ISSN: 2963-2536 (media online)

Proceedings of Malikussaleh International Conference on Multidisciplinary Studies (MICoMS)
Organized by center of Excellence of Technology Natural Polymer and Recycle Plastics

International Conference Proceedings 00010 (2024) DOI: https://doi.org/10.29103/micoms.v4.2024

Analysis of Briquettes Characteristics Made of Oil Palm Frond Waste and Sugarcane Bagasse with

Agam Muarif[1], Rizka Mulyawan[1], Ahmad Fikri [2], Desvina Yulisda [3], Dedi Sutarma[4], Intan Rahmi Rukmana[1], Ahmad Kasyir Pane [2]

[1] Chemical Engineering Department, Malikussaleh University, Kampus Bukit Indah, Aceh Indonesia
[2] Material Engineering Department, Malikussaleh University, Kampus Bukit Indah, Aceh Indonesia
[3] Information Systems Department, Malikussaleh University, Kampus Bukit Indah, Aceh Indonesia
[4] Department für Physik, Universität Duisburg-Essen, Campus Duisburg Lotharstr, Germany
* Correspondence: amuarif@unimal.ac.id

Abstract: Oil palm frond waste and sugarcane bagasse are high-fiber biomass materials that can be converted into alternative energy sources like briquettes. The carbonization method is used to create charcoal briquettes, converting raw organic materials into carbon. The produced charcoal is mixed with a adhesive and molded into cylindrical or block shapes. This study aims to determine the characteristics of briquettes with varying compositions of palm fronds and bagasse (50:50 ; 40:60 ; 30:70 ; 20:80 ; 10:90 (b/b)) and different tapioca starch adhesive amounts (40% ; 45% ; 50% ; 55% (v/b)). In this study, tests were conducted on moisture content, ash content, calorific value, and combustion rate. The research findings indicate that the best-quality charcoal briquettes were produced by combining sugarcane bagasse and palm fronds in a 50:50 ratio with a adhesive containing 40% tapioca starch. These briquettes have the following properties: moisture content of 4.4545%, ash content of 4.62021%, combustion rate of 0.2283 g/min, and calorific value of 6,232.67 cal/g. These results indicate that the briquettes made from a mixture of oil palm frond waste and sugarcane bagasse using tapioca starch as a adhesive have met the SNI 01-6235-2000 standard criteria.

Keywords: Charcoal briquettes, carbonization, sugarcane bagasse, oil palm fronds, and tapioca starch

1. Introduction

Energy is an essential component of many commercial activities and communal life. Fossil fuels, as non-renewable energy sources, continue to play a crucial role in meeting current energy needs. Since 1995, Indonesia's fuel demand has exceeded domestic production, and the country's oil reserves are projected to be depleted within 10 to 15 years. The scarcity of gasoline in various regions supports this projection. Despite the relatively low demand for chemical raw materials in Indonesia, it continues to grow and is fulfilled through imports. Indonesia is rich in biodiversity, which can be utilized for energy production.

Biomass energy is one type of alternative energy that can be used. Biomass is generally referred to as dry organic matter or the material remaining after plants or other organic materials have lost their water content. Burning is a common way to eliminate biomass, often regarded as waste. Biochar, a fuel with a relatively high calorific value, can be made from this biomass for daily use. Biomass is readily found from waste-producing activities such as agriculture, livestock, forestry, plantations, and fisheries.

On the other hand, biomass contains less carbon and a large amount of volatile substances. Although its calorific value is moderate, the ash content varies depending on the type of material.

Biomass combustion is initiated at a low temperature due to its high volatile component content. This low-temperature devolatilization process indicates that biomass combustion is simple. According to Jamalitun (2008), combustion occurs very quickly and can be difficult to control [1]. Biobriquettes made from sugarcane bagasse and oil palm frond waste are one such alternative fuel. Due to the ease of obtaining sugarcane bagasse and oil palm frond biomass, both high in cellulose content, they hold potential for conversion into biobriquettes. The quality of biobriquettes improves with higher cellulose content [2].

The sugarcane plant (Saccharum officinarum) grows well in tropical regions, including Indonesia. Generally, sugar factories process sugarcane into sugar, producing bagasse as a byproduct. Bagasse is a common term for sugarcane waste. Currently, bagasse is often used as boiler fuel in sugar factories and as a raw material for compost. Bagasse contains 48–52% water and its chemical composition includes 3.01% silica, 22.09% lignin, 37.65% cellulose, 27.97% pentosan, 3.82% ash, and 3.3% reducing sugars [3].

Given the above, researchers are considering utilizing sugarcane bagasse and oil palm frond waste as raw materials for briquette production to reduce waste accumulation, historically a human challenge. The most common oil palm plantation waste suitable for briquette production is oil palm fronds. To ensure optimal quality in accordance with SNI standards, researchers are experimenting with various combinations of bagasse and palm frond charcoal.

2. Materials and Methods

Materials and tools required for this study are: sugarcane bagasse, oil palm fronds, tapioca starch, porcelain crucible, analytical balance, spatula, basin, stirrer, desiccator, oven, 60-mesh sieve, cylindrical briquette mold, combustion furnace, beaker, hot plate, and measuring cylinder.

The preparation of raw materials for this research involves several stages. For sugarcane bagasse, it is cleaned, cut into 3-5 cm pieces, and sun-dried. Once dry, it is gradually burned in a furnace at 300°C for 30 minutes, cooled, ground into fine powder, and sieved with 50-mesh. Similarly, oil palm fronds are separated, cut, dried, and burned at 300°C for 60 minutes before being processed into powder. Tapioca starch adhesive is prepared by mixing it with distilled water, heated until clear and thick. The briquette mixture of oil palm frond powder and sugarcane bagasse (50:50, 40:60, 30:70, 20:80 and 10: 90) with adhesives of 40, 45, 50 and 55% is pressed into cylindrical molds, baked at 105°C for 2 hours, cooled, and tested for moisture, ash content, combustion rate and calorific value.

3. Results and Discussion

3.1. Moisture content analysis

The effect of the ratio of sugarcane bagasse and oil palm fronds with adhesive concentration variations on moisture content can be seen in Figure 1 as follows:

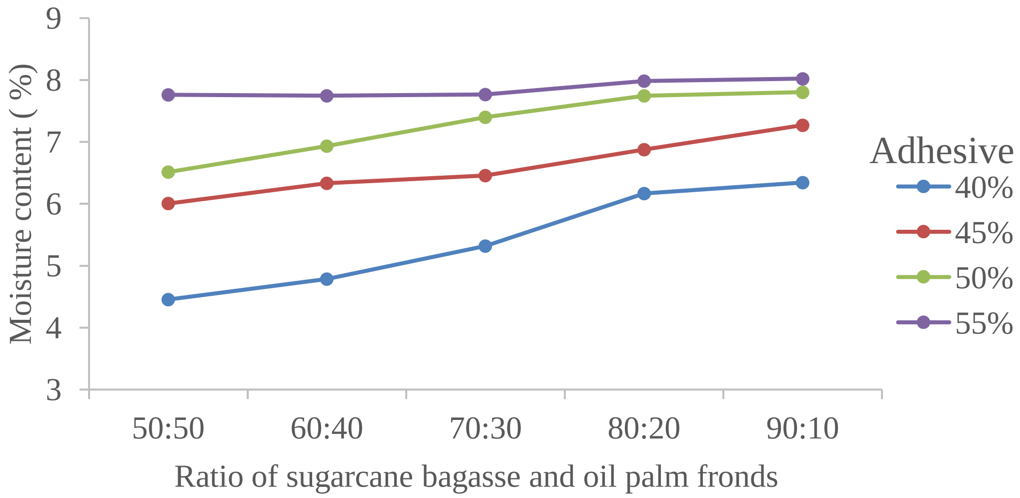

Figure 1. Effect of the ratio of sugarcane bagasse and oil palm fronds with adhesive concentration variations on moisture content

Based on Figure 1, it is shows that as the adhesive concentration increases, the resulting moisture content also increases. This is due to the adhesive's sticky and hard properties, which influence the bonding strength in briquettes. This observation aligns with the research conducted by Smith and Idrus (2017), which states that higher adhesive usage tends to increase the moisture content in briquettes [4]. The figure also demonstrates that the higher the proportion of sugarcane bagasse, the higher the resulting moisture content. This is because sugarcane bagasse has a higher moisture content compared to oil palm fronds. This finding is supported by another research stated that the variation in results is influenced by raw materials with significantly high moisture content [5].

From the analysis and testing of briquettes made from sugarcane bagasse and oil palm fronds, the lowest moisture content is 4.4545% was observed in a mixture of 50 grams of sugarcane bagasse and 50 grams of oil palm fronds with 40% tapioca flour adhesive. Meanwhile, the highest moisture content is 8.0229% was observed in a mixture of 90 grams of sugarcane bagasse and 10 grams of oil palm fronds with 55% tapioca flour adhesive.

The variation in moisture content percentages in the briquettes made from sugarcane bagasse and oil palm fronds with tapioca flour adhesive demonstrates that mixing these materials leads to an increase in moisture content in the charcoal briquettes. However, it can be concluded that the sugarcane bagasse and oil palm frond briquettes with tapioca flour adhesive meet the standards of SNI 01-6235-2000, which specify a maximum moisture content of 8% for charcoal briquettes. The test results in this study show an average moisture content of <8%, as illustrated in Figure 1.

Moisture content significantly affects the quality of the produced charcoal briquettes. The lower the moisture content, the higher the calorific value of the briquettes. High moisture content makes briquettes difficult to ignite during combustion, produces more smoke, and reduces ignition temperature and combustion efficiency [6].

3.2. Ash Content Analysis

The effect of the ratio of sugarcane bagasse and oil palm fronds with tapioca flour adhesive concentration show that the lowest ash content was found in the ratio of 90 grams of sugarcane bagasse and 10 grams of oil palm fronds with a 40% adhesive concentration, producing an ash content of

4.6172%. Meanwhile, the highest ash content is 7.877%. was observed in the ratio of 50 grams of sugarcane bagasse and 50 grams of oil palm fronds with a 55% adhesive concentration. The influence of sugarcane bagasse and oil palm fronds on the ash content is illustrated in Figure 2.

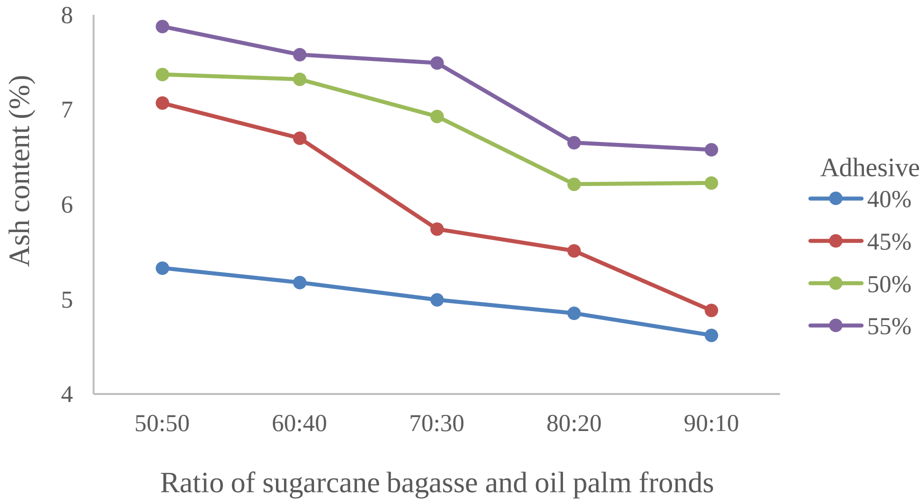

Figure 2. Effect of the ratio of sugarcane bagasse and oil palm fronds with adhesive concentration variations on ash content

The analysis in figure 2 shows that the adhesive concentration of 40% has a lower ash content compared to adhesive concentrations of 45%, 50%, and 55%. High ash content affects the calorific value produced; the higher the ash content, the lower the quality of the resulting charcoal briquettes. This is because ash contains silica, which can lower the calorific value. Ash content is also influenced by the type of raw material used. The higher adhesive concentrations increase the ash content of briquettes [7].

Based on the Indonesian charcoal briquette quality standard, SNI 01-6235-2000, which states that the maximum allowable ash content is 8%, the ash content produced in the study is in accordance with the SNI standard.

3.3. *Combustion Rate Analysis*

The results of the combustion rate analysis on briquettes made from sugarcane bagasse and oil palm fronds are shown in Figure 3.

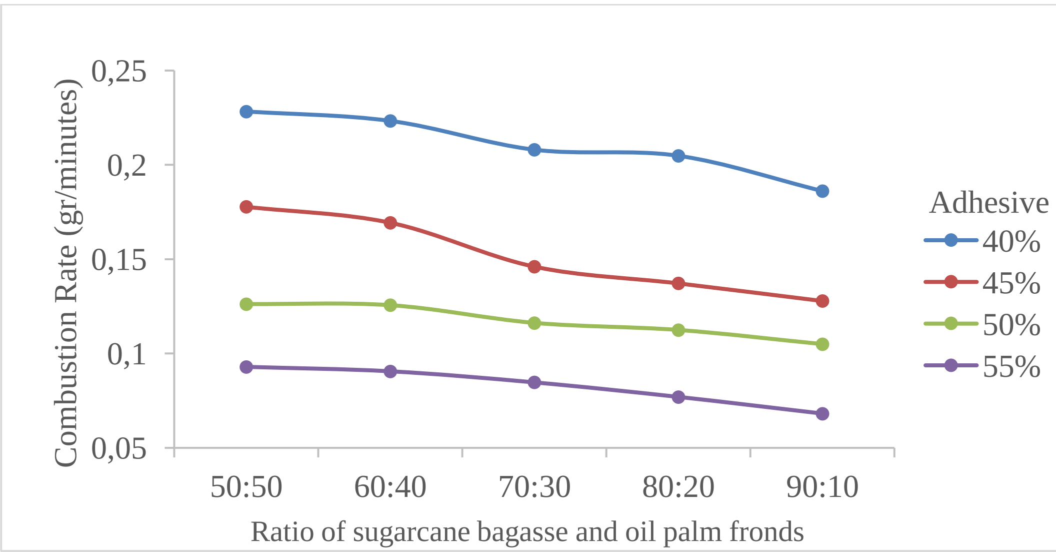

Figure 3. Effect of the ratio of sugarcane bagasse and oil palm fronds with adhesive concentration variations on combustion rate

Based on the above figure, it shows that the greater the amount of adhesive in the briquette, the longer the combustion time. This is because the higher the proportion of adhesive, the higher the moisture content, which slows down the combustion rate. A higher adhesive content also causes the briquette to become denser, making it harder for oxygen to penetrate, which results in a longer combustion process. This finding is consistent with the another research, which states that the higher the adhesive percentage, the lower the combustion rate of the briquette [8].

From the analysis and testing of sugarcane bagasse and oil palm frond briquettes conducted, the lowest combustion rate 0.0681 g/min was obtained in the mixture of 90 grams of sugarcane bagasse and 10 grams of oil palm fronds with a 55% adhesive. Meanwhile, the highest combustion rate 0.2283 g/min was obtained in the mixture of 50 grams of sugarcane bagasse and 50 grams of oil palm fronds with a 40% adhesive. Based on figure 3, the combustion rate of sugarcane bagasse and oil palm frond briquettes ranged from 0.0681 to 0.2283 g/min. The graph shows that as the composition of oil palm frond increases, the combustion rate also increases.

3.4. *Calorific Value Analysis*

The calorific value determining the quality of the briquettes produced. The higher the calorific value, the higher the quality of the briquettes [9]. The calorific value is important to know in order to determine the heat output that the briquettes can generate as fuel. This is because the combustion process requires carbon to react with oxygen to produce heat. The calorific value of charcoal briquettes is influenced by the amount of bound carbon in the briquette [10].

The calorific value is the amount of heat produced per unit weight from the combustion process of a combustible material [11]. The primary parameter in determining the quality of briquette fuel is the calorific value. The results of the calorific value analysis of the sugarcane bagasse and oil palm frond briquette mixture are shown in the table below.

Table 1. Calorific Value Analysis Results

No	Composition (grams)	Adhesive (%)	Calorific Value (J/g)	Calorific Value (Kal/g)
1	50 : 50	40	26077	6.232,67
2	50 : 50	50	25755	6.155,59
3	50 : 50	55	25650	6.130,497

The table above shows that the lower the adhesive concentration, the higher the calorific value obtained. This is because, as seen from the moisture content and ash content, the higher the moisture content in the briquette, the lower the calorific value of the resulting briquette. The higher the calorific value, the better the quality of the briquette, so the amount of briquettes needed for combustion decreasing [12].

From the analysis and testing of sugarcane bagasse and oil palm frond briquettes conducted, the lowest calorific value 6.130497 kcal/g was obtained in the mixture of 50 grams of oil palm fronds and

50 grams of sugarcane bagasse with 55% tapioca flour adhesive. Meanwhile, the highest calorific value 6.23267 kcal/g was obtained in the mixture of 50 grams of sugarcane bagasse and 50 grams of oil palm fronds with 40% tapioca flour adhesive. Based on the calorific value analysis, the sugarcane bagasse and oil palm frond briquette mixture meets the SNI 01-6235-2000 standard, with a minimum calorific value of 5000 kcal/gram

4. Conclusions

The best results from this research is the composition of sugarcane bagasse and oil palm fronds with tapioca flour adhesive at 40% adhesive, with a moisture content of 4.4545%, ash content of 4.6202%, a combustion rate of 0.2283 grams/minutes, and a calorific value of 6232.67 kcal/g. The less adhesive used, the higher the calorific value, the lower the moisture and ash content in the briquette, and the higher the combustion rate. The results of the charcoal briquette tests meet the SNI 01-6235-2000 standard, and the best briquette is found in the mixture of 50 grams of sugarcane bagasse and 50 grams of oil palm fronds with 40% tapioca flour adhesive.

References

[1] S. Jamilatun, "Ignition and Combustion Properties of Biomass Briquettes, Coal Briquettes, and Wood Charcoal," *J. Rekayasa Proses*, vol. 2, no. 2, pp. 37–40, 2008.

[2] A. R. Fachry, T. I. Sari, A. Y. Dipura, and J. Najamudin, "Techniques for Producing Briquettes from a Mixture of Water Hyacinth and Coal as an Alternative Fuel for Rural Communities," *Prosiding Seminar Nasional Perkembangan Riset dan Teknologi di Bidang Industri*, vol. 3, no. 1. pp. 52–58, 2010.

[3] N. Ameram *et al.*, "Chemical composition in sugarcane bagasse: Delignification with sodium hydroxide," *Malaysian J. Fundam. Appl. Sci.*, vol. 15, no. 2, pp. 232–236, 2019, doi: 10.11113/mjfas.v15n2.1118.

[4] H. Smith and S. Idrus, "The Effect of Sago and Tapioca Used Against Briquette Characteristics from Biomass Waste of Refining Cajuput Oils in Maluku," *Maj. BIAM*, vol. 13, no. 2, pp. 21–32, 2017, doi: 10.29360/mb.v13i2.3546.

[5] M. Baharoğlu, G. Nemli, B. Sarı, S. Bardak, and N. Ayrılmış, "The influence of moisture content of raw material on the physical and mechanical properties, surface roughness, wettability, and formaldehyde emission of particleboard composite," *Compos. Part B Eng.*, vol. 43, no. 5, pp. 2448–2451, 2012, doi: https://doi.org/10.1016/j.compositesb.2011.10.020.

[6] R. P. Dewi, T. J. Saputra, and S. J. Purnomo, "Testing the Fixed Carbon and Volatile Matter Content of Charcoal Briquettes with Variations in Charcoal Powder Particle Size," *Pros. Semin. Nas. Teknol. Ind. Lingkung. dan Infrastruktur*, vol. 3, pp. 2–5, 2020.

[7] R. P. Dewi and M. Kholik, "The effect of adhesive concentration variation on the characteristics of briquettes," *J. Phys. Conf. Ser.*, vol. 1517, no. 1, 2020, doi: 10.1088/1742-6596/1517/1/012007.

[8] S. M. Ulva and W. Romadhoni, "The Effect of Variations in Binder Mixture Quantity on the Characteristics of Briquettes Made from Rice Husk and Sawdust," *J. Pendidik. Fis. Tadulako Online*, vol. 8, no. 2, pp. 56–62, 2020.

[9] A. Muarif, L. Hakim, Z. Ginting, and R. Mulyawan, "Pengaruh Variasi Jenis Dan

Volume Perekat (Tepung Tapioka Dan Air Tebu) Terhadap Kualitas Briket Dari Pelepah Kelapa Sawit (Elaeis Guenensis Jacq)," *J. Inov. Tek. Kim.*, vol. 9, no. 2, pp. 136–143, 2024.

[10] F. Hamzah, A. Fajri, N. Harun, and A. Pramana, "The effect of adhesive concentration variation on the characteristics of briquettes," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1182, no. 1, 2023, doi: 10.1088/1755-1315/1182/1/012071.

[11] N. Iskandar, S. Nugroho, and M. F. Feliyana, "Uji Kualitas Produk Briket Arang Tempurung Kelapa Berdasarkan Standar Mutu SNI," *J. Ilm. Momentum*, vol. 15, no. 2, 2019, doi: 10.36499/jim.v15i2.3073.

[12] H. A. Ajimotokan, A. O. Ehindero, K. S. Ajao, A. A. Adeleke, P. P. Ikubanni, and Y. L. Shuaib-Babata, "Combustion characteristics of fuel briquettes made from charcoal particles and sawdust agglomerates," *Sci. African*, vol. 6, no. October, 2019, doi: 10.1016/j.sciaf.2019.e00202.