Journal of Technomaterial Physics Vol. 4, No. 2, 2022 | 157-166

talenta PUBLISHER

JoTP
Journal of Technomaterial Physics

Manufacture of Briquettes from Baking Filter Dust (BFD) Waste and Coconut Shell Charcoal

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Abstract. This research utilized baking filter dust (BFD) waste obtained from PT. INALUM., which functions as a heat retainer, is processed into briquettes with the addition of coconut shell charcoal, which has not been fully utilized. This research is also to determine the optimum quality of physical and chemical properties in good briquettes to be used as an alternative fuel. This study uses the method used is the pyrolysis method with the combustion process using a closed combustion furnace and sieving using a sieve with a size of 50-100 mesh. The quality of briquettes was analyzed using the Proximate Test, Ultimate Test, and Characterization of SEM – EDX. Furthermore, the quality test of briquettes refers to SNI 016235 2000 and the Minister of Energy and Mineral Resources No. 47 of 2006; the average moisture content of briquettes is 18.65 %, the average ash content of briquettes is 4.33 %, the average volatile matter content (volatile matters) is 13.30 %, the average fixed carbon content (fixed carbon) is 63.73 %, the average heating value is 6,200 cal/g, and the sulfur content is 49.75 % on average.

Keywords: Composites, Epoxy Resins, Mechanical Properties, Physical Properties, Salak Pelepah Fibers.

Received 05 August 2022 | Revised [15 August 2022] | Accepted [29 August 2022]

1 Introduction

Scarcity and rising oil prices will continue due to their non-renewable nature. This condition must be immediately balanced by the provision of alternative energy sources that are renewable, abundant, and low-cost so that they are affordable for the whole society [1]. Indonesia has many alternative renewable energy sources, including biomass or organic waste. A small quantity of biomass that is quite potential is waste - agricultural waste, industrial waste, and domestic waste. Biomass, such as briquette, can be altered and used as an alternative fuel. Briquette has its economic advantages because it can be easily produced, has a high calorific value, and is easy to obtain [2].

The current state of energy use in Indonesia requires a breakthrough to find solutions to the use of alternative energy sources that are environmentally friendly [3]. According to field

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Journal Homepage: https://talenta.usu.ac.id/JoTP

observations, PT. Indonesia Asahan Aluminium (PT INALUM), one of the biggest companies in Indonesia, produces more than 30 tons of baking filter dust (BFD) per month collected in the B2 building of the carbon department. However, the total BFD from 2009 – 2021 is 1,239,450 kg which has not been utilized. PT. INALUM is a collaborative project between the Indonesian government and a private Japanese company engaged in the aluminum smelting industry. PT. Inalum is the only aluminum smelting plant in Indonesia [4].

In other cases, some industrial waste is studied to obtain its benefits, including in the manufacture of briquettes. Although due to regulation, the industry is not allowed to sell or dispose of its waste directly into the environment without proper treatment. However, within certain limits, it must research to find the best way to solve waste. The carbon has a relatively high carbon, up to 85%, which has the potential to be converted into activated carbon. Nevertheless, the available data is limited in using this waste as a useful product. Therefore, ongoing research must be carried out to overcome accumulated waste [5]. Furthermore, energy demand, both domestically and at the international level, continues to increase in line with the development of industrialization in the world [2]. Based on the above explanation, this research was conducted.

2 Materials and Methods

2.1 Materials

BFD, with a carbon level of up to 85%, was produced from PT. INALUM, Indonesia, the remaining waste reaching BFD from 2009 - 2021 is 1,239,450 kg. Coconut shells are taken from the remaining coconut meat. The tapioca flour was used as a binder.

2.2 Coconut Shell Carbonization Process

The manufacture of coconut shell charcoal was carried out by preparation of coconut shell samples. The sample was then cleaned from the attached fibers. The combustion drums were then provided for the pyrolysis method for approximately 5 hours. The results were ground using a 50 mesh disk; then, the powder was filtered using 100 mesh. As for making tapioca adhesive, it was done by mixing water and heating it. Then the whole ingredients were mixed and stirred until evenly distributed. After evenly distributed, it is directly inserted into the hydraulic printer, after printing and then drying in the sun for approximately two days.

2.3 Briquettes Test Analysis

Briquette test analysis was conducted using proximate, ultimate, and microscopic analysis. The proximate analysis consists of the physical and chemical tests (moisture content and heat value tests) and the tests (ash content, fixed carbon level, and volatile matter level). The ultimate analysis consists of sulphuric level and calorific value tests. In comparison, microscopic analysis and elemental composition were conducted by using SEM-EDX.

3 Results and Discussion

3.1 Moisture Content Test

The type of raw material strongly influences the moisture content of briquettes—the type of fastener and the means of testing that can be used. In general, a high-water content can reduce the calorific value. Because the heat released is first used to evaporate the water in a briquette. In addition, a briquette with a high moisture content will be easily destroyed and attacked by fungi [6].

Table 1. Moisture Contents

Sample	Moisture Contents
BFD0	23.4 %
BFD1	19.1 %
BFD2	19.1 %
BFD3	13.0 %

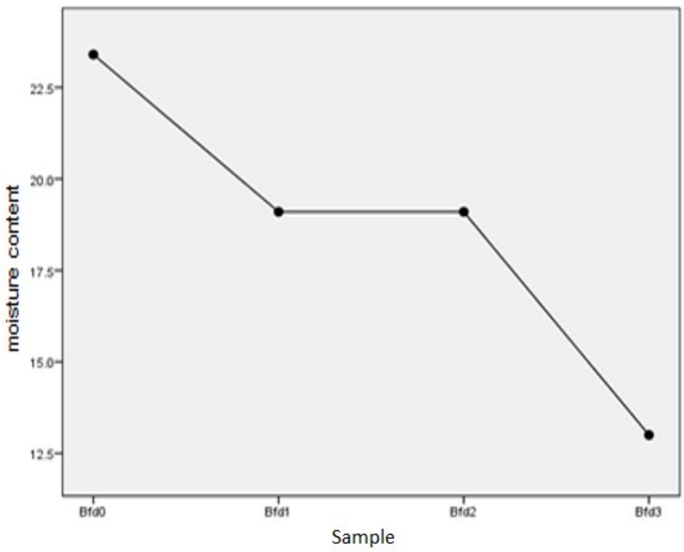

Figure 1. Moisture content test values on each sample

Based on Figure 1, the water content of PT. INALUM coconut filter dust briquettes produced varied between 13.0 – 23.4%. The lowest average water content of 13.0% was obtained in 600 g baking filter dust and 400 g coconut shell charcoal. The highest average moisture content of 23.4% was obtained in the composition of 0 g baking filter dust and 1,000 g coconut shell charcoal. The moisture content of PT. INALUM coconut shell charcoal briquettes for all samples do not meet the water content requirements of SNI – 01 – 6235 - 2000 < 8% (Table 1). If the parameters of the moisture content are high, the quality of the briquettes will decrease, especially affecting the calorific value and the more difficult it is to ignite. Charcoal is very easy to absorb water or has high (hygroscopic) absorbing properties of water molecules [7].

3.2 Heat Value Test

The calorific value is a value that is willing to indicate the amount of calorific value contained in the fuel. The calorific value is the main quality of the fuel [8]. Therefore, the calorific value determines the quality of a briquette. High and low calorific values will greatly affect a briquette's moisture and ash content. If there is a high moisture and ash content in a briquette, a lower calorific value of the briquettes is produced [9].

Table 2. Calorific Values

Sample	Calorific Values
BFD0	7,061.7 cal/g
BFD1	5,170.2 cal/g
BFD2	6,010.8 cal/g
BFD3	6,557.3 cal/g

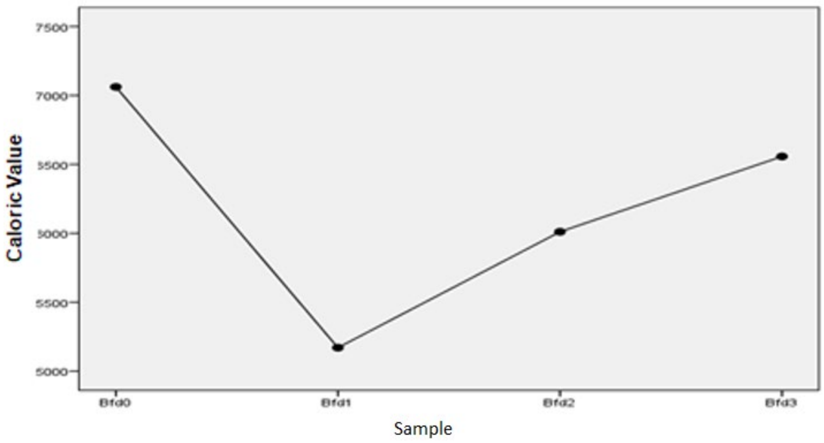

Figure 2. Calorific values of each sample

From Figure 2, it can be seen that the average calorific value of PT. INALUM's lowest coconut shell charcoal briquettes are 5,170.2 cal/g at a treatment of 200 g baking filter dust and 800 g coconut shell charcoal. The highest was 7,061.7 cal/g at the treatment of 0 g baking filter dust and 1,000 g coconut shell charcoal.

The calorific value of PT. INALUM coconut shell charcoal ranges from 5,170.2 – 7,061.7 cal/g; it meets the quality requirements of SNI calorific value – 01 - 6235 - 2000 (5,000 cal/g) (Table 2). The quality of coal is mainly determined by its calorific value, which can be calculated with a bomb calorimeter. The calorific value is a reference value for whether it is suitable for stone to be used as a substitute for oil. If the calorific value is too minimum, the economic value of carbon charcoal gets smaller, and there is no advantage if the calorific value is too low [10].

The calorific value is closely related to the content of bound carbon parameters if the carbon content increases. The calorific value will also increase and vice versa. If the carbon content is minimum, then the calorific value will also be very minimum [11], and the higher calorific value that can be produced is better in a briquette [7].

3.3 Ash Content Test

The ash content is a combustible residue with no calorific value. One of the components of ash is silica. Therefore, the effect of ash content on the quality of briquettes, especially the calorific value produced, is not good. High ash content lowers the calorific value of briquettes and can degrade the quality of briquettes [7].

Table 3. Ash Contents

Sample	Ash Contents
BFD0	3.90 %
BFD1	3.88 %
BFD2	4.69 %
BFD3	4.84 %

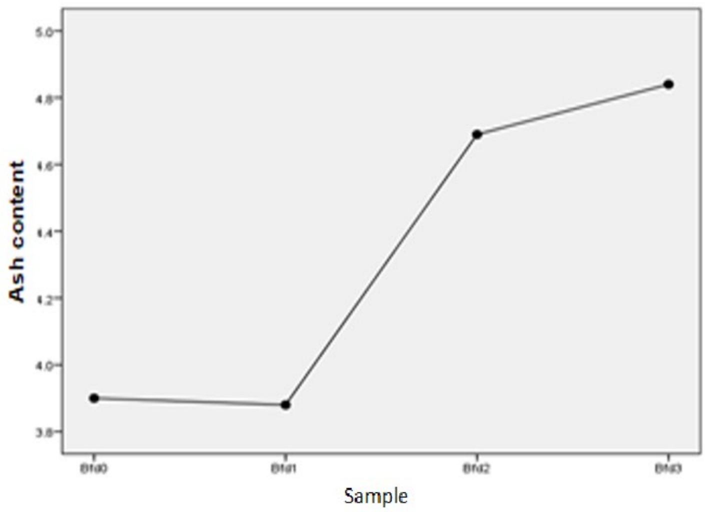

Figure 3. Ash contents of each sample

In Figure 3, the lowest average ash content of PT. INALUM's baking filter dust briquettes are 3.88% at a sample of 200 g baking filter dust and 800 g of coconut shell charcoal. In comparison, the highest average ash content was 4.84% in the sample of 600 g baking filter dust and 400 g coconut shell charcoal. Therefore, the ash content of the coconut shell charcoal baking filter dust briquettes is between 3.88 – 4.84%. The value meets the quality requirements of the ash content of SNI - 01 - 6235 - 2000 (<8 %). Ash is an inorganic substance that already remains left after the biomass burns. Ash mainly comprises calcium, magnesium, phosphorus, etc. [12]

3.4 Carbon Content Test (Fixed Carbon)

Carbon content is the amount of pure carbon present in the rock. Higher temperatures at the time of carbonization greatly affect the stone's quality, including its carbon content [8]. Carbon fraction (C) is bound in a briquette along with ash, water, and steam. The carbon content will have a high value when the ash content and vapor ratio of the briquettes are low. The carbon content of these briquettes affects the amount of heat generated. The higher the carbon content, the higher the heat. The higher the carbon content of the briquettes, the higher the quality of such briquettes [13].

Table 4. Carbon levels

Sample	Carbon Levels
BFD0	58.6 %
BFD1	62.9 %
BFD2	64.0 %
BFD3	69.4 %

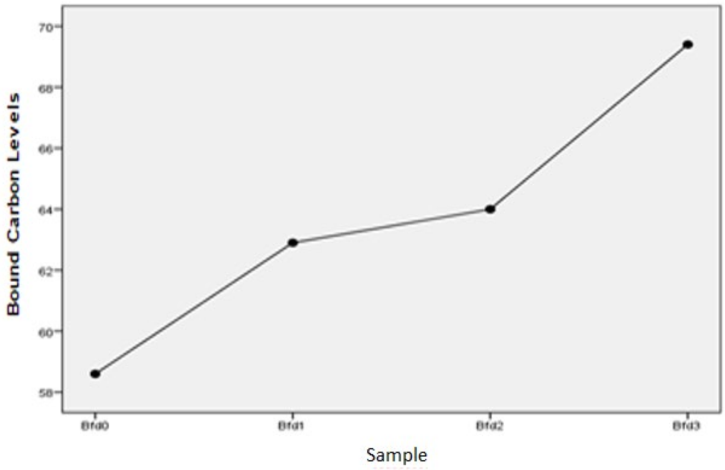

Figure 4. Carbon levels of each sample

Figure 4 shows the smallest average carbon content bound of baking filter dust PT. INALUM coconut shell charcoal is 58.6% at the sample of 0 g baking filter dust and 1,000 g coconut shell charcoal. In comparison, the highest is 69.4% at the sample of 600 g baking filter dust and 400 g coconut shell charcoal. The carbon content of bound briquettes baking filter dust PT. INALUM coconut shell charcoal averages 58.6 – 69.4% and does not meet the quality requirements of carbon content SNI - 01 - 6235 - 2000 (77 %) (Table 4). The bound carbon content affects the calorific value of briquettes. If the carbon value of the briquettes is high, the calorific value of the briquettes will be high [7]. The highest carbon content in a briquette will produce good quality briquettes [13].

3.5 Volatile Matter Test

The high component of volatile briquettes is due to the absence of carbonization. Carbonization can reduce volatile materials because no oxygen in the pyrolysis process can do that. Therefore, the higher the starch content, the higher the volatile matter obtained, and those contained in the starch binder and coconut shell charcoal are used for evaporation [13].

Due to the high volatility of the briquettes, the combustion of briquettes produces much smoke. The high proportion of smoke is due to the reaction of carbon dioxide with carbon dioxide. (CO_2) with alcohol derivatives [7].

Table 5. Evaporating Substance Levels

Sample	Evaporating substance levels
BFD0	14.1 %
BFD1	14.2 %
BFD2	12.2 %
BFD3	12.7 %

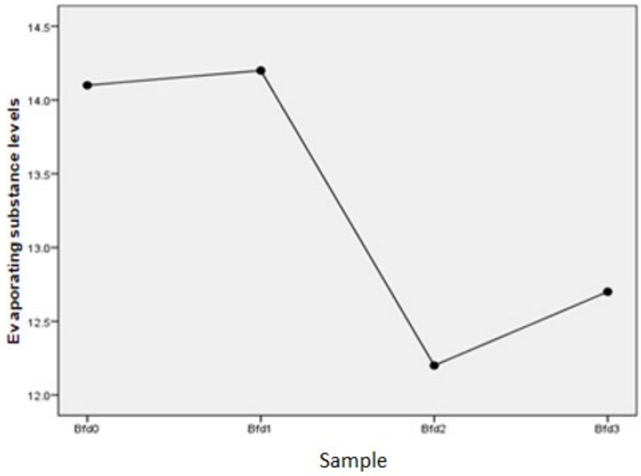

Figure 5. Evaporating substance levels of each sample

Figure 5 shows that the lowest average evaporating substance content is 12.2% at the sample of 400 g of baking filter dust and 600 g of coconut shell charcoal. The highest average evaporating substance content is 14.2% in treating 200 g of baking filter dust and 800 g of coconut shell charcoal. The content of volatile substances in this study ranged from 12.2 – 14.2%, meeting the quality requirements of evaporative substance levels SNI - 01 - 6235 - 2000 (<15%) (Table 5). High and low levels of volatiles in briquettes for the perfection of the smelting process. The longer the temperature and cooking time, the more volatile components that are wasted checking the evaporation rate is obtained low volatile [7]. Briquettes should have the lowest possible level of volatile matter [14]. Volatile substances exhibit a warming effect on solid fuels [9].

3.6 Sulphuric Level Testing

The burning of existing rocks to this day still produces quite high emissions due to the sulphuric content in the rocks. Therefore, at the time of combustion, briquettes will produce gas in the form of SO_2, a gas that is harmful to the environment because SO_2 gas released into the air will form sulphuric acid (H_2SO) to cause acid rain [15].

Table 6. Sulphuric Levels

Sample	Sulphuric levels
BFD0	0.52 %
BFD1	0.50 %
BFD2	0.50 %
BFD3	0.47 %

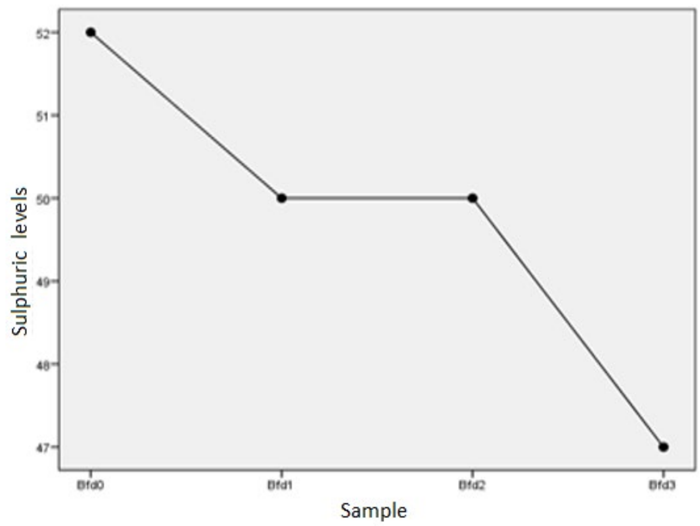

Figure 6. Sulphuric levels of each sample

In Figure 6, the lowest average sulphuric level is 0.47 % at 600 g baking filter dust and 400 g coconut shell charcoal sample. The highest sulfur content is 0.52% at the sample of 0 g baking filter dust and 1,000 g coconut shell charcoal. Therefore, sulphuric levels are eligible for T_0 to T_3. This is because it has met the standards based on ESDM regulation No. 47 of 2006 (Table 6). The high sulphuric content of biochar combustion causes environmental pollution [15]. Therefore, it is necessary to avoid the level of sulfur in briquettes to reduce air pollution when used [16].

3.7 Microscopic Analysis and Elemental Composition

Surface pore structure analysis can be performed on coconut charcoal briquette baking filter dust using a Scanning Electron Microscope (SEM). SEM micrograph uses to determine the surface morphology of the briquette dust filter PT. INALUM.

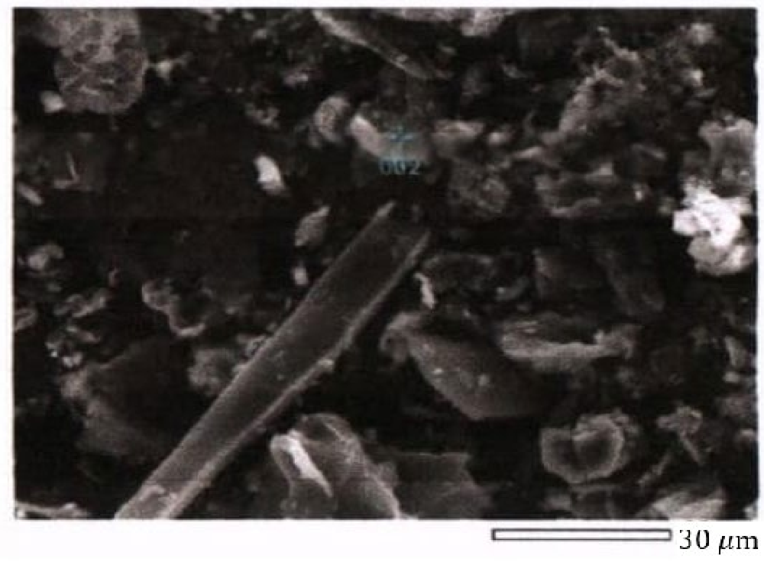

Figure 7. Micrograph of sample with 1000x magnification

Table 7. Elements of BFD

Element	(keV)	Mass %	Error %	Atom %
C	0.277	92.19	0.08	93.37
O	0.525	5.59	1.55	4.36
Mo	2.293	2.22	0.57	0.29
		100.00		100.00

From Figure 7, the morphological structure of the baking filter dust material PT. INALUM has a tenuous, porous, fibrous structure and a rough surface. The morphology of this sample was seen by using the Scanning Electron Microscope (SEM) with a magnification of 1000 times. Furthermore, the EDX (Energy Dispersive X-Ray Spectrometer) can be used to determine the elemental compositions of the sample. Based on Table 7, the largest composition in baking filter dust material of PT INALUM is a carbon (C). The percentage of mass composition C is 92.19%. In addition to the C element, there are also elements O and Mo, with percentages of 5.59% and 2.22%, respectively.

4 Conclusion

There are several test parameters, namely calorific value, ash content, and evaporating substances, to determine the best variation of coconut shell charcoal on baking filter dust PT. INALUM briquettes. The effect of adding coconut shell charcoal on baking filter dust PT. INALUM is decreased for water content, evaporating substances, and sulphuric levels and increased for calorific value, carbon content, and ash content. Therefore, the optimum value of the physical and chemical properties in briquettes is 7,062 cal/g, 0.52%, 69.4%, 14.2%, 23.4%, and 4.84% for calorific value, sulphuric content, carbon level, evaporating substance level, moisture content, and ash content, respectively.

REFERENCES

[1] Arni, H. M. D Labania and A. Nismayanti, "Studi Uji Karakteristik Fisis Briket Bioarang sebagai Sumber Energi Alternatif," *Online Jurnal of Natural Science*, vol. 3, no. 1, pp. 89-98, 2014.

[2] M. R. Fahlevi, "Pengaruh Variasi Komposisi Bahan Perekat terhadap Karakteristik Fisik dan Mekanik Briket Limbah Organik," Undergraduate thesis, Universitas Negeri Semarang, Semarang, 2016.

[3] M. Arman, A. Makhsud, A. Aladin, Mustafiah and R. A. Majid, "Produksi Bahan Bakar Alternatif Briket dari Hasil Pirolisis Batubara dan Limbah Biomassa Tongkol Jagung," *Journal of Chemical Process* Engineering, vol. 2, no. 2, pp. 16-21, 2017.

[4] J. A. Putra, "Proses Peleburan Aluminium dalam Tungku Reduksi pada PT. Inalum Kuala Tanjung Batubara," Undergraduate thesis, Universitas Sumatera Utara, Medan, 2010.

[5] Raudah, Z. Fona, U. Habibah, A. Ulfa, Ayuni, Maysarah and Syurufirrahmah, "Sorption Isotherm Models on Methylene Blue-Baking Filter Dust Activated Carbon." In *Proceeding International Conference on Science and Innovated Engineering (I-COSINE) 21–22 October 2018, Aceh, Indonesia,* vol. 536, 012113, IOP Conference Series: Materials Science and Engineering, 2019.

[6] Maryono, Sudding and Rahmawati, "Pembuatan dan Analisis Mutu Briket Arang Tempurung Kelapa Ditinjau dari Kadar Kanji," *Jurnal Chemica*, vol. 14, no. 1, pp. 74-83, 2013.

[7] Suprapti and S. Ramlah, "Pemanfaatan Kulit Buah Kakao untuk Briket Arang," *BIOPROPAL INDUSTRI*, vol. 4, no. 2, pp. 65-72, 2013.

[8] Sari, "Optimasi Nilai Kalor Pembakaran Biobriket Campuran Batubara dengan Arang Tempurung Kelapa," Undergraduate thesis, Universitas Sebelas Maret, Surakarta, 2011.

[9] J. O. Akowuah, F. Kemausuor and S. J. Mitchual, "Physico-chemical Characteristics and Market Potential of Sawdust Charcoal Briquette," *International Journal of Energy and Environmental Engineering*, vol. 3, 20, 2012.

[10] N. Wiyartha, "Proses Pembuatan Briket Bio-Arang dari Pelepah Kelapa Sawit sebagai Energi Alternatif dengan Variasi Suhu Karbonisasi dan Rasio Perekat," Undergraduate thesis, Universitas Sumatera Utara, Medan, 2019.

[11] T. U. Onuegbu, I. M. Ogbu and C. Ejikeme, "Comparative Analyses of Densities and Calorific Values of Wood and Briquettes Samples Prepared at Moderate Pressure and Ambient Temperature," *International Journal of Plant, Animal and Environmental Sciences*, vol. 2, no. 1, pp. 40-45, 2011.

[12] W. Deglas and Fransiska, "Analisis Perbandingan Bahan dan Jumlah Perekat terhadap Briket Tempurung Kelapa dan Ampas Tebu," *TEKNOLOGI PANGAN: Media Informasi dan Komunikasi Ilmiah Teknologi Pertanian*, vol. 11, no. 1, pp. 72-78, 2020.

[13] D. Sandri, Fatimah and Faridah, "Analisis Kualitas Biobriket Cangkang Biji Karet dengan Perbedaan Konsentrasi Perekat Tapioka," *Jurnal Teknologi Agro-Industri*, vol. 8, no. 1, pp. 55-64, 2021.

[14] R. Arifah, "Keberadaan Karbon Terikat dalam Briket Arang Dipengaruhi oleh Kadar Abu dan Kadar Zat yang Menguap," *Wahana Inovasi*, vol. 6, no. 2, pp. 365-377, 2017.

[15] Kamarullah, Khairil and Mahidin, "Kajian Desulfurisasi pada Pembakaran Biobriket dengan Adsorben Berbasis Kalsium," *Jurnal Teknik Mesin Unsyiah*, vol. 1, no. 4, pp. 157-161, 2013.

[16] P. D. Susanti, R. S. Wahyuningtyas and A. Ardhana, "Pemanfaatan Gulma Lahan Gambut sebagai Bahan Baku Bio-Briket," *Jurnal Penelitian Hasil Hutan*, vol. 33, no. 1, pp. 35-46, 2015.