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PARTICLE BOARD QUALITY FROM PALM FROND WASTE (ARENGA PINNATA)

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ABSTRACT
The need for housing for the Indonesian population is increasing with the increase of the population, so it is very important to meet the community's need for housing. Particle board is an alternative artificial board that can be developed by utilizing the potential of waste in South Kalimantan, one of which is processing particleboard made from sugar palm fronds and cement adhesive. This research was conducted at the ULM Faculty of Forestry Workshop and Forest Products Technology Laboratory, and at the Banjarbaru Industrial Research and Standardization Center using the Completely Randomized Design (RAL) method. Sampling was carried out in 3 treatments and 3 repetitions, namely sugar palm fronds with the composition of the binding material and using assessments based on the SNI-03-2105-2006 BSN (2006) standard. The results of testing the physical properties of palm frond particle cement board showed that the average water content value was 7.38% - 8.96%, density with an average value of 1.14 g/cm^3 - 1.19 g /cm^3, and the average thickness expansion value is between 0.93% - 1.43%. The MoE test results were obtained with an average value between 5242.52 kgf/cm^2 - 7513.56 kgf/cm^2, and MoR with an average value obtained ranging from 9.45 kgf/cm^2 - 11.68 kgf/cm^2. Based on the results of diversity analysis, adhesive concentration has a significant effect on water content, while it has no significant effect on density, thickness expansion, MoE and MoR. Particleboard from sugar palm fronds can be used as a source of board for communities around wetlands. The development of particle boards from sugar palm fronds needs to be encouraged to emerge and develop by exploiting the potential that exists in the community.

KEY WORDS
Wood, quality, frond waste, technology, Indonesia.

The need for housing for the Indonesian population is increasing with the increase in Indonesia's population. Until September 2020, based on the results of the 2020 population census, Indonesia's population reached 270.2 million people. Meanwhile, every year there is an increase in population of 32.56 million people or an average of 3.26 million people. On the other hand, this causes a decrease in the area of forests in Indonesia so that the ability of forests to produce wood is decreasing. Biocomposite development is very important to meet the needs of the community for board needs. Particle board is one of the alternative artificial boards that can be developed by utilizing the potential of waste in South Kalimantan, one of which is particle board processing made from palm fronds and cement adhesive.

Particle board is an artificial board that can be made from waste pieces/particles or waste from the forestry, plantation and agriculture industries that are bonded with organic adhesives through a pressing process. The waste pieces or particles used can be from low-grade materials (lathe scraps, sawn wood scraps, branches, fiber scraps and others) that contain lignin and sellulose.

Particle board with cement adhesive is also more resistant to subterranean termite attack than its wood raw material. Thus cement board is one of the building materials that is durable in use so that the cost of maintaining a house made of cement board will be cheaper. In addition, the particleboard industry can utilize plantation waste such as palm fronds, palm fruit shells or empty palm bunches so that the optimization of the utilization of linocellulose-based waste can be improved. Therefore, the particleboard industry needs to be developed in South Kalimantan, given the abundance of potential raw materials.

Besides having advantages, particleboard also has disadvantages compared to other artificial boards, such as weight and more limited use as a building material. It takes a long time for particleboard to completely harden before it reaches sufficient strength. Another disadvantage is that not all types of wood or lignocellulosic materials can be used as raw materials for particleboard with cement adhesives due to the presence of extractive substances such as sugars, tannins and oils that can interfere with the hardening of cement with these raw materials.

The purpose of this research is to analyze the physical and mechanics properties of palm frond particleboard which includes density, moisture content, flexural strength (MoE) and fracture strength (MoR) using SNI 03-2105-2006 standards. The benefits of this research can provide information and input to the government and the community that quality palm frond particle boards have the potential to be developed as a potential source of new boards and developed into small and medium industries so that they can become regional icons or regional superior products, especially around wetlands. The community can process aren palm frond waste into particleboard. This particle board processing has a great opportunity to become a business that can increase the income and welfare of the community around the wetland, especially palm farmers.

METHODS OF RESEARCH

This research was conducted for 5 months at the ULM Faculty of Forestry Workshop, Forest Products Technology Laboratory, ULM Faculty of Forestry and at the Banjarbaru Industrial Research and Standardization Center. The implementation of this research starts from the stages of licensing and preparation, sampling, particle board making, testing, data processing, and preparation of research reports.

The materials used were palm frond powder, Portland cement, catalyst ($MgCl2$), and clean water. The equipment used included iron molds (30 cm × 30 cm × 1 cm), cold felts, moisture meters, digital calipers, ovens, Universal Testing Machines (UTM), grinders, containers, digital scales, plastic cups, rubber gloves, cameras, calculators, and stationery.

This study used the Completely Randomized Design (CRD) method with sampling of 3 treatments (A, B, and C) with 3 replications so that the total number of tests was 3 × 3 = 9. The treatment consisted of binder (g) and acacia wood powder in the ratio of A (3:1), B (4:1), and C (5:1) (Composition of Binder + Wood Powder):

- A: (Cement 675 g + MgCl 45 g) + Wood powder 225 g);
- B: (Cement 900 g + MgCl 45 g) + Wood powder 225 g);
- C: (1125 g cement + 45 g MgCl) + 225 g wood powder).

Preparation of particle cement board test samples for testing physical properties and mechanical properties can be seen in Figure 1.

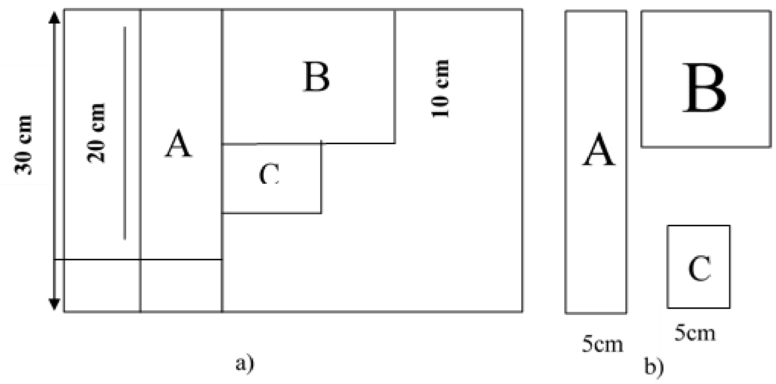

Figure 1 – Sample test cutting pattern
Description: A = Test sample for fracture firmness and flexibility measuring 5 cm × 20 cm; B = Test sample for moisture content and density measuring 10 cm × 10 cm; C = Test sample for thickness development and Shrinkage measuring 5 cm × 5 cm.

RESULTS AND DISCUSSION

The results of testing the water content of cement boards that meet the standards based on SNI-03-2115-2006, namely the maximum water content of 14%. Data on the average value of moisture content for each treatment can be seen in Table 1.

Table 1 – Moisture content (%) of Aren palm frond (Arenga pinnata) particle cement board

Treatment	Repeat (%)			Total (%)	Average (%)	Inf	SNI-03-2105-2006 BSN (2006)
	1	2	3				
A	9,35	8,68	8,84	26,87	8,96	MS	
B	7,43	7,43	7,74	22,6	7,53	MS	≤ 14%
C	7,29	7,39	7,47	22,15	7,38	MS	

Source: Calculated physical properties of particle cement board.
Description:
- A: (Cement 675 g + MgCl 45 g) + Wood powder 225 g);
- B: (Cement 900 g + MgCl 45 g) + Wood powder 225 g);
- C: (1125 g cement + 45 g MgCl) + 225 g wood powder).

Based on the calculation results, the highest water content is found in treatment A with an average value of 8.95%, treatment B with an average value of 7.53%, and treatment C with an average of 7.38%. The moisture content obtained from each treatment meets the SNI 03-2105- 2006 standard, which is less than 14%. Moisture content is one of the physical properties of cement boards that show the water content of cement boards in a state of equilibrium with the surrounding environment. The condition of the board that contains excess water will affect the physical and mechanical properties of the board (Maail & Derlauw, 2019).

The moisture content value is influenced by the cement composition contained in the cement board. The higher the cement composition, the lower the moisture content. This is due to the large number of particles that can be bound by cement and minimize empty space. The moisture content value is also influenced by the density value of the cement board. The higher the density value of a particleboard, the lower the moisture content (Simbolon et al., 2015). Another influencing factor for the moisture content value is the raw material itself, if the raw material has high moisture content, the adhesive will dilute (Astutik et al., 2020).

Table 2 – Analysis of Variance of Moisture Content (%) of Particle Cement Boards of Aren Fronds (Arenga pinnata)

Source of Diversity	Free Degree	Sum of Squares	Center square	F Count	F Table		Inf
					5%	1%	
Treatment	2	4,52	2,26	41,73**	4,46	8,65	N
Error	6	0,33	0,05				
Total	8	4,85					

*Source: Computerized and static results. Description: ** = Very significant effect; KK= 2.93%.*

The results of the analysis of variability showed that the composition of the raw material of the palm frond particle cement board had a significant effect on the value of moisture content. The coefficient of variation obtained is 2.93% and the value of F count = 41.73 which is greater than F table 5% (4.46) and less than F table 1% (8.65).

Based on the calculated F value, it is necessary to conduct further tests to determine the differences between treatments by conducting further tests, namely the BNJ (Differential Real Honest) test. The BNJ further test can be seen in Table 3.

Based on the results of the analysis of variance and BNJ test, treatment A had a very significant effect on treatment B and C at the 5% and 1% levels. Meanwhile, treatment B did not significantly affect treatment C.

Particle cement board density is a measure that expresses the weight of particle cement board per unit area. The results of the calculation of particle cement board density from acacia wood sawdust can be seen in Table 4. The highest value is in treatment B with an average density value of 1.19 g/cm^3, while the lowest value is in treatment C with average density data of 1.14 g/cm^3. Based on SNI 03-2105-2006 data where the density value ranges from 0.4 g/cm^3 to 0.9 g/cm^3, it can be concluded that the density results with different treatments all do not meet SNI 03-2105-2006 standards.

Table 3 – Further Test of BNJ (Differential Real Honest) on the Value of Water Content (%)

Treatment	Average	Differential Value	
		A	B
A	8,96		
B	7,53	1,42**	
C	7,38	1,57**	0,15
BNT	5%	0,70	0,72
	1%	1,06	1,11

Source: Computerized and Statistical Results.

Table 4 – Density Value (g/cm^3) of Particle Cement Board Aren Fronds (Arenga pinnata)

Treatment	Repeat (g/cm^3)			Total (g/cm^3)	Average (g/cm^3)	Inf	SNI-03-2105-2006 BSN (2006)
	1	2	3				
A	1,18	1,14	1,13	3,45	1,15	TMS	
B	1,16	1,29	1,12	3,57	1,19	TMS	0.4 g/cm^3 - 0.9 g/cm^3
C	1,13	1,22	1,09	3,44	1,14	TMS	

Source: Calculated physical properties of particle cement board.
Description:

- *A: (Cement 675 g + MgCl 45 g) + Wood powder 225 g);*
- *B: (Cement 900 g + MgCl 45 g) + Wood powder 225 g);*
- *C: (1125 g cement + 45 g MgCl) + 225 g wood powder).*

According to (Winanti et al., 2015) the use of cement content that is too high is followed by a decrease in the density value of the resulting cement board. The more cement composition used, the lower the density value produced. Likewise with the particles used, the more particles used, the higher the density produced. Conversely, according to (Purwanto, 2014) and (Sushardi, 2011) the increase in density is influenced by the cement ratio, where a denser mixture can increase bonding and fill empty spaces in the board. A higher cement content at the same volume will obtain a higher weight, thus increasing the density value. Another factor that affects the high density value is the fiber owned by the raw material, if it has long fibers with thick skin cell walls, the density value will be higher (Thamrin, 2011).

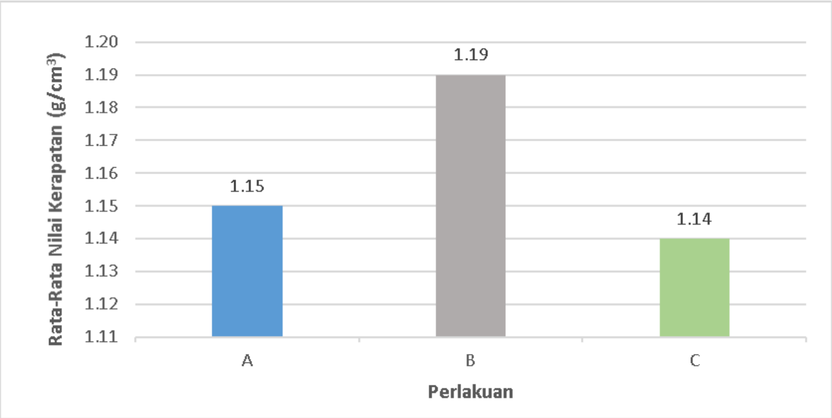

Figure 2 – Diagram of Average Density Value (g/cm^3)
Description: A: (Cement 675 g + MgCl 45 g) + Wood powder 225 g); B: (Cement 900 g + MgCl 45 g) + Wood powder 225 g); C: (1125 g cement + 45 g MgCl) + 225 g wood powder)

The effect of the treatment given can be known by conducting an analysis of variance. The results of the analysis of variance can be seen in Table 5.

The results of the analysis of variance in the table above show that the different treatment factors of palm frond powder particle cement board do not significantly affect the density because the value of F count = 0.40 is smaller than F table (5%) = 4.46 and from F table (1%) = 8.65. Therefore, no further tests were carried out because the data was not significant or had no real effect (F count < F table), which means that the density value did not change despite the addition of adhesive composition.

Table 5 – Analysis of Variance on Density (g/cm^3) of Aren Frond Particle Cement Board (*Arenga pinnata*)

Source of Diversity	Free Degree	Sum of Squares	Center square	F Count	F Table		Inf
					5%	1%	
Treatment	2	0.00	0.00	0,40tn	4,46	8,65	TN
Error	6	0.03	0.00				
Total	8	0.03					

Source: Computerized and Statistical Results. Description: TN= No significant effect; KK= 5.67%.

Based on the results of the thickness development test, the average thickness development of the palm frond particle cement board can be seen in Table 6.

The highest average thickness development is in treatment A with an average value obtained of 1.43%, while the lowest value is in treatment C with data obtained of 0.93%. The average density values of treatments A, B, and C obtained meet the SNI 03-2105-2006 standard of ≤12%. The value of thick development can be influenced by low density, thus causing water to be easily absorbed and thick development of cement boards occurs when soaked (Thamrin, 2011).

The thickness development value indicates the amount of particle cement board thickness development that is calculated against the thickness dimension of the board before immersion in water. Thickness development is influenced by the product processing variables themselves, such as raw material density, particle thickness, adhesive content, and the amount of felt pressure applied to the layers (Siska et al., 2018).

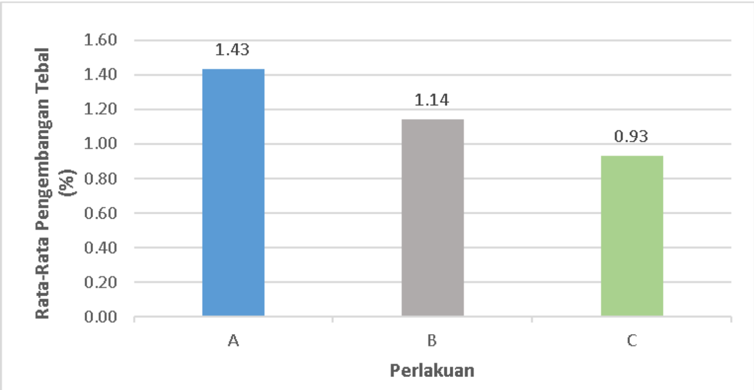

Figure 3 – Diagram of Thickness Development Value (%)
Description: A: (Cement 675 g + MgCl 45 g) + Wood powder 225 g); B: (Cement 900 g + MgCl 45 g) + Wood powder 225 g); C: (1125 g cement + 45 g MgCl) + 225 g wood powder)

Table 6 – Diversity Analysis of Thickness Development (%) of Aren Frond Particle Cement Board (*Arenga pinnata*)

Source of Diversity	Free Degree	Sum of Squares	Center square	F Count	F Table		Inf
					5%	1%	
Treatment	2	0.38	0.19	6.97*	4,46	8,65	N
Error	6	0.16	0.03				
Total	8	0.54					

*Source: Computerized and Statistical Results. Description: * = No significant effect; KK= 14.09%.*

The results of the diversity analysis of thick development showed that the calculated F value (6.97) was greater than the F table value of 5% (4.46) and smaller than the F table 1% (8.65), so the treatment did not have a significant effect, therefore there was no need for further tests. The coefficient of variation obtained was 14.09%.

The modulus of elasticity shows the board's ability to maintain its original shape and size when subjected to a force. The higher the value of flexural firmness, the more elastic/bending the object will be.

Table 7 – MoE (Modulus of Elasticity) Data (kgf/cm^2) of Aren Frond Particle Cement Board (*Arenga pinnata*)

Treatment	Repeat			Total	Average	Inf	SNI-03-2105-2006 BSN (2006)
	1	2	3				
A	7609.916	4632.549	3485.093	15727.56	5242.52	TMS	
B	9628.169	5925.351	6987.173	22540.69	7513.56	TMS	≥ 20.400 kgf/cm^2
C	8619.043	5278.95	5236.133	19134.13	6378.04	TMS	

Source: Computerized and Statistical Results.
Description:
- *A: (Cement 675 g + MgCl 45 g) + Wood powder 225 g);*
- *B: (Cement 900 g + MgCl 45 g) + Wood powder 225 g);*
- *C: (1125 g cement + 45 g MgCl) + 225 g wood powder).*

Table 12 shows that the average value of MoE of particle cement board is highest in treatment B with a value of 7513.56 kgf/cm^2 but still far from reaching the Standard (SNI-03-2105-2006). The analysis of the three treatments showed that all treatments did not meet the standard which requires a minimum MoE value of ≥ 20,400 kgf/cm^2.

The low MoE value is thought to be caused by the length of stirring the ingredients. The longer the stirring, the effect on the water contained in the vaporized so that the result becomes thicker. Stirring time can affect viscosity so that the air content increases and the flexibility properties are lower (Yogi et al., 2021).

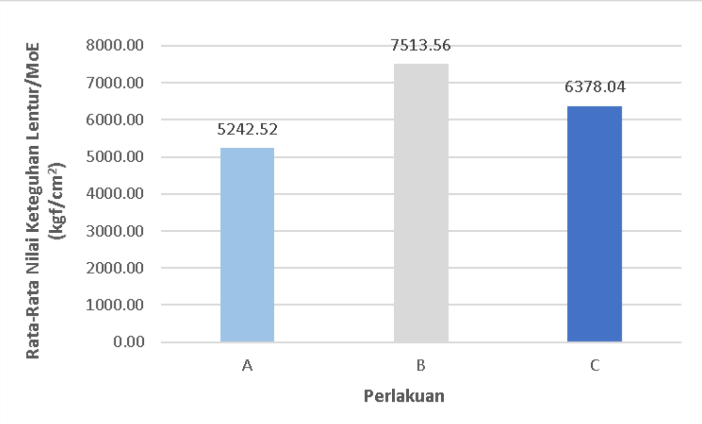

Figure 4 – Diagram of Modulus of Elasticity (MoE) Value (kgf/cm^2)
Description: A: (Cement 675 g + MgCl 45 g) + Wood powder 225 g); B: (Cement 900 g + MgCl 45 g) + Wood powder 225 g); C: (1125 g cement + 45 g MgCl) + 225 g wood powder)

Table 8 – Diversity Analysis Data of MoE (Modulus of Elasticity) (kgf/cm^3) of Aren Frond Particle Cement Board (*Arenga pinnata*)

Source of Diversity	Free Degree	Sum of Squares	Center square	F Count	F Table		Inf
					5%	1%	
Treatment	2	7736468.09	3868234.04	0.97tn	4,46	8,65	TN
Error	6	23870285.30	3978380.88				
Total	8	31606753.39					

Source: Computerized and Statistical Results. Description: TN = No significant effect; KK= 31.27%.

The results of the MoE diversity analysis show that each treatment has no effect, this is evident from the calculated F value (0.97) which is smaller than the F table value of 5% (4.46) and F table 1% (8.65), so that with the calculated F value, no further tests are carried out because the data is not significant or has no real effect. The modulus of fracture shows the ability of an object to withstand loads from the perpendicular direction of the object trying to break it.

Table 9 – MoR (Modulus of Rupture) Data (kgf/cm^2) of Aren Frond Particle Cement Board (*Arenga pinnata*)

Treatment	Repeat			Total	Average	Inf	SNI-03-2105-2006 BSN (2006)
	1	2	3				
A	21.473	8.993	4.583	35.05	11.68	TMS	
B	13.45	8.284	6.621	28.36	9.45	TMS	≥ 82 kgf/cm^2
C	17.462	8.639	5.602	31.70	10.57	TMS	

Source: Computerized and Statistical Results
Description:
- *A: (Cement 675 g + MgCl 45 g) + Wood powder 225 g);*
- *B: (Cement 900 g + MgCl 45 g) + Wood powder 225 g);*
- *C: (1125 g cement + 45 g MgCl) + 225 g wood powder).*

The value of the modulus of fracture of particle cement boards was obtained through the test results using the UTM tool at the Banjarbaru Standardization and Industrial Services Research Center. The test results showed that the highest average value was found in treatment A with an average value of 11.68, treatment C 10.57, and treatment B 9.45. Based on these results, the three treatments did not meet the SNI-03-2105-2006 Standard where the min value of (MoR) ≥82 kgf/cm^2.

The fracture toughness is closely related to the density of the particle cement board, the higher the density of the particle cement board, the higher the fracture toughness. This is due to the number of particles that can be bound by cement so that the value of fracture toughness increases (Syafriani et al., 2015). The increase in the value of fracture toughness can also be caused by the release of extractive substances during boiling, thereby increasing the bond between cement and particles. The decrease in the value of fracture toughness is due to the length of the boiling process. So in addition to many extractive substances are dissolved along with the mass and structure of the degraded particles, causing a decrease in the value of the fracture strength of the particle cement board (Fahmi & Zainuri, 2017).

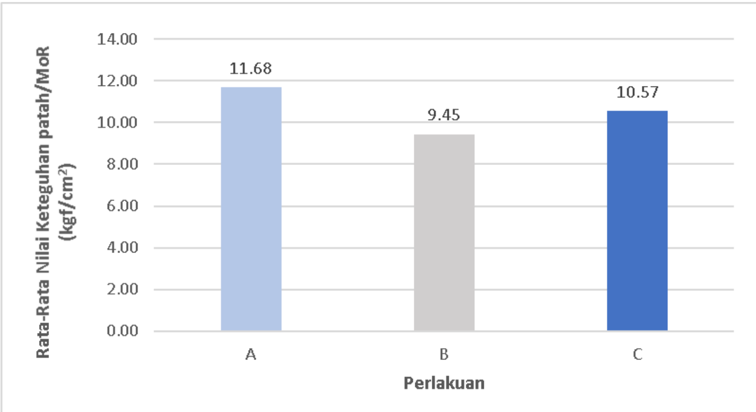

Figure 5 – Diagram of Modulus of Elasticity (MoR) Value (kgf/cm^2)
Description: A: (Cement 675 g + MgCl 45 g) + Wood powder 225 g); B: (Cement 900 g + MgCl 45 g) + Wood powder 225 g); C: (1125 g cement + 45 g MgCl) + 225 g wood powder)

Table 10 – Diversity Analysis Data of MoR (Modulus of Rupture) (kgf/cm^2) of Aren Frond Particle Cement Board (*Arenga pinnata*)

Source of Diversity	Free Degree	Sum of Squares	Center square	F Count	F Table		Inf
					5%	1%	
Treatment	2	7.47	3.73	0.09tn	4,46	8,65	TN
Error	6	254.76	42.46				
Total	8	262.23					

Source: Computerized and Statistical Results. Description: TN= No significant effect; KK = 61.66%.

Based on the results of the analysis of the diversity of the value of broken firmness (MoR) shows that the treatment has no real effect because the value of F count (0.09) is smaller than F table 5% (4.46) and F table 1% (8.65), so from the value of F count is not done further test because the data obtained or obtained is not significant.

CONCLUSION

The results of testing the physical properties of palm frond particle cement boards show the average value of moisture content obtained with an average value of 7.38% - 8.96%, density with an average value of 1.14 g/cm^3 - 1.19 g/cm^3, and average thickness development value between 0.93% - 1.43%. MoE test results were obtained with an average value between 5242.52 kgf/cm^2 - 7513.56 kgf/cm^2, and MoR with an average value obtained ranging from 9.45 kgf/cm^2 - 11.68 kgf/cm^2.

Based on the results of the analysis of variance, adhesive concentration has a significant effect on moisture content, while it has no significant effect on density, thickness development, MoE and MoR.

Particleboard from palm fronds can be utilized as a source of board for communities around wetlands. The development of particleboard from palm fronds needs to be encouraged to emerge and develop by utilizing the potential around the community.

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