Characteristics Of Particleboard Made From Trees Pine Bark (Jungh. Et De Vr.) And Oil Palm Empty Fruit Bunches

Asfarizal Saad., Anwar Kasim., Gunawarman., Santosa.

Abstract: This study aimed to evaluate of particleboard made of trees pine bark (TPB) and oil palm empty fruit bunches (OPEFB) and give a recommended. The composition TPB namely 20%, 15%, and 10%, pressing temperatures of 190, 180, 170, 160, and 150ºC, pressing times of 30, 25, 20, 15, and 10 minutes. The particleboard was evaluated for its physical properties, namely density, moisture content, thickness swelling, and water absorption and its mechanical properties, including modulus of rupture, modulus of elasticity, modulus of elasticity, and internal bond. The pressure working on the particleboard was 22 kg/cm2. The test results show that the density and moisture content met the standards while thickness swelling and water absorption did not meet the standards of particleboard with a thickness of ≤12.7 mm. The optimum conditions of MOR and IB met JIS A 5908-2015 at 20% TPB composition with a pressing temperature of 165-175ºC and a press time of 20-25 minutes. However, MOE did not meet the standard. Hence, the mechanical properties of particleboard can still be improved and the manufacture of particleboard from TPB and OPEFB materials can be recommended

Keywords: Pine Trees, Particleboard, Composition effect, Temperature effect, Time control.

Highlight

- The particleboard produced consists of trees pine bark and oil palm empty fruit bunches.
- Particleboards do not use synthetic adhesives
- Particleboards were made to reduce waste and increase economic value
- Particleboard has physical and mechanical properties that meet the standard

1. INTRODUCTION

Applying UF, PF, MF, RF and CF resins on particleboards can cause irritation to the eyes and skin and can even cause cancer [1] The manufacture of particleboard from agricultural resources without synthetic adhesives that have been developed since the early 1980s [2][3], by using various types of renewable raw materials such as lignocellulose-based agricultural waste and recycled fibers encouraged the author to perform a study. In general, the properties of particleboard made from oil palm trunks with the addition of polyhydroxyalkanoates meet the standards [2][4]. that showing that the manufacture of particleboards without synthetic adhesives meeting the standards is very possible. Several studies of particleboards have been carried out from various materials such as corn biomass [5], pineapple biomass [4] palm oil trunks [3], rice straw [6], Neolamarckia cadamba[7], date palm branches [8], coir pith[9] young and old oil palm trunks[10], Jatropha curcas[11], black pinewood and red pine[12], acacia wood[13], coconut fiber[14], durian skin[15], mahogany wood[16], bamboo[17] and pine bark no yet applied on the particleboard, and given author opportunity making into particleboards. In this study, the author used trees pine bark (TPB) as adhesive material in the manufacture of particleboards made from oil palm empty fruit bunches (OPEFB). TPB that is mostly left on the ground after the wood is separated, thus becoming a waste, then can cause environmental problems. TPB contains tannin polyphenols, with a melting temperature of 101.6°C. Tannins are a complex compound form of protein, starch, cellulose, and minerals and have a structure with the empirical formula $C_{72}H_{52}O_{46}$. It can be used as a material for making adsorbents. Besides, it is also applicable as adhesive materials (substitute for phenol in formulations), medicines, cosmetics, pharmaceuticals, and heavy metal adsorbents, and industrial food applications. The tannin content in pine bark reaches about 22.5%[18]. Pine trees thrive on the island of Sumatra and Kalimantan. Oil palm empty fruit bunches (OPEFB) are used as raw material for the manufacture of particleboards without adhesives synthetics. In one ton of oil palm fruit processing, 23% is in the form of oil palm empty fruit bunches. Nationally, in 2015 oil palm empty fruit bunch waste is equivalent to 7,118,254.2 and 2018 is 9,863,235 tons/year, hereinafter referred to as by-products. Trees pine bark (TPB) and OPEFB, have the potential processed into particleboards. At present, there is no information in the form of articles about the properties of non-adhesive particleboards made from TPB and OPEFB. Therefore, the purpose of this study was to study the effect of the addition of TPB and changes in temperature and time on the particleboard feasibility. In this study, density, moisture content, water absorption, thickness swelling, modulus of rupture, modulus of elasticity, and internal bonding of the particleboard were evaluated.

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2. MATERIAL AND METHOD

Fibers preparation of OPEFB

OPEFB was taken from Agam Regency, Sumatra Barat, 210 km from the city of Padang. Still mixed with soil and sands, the OPEFB were immersed and rubbed in running water for 10 minutes to be clean, and then steamed for 30 minutes with water containing 1-2% NaOH, and, subsequently, left under sunlight exposure with radiations ranging from 400 to 770 watts from 9:00 a.m. to 3:30 p.m. The sunlight radiation was measured with a solarimeter. The air temperature, at the time, ranged from 26 to 31°C with sunny weather. Furthermore, the OPEFB were cut with a rotational cut machine and result filtered using a 16 mesh filtering. The length of each fiber that passed the filter ranged from 0.1 to 2 cm, referring to the initial study of the effect of fiber length on particleboards[19]. The fibers passing the filter were dried with an oven at 103°C; the desired moisture content was 5-6% dry basis.

Powder preparation of TPB

TPB was obtained from a pine plantation in Tanah Datar Regency, 120 km from the city of Padang. TPB as waste wood pine was cleaned with pressured water and then dried. The drying method is the same as the OPEFB drying. Pine trees bark dry was cutt using a rotational cutting machine with a cut blade sized 10 teeth/in. The product was then filtered using a 40 mesh filter, the powder which passes the sieving was dried in an oven at a temperature of 103°C, the desired moisture content of 5-6%[20]

Particleboard

The dimensions of the particleboard, namely L, b, and h, respectively, were 30 × 30 × 1.1 cm^3. The TPB and OPEFB ratio used was 10:90; 15:85; and 20:80. The pressing temperature was 190°C; 180°C; 170°C; 160°C, and 150°C, with press times of 30, 25, 20, 15 and 10 minutes. The density was 0.9 $g.cm^{-3}$. After mixing TPB and OPEFB evenly, it was put into a mold measuring 30 × 30 × 8 cm^3, closed then cold-pressed. Pressing takes place at room temperature (26ºC) for 5 minutes, then removed from the mold. The number of panels made was 75. Furthermore, the particleboard was hot-pressed to 1.1 cm thick, under the pressure of 20 tons (22 kg/cm^2). The ready particleboard was cooled in a wooden box for seven days at 26ºC. Particleboard standard refers to JIS A 5908-2015[21]

Moisture content

The moisture content test specimen was a piece of particle board measuring 10 × 10 × 1.1 cm^3. The initial weight before drying was recorded as W_1. After drying in an oven at 103ºC for 24 hours, the specimens were weighed every 6 hours. The final weight was recorded as W_2. Moisture content is calculated using Equation:

$$\text{Moisture content} = \frac{W1-W2}{W2} x100\% \qquad (1)$$

Fig 1. OPEFB, TPB and Particleboard

MOE and MOR

The specimen for testing modulus of elasticity and modulus of rupture, referring to ASTM D1037-99 (American Society for Testing and Materials, 1999), was measuring 4.1 × 22 × 1.1 cm^3. The flexural test was carried out using the triple-point method with a UH-300 KN universal testing machine. Data analysis (ANOVA) was done using Design-Expert version 10, a quadratic system with $\alpha \leq 0.05$ for significant differences between the variables

$$\text{Modulus of elasticity} = \frac{\Delta P.L^3}{4b.h^3.\Delta y} \qquad (2)$$

$$\text{Modulus of rupture} = \frac{3.P.L}{2.b.h^2} \qquad (3)$$

Internal Bonding (IB)

The specimen for internal bonding test was measuring 4.1 cm × 23 cm and calculated by Equation:

$$\text{Internal bonding} = \frac{\Delta P}{A} \qquad (4)$$

where W: specimen weight (gram), W_1 and W_2: initial and final weight (gram), ΔP: the difference between the final and initial compressive forces (N), L: length of span (cm), b: width of the tested specimen (cm), h: the thickness of the specimen tested, y_1: deflection (cm), P: maximum load (N), and A: cross-sectional area (cm^2); UF: urea-formaldehyde, PF: phenol-formaldehyde, MF: melamine-formaldehyde, RF: resorcinol-formaldehyde and CF: cresol-formaldehyde.

Result dan discussion

PHYSICAL PROPERTIES

Chemical components of OPEFB and TPB

The chemical components of the OPEFB fiber were analyzed by extraction methods in the laboratory of the Faculty of Agricultural Technology, Andalas University. The results are shown in Table 1, the percentage of cellulose, hemicellulose, and lignin were 53.51%, 17.11%, and 17.46%, respectively. The chemical components of TPB are cellulose, hemicellulose, lignin, and tannins respectively 23.31%, 15.22%, 56.69%, and 8.537%. The tannin content obtained was lower than the bark of acacia trees, which reaches 30.98%[22]

***Table 1.** Chemical components of OPEFB and TPB*

Chemical component	OPEFB	TPB
	Content (%)	Content (%)
Holocellulose	70.62	38.53
Cellulose	53.51	23.31
Hemicellulose	17.11	15.22
Lignin	17.46	56.69
Tannin	-	8.537

DENSITY

Particleboards made from oil palm empty fruit bunches and trees pine bark after undergoing the hot pressing process was conditioned in a box for seven days at room temperature (26°C) with $60^{\pm5}$% relative humidity. This treatment aims to reduce the temperature of the particleboard slowly in all parts so that there is no bending as shown in figure 1. Particleboard then cut for specimen physical and mechanical tests. Density and moisture content tests were carried out on particleboards with a composition of TPB/OPEFB: 20/80, press temperature of 190ºC, 180ºC, 170ºC, 160ºC, and 150ºC with press time of 10 minutes and 20 minutes. The results are shown in figures 2A and 2B. The density of particleboard was ranging from 0.72 to 0.78 $g.cm^{-3}$ at all variations of temperature and time of the pressure and met the JIS A 5908-2015 standards for medium density[23][21]. Figure 2A shows that the increase in pressing temperature tends to decrease in density as the effect of rising temperatures that accelerates the evaporation of H_2O and reduces the mass of particleboards at the same pressing time. On the other hand, the increase in the pressing time tends to reduce the moisture content at the same pressing temperature, as shown in figure 2B. Particleboards with a composition of TPB/OPEFB: 15/85 and 10/90 also met the standards.

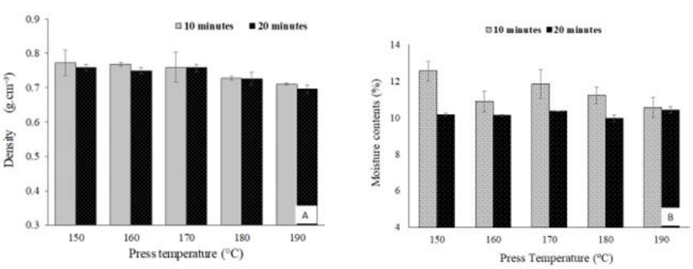

***Fig 2.** OPEFB, TPB and Particleboard*

Moisture contents

The moisture content was tested on a dry basis, the composition of TPB/OPEFB: 20/80 with a pressure time of 10 and 20 minutes. On the press time of 10 minutes shows that at all press temperatures, the values were in the range of 10.56-12.54%, all of them were less than the maximum value of 14%, so they meet the standards, as shown in figure 2B. Moisture content is relatively stable at the press time of 20 minutes at all pressing temperatures, which is in the range of 9.96-10.33%. Significant differences occur at press time 10 minutes. The highest moisture content of 12.54% was obtained at a pressing temperature of 150ºC, reduced gradually at temperatures of 160ºC, 170ºC, and 180ºC, and reached the lowest value at 190ºC, i.e. 10.56%. These changes indicate that an increase in suppressor temperature reduces the water content at the same press time. The same level of reduction also occurs at a press time of 15 minutes and at a press time of 20, 25, and 30 minutes, the role of temperature in reducing water content does not have much effect. Moisture contents in compositions 15/85 and 10/90 were in the range of 10-12%.

Thickness swelling

Physical changes particleboard when contacting with water were important to observe in terms of its thickness swelling and water absorption. JIS has set a maximum value of thickness swelling of 25% for particleboard whose thickness is ≤12.7 mm. Observation focused more on physical changes in the composition of TPB, namely 10%, 15%, and 20%. Three specimens of particleboard, after treated under a pressing temperature of 180ºC for 20 minutes, were taken randomly and then immersed in water for 2 hours and 24 hours. The results were shown in figures 3A. The average thickness swelling was after immersed for 2 hours showed values of 40.5%, 39%, 33%, and greater than the standards set. Likewise, after being immersed for 24 hours, the values became 81.8%, 65.7%, and 61.9% respectively. The thickness swelling tends to decrease after being immersed for 2 hours and 24 hours to the increase of TPB in particleboard. On the other hand, the quality of the inter-fiber bond and the surface area also influence the thickness swelling. A study conducted on particleboard made from coconut fiber sized 20-40 mesh without synthetic adhesive found that the thickness swelling value was 22.6%[9] Another study conducted on particleboard without synthetic adhesive made from oil palm fronds obtained a thick swelling value at a range of 150-200%[24]. and particleboard from oil palm trunks with three treatments suggested a thickness swelling value in the range of 50-66%[25]

Water absorption

Water absorption is one of the parameters in evaluating the physical quality of wood-based products. Figure 3B shows the percentage of water absorption of particleboards with different TPB compositions. All tested particleboards showed average water absorption after the initial immersion for 2 hours until equilibrium moisture content was reached at 24 hours. Particleboard water absorption is caused by hydrogen bonds of water molecules with free hydroxyl groups present in cellulose cell wall material and diffusion of water molecules into the filler-matrix interface. In addition, the large number of porous tubular structures present in the fiber accelerates water penetration by capillary action[8]. The water absorption at the 2-hour immersion tended to decrease with increasing TPB ratio.

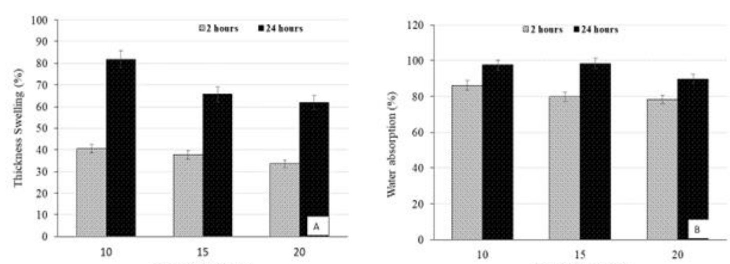

***Fig 3.** Thickness Swelling (A) and Water absorption (B)*

The average water absorption values for immersion for 2 hours and 24 hours were in the ranges of 78.6-86.2% and 89.7-98.4%, respectively. The water absorption values obtained were higher than those of particleboards using synthetic adhesives. This is possible due to poor adhesion between the matrix and lignocellulosic material that is caused by the presence of more gaps in the interface region and, also, the presence of more hydrophilic groups as hydroxyls available for hydrogen bonding to water. The results show that when the number of TPB particles increases, the absorption of particle board water tends to decrease. A study of particleboard made from palm trunks with hot water treatment obtained water absorption in the range of 125-148%[25]. Another study studying particleboards made from palm trunks steamed for 10, 30, and 50 minutes obtained water absorption and thickness swelling in the ranges of 72-100% and 40-60%, respectively[26]

MOE and MOR

The results of the flexural test are included in equations 2 and 3 to calculate the Modulus of Elasticity (MOE) and the modulus of rupture (MOR) values. The mean values are arranged in order of composition, Figures 4, 5, and 6 show the mean values of the mechanical properties of particleboards, namely MOR and MOE. ANOVA results of the mean value of the experiment indicate the probability p> F. where p = 0.05, F <0.0001 (significant), std. deviation 0.021 and R2 = 0.9828. At a TPB/OPEFB: 10/90, the best conditions of MOR and MOE respectively were 7.3-7.5 MPa and 672-683 MPa. The pressing time and temperature were 25 minutes and 170ºC. The weakest MOR and MOE occurred at a pressing time of 10 minutes and a temperature of 150ºC; namely, 5.91 MPa and 308.3 MPa, as shown in figure 4. At the pressing times and temperatures of 10, 15, 20, 30 minutes and 150ºC, 160ºC, 180ºC, 190ºC, respectively, the MOR value had not reached the best. The amount of TPB was increased from 10% to 15%, and OPEFB was reduced from 90% to 85% so that the ratio of TPB/OPEFB became 15/85, as shown in figure 5. The results showed an increase in MOR and MOE, which were 7.8 MPa and 690.2 MPa, respectively. The pressing time and temperature were, respectively 20 minutes and 180ºC. The increase in MOR was from 5.91 MPa to 7.8 MPa and MOE was from 308.3 MPa to 690.2 MPa. The weakest MOR condition occurred at a pressing time of 10 minutes and a temperature of 150ºC; were MOR and MOE were 6.1 MPa and 324.6 MPa, respectively. Although the weakest, the MOR and MOE values were observed to increase. The MOR values of the two compositions did not meet the Standards. Furthermore, the amount of TPB was increased from 15% to 20%, and OPEFB was reduced from 85% to 80% so the ratio of TPB/OPEFB became 20/80, as shown in figure 6. The results showed that MOR was optimum, namely 8.2 MPa, and MOE was 766 MPa, at a pressing time of 20 minutes and a temperature of 180ºC. There were increases in MOR from 7.8 MPa to 8.2 MPa and in MOE from 690.2 MPa to 766 MPa. In this condition, the MOR value obtained meets Japanese Industrial Standards for type 8, which is 8 MPa. The weakest MOR and MOE occurred at a press time of 10 minutes and a temperature of 150ºC, namely 6.6 MPa and 406 MPa

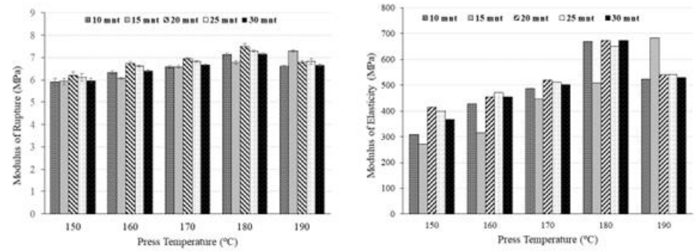

Fig 4. MOR and MOE, Composition TPB/OPEFB. 10/90

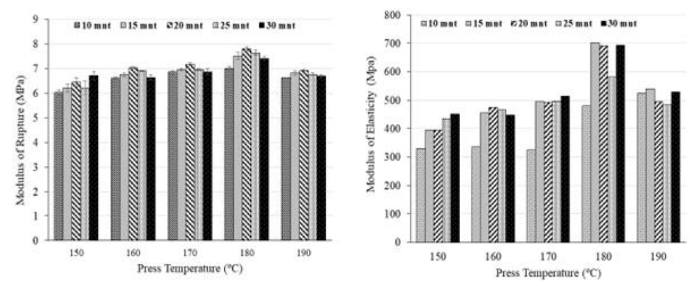

Fig 5. MOR and MOE, Composition TPB/OPEFB:15/85

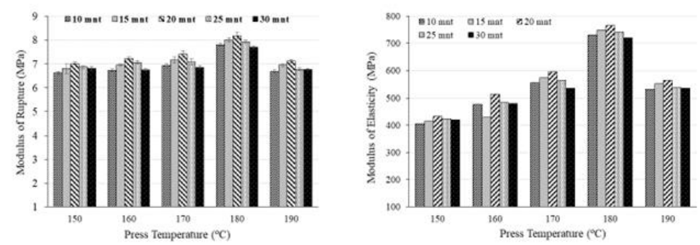

Fig 6. MOR and MOE, composition TPB/OPEFB: 20/80

In the composition of TPB / OPEFB: 20/80, increasing TPB in particleboard tends to improve the mechanical properties of MOR and MOE. The values obtained were equivalent to the results of the study of particleboards from palm oil trunks, namely 7.09 MPa and 863.93 MPa, respectively [25]. This result is better than a study of particleboards made from corncobs and bagasse, where the best MOR values are 4.4 MPa and 3.7 MPa respectively [27] The study of particleboard from oil palm trunks using the material steaming method showed that the mechanical properties obtained were MOR 25.84 MPa and IB 1.04 MPa [26]. Work carried out on particleboards made of black pine bark and PE with a particle size of 0.18-1 mm, obtained MOR values from 20.6 to 27.3 MPa [28]. A study of particleboard made from coconut fiber pith with particle-sized 20-40 mesh without adhesives obtained MOE, MOR, and IB values, respectively, of 2398 MPa, 24.7 MPa, and 1.1 MPa [9]. Studies on particleboards made from oil palm trunk (OPT) with the addition of ammonium dihydrogen phosphate (ADP) yielded a maximum MOR of 9 MPa and MOE of 8.5 MPa at 10% ADP composition [29]. Another study of particleboard made from wood waste and cassava starch as a binder with a composition of 1.5% and 2.5% produced MOR: 23.5 MPa and 35.7 MPa [30]. This result is better than our study which shows that the particle size of material can increase the value of MOR and MOE. Another study on particleboard made from OPEFB obtained MOR: 9.08 MPa and MOE: 689.48 MPa with 50 mesh TPB particle size [20]. Even though at the 20% TPB composition, the MOR has met the Standards, the MOE has not. The mechanical properties of particleboard can be improved through several methods, namely by increasing the pressure and the percentage of TPB and reducing the particle size. The optimal pressing time is one important thing in making particle board to get the best mechanical properties [31], figures 4, 5, and 6 show that a 10 minute pressing time is not enough to produce good mechanical properties. At 170°C, the composition of TPB/OPEFB: 10/90, 15/85, and 20/80 show MOR values of 6.58 MPa, 6.85 MPa and 6.93 MPa, respectively. At the same temperature, increasing the pressing time can increase the MOR value, and the best pressing time is in the range of 20-25 minutes. Particleboard material contains cellulose, hemicellulose, and lignin whose melting temperatures range between 170-200ºC[31]. Figures 4, 5, and 6 show that the best mechanical properties occur at temperatures of 170-180ºC, that cellulose, hemicellulose, and lignin have reached their melting point to form hydrogen bonds. Particleboard product is not a good conductor of heat, propagation of heat starts from two surfaces, namely top and bottom. The heat radiates from the surface to the middle of the thick requires sufficient time so that the temperature was the same as the surface. Pressing time of 20-25 minutes was predicted to be sufficient to even out the temperature in the middles of the thick and surface. We have not yet investigated how heat propagation in the manufacture of particleboards consists of natural fibers without synthetic adhesives at the same pressure.

Internal Bonding (IB)

By using analytical following equation 4, the value of internal bonding (IB) such as figure 7A, 7B, and 7C, shows optimal results. From the graph, the optimal IB values differ from each other, but each of them meets the standard. The maximum internal bond (IB) values in the TPB ratios of 10%, 15%, and 20% were 0.164 MPa, 0.179 MPa, and 0.187 MPa, respectively. The IB values obtained met the standard, which is 0.15 MPa, but smaller than the results obtained by previous researchers [25][9]. The adhesion on the particleboard is predicted to occur between the elements of cellulose and tannins contained pine bark. The temperature of the hot press which is applied in the range 170-180ºC causes the tannin to melt well, the melting temperature of 102ºC. On the other hand, cellulose has not yet melted but is enough to bind tannins. The adhesion tannins with cellulose occur in the outer skin of its structure, known as hydrogen bonding. Hydrogen bonds were intermolecular attractions or dipoles that occur between two partial electric charges with opposite polarity. Despite the strong intermolecular forces, hydrogen bonds were much weaker than covalent bonds and ionic bonds. Table 2 shows a comparison of the acquisition of particleboard properties made from natural fibers.

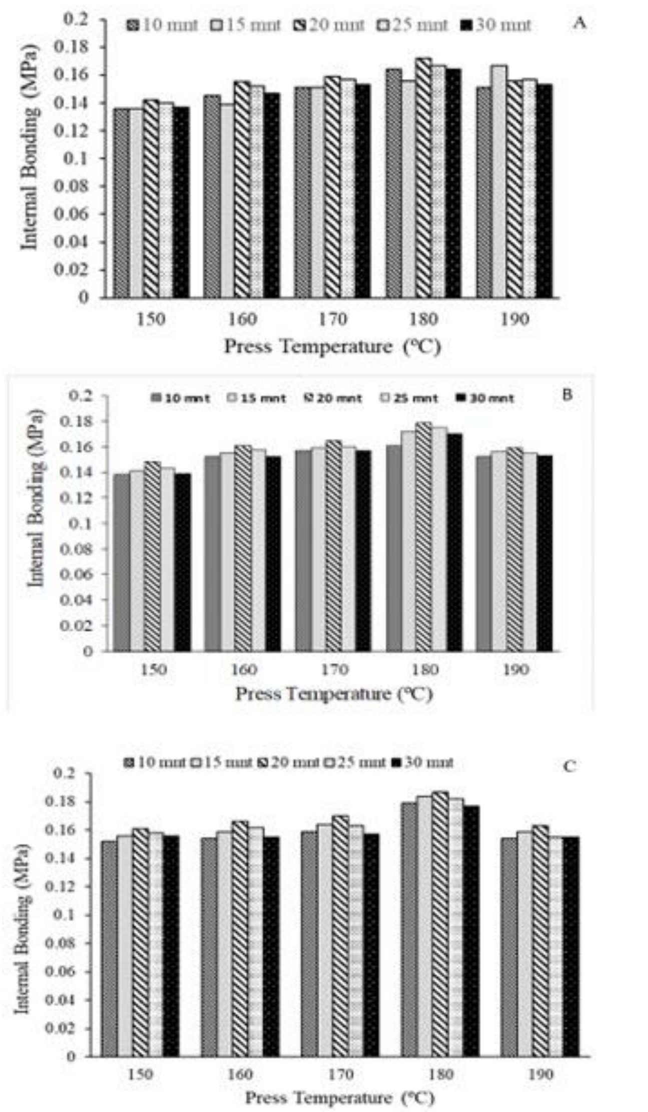

Fig 7. *Internal Bonding, composition TPB: 10% (A), 15% (B) and 20%(C)*

Table 2. *Comparison of the acquisition of particle board properties made from natural fibers*

Materials	TS (%)	WA(%) for 2 h	MOR (MPa)	IB (MPa)	Adhesive
corn biomass [5]			10.89		
Oil palm trunks [3]	51.8-147.1	51.8-147.1	11.08	1.81	polyhydroxyalkanoates
Neolamarckia cadamba [7]	30.7-53.6	112.7-131.9	17.6-35.85	0.55-0.81	UF
date palm branches [8]	5 - 26	35-83	2.1-7.3	0.04-0.43	vermiculite (VER)
coir pith [9]	24.7-31	51-68	18-22	0.8-1	
young and old oil palm trunks [10]	15.92-111	56.74-136.	7.99-13.59	0.17-1.91	
OPT and Acacia mangium[12]	28.72	47.22	19.96	0.2	
Jatropha curcas[11]	20	52	7.2	0.14	
mahogany wood[14]	13.6-19.2	69.4-90.9	2.6-6.2	0.1-0.18	
Bamboo[16]	4.32	13.2	6.29		PLA
OPEFB	33.6	78.5	8.2	0.187	TPB

The presence of a smooth cavity indicates the bonding imperfection of cellulose with tannin, the imperfection is caused by insufficient pressure, the press temperature in the middle of the thickness is not evenly distributed. This cavity also shows that there is no bonding reaction and mechanical properties that were not yet optimal. SEM from the cross-section at pressing time for 20 minutes shows is a cavity, as in figure 8. On the other hand, increasing the pressure on the particleboard will increase the air pressure in the cavity and if this compressed air persists until the process is complete, it can reduce the bond strength, therefore the cavity on the particle board must be removed. Several methods can be applied to remove air cavities, namely reducing the length of the fiber, increasing the pressure, increasing the TPB composition, and creating an air duct in the molded wall that allows compressed air to escape from the particleboard.

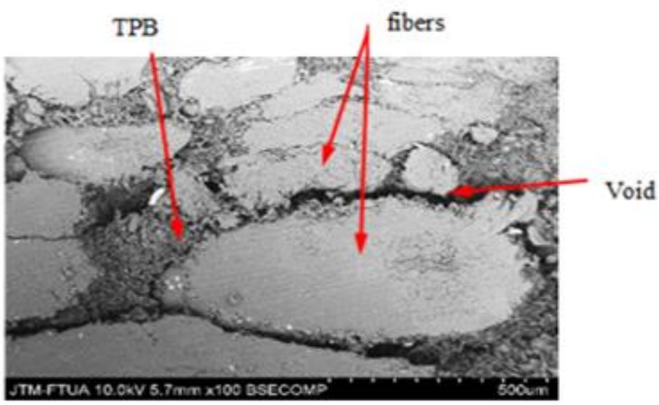

Fig 8. *SEM on the particleboard cross-section, pressing time: 20 minutes*

Mechanism of failure
Particleboard failure can occur but is not desirable. Studying failure is needed to improve the quality of the particleboard. Therefore, the author observed and studied the failure of particleboard when subjected to external loads. The flexural test was carried out using the triple-point method with a buffer distance of 15 cm. Testing was carried out until failure occurs on the particleboard. The pressure applied was as much as P. Observation on broken sections showed fracture patterns, which can be divided into two as follows:

Release of fiber bond
Failure due to loosse fiber adhesion. On particleboard, hydrogen bonds were formed from its elements, namely cellulose and tannins. Figures 9a and 9b show failures that begin with cracks on the surface of the tensile side and then propagate and cut through thick particleboard. Increased cracking stops after pressure P decreases. The fracture that occurs forms an angle of 45º to the elongated cross-section. The loosening of the fiber bond that starts from the pull side continues towards the center of the cross-section and, partly in the elongated direction, as shown in Figures 9a and 9b. The failure was marked by the formation of dimples on the damaged surface and the observation of TPB powder in groups, showing that the mixing of OPEFB fibers with TPB was not evenly distributed. The perfect mixing of OPEFB fibers with TPB is important and the parameters that affect mixing were time, rotational speed, and volume.

Disconnected fiber
Figure 9c shows the failure of the particle board cross section after the bend test. Failure (fracture) occurs perpendicular to the longitudinal section, in contrast to the failure that occurs in Figure 9b. The cross section shows the failure of some broken fibers due to external forces (P). The interrupted fibers have a smooth cross-section of the others, and have little tensile strength. A nice thing is that the fiber bond is better than the strength of the fiber. Reducing fine-looking fibers can be done at a laboratory scale but is difficult to apply to mass production in the particle board industry. Reducing the length of the fiber is the most likely thing to do to improve its mechanical properties and reduce cavities.

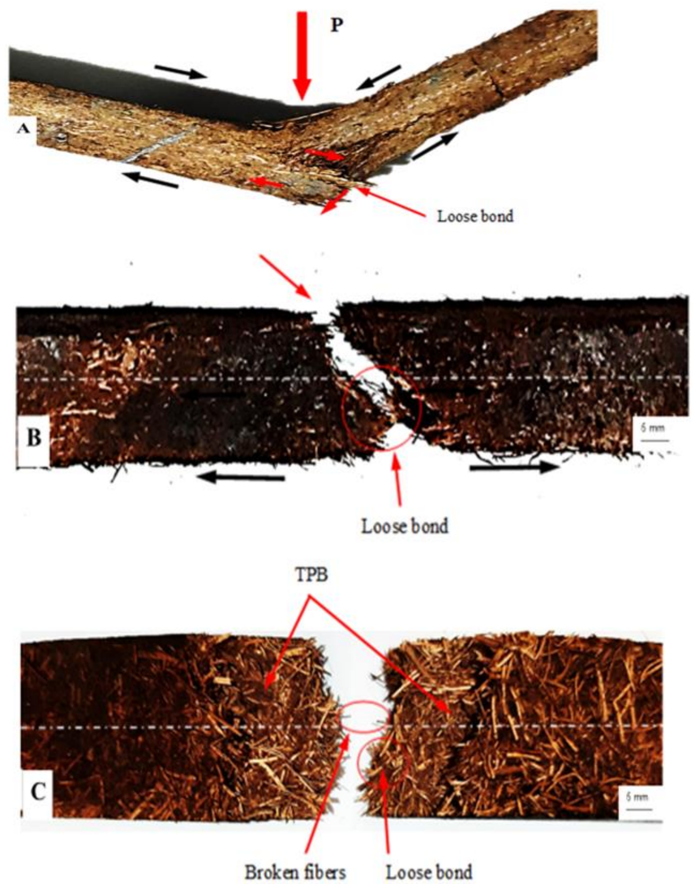

Fig 9. *Failure of particleboard*

CONCLUSION

Based on the results of tests and discussions on the properties of particleboards made from oil palm empty fruit bunches and tree pine bark, several conclusions can be drawn as follows:
By-products of TPB and OPEFB can be processed into particleboards without synthetic adhesive. This practice is very helpful in reducing and functioning by-products of processing oil palm and pine tree plantations. The optimum mechanical property value of the particleboard has fulfilled JIS A 5908-2015 with composition TPB/OPEFB namely 20/80, pressing temperature of 170-180ºC and pressing time of 20-25 minutes. However, MOE has not met the Standards. Improving the mechanical properties of particleboard can still be done and

manufacturing particleboard with TPB and OPEFB materials can be recommended.

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