on $3726.47 \, \text{cm}^{-1}$ area. Whereas the area of $1651.07 \, \text{cm}^{-1}$ is overlap between C=O and C=O amide band I. The area of $1074.35 \, \text{cm}^{-1}$ is C-O absorbs that supported by sharp band intensity on $920.05 \, \text{cm}^{-1}$ area as C-OH deformation.

IR spectrum on figure 10 indicated that decrease of intensity from band absorbs after glycerin was added. The area of $3442.94 \, \text{cm}^{-1}$ with broadband is O-H. The area of $2926.01 \, \text{cm}^{-1}$ is C-H aliphatic. The area of $3739.97 \, \text{cm}^{-1}$ is N-H with weak intensity that was supported by double band in $2380.87 \, \text{cm}^{-1}$ and $2333.87 \, \text{cm}^{-1}$ area is $\text{–NH}_3^+$. The area of $1645.26 \, \text{cm}^{-1}$ is stretch overlap between C=O and C=O amide band I. The area of $1678.07 \, \text{cm}^{-1}$ is C=O amide band II. The area of $1039.63 \, \text{cm}^{-1}$ is C-O absorbs that was supported by $921.97 \, \text{cm}^{-1}$ area is C-OH deformation.
Figure 11. The IR spectrum of BSW + Gelatine + Glycerin + Acetic Acid.

The FT-IR spectrum showed on figure 11 indicated that there is -OH group on 3423.65 cm\(^{-1}\) area. There is N-H with weak intensity on 3739.97 cm\(^{-1}\) area that was supported by double band on 2360.67 cm\(^{-1}\) and 2335.60 cm\(^{-1}\) is \(-\text{NH}_3^+\). The area of 2927.94 cm\(^{-1}\) is C-H aliphatic. The area of 1653.00 cm\(^{-1}\) is stretch overlap between C=O and C=O amide band I. The area of 1678.07 cm\(^{-1}\) is C=O amide band II. The area of 1035.77 cm\(^{-1}\) is C-O absorbs that was supported by 920.05 cm\(^{-1}\) area is C-O H.

Figure 12. The FT-IR of BSW + Gelatine + Glycerin + Acetic Acid + *Pinus merkusii* Latex mixed.

Spectrum on figure 12 indicated there was spectrum change clearly after it was added *Pinus merkusii* latex. The spectrum showed intensity decrease on 3730.33 cm\(^{-1}\) area is N-H. It was supported by double band with weak intensity is \(-\text{NH}_3^+\) on 2360.67 cm\(^{-1}\) and 2335.60 cm\(^{-1}\) area. It happened on O-H that intensity decrease on 3437.15 cm\(^{-1}\) area and weak intensity on 950.91 cm\(^{-1}\) area is C-OH deformation. Whereas strong band on 2931.60 cm\(^{-1}\) area that is C-H aliphatic. It is supported by CH\(_3\) deformation on 1384.89 cm\(^{-1}\) area. The area of 1695.43 cm\(^{-1}\) is strong intensity C=O but it isn’t overlap with C=O amide band I. Whereas the area of 1463.97 cm\(^{-1}\) with strong intensity is C=C.

Figure 13. BSW + Gelatine + Glycerin + Acetic Acid + *Pinus merkusii* Latex + NaOH FT-IR Result.

The Spectrum on figure 13 indicated that N-H on 3724.54 cm\(^{-1}\) area was supported by double band on 2358.94 cm\(^{-1}\) and 2333.87 cm\(^{-1}\) areas is \(-\text{NH}_3^+\). The area of 3415.93 cm\(^{-1}\) with broad band is O-H. The area of 2927.94 cm\(^{-1}\) is C-H aliphatic. The area of 1662.64 cm\(^{-1}\) is C=O. The area of 1546.91 cm\(^{-1}\) is C=O amide band I. The area of 1043.49 cm\(^{-1}\) is C-O absorbs that was supported by C-OH on 665.44 cm\(^{-1}\) area.
Figure 14. The spectrum of BSW + Gelatine + Glycerin + Acetic Acid + Pinus merkusii Latex + NaOH + SiO$_2$ mixed.

The Spectrum on figure 14 indicated that O-H and Si-OH on 3402.43 cm$^{-1}$ area. There was double band on 2362.60 cm$^{-1}$ and 2335.80 cm$^{-1}$ areas is $-\text{NH}_3^+$. The area of 2927.94 cm$^{-1}$ is C-H aliphatic. The area of 1664.57 cm$^{-1}$ is C=O. The area of 1543.05 cm$^{-1}$ is C=O amide band I. The area of 1041.56 cm$^{-1}$ is Si-O.

3.3.2 Particle Board Interact Analysis

Figure 15 indicated that interact between raw material was added adhesive and became particle board with hot-pressing. Based on spectrum on figure 15 can be seen changing that happened before and after mixed. It explained that there was interact of adhesive and raw material. Figure 15a was C=O absorbs, whereas figure 15b was Si-O. The increase of intensity of Si-O shown when the raw material and adhesive was mixed obviously (figure 15c). It was indicated that Si on adhesive reacted with raw material of particle boards.

Figure 15. (a) The 1:4 ratio of Rice husk:Sawdust FT-IR Results (b) BSW Adhesives and (c) Particle board FT-IR spectrum results.
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Based on FT-IR spectrums, suggest that the reaction hypotheses between adhesive and raw material as figure 16, while -NH\textsubscript{2} and SiO\textsubscript{2} in adhesive present could interact with -OH group from raw material (selulose), where the presence of SiO\textsubscript{2} as bridge between protein and selulose form particle board was stronger (figure 16).

3.4 Particle board Morphology Characterization Using SEM-EDX
SEM using on sample to analysis the sample surface. Emnission beam to sample will be reflected and diffracted. The presence of electron that was diffracted can be observed that diffraction pattern. SEM that connected by EDX (Energy Dispersive X-Ray). EDX has resulted from X-Ray that shooted on position which we will known the contain.

![Figure 16. Reaction Hypotheses.](image)

The result of particle board SEM on figure 17 shown that still has pore that affected the immersion and thickness. It has explained about the effect of pore on particle board. But, it was not too big, so that the immersion and thickness were low.

![Figure 17. (a) Magnification 500x SEM Result (b) Magnification 1000x SEM Result (c) Magnification 2000x SEM Result.](image)

4 Conclusion
The best composition of adhesive was occupy based on SNI 06-4567-1998 and particle board from ricehusk and sawdust composite occupy based on SNI 03-2105-1996. The adhesive composition were BSW 60 mL, gelatine 20 g, glycerin 25 mL, acetic acid 12 mL, latex pine 33 g, NaOH 8.5 mL, and
SiO$_2$ 4.5 mL. Quality of adhesive according of SNI 06-4567-1998 were appearing yellowish colour, pH of 10, solid contain of 44.70%, gelatination time of 56 minutes 29.71 seconds, density of 1.1656 g/cm$^3$, and viscosity of 182.4387 cP.

The best comparison of ricehusk and sawdust composite according of SNI 03-2105-1996 was 1:4. The result of particle board testing were density of 0.7735 g/cm$^3$, moisture contain of 5.79%, immersion for 2 hours of 26.90% and for 24 hours of 39.77%, thickness for 2 hours of 1.80% and for 24 hours of 3.86%, MOR of 101.1592 kg/cm$^2$ and MOE of 18,248.3063 kg/cm$^2$.

Conflict of interest
The author(s) declare(s) that there is no conflict of interests regarding the publication of this paper.

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