p-ISSN: 2301-6663, e-ISSN: 2477-250X
URL: http://ojs.ummetro.ac.id/index.php/turbo

Characteristics of Briquettes Produced from Rubber Seed Shell and Palm Kernel Shell Using Tapioca Flour as Binder

Muhammad Hasbi Pratama[1], Fajar Perdana Nurullah[2], Dicky Januarizky Silitonga[3], Farid Jayadi [4], Lathifa Putri Afisna [5], Devia Gahana Cindi Alfian[6]*

[1,2,3,5,6] Program Studi Teknik Mesin, Institut Teknologi Sumatera
Jalan Terusan Ryacudu, Way Hui, Jati Agung,Lampung Selatan, 35365, Indonesia
[4] Prodi Teknik Mesin, Fakultas Teknik, Universitas Teuku Umar
Indonesia
Jl. Alue Peunyareng, Aceh Barat, Aceh, Indonesia 23681
Corresponding author: devia.gahan@ms.itera.ac.id

Abstract

Indonesia faces challenges in managing renewable energy as an alternative to fossil fuels. This study aims to compare commercially available briquettes with experimental briquettes produced from a mixture of rubber seed shells and palm shells using tapioca flour as a binder. The raw material composition variations between rubber seed shells and palm shells used were 80:20, 50:50, and 20:80, with 10% tapioca flour binder, and dried at a temperature of 100°C for 3 hours. The purpose of this research is to compare the produced briquettes with those already marketed. Based on the experiments and tests carried out, the results show that the 20:80 variation produced briquettes most comparable to the market samples, with a density of 0.7438 g/cm³, moisture content of 3.43%, calorific value of 6849.46 cal/gram, combustion rate of 0.1117 g/minute, and a drop test value of 4.7672%.
Keywords*: *renewable energy, biomass briquettes, rubber seed shell, palm shell.

1. Introduction

Indonesia is an agrarian country with enormous biomass resource potential, particularly from the plantation sector. In the midst of the energy crisis challenges and the increase in carbon emissions from fossil fuels, the utilization of biomass waste as an alternative energy source becomes a strategic step toward sustainability [1]. Plantation waste such as palm shell and rubber seed shell is an abundant by-product, but it has not been optimally utilized [2]. Lampung Province, as one of the production centers of palm oil and rubber in Indonesia, generates a significant amount of waste every year [3], which, if properly managed, can become a promising renewable energy source.

Several previous studies have shown the potential of biomass as an alternative fuel in the form of briquettes. Research by Antonius Paulus Tueng Ruing and Dady Sulaiman (2022) showed that a mixture of palm shells and rice husks with a ratio of 60:40 provided the highest calorific value and the lowest moisture content [4]. Nurhamida et al. (2023) studied coconut shells and palm shells with variations of adhesive, and found that the 0:100 composition produced the highest calorific value [5]. Research by Eykel Sura Bema et al. (2021) using palm leaf charcoal and rubber seed shell showed the best results at a 10:90 ratio, with the characteristics of high calorific value and low ash content [6]. Nevertheless, there is still very limited research that specifically evaluates the combination of rubber seed shell and palm shell in varying proportions.

Based on this, there is a research gap that has not been widely explored, namely the utilization of the combination of rubber seed shell waste and palm shell waste as raw materials for briquettes. This research focuses on the use of natural adhesive in the form of tapioca flour, the use of a 60-mesh sieve for particle size homogenization, as well as briquette molding using a continuous molding machine with a speed of 40 RPM to ensure optimal briquette density and strength. This becomes both a distinction

DOI: http://dx.doi.org/10.24127/trb.v14i2.4607
Received October 07, 2025; Received in revised form December 30, 2025; Accepted December 31, 2025
Available online December 31,2025

and a new contribution offered by this research to the development of renewable energy based on local waste.

The purpose of this research is to examine the effect of variations in the raw material ratio of rubber seed shell (RSS) and palm shell (PS) (80:20, 50:50, and 20:80) on the characteristics of the resulting briquettes, which include moisture content, calorific value, combustion rate, density, and physical strength through the drop test. In addition, this research also aims to compare the obtained briquette results with the quality of commercial briquettes or quality standards as a reference to determine the most optimal formulation composition that is feasible to be developed as an efficient and environmentally friendly alternative energy.

2. Method

The main raw materials used in this study are rubber seed shell and palm shell, which serve as the primary sources of biomass. These agricultural by-products are selected due to their abundance, low cost, and potential to be converted into renewable energy. To bind the particles together and improve the mechanical strength of the briquettes, tapioca flour is used as a natural adhesive with a composition of 10% of the total mass. The use of tapioca flour not only ensures that the briquettes maintain their shape during handling and storage but also contributes to environmentally friendly production, as it is biodegradable and non-toxic.

The research stages begin with material preparation, namely cleaning and drying the shells for three days under sunlight. Next, a carbonization process is carried out at a temperature of ±400 °C for three hours using a pyrolyzer. The carbonized product is then ground with a grinder and sieved using a 60-mesh sieve. The charcoal powder is then mixed with tapioca flour adhesive and water according to the material ratio variations, namely 80:20, 50:50, and 20:80 (rubber seed shell : palm shell).

Briquette molding is carried out using a molding machine with a speed of 40 RPM, then dried in an oven at a temperature of 100 °C for 3 hours. The resulting briquettes are tested for their characteristics, including moisture content, calorific value, density, combustion rate, and physical durability through a drop test. Moisture content testing is conducted using an oven, calorific value with a bomb calorimeter, density using a digital caliper and an analytical balance, combustion rate with the direct burning method, while durability is tested by dropping the briquettes from a height of 1.8 meters.

The test results of each briquette variation are then analyzed with reference to the briquette quality standard SNI 1683-2021 and compared with the characteristics of commercial briquettes available in the market, in order to assess the feasibility and competitiveness of the produced product.

3. Result and Discussion

3.1 Research Data

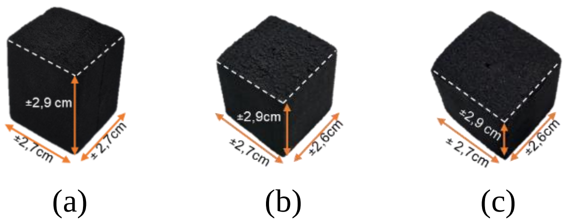


Figure 1. Briquettes of rubber seed shell and palm shell with variations in raw material ratios (a) Variation A (80%:20%), (b) Variation B (50%:50%), (c) Variation C (20%:80%)

Biomass briquettes made from a mixture of rubber seed shell (RSS) and palm shell (PS) with tapioca flour adhesive were produced in three composition variations: composition A (80%:20%), composition B (50%:50%), and composition C (20%:80%). The resulting briquettes had relatively uniform dimensions with an average length of 2.7 cm, width of 2.6 cm, and height of 2.9 cm. Visually, the variations in raw material composition showed differences in surface texture, where briquettes dominated by RSS tended to be smoother and denser, while an increased proportion of PS resulted in a rougher surface. This indicates that the raw material composition affects the physical characteristics of the briquettes.

3.2 Density

Density is an important factor that significantly influences the compressive strength and combustion performance of briquettes, while also serving as the main parameter that determines mechanical strength and combustion efficiency [7]. The density values obtained were 0.6920 g/cm³ for variation A, 0.7423 g/cm³ for variation B, and 0.7438 g/cm³ for variation C. The results showed that all briquette variations had lower density values compared to commercial briquettes, which reached 1.2224 g/cm³. This difference is suspected to be influenced by the variation of molding pressure used in the production process, resulting in different levels of compactness compared to commercial briquettes.

The increase in density is influenced by the molding method, where the compaction and pressing process helps charcoal particles bond more tightly, thereby increasing the compactness and strength of the briquettes [8]. Briquettes with high density have advantages in terms of mechanical durability as well as energy content per unit volume, making them more efficient when used [9].

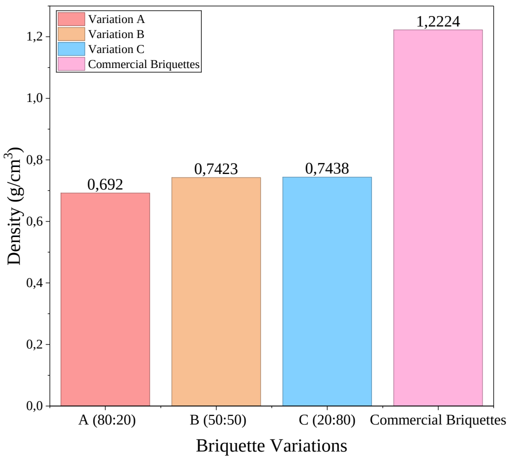


Figure 2. Effect of ratio variation on density

3.3 Moisture Content

Moisture content analysis was conducted to determine the amount of water contained in the briquettes [10]. The moisture content obtained in this study was 5.18% for variation A, 3.94% for variation B, and 3.43% for variation C. These values are still within the SNI standard limit (≤ 8%). When compared to commercial briquettes, which have a moisture content of 7.33%, all variations of the briquettes in this study showed lower moisture content. This condition indicates that briquettes made from a mixture of rubber seed shell and palm shell have better quality in terms of dryness compared to similar products in the market.

The higher the PS content, the lower the briquette moisture content. This is related to the structure of PS, which has smaller porosity, allowing it to retain less water [11]. Low moisture content is important to increase storage durability and accelerate the combustion process [12]. In addition, low moisture content contributes to a higher calorific value because energy is not wasted to evaporate water [13].

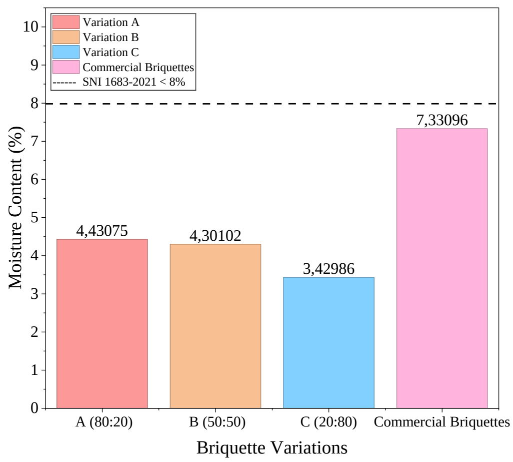


Figure 3. Effect of ratio variation on moisture content

3.4 Calorific Value

The calorific value is the maximum amount of heat energy of a fuel through complete combustion per unit volume [14]. Based on the results of calorific value testing, all briquette variations met the minimum standard of SNI 1683-2021 of 6,000 cal/g. Variation A produced a calorific value of 6,302.39 cal/g, variation B of 6,367.16 cal/g, and variation C reached 6,849.46 cal/g. The differences among the variations were not too significant, but there was a tendency for an increase in calorific value along with the higher proportion of palm shell in the briquette composition. When compared to commercial briquettes (6,852.19 cal/g), all briquette variations from this study showed competitive performance, with variation C having the calorific value closest to market products.

These results indicate an increase in calorific value with the rising proportion of PS [5]. The higher lignin content in PS plays an important role in generating greater heat energy [15]. According to the SNI standard, a calorific value above 6,500 cal/g is categorized as good quality. Thus, variation C not only meets the standard but also provides a higher calorific value compared to the average commercial briquettes. The calorific value serves as a key indicator of briquette quality and determines its feasibility as a fuel [16].

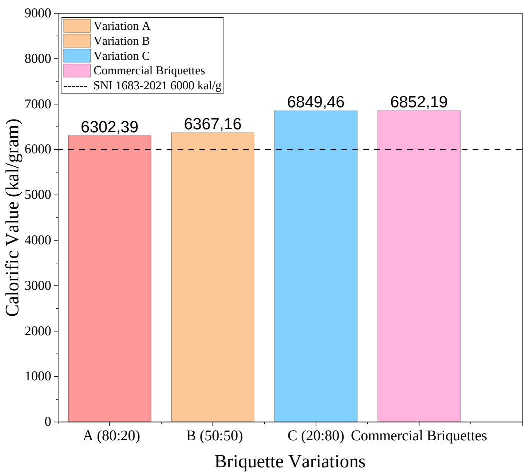


Figure 4. Effect of ratio variation on calorific value

3.5 Combustion Rate

Based on the combustion rate test results, variation B showed the highest value of 0.1140 g/min, followed by variation C at 0.1117 g/min, and variation A at 0.1072 g/min. These results indicate differences in combustion speed among the variations, with a tendency for the rate to increase along with the differences in raw material proportions used. When compared to commercial briquettes, which have a combustion rate of 0.1064 g/min, briquettes with a higher proportion of RSS tend to burn faster but have a shorter burning time [17]. The combustion rate test was conducted to determine the efficiency level of briquette utilization as a fuel [18].

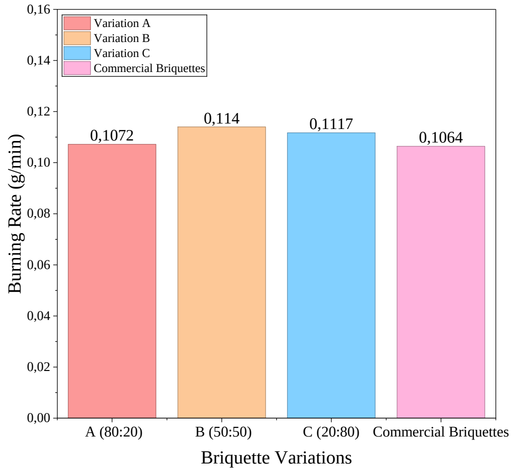
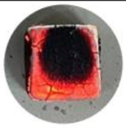
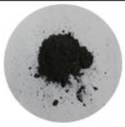
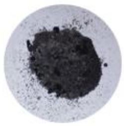
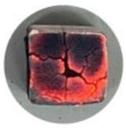
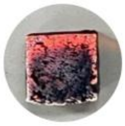
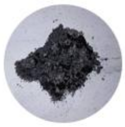


Figure 5. Effect of ratio variation on combustion rate

Table 1. Briquette combustion process

Briquette Variation	Initial Burning	After 60 Minutes	Final Burning
A			
B			
C			
Commercial Briquettes			

3.6 *Drop Test*

The drop test aims to assess the durability of briquettes when subjected to impact with hard objects, thereby providing an overview of their resistance [19]. The physical durability of the briquettes was tested by dropping the samples from a height of 1.8 meters [20]. Based on the impact resistance test results, briquette variation A showed a damage percentage of 0.44% and variation B of 0.60%. In contrast, variation C had a higher damage percentage of 4.77%, indicating lower mechanical durability compared to the other two variations. When compared to commercial briquettes, which only experienced 0.32% damage, variations A and B showed performance relatively close to market products. Briquettes dominated by RSS are more resistant to impact because they have good particle density, making them less prone to breaking. This physical durability is also influenced by the amount of adhesive and compaction pressure applied [21][22].

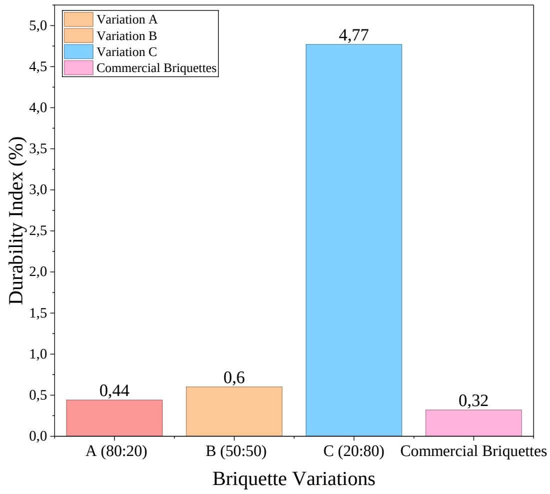


Figure 6. Effect of ratio variation on drop test

3.7 Comparison with Commercial Briquettes

Table 2. Comparison of briquette results with commercial briquettes [24][25].

Variable	SNI 2021 (2nd Grade)	SNI 2000	Commercial Briquettes	Rubber Seed Shell : Palm Shell Ratio		
				80:20 (A)	50:50 (B)	20:80 (C)
Moisture Content (%)	≤ 8	≤ 8	7,3	4,4	4,3	3,4
Calorific Value (kal/g)	≥ 6000 – 6500	≥ 5000	6852,1	6302,3	6367,1	6849,4

When compared to commercial briquettes in the market, variation C shows the closest quality and even exceeds the standard. Its high density, low moisture content, calorific value of more than 6800 cal/g, stable combustion rate, and good drop test results make this variation the most optimal. Overall, the use of a 20% RSS : 80% PS composition produces briquettes with the best characteristics according to SNI 1683-2021, while also demonstrating the potential of utilizing plantation waste as an environmentally friendly alternative energy source [23].

Table 3. Comparison of briquette results with commercial briquettes [26]

Variable	Briquette Quality Standard	Commercial Briquettes	Rubber Seed Shell : Palm Shell Ratio		
			80:20 (A)	50:50 (B)	20:80 (C)
Density (g/cm³)	≥ 0,5–0,6	1,22	0,80	0,83	0,83
Burning Rate (g/menit)	-	0,10	0,10	0,11	0,11
Durability Index (%)	Min ±2 meters	0,31	0,44	0,59	4,76

4. Conclusion

This study aims to determine the effect of variations in the ratio of rubber seed shell (RSS) and palm shell (PS) on the characteristics of biomass briquettes using 10% tapioca flour as an adhesive. The results showed that differences in raw material composition significantly affected the quality of the briquettes in terms of density, moisture content, calorific value, combustion rate, and physical durability.

Based on the test results, variation A (80% RSS : 20% PS) had a density of 0.6920 g/cm³ with the highest moisture content of 5.18%. The calorific value produced was 6532.75 cal/g with a combustion rate of 0.1378 g/min and a drop test result of 7.63%. This briquette burned relatively faster but had weaknesses in higher moisture content and lower mechanical durability compared to the other variations.

In variation B (50% RSS : 50% PS), the density increased to 0.7423 g/cm³ with a moisture content of 3.94%. The calorific value produced was 6623.68 cal/g, the combustion rate was 0.1246 g/min, and the drop test result was 6.42%. This composition showed a balance between combustion performance, physical durability, and moisture content, making its quality better than variation A, although its calorific value was not as high as variation C.

Variation C (20% RSS : 80% PS) gave the best results with a density of 0.7438 g/cm³, the lowest moisture content of 3.43%, the highest calorific value of 6849.46 cal/g, the most stable combustion rate of 0.1117 g/min, and a drop test resistance of 4.77%. This combination produced briquettes with optimal density, low moisture content, high heat energy, and good mechanical durability. These values not only meet the briquette quality standards according to SNI 01-6235-2000 and SNI 1683-2021 but also approach and even exceed the quality of commercial briquettes on the market.

Overall, it can be concluded that the higher the proportion of PS in the mixture, the better the quality of the resulting briquettes. This is due to the physical properties of PS, which have high lignin content, low moisture content, and produce charcoal with higher density. This study confirms that the utilization of RSS and PS waste has great potential as raw materials for renewable energy.

Thus, the use of rubber seed shell and palm shell in briquette production not only contributes to the supply of environmentally friendly alternative energy but also supports the reduction of plantation waste and the development of sustainable biomass energy in Indonesia.

References

[1] A. Huda, "Transisi Energi di Indonesia: Overview & Challenges," *Buletin Pertamina Energy Institute*, vol. 9, pp. 49–61, 2023, [Online]. Available: https://www.researchgate.net/publication/374417692

[2] W. Fitriana and W. Febrina, "Analisis Potensi Briket Bio-Arang Sebagai Sumber Energi Terbarukan," *Jurnal Teknik Pertanian Lampung (Journal of Agricultural Engineering)*, vol. 10, no. 2, p. 147, Nov. 2021, doi: 10.23960/jtep-l.v10i2.147-154.

[3] Badan Pusat Statistik, "Produksi Tanaman Perkebunan," Lampung, 2023.

[4] A. P. T. Ruing and D. Sulaiman, "Analisis Karakteristik Briket Berbahan Cangkang Kelapa Sawit Dan Sekam Padi Menggunakan Perekat Tapioka," *Jurnal Sains Benuanta*, vol. 1, no. 1, pp. 15–24, Nov. 2022, [Online]. Available: http://journal.unikaltar.ac.id/index.php/JSB/index

[5] Nurhamida, Rusdianasari, and M. Zamhari, "Pembuatan Briket Komposit Cangkang Sawit Dan Tempurung Kelapa Dengan Variasi Perekat Tepung Tapioka," *J Teknol*, vol. 23, no. 2, pp. 106–112, Nov. 2023.

[6] E. S. Bema, F. Hamzah, and Y. Zalfiatri, "Karakteristik Briket Dari Arang Daun Kelapa Sawit Dan Arang Cangkang Biji Karet Dengan Perekat Tapioka," *SAGU Journal: Agricultural Science and Technology*, vol. 20, no. 1, p. 1, Nov. 2021, [Online]. Available: https://sagu.ejournal.unri.ac.id

[7] Z. Sirajuddin, "PENGARUH DENSITAS BAHAN TERHADAP MUTU BRIKET ARANG TEMPURUNG KELAPA," *MEDIAGRO: journal of agricultural sciences*, vol. 17, no. 1, pp. 26–37, Apr. 2021.

[8] E. D. Safitri, "Pembuatan Briket Dari Campuran Cangkang Biji Karet (Hevea Brasiliensis) Dan Tandan Kosong Kelapa Sawit," Bandar Lampung, Dec. 2020.

[9] M. Ervando, A. Satmoko, ∗ Danang, D. Saputro, and A. Budiyono, "Karakterisasi Briket Dari Limbah Pengolahan Kayu Sengon Dengan Metode Cetak Panas," 2013. [Online]. Available: http://journal.unnes.ac.id/sju/index.php/jmel

[10] M. Y. P. Setyono and Yayok Suryo Purnomo, "Analisis Kadar Air dan

Kadar Abu Briket Lumpur IPAL dan Fly Ash dengan Penambahan Serbuk Gergaji Kayu," *INSOLOGI: Jurnal Sains dan Teknologi*, vol. 1, no. 6, pp. 696–703, Dec. 2022, doi: 10.55123/insologi.v1i6.1047.
[11] M. Indah, A. Hasan, and R. Junaidi, "Pembuatan Biobriket Cangkang Sawit dan Tandan Kosong Kelapa Sawit Menggunakan Muffer Furnace," vol. IX, no. 4, 2024.
[12] M. Wzorek, A. Król, R. Junga, J. Małecka, E. Yilmaz, and A. Kolasa-Więcek, "Effect of storage conditions on lignocellulose biofuels properties," *Sci Rep*, vol. 14, no. 1, Dec. 2024, doi: 10.1038/s41598-024-66118-6.
[13] A. A. H. Saeed *et al.*, "Moisture content impact on properties of briquette produced from rice husk waste," *Sustainability (Switzerland)*, vol. 13, no. 6, Mar. 2021, doi: 10.3390/su13063069.
[14] Sukati, D. Pangga, and S. Ahzan, "Pengaruh Persentasi Perekat Briket Berbahan Dasar Tempurung Kelapa terhadap Nilai Kalor dan Laju Pembakaran," *Jurnal Ilmiah IKIP Mataram*, vol. 10, no. 1, p. 2023, 2023, [Online]. Available: https://ojs.ikipmataram.ac.id/index.php/jiim
[15] M. R. Vegatama, E. Megawati, Y. Yuniarti, and A. Adhiksana, "Analisa Kandungan Proksimat Biobriket Berbahan Baku Limbah Cangkang Sawit Di Kabupaten Paser Kalimantan Timur," *Jurnal Ilmiah Ecosystem*, vol. 24, no. 1, pp. 106–113, Apr. 2024, doi: 10.35965/eco.v24i1.4223.
[16] Imam Ardiansyah, A. Yandra Putra, and Y. Sari, "Analisis Nilai Kalor Berbagai Jenis Briket Biomassa Secara Kalorimeter," *Journal of Research and Education Chemistry*, vol. 4, no. 2, p. 120, Dec. 2022, doi: 10.25299/jrec.2022.vol4(2).10735.
[17] N. P. Carnaje, R. B. Talagon, J. P. Peralta, K. Shah, and J. Paz-Ferreiro, "Development and characterisation of charcoal briquettes from water hyacinth (Eichhornia crassipes)-molasses blend," *PLoS One*, vol. 13, no. 11, Nov. 2018, doi: 10.1371/journal.pone.0207135.
[18] A. Fajari, Sudarti, and Yushardi, "Pengujian Laju Pembakaran Briket Biomassa Dari Tempurung Kelapa dan Sekam Padi," *Jurnal Ilmiah Wahana Pendidikan, Desember*, vol. 2024, no. 23, pp. 1208–1216, Dec. 2024.
[19] I. Kamar, N. ZA, M. Meriatna, S. Bahri, R. Nurlaila, and A. Alifnur, "Pembuatan Briket Dari Kulit Jagung Menggunakan Perekat Getah Nangka Dan Pulut," *Jurnal Teknologi Kimia Unimal*, vol. 12, no. 1, pp. 66–73, Jul. 2023, doi: 10.29103/jtku.v12i1.11633.
[20] O. F. Obi, R. Pecenka, and M. J. Clifford, "A Review of Biomass Briquette Binders and Quality Parameters," Apr. 01, 2022, *MDPI*. doi: 10.3390/en15072426.
[21] A. Biantoro and W. Widayat, "Pengaruh Tekanan Kompaksi dan Perekat terhadap Karakteristik BriketLimbah Daun Cengkeh," *Jurnal Inovasi Mesin*, vol. 3, no. 2, 2021, [Online]. Available: https://journal.unnes.ac.id/sju/index.php/jim
[22] Machsalmina, A. Saputra Ismy, and M. Razi, "Pengaruh Variasi Tekanan Terhadap Karakteristik Biobriket Cangkang Kelapa Sawit Dengan Menggunakan Mesin Pencetak Biobriket," *JURNAL MESIN SAINS TERAPAN*, vol. 6, no. 2, Aug. 2022.
[23] N. A. Adistia, R. A. Nurdiansyah, J. Fariko, and J. W. Simatupang, "Potensi Energi Panas Bumi, Angin, Dan Biomassa Menjadi Energi Listrik Di Indonesia," Nov. 2020.
[24] B. S. Nasional, "SNI-1683-2021-Arang-kayu," Nov. 2021.

[25] B. S. Nasional, “SNI-01-6235-2000-Arang-Kayu,” 2009.
[26] D. Fatmawati and P. H. Adiwibowo, “Pembuatan Biobriket dari Campuran Enceng Gondok dan Tempurung Kelapa dengan Perekat Tetes Tebu.”