World Journal of Advanced Research and Reviews

eISSN: 2581-9615 CODEN (USA): WJARAI

Cross Ref DOI: 10.30574/wjarr

Journal homepage: https://wjarr.com/

(Research Article)

Check for updates

Properties changes of rice husk-particleboard during indoor and outdoor exposure

Tamrin [1, *], Filli Pratama [2], Rahmad Hari Purnomo [1], Jonesman Sidabutar [1] and Edison Sitanggang [1]

[1] *Study Program of Agricultural Engineering, Department of Agricultural Technology, Faculty of Agriculture, Sriwijaya University, South Sumatera, Indonesia.*

[2] *Study Program of Agricultural Product Technology, Department of Agricultural Technology, Faculty of Agriculture, Sriwijaya University, South Sumatera, Indonesia.*

World Journal of Advanced Research and Reviews, 2023, 20(03), 1334–1340

Publication history: Received on 29 October 2023; revised on 16 December 2023; accepted on 19 December 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.20.3.2511

Abstract

Rice husk particles were used as a major material in making of particleboard. The experimental research used a factorial randomized block design with two factors. The first factor was the relative humidity (RH) that consisted of indoors RH of 83-85% and outdoors RH of 87-91%; the second factor was the exposure time (1-6 week(s)). The physical and mechanical properties changes of rice husk-particleboard during 6 weeks of indoor and outdoor exposures were measured. The internal bond (IB), modulus of rupture (MOR), modulus of elasticity (MOE) of rice husk-particleboard decreased and the thickness of swelling as well as density of rice husk-particleboard increased during exposing to indoors and outdoors open-air.

Keywords: Indoor; Outdoor; Particleboard; Properties changes; Rice husk

1. Introduction

Paddy is the important crop in Indonesia due to it is the staple for most of Indonesians. Rough rice is the fruit of paddy that should go through some processes to produce milled rice. Rice husk is the by-product during milling of rough rice into milled rice. A rough rice grain consists of 20% hull and 80% brown rice [1]. Local farmer in Indonesia used to burn rice husk as solid fuel or dumped as a solid waste. The improper handling of agricultural waste product could harm the environment. Alternative solution is to recycle agricultural waste into other product for human needs.

Rice husk has unique properties such as toughness, resistance to weathering, high in silica and cellulose, low water, and moisture permeability [2][3]; therefore, rice husk is a potential material for briquette [4] and particleboard [5] [6] [7] [8]. Furthermore, Johnson and Nordin [9]stated that rice husk was potential for various types of boards such as particleboards, insulation boards and ceiling boards. Among those, particleboard is the most produced by manufacturer due to its many uses for housing and industries.

Owing to declining forest potential, alternative raw material from organic wastes were used for particleboard [10]. Rice husk which is as agricultural waste is continuously available at a relative low price and is potential as major material for particle boards. Particleboard used to be manufactured using wood particles and binder; however, recently particleboard is produced in a composite material consisting of wood particle with other materials such as agricultural waste. Previous works on particleboard were carried out by Melo et al. [6] by mixing wood particle with bamboo and rice husk; Das [11] produced particleboard from leaf fiber residues of sugar beet, Aisien [12], [13] made particleboard from cassava stalks; Vancai [13], Amenaghawon et al. [14] and Kalaycioglu et al. [15] used bamboo waste, cobs, cassava stalks and paulownia as raw materials for particleboard. Different raw materials in particleboard will result in different physical and mechanical properties of the particleboards. In addition, the different types of binder in the particleboard

* Corresponding author: Tamrin

might have an effect on different properties of the product. Other material might be added in the manufacturing of particleboard to produce a particleboard with particular properties, for example polyethylene was added in particleboard to increase the water resistance [16].

Rice husk has been long recognized as raw material for particleboard. Some studies have been performed on the particleboard made of rice husk [3] [7] [8] [5] [17]. Most of those studies investigated the physical and mechanical properties of particleboards. As stated earlier, particleboards are used for furniture that might be placed outdoors or indoors. There have not many studies on the property changes of particleboard during outdoors and indoors. One of the problems encountered with the tropical countries was the high humidity. This is unfavorable condition for maintain the quality of particleboard. Therefore, the objective of this study was to analyze the properties changes of rice husk-particleboard during outdoors and indoors.

2. Materials and Methods

2.1. Materials used

Rice husks were collected from a local rice processing mill in Palembang city, province of south Sumatera, Indonesia. They were dried under the sun up to 5% of moisture content and crushed in a blender to obtain particle size of 1.18 mm in diameter. The adhesive of polyvinyl acetate (PVA) was used as particleboard binder. The PVA (200 g) was diluted by adding distilled water as amount of 10% of the total weight of PVA. Paraffin liquid (KGaA 64271 Darmstadt Germany).

2.2. Particleboard manufacturing

Rice husk particles as amount of 300 g was placed in a stainless container. The diluted PVA and paraffin (4% w/w of rice husk) were gradually added into the rice husk particles and homogenously mixed. Afterwards, the mass of particles was taken to a wooden mold with the size of 25 cm x 20 cm x 1 cm and manually pressed. Then, the definitive pressing was performed in a hydraulic press at the pressure of 15 kg cm-2 for 10 minutes, followed by a hot press for 15 minutes at the temperature of 110 ^{0}C and 15 kg cm-2 of pressure. The particleboard was then dried under sun for three days.

There were 42 rice husk-particleboards for the analysis of the property's changes during indoors (83%-85%) and outdoors (87-91%) for 6 weeks. The experiments were run in triplicates.

2.3. Particleboard testing

2.3.1. Thickness of swelling

The particleboard was periodically measured for its thickness. The thickness of swelling was calculated according to Standard National Indonesia 03-2105-2006 as follows:

$$Thickness of swelling = \frac{T_2 - T_1}{T_1} \times 100\%$$

Where T_2 is the thickness (mm) after the exposure time and T_1 is the initial thickness of particleboard.

2.3.2. Density

Density of the particleboard was measured according to Standard National Indonesia 03-2105-2006. It was defined as weight (g) divided by volume (cm^3).

2.3.3. Modulus of Rupture (MOR) and Modulus of Elasticity (MOE)

Specimens for analysis of MOR and MOE were in the size of 5 cm × 20 cm × 1 cm. The bending of MOR and MOE were calculated from load deflection curves according to Standard National Indonesia 03-2105-2006, as follows:

$$MOR(Nmm^{-2}) = \frac{3BS}{2L \rightleftarrows T^2}$$

$$MOE(Nmm^{-2}) = \frac{\Delta BS^3}{4\Delta DL \rightleftarrows T^3}$$

Where B is the maximum load (N), ∆B is the load at the proportional limit (N), S is the span (mm), L is the width of the specimen (mm), T is the thickness of specimen (mm) and ∆D is the deflection corresponding to ∆B (mm).

2.3.4. Internal Bond Strength (IB)

The specimen for IB was in the size of 5 cm × 5 cm. The rupture load (B) was determined and the IB was calculated according to Standard National Indonesia 03-2105-2006 as follows:

$$IB(Nmm^{-2}) = \frac{B}{2PL}$$

Where B is the maximum load (N), P is the length of specimen (mm); L is the width of the specimen (mm).

2.4. Experimental design

Factorial randomized block design was used with two treatment factors and three repetitions. The treatment factors were environmental conditions and exposure time. The first factor consisted of two levels, indoors (relative humidity of 83%-85%) and outdoors (relative humidity of 87%-91%), whereas the second factor consisted of 7 levels, 0, 1, 2, 3,4, 5 and 6 week(s). The data obtained were evaluated using analysis of variance (ANOVA) and honestly significant difference test at the 5% level.

3. Results and Discussion

3.1. Physical properties (Density and thickness of swelling)

Statistical analysis showed that the factor A (environmental conditions) and factor B (exposure time) had significant effect on the density as well as the thickness of swelling of rice husk-particleboard, whereas the interaction between factor A and B had significant effect on the thickness of swelling. The mean values of density and thickness of swelling during 6 weeks of exposure time in both outdoor and indoor are presented in Table 1. Density of rice husk-particleboard increased during exposure to open-air both in indoor and outdoor (Figure 1). Similar trend was also found in the thickness of swelling of the rice husk-particleboard during exposure to open-air (Figure 2). The thickness of swelling increased more than twice as much as thickness of swelling of rice husk-particleboard in indoor exposure.

Table 1 Density and thickness of swelling of rice husk particleboard in indoor and outdoor

Exposure Time (week(s))	**Density (kg m^{-3})**		**Thickness of swelling (%)**	
	indoor	outdoor	indoor	outdoor
0	557.98	557.98	0.00	0.00
1	560.52	566.43	0.40	0.90
2	564.05	568.55	0.46	1.06
3	568.26	571.88	0.53	1.22
4	570.27	572.87	0.63	2.06
5	570.76	575.89	0.67	2.08
6	570.77	576.00	0.71	2.10

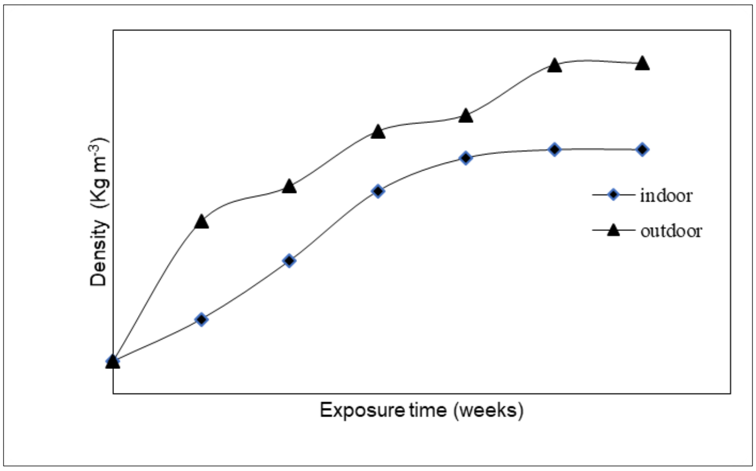

Figure 1 Density changes of rice husk-particleboard during indoor and outdoor

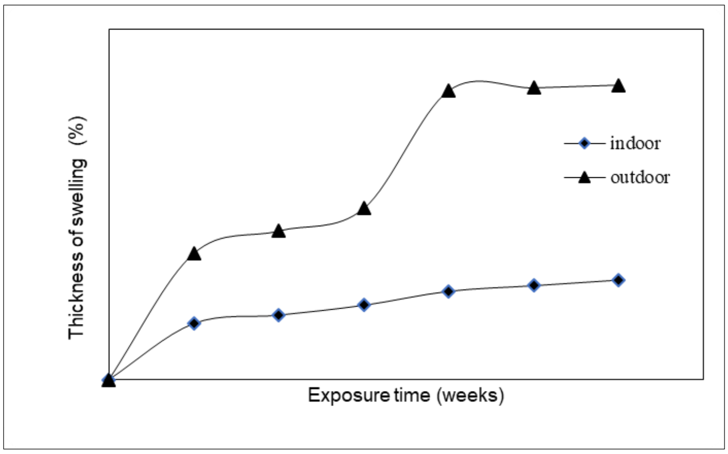

Figure 2 Thickness of swelling changes of rice husk-particleboard during indoor and outdoor

3.2. Mechanical Properties (IB, MOR and MOE)

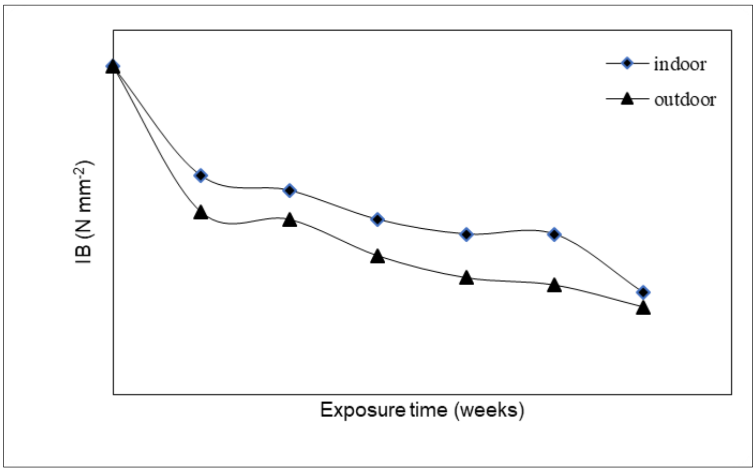

Figure 3 IB changes of rice husk-particleboard during indoor and outdoor

Statistical analysis showed that factor A (environmental condition) and factor B (exposure time) had significant effect on the IB, MOR and MOE. The mean values of IB, MOR and MOE were presented in Fig. 3 to 5. The IB, MOR and MOE decreased concomitantly during exposure to open-air indoor and outdoor. The decreases of IB, MOR and MOE were higher during exposure to outdoor than that of exposure to indoor.

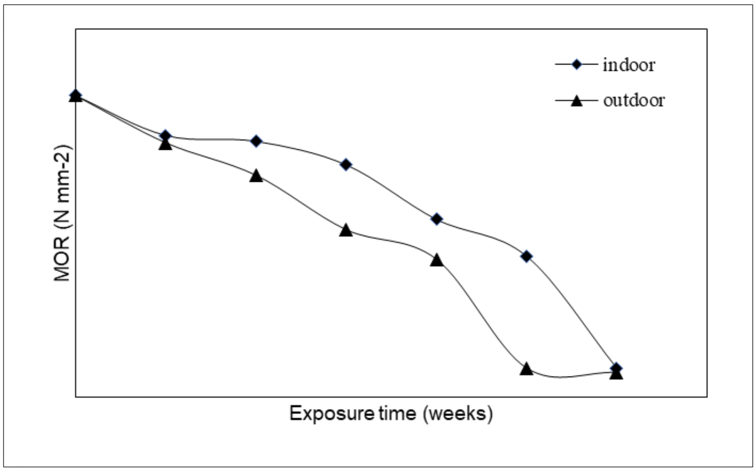

Figure 4 MOR changes of rice husk-particleboard during indoor and outdoor

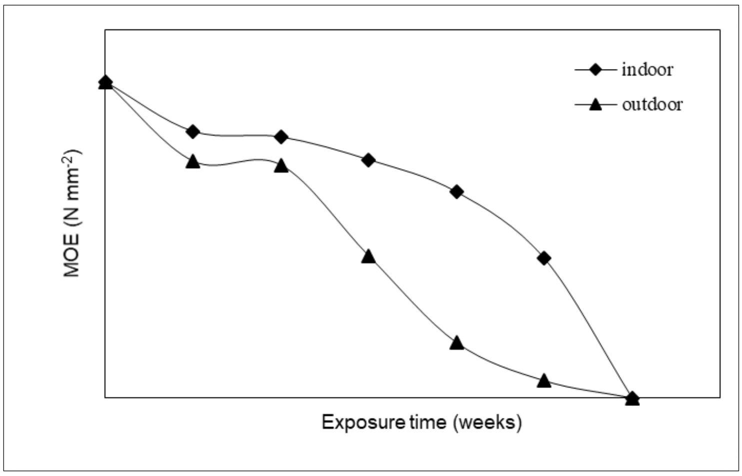

Figure 5 MOE changes of rice husk-particleboard during indoor and outdoor

Both density and thickness of swelling increased along with the longer of exposure time. It was due to more moisture was absorbed by rice husk-particleboard. The increase of density and thickness of swelling were larger in the outdoor. Rice husk contained cellulose, silica, and lignin 15 which are hygroscopic. Previous studies reported that the cellulose content in the ranges between 25 to 35% [18], [19]. Water vapor absorption by cellulose occurred during exposure of rice husk-particleboard to open-air. The hydroxyl group in the chain of cellulose is the reason for the moisture vapor absorption. It resulted in increase of moisture in particleboard; therefore, it affected the density and thickness of swelling. The most abundant chemical composition in rice husk is silicon dioxide which might be in the ranges of 14.8% to 17.9% [2] [3]. It is known as desiccant and widely used in food industries to keep the crispness of the product during storage.

The water vapor absorption of rice husk-particle board increased higher during outdoor rather than indoor. The outdoors temperature could reach 45°C at the afternoon which might have an impact on the particleboard to swell, therefore the thickness of swelling in outdoor is larger than in indoor.

The outdoors relative humidity was higher than the indoors humidity; in addition, the fluctuated temperature outdoor had an impact to rice husk-particleboard. With respect to moisture absorption, it was speculated that desorption and absorption of water vapor might frequently occur during exposure to outdoor. Moisture in the particleboard might hydrolyze the binder and soften the particleboard; therefore, the IB, MOR and MOE declined. It agreed with [7] who stated that the amount of purified water should be controlled in particleboard to produce a strong bond among the rice husk particles. The initial moisture content of the rice husk-particleboard was 9.27%. It was increased to 15.97% and 18.01% during six weeks of exposure time to indoor and outdoor, respectively.

The changes of MOR and MOE properties as shown in Fig. 1 and 2 almost have the similar pattern. Unlike MOR and MOE, the IB sharply decreased during the first week of exposure time and gradually declined during exposure to indoor and outdoor. Within the properties analyzed in the present work, internal bonding played an important role in determining other particleboard's properties. The initial IB of the rice husk-particleboard met the minimum values required by Standard National Indonesia 03-2105-2006. However, the IB values decreased during exposure to indoor and outdoor; it reached 0.14 and 0.12 N mm2 after 5 weeks of exposure time to indoor and outdoor, respectively. Unfortunately, after six weeks of exposure time, the particleboard did no fulfill the minimum requirements established by Standard National Indonesia 03-2105-2006. It might need some modifications in rice husk-particleboard manufacturing to increase the water resistivity during exposure the panels to indoor and outdoor. The physical and mechanical properties of particle board according to Standard National Indonesia 03-2105-2006 were presented in Table 2. The surface appearance of particleboard as presented in Figure 6.

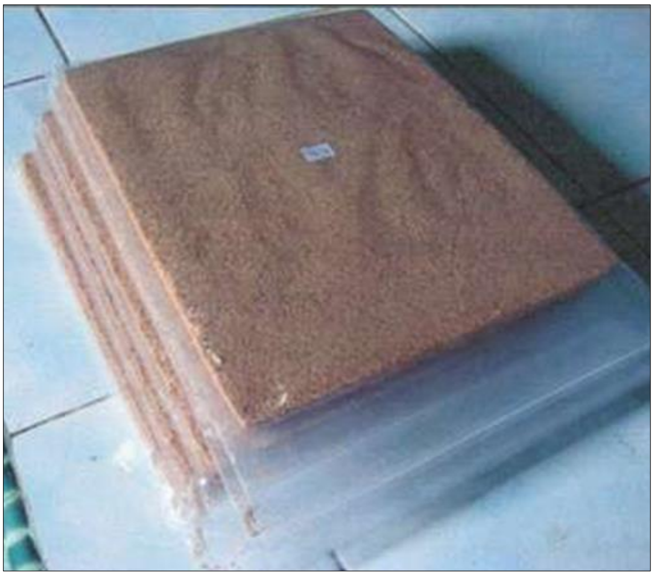

Figure 6 The rice husk particleboard

4. Conclusions

The initial density of rice husk-particleboard was 557.98 kg mm-3 increased to 570.77 and 576 kg mm-3; thickness of swelling increased to 0.71 and 2.10% after 6 weeks of exposure time to indoor and outdoor, respectively. On the other hand, IB, MOR and MOE decreased during the exposure times. The moisture absorption into the particleboard was suspected to be the factor of the physical changes during exposing to open-air.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] H. U. Syarif, M. S. DA, and W. Wahab, The Chemical Composition And Physics Rice Husks Used As An Absorber Plate, 2015.

[2] I. Valchev, V. Lasheva, T. Tzolov, and N. Josifov, Silica products from rice hulls, Journal of the university of chemical technology and Metallurgy, vol. 44, no. 3, pp. 257–261, 2009.

[3] T. G. Korotkova, S. J. Ksandopulo, A. P. Donenko, S. A. Bushumov, and A. S. Danilchenko, Physical properties and chemical composition of the rice husk and dust, Orient. J. Chem, vol. 32, no. 6, pp. 3213–3219, 2016.

[4] D. B. Yahaya and T. G. Ibrahim, Development of rice husk briquettes for use as fuel, Research journal in engineering and applied sciences, vol. 1, no. 2, pp. 130–133, 2012.

[5] A. K. Temitope, A. T. Onaopemipo, A. A. Olawale, and O. O. Abayomi, Recycling of rice husk into a locally-made water-resistant particle board, Ind Eng Manage, vol. 4, no. 164, pp. 316–2169, 2015.

[6] R. R. de Melo, D. M. Stangerlin, R. R. C. Santana, and T. D. Pedrosa, Physical and mechanical properties of particleboard manufactured from wood, bamboo and rice husk, Materials Research, vol. 17, no. 3, pp. 682–686, 2014.

[7] T. Ota and T. Okamoto, Mechanical properties of particleboard made from rice husk, Journal of Materials Science and Engineering B, vol. 5, no. 8, pp. 263–269, 2015.

[8] I. Y. Suleiman, V. S. Aigbodion, L. Shuaibu, and M. Shangalo, Development of eco-friendly particleboard composites using rice husk particles and gum Arabic, J. Mater. Sci. Eng. Adv. Technol, vol. 7, no. 1, pp. 75–91, 2013.

[9] A. C. Johnson and Y. B. D. D. Nordin, Particleboards from rice husk: a brief introduction to renewable materials of construction, Cellulose, vol. 28, p. 38, 2009.

[10] L. Muruganandam, J. Ranjitha, and A. Harshavardhan, A Review Report of Physical and Mechanical Properties of Particle Boards from Organic Waste, Journal of ChemTech Research, vol. 9, no. 1, pp. 64–72, 2016.

[11] S. Das, S. Chanda, R. N. Das, and S. K. Bhaduri, Particle board from leaf fibre residues of sugarbeet, 2000.

[12] F. A. Aisien, A. N. Amenaghawon, and K. C. Bienose, Particle boards produced from cassava stalks: Evaluation of physical and mechanical properties, S Afr J Sci, vol. 111, no. 5–6, pp. 1–4, 2015.

[13] L. Vancai, Physical and mechanical properties of particleboard from bamboo waste, World Acad Sci Eng Technol, vol. 40, pp. 566–570, 2010.

[14] N. A. Amenaghawon, W. Osayuki-Aguebor, and C. O. Okieimen, Production of particle boards from corn cobs and cassava stalks: optimisation of mechanical properties using response surface methodology, J. Mater. Environ. Sci, vol. 7, no. 4, pp. 1236–1244, 2016.

[15] H. Kalaycioglu, I. Deniz, and S. Hiziroglu, Some of the properties of particleboard made from paulownia, Journal of Wood Science, vol. 51, no. 4, pp. 410–414, 2005.

[16] S. Waelaeh, V. Tanrattanakul, K. Phunyarat, P. Panupakorn, and K. Junnam, Effect of polyethylene on the physical and mechanical properties of particleboard, in Macromolecular Symposia, Wiley Online Library, 2017, pp. 8–15.

[17] J. Torkaman, Improvement of bondability in rice husk particleboard made with sodium silicate, in Proceedings of the 2nd International Conference on Sustainable Construction Materials and Technologies, Citeseer, 2010, pp. 1–31.

[18] L. N. Ludueña, D. P. Fasce, V. A. Alvarez, and P. M. Stefani, Nanocellulose from rice husk following alkaline treatment to remove silica, 2011.

[19] H. G. B. Premalal, H. Ismail, and A. Baharin, Comparison of the mechanical properties of rice husk powder filled polypropylene composites with talc filled polypropylene composites, Polym Test, vol. 21, no. 7, pp. 833–839, 2002.