SINTEK JURNAL: Jurnal Ilmiah Teknik Mesin
ISSN: 2088-9038, e-ISSN: 2549-9645
Homepage: http://jurnal.umj.ac.id/index.php/sintek

UTILIZATION OF BAGASSE WASTE BRIQUETTES AS AN ALTERNATIVE TO ENVIRONMENTALLY FRIENDLY TECHNOLOGY

Febi Fitriana[1], Rendy Wikrama Wardana[1,*], Mellyta Uliyandari[1], Sutarno[1], Saprudin[2]
[1]Science Education, Faculty of Teacher Training and Education, Universitas Bengkulu, Kota Bengkulu, 38371, Indonesia
[2]Physics Education, Faculty of Teacher Training and Education, Universitas Khairun, Kota Ternate, 97719, Indonesia

[*]E-mail: rendywardana@unib.ac.id

Accepted: 30-03-2024 Revised: 21-05-2024 Approved: 01-06-2024

ABSTRACT

Briquettes represent environmentally sustainable solid fuels that utilize renewable resources. This study aimed to assess the quality of bagasse waste briquettes as an alternative in eco-friendly technology. The experimental method was conducted internally at the PT SUCOFINDO Bengkulu laboratory. Briquettes were produced using varying compositions of bagasse waste: A1 (80 grams charcoal flour and 12 grams tapioca flour), A2 (30 grams charcoal flour and 6 grams tapioca flour), and A3 (20 grams charcoal flour and 5 grams tapioca flour). The production process involved preparation, drying, monitoring, grinding, adhesive mixing, molding, and final drying. Quantitative data analysis focused on key parameters including water content, ash content, and calorific value. Results indicated that the briquettes with 80% charcoal flour and 20% tapioca flour exhibited the highest calorific value at 6155 kcal/kg. It was concluded that all types of bagasse waste briquettes met Indonesian National Standards, demonstrating their potential as an alternative energy source through environmentally friendly briquette technology.

Keywords: briquettes; bagasse; eco-friendly technology.

ABSTRAK

Briket merupakan bahan bakar padat ramah lingkungan yang memanfaatkan sumber daya terbarukan. Penelitian ini bertujuan untuk mengkaji kualitas briket limbah ampas tebu sebagai salah satu alternatif teknologi ramah lingkungan. Metode eksperimental dilakukan secara internal di laboratorium PT SUCOFINDO Bengkulu. Briket dibuat dengan menggunakan komposisi limbah ampas tebu yang bervariasi: A1 (80 gram tepung arang dan 12 gram tepung tapioka), A2 (30 gram tepung arang dan 6 gram tepung tapioka), dan A3 (20 gram tepung arang dan 5 gram tepung tapioka). Proses produksi meliputi persiapan, pengeringan, pemantauan, penggilingan, pencampuran perekat, pencetakan, dan pengeringan akhir. Analisis data kuantitatif difokuskan pada parameter utama termasuk kadar air, kadar abu, dan nilai kalor. Hasil penelitian menunjukkan bahwa briket dengan 80% tepung arang dan 20% tepung tapioka menunjukkan nilai kalor tertinggi yaitu 6155 kkal/kg. Disimpulkan bahwa semua jenis briket limbah ampas tebu memenuhi Standar Nasional Indonesia, yang menunjukkan potensinya sebagai sumber energi alternatif melalui teknologi briket yang ramah lingkungan.

Kata Kunci: *briket; ampas tebu; teknologi ramah lingkungan.*

1. Introduction

As the population grows, the demand for energy will continue to increase and the amount of energy used is limited, so it is necessary to find and start using more sustainable alternatives. New Energy and Renewable Energy (EBT) are one of the alternative sources of energy supply, because in addition to having a low impact on environmental damage, it also guarantees energy sustainability for the future [1]. One potential alternative energy source that can be developed is biomass. Biomass energy is a renewable alternative energy source derived from plant waste or organic matter that is easily found and has abundant availability, such as rice husks, wood waste, coconut shells and bagasse [2]. The manufacture of fuel briquettes from a mixture of forest and agro residues shows the potential of appropriate technology for the use of biomass residues as energy fuel [3]. One of the biomass wastes that can be used as raw material for making briquettes is bagasse, because it has a fiber content of 48% [4].

Sugarcane plants are found in the Bengkulu area which in fact the pulp of sugarcane is still widely discarded and burned carelessly. Bagasse waste has a bad impact if it is not used properly. The adverse effects that can be caused include pollution in the form of smoke, dust and pollution in the form of solids and liquids. The depiction is that if it is in the form of smoke and dust, it will endanger lung health. In the form of solids can reduce the level of soil fertility and if in liquid form will cause damage to water ecosystems [5]. One of the efforts to reduce the adverse effects of bagasse waste on the environment is to be used as a more economically valuable material, namely as an alternative energy source fuel in the form of briquettes. Briquettes are a simple alternative fuel, both in terms of the production process and the use of raw materials for making briquettes, so they have considerable potential to be developed into fuel, because briquettes have a relatively high calorific value with a long combustion time [6]. In this study, the manufacture of briquettes made from bagasse with the addition of tapioca flour as an adhesive was made. The use of tapioca flour adhesive tends to produce briquettes of better quality than sago adhesive [7].

Research on bagasse waste briquettes has been carried out by other researchers. Namira [8] has conducted research on bagasse waste briquettes using glue K adhesive. Muriyani [9] has conducted research on the characteristics of bagasse charcoal briquettes (*Saccharum officinarum l*) and kaliandra sawdust (*Calliandra calothyrsus*) with tapioca flour adhesive. From the results of the study, the chemical composition of bagasse includes ash 3.82%; 48-52% water; cellulose 37.65%; lignin 22.09%; silica 3.01%; pentosan 27.97%; and 3.3% reducing sugar. The content of pentosan is quite high in bagasse, allowing bagasse to be processed into briquettes. Wibowo [10] has conducted research on thermal analysis of calorific value of bagasse briquettes and sawdust. The results showed that the treatment of variations in bagasse composition had a higher briquette calorific value than the composition of wood sawdust. Bagasse squander can be utilized as fuel, paper mash making fabric, natural fertilizer and creature bolster [4]. Not numerous businesses have created items made from bagasse , so an innovation is needed related to the use of bagasse waste as a fuel for alternative energy sources.

Based on these studies, inquire about on making briquettes from bagasse squander should be carried out assist such as the impact of composition varieties on the quality of briquettes. Different composition variations in the manufacture of bagasse waste briquettes are the novelty of this study. This study aims to make briquettes from bagasse waste with variations in composition to decide the quality of the briquettes delivered, which can be utilized as elective vitality to create naturally neighborly innovation items. So it is necessary to carry out limited tests including ash content, moisture contentand calorific value to see the quality of briquette products.

2. Methods

Briquette testing was carried out at the PT SUCOFINDO Laboratory, Bengkulu. This research method is an experiment and internal method laboratory of PT SUCOFINDO, Bengkulu. The experimental group was divided into 3 groups, namely briquettes A1 80 grams of charcoal flour and 12 grams of tapioca flour (87% charcoal flour and 13% tapioca flour), A2 briquettes 30 grams of charcoal flour and 6 grams of tapioca flour (83% charcoal flour and 17% tapioca flour), A3 briquettes 20 grams of charcoal flour and 5 grams of tapioca flour (80% charcoal flour and 20% tapioca flour). This study used descriptive analysis techniques. The investigate information is at that point handled and displayed within the shape of tables and graphs that show the influence of composition variations on briquette quality. Sample analysis carried out in this study included moisture content, ash content and calorific value in accordance with ASTM D 5142-02.

2.1. Determination of Moisture Content

To determine the moisture content according to ASTM D 5142-02, the test sample (charcoal briquettes) was weighed ± 1 gram, at that point put within the broiler at 104-110ºC for 1 hour until the weight was steady and weighed Sulistyaningkarti [11]. The dampness substance can be decided utilizing the condition:

$$Moisture\ (\%) = \left(\frac{m_1 - m_2}{massa\ sampel}\right) \times 100\,\% \quad (1)$$

Statement:

m_1 : mass of empty cup + mass of sample before heating (grams).

m_2 : empty cup mass + sample mass after heating (grams).

2.2. Determination of Ash Content

To determine the ash content of briquettes according to ASTM D 5142-02, weigh a crucible dish without a lid with specimens taken 1 gram from a charcoal briquette sample, Place in the oven and heat at 450-500°C for 1 hour, 700-750°C for 2 hours, and then incinerate at 900-950°C for 2 hours. The crucible was removed from the oven, cooled in a desiccator, and weighed immediately [11]. Ash content can be calculated using the following formula:

$$Ash\ Content\ (\%) = \left(\frac{A}{B}\right) \times 100\% \quad (2)$$

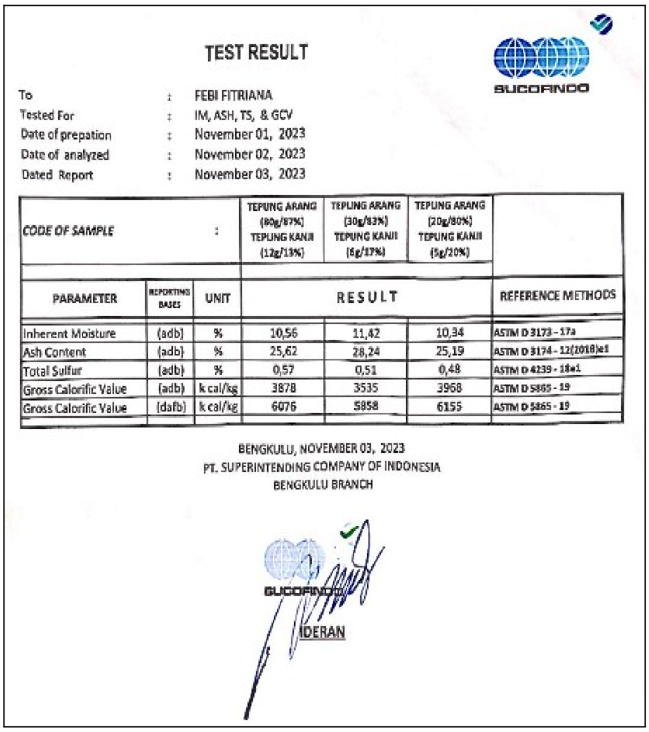
Statement:
A : mass of ash (grams)
B : sample mass (grams)

2.3. Determination of Calorific Value

The calorific value is tested using a bomb calorimeter. Calorific value can be calculated using the following formula:

$$Q = m\ x\ c\ x\ \Delta T \quad (3)$$

Statement:
Q : heat needed (Joule)
c : heat type (J/kg^{0}C)
m : mass of object (kg)
ΔT : temperature change (^{0}C)


TEST RESULT

SUCOFINDO

To : FEBI FITRIANA
Tested For : IM, ASH, TS, & GCV
Date of prepation : November 01, 2023
Date of analyzed : November 02, 2023
Dated Report : November 03, 2023

CODE OF SAMPLE :			TEPUNG ARANG (80g/87%) TEPUNG KANJI (12g/13%)	TEPUNG ARANG (30g/83%) TEPUNG KANJI (6g/17%)	TEPUNG ARANG (20g/80%) TEPUNG KANJI (5g/20%)	
PARAMETER	REPORTING BASES	UNIT	RESULT			REFERENCE METHODS
Inherent Moisture	(adb)	%	10,56	11,42	10,34	ASTM D 3173 - 17a
Ash Content	(adb)	%	25,62	28,24	25,19	ASTM D 3174 - 12(2018)e1
Total Sulfur	(adb)	%	0,57	0,51	0,48	ASTM D 4239 - 18e1
Gross Calorific Value	(adb)	k cal/kg	3878	3535	3968	ASTM D 5865 - 19
Gross Calorific Value	(dafb)	k cal/kg	6076	5858	6155	ASTM D 5865 - 19

BENGKULU, NOVEMBER 03, 2023
PT. SUPERINTENDING COMPANY OF INDONESIA
BENGKULU BRANCH

SUCOFINDO

IDERAN

Figure 1. Data of PT SUCOFINDO Bengkulu Laboratory Test Results

The materials utilized in this think about were bagasse and custard flour as cements. The equipment used is a smoothing machine, manual molding, scales, and trays. Briquette charcoal making consists of seven stages, namely preparation, drying, surveillance, smoothing, mixing adhesives, printing, and drying. The method stream of making bagasse squander briquettes can be seen in Figure 2.

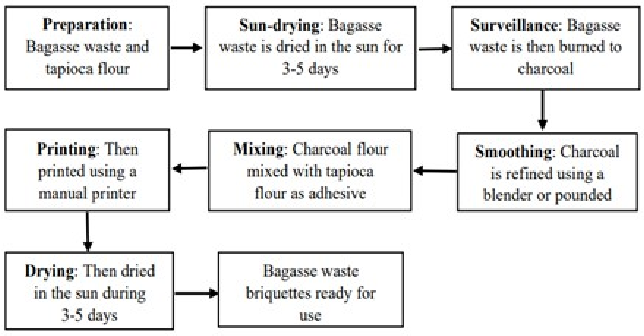


Figure 2. Briquette Making Flow Chart

3. Results and Discussion

Based on the results of the quality test of burning sugarcane bagasse waste briquettes, several data were obtained in the following Table 1.

Table 1. Briquette Combustion Quality Test Results

Kind	Percentage Flour Charcoal and Flour Tapioca	Power Water (%)	Ash Content (%)	Value Heat (kcal/kg)
A1	87%:13%	10.56	25.62	6076
A2	83%:17%	11.42	28.24	5858
A3	80%:20%	10.34	25.19	6155

3.1. Moisture Test

Water content testing is a way to measure the amount of water contained in briquettes [12]. The dampness substance will influence whether or not the briquettes are simple to burn. The dampness substance of charcoal briquettes influences the calorific esteem. The littler the dampness substance esteem, the higher the calorific esteem [13]. The lower the dampness substance, the higher the calorific esteem and combustion control. The higher the dampness substance will cause the quality of charcoal briquettes to diminish [14]. Based on the comes about of the consider, water substance information were gotten in Figure 3.

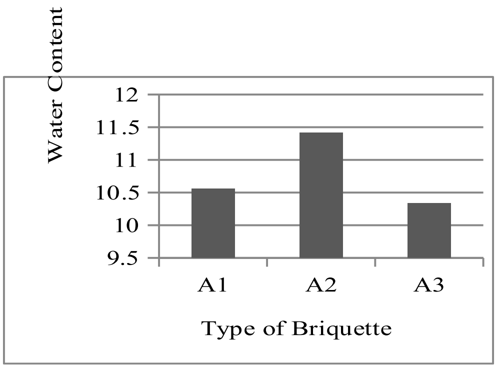


Figure 3. Bagasse Waste Briquette Water Content Graph

Based on Figure 3, the dampness substance of sugarcane bagasse squander briquettes is around 10.34% to 11.42%. From the test information conducted, it was gotten that the dampness substance of all sorts of bagasse squander briquettes had not met SNI 01-6235-2000, which was a maximum of 8%. Factors that can affect the results of the study are the lack of briquette density in the printing process so that the evaporated moisture content is not constant. Then there is still the influence of air outside the environment on the cooling process carried out manually in open spaces [14]. Another calculate that influences the dampness substance in briquettes is the flawed drying of briquette crude materials with the drying time after getting to be briquettes, so it is still necessary to extend the drying time [15].

3.2. Ash Content Test

Cinder substance is the rate of substances cleared out over from the combustion handle and as of now destitute of the component carbon. Tall cinder substance can diminish the calorific esteem of charcoal briquettes so that the quality of charcoal briquettes diminishes. The more noteworthy the calorific esteem, the more warm vitality delivered by combustion [16]. The esteem of fiery remains substance moreover influences the calorific esteem of charcoal briquettes, that the tall esteem of cinder substance will decrease the calorific esteem of charcoal briquettes [17]. Based on the comes about of the think about, cinder substance information were gotten in Figure 4.

Based on Figure 4, the ash content in bagasse briquettes is around 25.19% to 28.24%. The ash content value that must be achieved in briquettes that have been produced based on SNI No.1/6235/2000 is ≤ 8%. So that when compared with the SNI, all types of sugarcane bagasse waste briquettes that have been made have not met the Indonesian National Standard. This is likely caused by environmental factors, where the authoring process is carried out in the open air so that air contact occurs which results in the formation of imperfect charcoal and the formation of ash is also getting bigger.

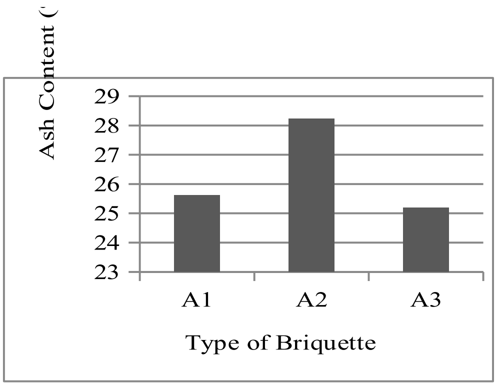


Figure 4. Bagasse Waste Briquette Ash Content Graph

3.3. Calorific Value Test

Calorific esteem is the sum of warm created per one weight of the combustion handle sufficient from one fabric that's combustible sufficient. Calorific esteem to a great extent decides the quality of charcoal briquettes. The higher the calorific esteem of charcoal briquettes, the superior the quality of the charcoal briquettes delivered. Based on the results of the study, Figure 5 data was obtained.

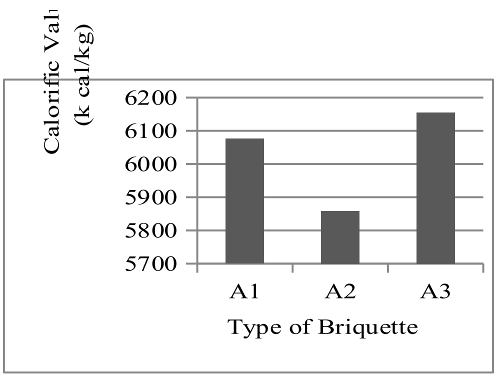


Figure 5. Calorific Value Graph of Bagasse Waste Briquettes

Based on the study, the highest calorific value test results were obtained in the A3 briquette type of 6155 kcal / kg and the lowest calorific value in the A2 briquette type of 5858 kcal / kg. From the information gotten, it appears that all sorts of bagasse squander briquettes have met SNI 01-6235-2000 with a least calorific esteem of 5000 kcal / kg. Calorific esteem is the foremost critical quality parameter for briquettes. Since the higher the calorific esteem of briquettes, the superior the quality of the briquettes delivered.

The calorific esteem is emphatically impacted by the esteem of fiery remains substance and water substance [18]. The calorific esteem affected by the dampness substance can be seen within the drying handle. The longer the drying time of briquettes, resulting in an increase in calorific value due to decreased moisture content. The calorific esteem is additionally impacted by fiery debris substance, cinder is the remaining portion of the combustion item. The lower the fiery debris substance, the higher the calorific esteem.

It can be seen from the graph obtained that the data on the quality test results of burning sugarcane bagasse waste briquettes are balanced. Where the sort of A3 briquettes has the most noteworthy calorific esteem and the most reduced dampness substance and fiery debris substance. The A2 briquette sort has the most reduced calorific esteem and the most elevated dampness substance and cinder substance. The variety in composition influences the dampness substance, fiery remains substance, and calorific esteem of charcoal briquettes [19]. Variations in composition affect the relationship between water content, ash content and calorific value, namely the lower the water content and ash content, the higher the calorific value of the briquettes produced. The higher the moisture content and ash content of briquette charcoal, it will reduce the calorific value of the charcoal briquette fuel produced [15]. This is in accordance with Kahariayadi's research [20] expressing that the calorific esteem enormously decides the quality of briquette charcoal. The higher the calorific esteem of briquette charcoal, the superior the quality of the briquette charcoal created. The higher the dampness substance and cinder substance of briquette charcoal, it'll diminish the calorific esteem of the briquette charcoal burnt created. The most parameter in deciding the quality of briquette fuel is the calorific esteem [21]. Therefore, the basic material of bagasse waste has good quality to be developed into briquettes.

Briquettes are flammable chunks commonly used to ignite and maintain fires in open spaces such as boilers or grills. Briquettes are usually square or rectangular, but can also be lump-shaped or other shapes. Briquettes are environmentally friendly solid fuels and are renewable so that their use as fuel can reduce the negative impact of using fossil or conventional fuels [22]. Briquettes with great quality incorporate properties such as smooth surface, not effortlessly broken, difficult, secure for people and the environment and have great start properties. These start properties incorporate combustibility, long fire time, no side effects, small smoke and quick scattering and tall calorific esteem [23]. The most points of interest of briquettes from biomass are less volume, simple taking care of, moo transportation costs, idealize fuel combustion and simple capacity. Amid taking care of, capacity and transportation, briquettes will not be harmed [24].

Bagasse waste briquettes apply the principle of environmental conservation and are an example of environmentally friendly technology products. Environmentally friendly technology is technology that is created to facilitate human life but does not cause damage or have a negative impact on the surrounding environment [25]. Environmentally friendly technology is a technology that uses environmentally friendly raw materials in its production and use. The management of bagasse waste briquettes can help reduce waste problems by processing organic waste into alternative energy source fuel in the form of briquettes. Briquettes are also efficient in their use, briquettes are more environmentally friendly because they have a high calorific value and can ignite for a long time and emit combustion smoke that is relatively lower than ordinary charcoal [26].

4. Conclusion

From the comes about of the investigate conducted, it can be concluded that bagasse squander can be utilized as an elective to ecologically neighborly innovation. The quality test of bagasse waste briquettes comparing 80% charcoal flour to 20% tapioca flour showed the best results with a calorific amount of 6155 kcal/kg. Meanwhile, the ratio of 87% charcoal flour to 13% tapioca flour resulted in a calorific amount of 6076 kcal/kg and a ratio of 83% charcoal flour to 17% tapioca flour resulted in a calorific amount of 5858 kcal/kg. The calorific value of all types of bagasse waste briquettes has met the Indonesian National Standard. So that the potential of bagasse waste briquettes as an alternative fuel to replace coal and charcoal is quite large because: 1) it emits little smoke when burned, 2) it is made of renewable materials, 3) it has a high calorific value, and 4) the technology is simple and easy to learn so that it can be used by ordinary people.

Based on the research that has been done, suggestions can be given that there is a need to add more adhesive variations so that the resulting data can be more specific and in making briquettes, further attention to the equipment and manufacturing process, especially during the combustion process into charcoal. We recommend using an oven so as not to be contaminated with dust from outside, so as to get results that are in accordance with the Indonesian National Standard briquettes.

References

[1] J.S. Setyono, H.M. Fadjar, and F.K.A. Mega, "Potensi Pengembangan Energi Baru dan Energi Terbarukan di

Kota Semarang," J. Riptek., vol. 13, no. 2, pp. 177, 2019.
[2] A.Z. Amin, Pramono, and Sunyoto, "Pengaruh Variasi Jumlah Perekat Tepung Tapioka terhadap Karakteristik Briket Arang Tempurung Kelapa," J. Sains dan Teknol., vol. 15, no. 2, pp. 111, 2017.
[3] H.A. Ajimotokan et al., "Combustion Characteristics of Fuel Briquettes Made from Charcoal Particles and Sawdust Agglomerates," J. Sci. Afr., vol. 6, pp. 2, 2019.
[4] N.L. Li-An'Amie and N. Adhi, "Pemanfaatan Limbah Ampas Tebu melalui Desain Produk Perlengkapan Rumah," J. Tingkat Sarjana Senirupa dan Desain., vol. 3, no. 1, pp. 1, 2014.
[5] Rendi et al., "Edukasi Pengelolaan Sampah dan Pendampingan Penggunaan Mesin Pembakar Sampah di Desa Semangat Dalam," J. Pengabdian Al-Ikhlas., vol. 7, no. 1, pp. 140, 2021.
[6] I. Ardiansyah, Y.P. Arief, and S. Yelfira, "Analisis Nilai Kalor Berbagai Jenis Briket Biomassa secara Kalorimeter," J. Res. Educ. Chem., vol. 4, no. 2, pp. 121, 2022.
[7] A. Mustain et al., "Pembuatan Briket Campuran Arang Ampas Tebu dan Tempurung Kelapa sebagai Bahan Bakar Alternatif," J. Tek. Kim. Lingkung., vol. 5, no. 2, pp. 105, 2019.
[8] S. Namira et al., "Pemanfaatan Limbah Ampas Tebu untuk Pembuatan Arang Briket dengan Menggunakan Bahan Perekat Lem K," Chem. Eng. J. Storage., vol. 3, no. 2, pp. 188, 2023.
[9] A. Muriyani, W. Evy, and I. Yuliati, "Karakteristik Briket Arang Ampas Tebu (Saccharum officinarum L) dan Serbuk Kayu Kaliandra (Callliandra Calothyrsus) dengan Perekat Tepung Tapioka," J. Hutan Lestari., vol. 11, no. 2, pp. 470, 2023.
[10] R. Wibowo, "Analisis Thermal Nilai Kalor Briket Ampas Batang Tebu dan Serbuk Gergaji," J. Rekayasa Mesin., vol. 10, no. 1, pp. 14, 2019.
[11] L. Sulistyaningkarti and U. Budi, "Pembuatan Briket Arang dari Limbah Organik Tongkol Jagung dengan Menggunakan Variasi Jenis dan Persentase Perekat," J. Kim. dan Pendidik. Kim., vol. 2, no. 1, pp. 47, 2017.
[12] E. Kambey, D. Tooy, and D. Rumambi, "Uji Kualitas Briket Sabut Kelapa sebagai Sumber Energi Bioamassa Alternatif," J. Garuda., vol. 15, no. 1, pp. 2, 2022.
[13] Mislaini Santosa, R. Mislaini, and P.A. Swara, "Studi Variasi Komposisi Bahan Penyusun Briket dari Kotoran Sapi dan Limbah Pertanian," Universitas Andalas Kampus Limau Manis., 2010.
[14] Masthura, "Analisis Fisis dan Laju Pembakaran Briket Bioarang dari Bahan Pelepah Pisang," J. Islam. Sci. Technol., vol. 5, no. 1, pp. 61-64, 2019.
[15] O.H. Usmayadi, Dina, and S. Nurhaida, "Kualitas Briket Arang dari Batang Kelapa Sawit (Elaeis guineensis Jacq) Berdasarkan Ukuran Serbuk," J. Tengkawang., vol. 8, no. 1, pp. 21-23, 2018.
[16] E. Yulianti et al., "Briket Arang Tempurung Kawista (Limonia acidissima) Teraktivasi NaOH dengan Perekat Alami," J. Al-Kimiya., vol. 6, no. 1, pp. 2, 2019.
[17] R.P. Dewi, J.S. Trisma, and J.P. Sigit, "Analisis Karakteristik Briket Arang dengan Variasi Tekanan Kempa Pembriketan," J. Media Mesin., vol. 23, no. 1, pp. 17, 2022.
[18] J.S. Wibowo and R. Wegie, "Pemanfaatan Buah Pinus dengan Serbuk Gergaji Kayu Jati Menjadi Briket sebagai Energi Alternatif," J. Ilm. Tek. Mesin., vol. 7, no. 2, pp. 102, 2021.
[19] D. Patabang, "Karakteristik Termal Briket Arang Sekam Padi dengan Variasi Bahan Perekat," J. Mekanikal., vol. 3, no. 2, pp. 286-292, 2012.
[20] A. Kahariayadi et al., "Kualitas Arang Briket Berdasarkan Persentase Arang Batang Kelapa Sawit (Elaeis Guineensis Jacq) dan Arang Kayu Laban (Vitex Pubescens Vahl)," J. Hutan Lestari., vol. 3, no. 4, pp. 566, 2015.
[21] N. Iskandar, N. Sri, and F.F. Meta, "Uji Kualitas Produk Briket Arang Tempurung Kelapa Berdasarkan Standar Mutu Sni," J. Momentum., vol. 15, no. 2, pp. 104, 2019.
[22] R. Haryono, E. Evy, and D.A.S. Solihudin, "Uji Kuallitas Briket dari Tongkol Jagung dengan Perekat Kanji/Pet dan Komposisi Gas Buang Pembakarannya," J. Ilmu dan Inovasi Fisika., vol. 4, no. 2, pp. 132, 2020.
[23] R. Handoko, M. Fadelan, and M. Muh, "Analisa Kalor Bakar Briket Berbahan Arang Kayu Jati, Kayu Asam, Kayu Johar, Tempurung Kelapa dan Campuran," J. Mahas. Univ. Muhammadiyah Ponorogo., vol. 3, no. 1, pp. 15, 2019.
[24] J.A. Kumar et al., "Comparative Analysis of Briquettes Obtained from Biomass and Charcoal," J. Mater. Today: Proc., vol. 45, no. 2, pp. 1, 2020.
[25] A.A. Sani, "Pengaruh Teknologi Ramah Lingkungan dan Kualitas Pelayanan Terhadap Keunggulan Kompetitif dan Kinerja Perusahaan," E-J. Manaj. Unud., vol. 6, no. 7, pp. 3488, 2017.
[26] W. Fitriana and F. Wetri, "Analisis Potensi Briket Bio-Arang sebagai Sumber Energi Terbarukan," J. Tek. Pertan. Lampung., vol. 10, no. 2, pp. 148-153, 2021.