International Journal of Applied Sciences and Smart Technologies

Volume 5, Issue 2, pages 145–156

p-ISSN 2655-8564, e-ISSN 2685-9432

Production and Characterization of Bio-Briquettes from Coconut Leaves and Cassava Peels

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(Received 19-12-2022; Revised 06-02-2023; Accepted 11-02-2023)

Abstract

Bio-briquettes from a mixture of coconut leaves charcoal and cassava peel charcoal have been produced and characterized in this study. The analysis carried out included density, burning rate, water content, ash content, and calorific value. Bio-briquette samples were produced with composition variations between coconut leaves charcoal and cassava peel charcoal with mass percentage ratios of 100:0, 75:25, 50:50, 25:75 and 0:100. The mixture used to produce briquettes with a ratio of tapioca flour, water and charcoal as raw materials is 1.5:1.5:2. The results of the study show that the density and calorific value of bio-briquettes increases with the increase in the amount of cassava peel in the briquette content. The optimum bio-briquette product from this research was found in variations of coconut leaves and cassava peel with a ratio of 75:25. The density is 0.96 g/ml, the burning rate is 0.190 g/min, the water content is 3%, the ash content is 18.81%, and the calorific value is 3521.47 Cal/g.

Keywords: bio-briquette, coconut leaves, cassava peels, bioenergy, biomass

1 Introduction

The potential for an energy crisis can be caused by various factors. Not only experienced by the least developed countries, but this condition also has the potential to occur in developed countries. In the least developed countries, it is easy to understand that there are many factors that cause energy crisis that these countries often face.

Developing countries have different potential causes of energy crisis, including dependence on technology, fuel prices and fuel supply. For example, in South America, there was an energy crisis caused by the unpreparedness of technology related to the lack

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of stored hydropower, which resulted in the length of construction of hydropower plants [1].

In developed countries, the occurrence of an energy crisis can be caused by a country's dependence on one type of energy source, as happened in several countries in Europe due to dependence on gas and not ready to transfer technology when a crisis occurs.

To overcome the energy crisis, research and development has been carried out on various types of energy sources including solar, wind, biomass, geothermal, tidal, and hydro. Problems with renewable energy include the high cost of technology and regulations that do not support its mass use [2].

The unpreparedness of technology transfer during a crisis makes it difficult to mitigate these problems. The use of non-fossil energy is still minimal in many countries, The portion of its production worldwide is around 20-30% of all energy production. This is also related to energy dependence and the difficulty of implementing technology transfer, so it becomes an obstacle in reducing the potential for an energy crisis [3], [4].

Technology in the production of non-fossil energy such as solar panels, vertical wind turbines, sea wave turbines which are still undergoing development cause the production costs to be relatively more expensive than some other alternative technologies such as waste-to-energy.

Energy technology from waste already existed and was operated in the early 1980s. But this technology was considered a failure because it has not been able to reduce the environmental impact of combustion in the form of residual solids and gases. This has caused this technology to disappear from the energy market, although its operation has the potential to be used in several pioneer industries that use waste energy, such as cement factories and coal-fired power plants [5].

The use of all types of waste that is directly burned using an incinerator to become heat energy does cause environmental pollution. It is because the combustion products contain various chemical elements because they do not come from one type of waste.

To overcome this, waste-to-energy technology has the potential to be used if it uses similar waste and is always produced. For example, waste from the agro industry which harvests every time. Agro-industrial waste that have the potential to become

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energy sources that have been studied previously are tuber peels, fruit peels, straw, husks, plant stems and leaf midribs [6].

Industrial waste through waste-to-energy technology can show potential as a non-fossil energy source, The use of this waste can be an alternative mitigation route when facing an energy crisis. Agro-industrial waste whose crops are harvested throughout the year is highly preferred. This is because it is able to ensure the availability of materials in a sustainable manner. Agro-industrial wastes included in this criterion include cassava peels and coconut leaf.

Cassava peel has been studied and has shown satisfactory characterization results, namely the calorific value of 5126 Cal/g with a mixture of 20% adhesive mass and 80% charcoal, where the adhesive is made from a mixture of water and tapioca flour with a ratio of 9:1 [7].

It is known that dried coconut leaves contain energy, so they are often used as a fire starter for bonfires. However, coconut leaves have not been widely studied regarding the use of energy as raw material for bio-briquette charcoal. The composition used in several previous studies provides a high calorific value but has a weakness, namely the bio-briquette product which is brittle when printed. This is because of the adhesive content that does not bind the entire charcoal mixture.

In this study, data were searched regarding the characteristics of bio-briquettes including density, burning rate, moisture content, ash content and calorific value of a mixture of coconut leaf charcoal and cassava peel charcoal. It is hoped that the results of this study will obtain a composition with optimum characteristics.

2 Research Methodology

The materials used in this study include coconut leaves charcoal, cassava peel charcoal, tapioca flour, and water. Coconut leaves that have fallen naturally are taken from coconut trees in the park. Cassava peel comes from traditional market waste, unbranded bulk tapioca flour and tap water is used. The equipment used includes digital balance, blender, plastic container, porcelain dish, cube briquette molds, oven, furnace and Leco AC600 calorimeter.

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The experimental stages consist of handling raw materials, making charcoal blending and molding bio-briquettes. The handling of coconut leaves is done by removing it from the midrib, reducing its size to about 20 cm to fit in the furnace. Meanwhile, the cassava peel is washed to clean it from impurities such as soil, then dried in the sun for a day to dry before being processed in the furnace.

After the material is ready, then the carbonization process is carried out using a furnace at temperatures of 400, 500, 600, 700 and 800^{o}C for 1 hour, which aims to determine the optimum temperature in the formation of charcoal.

After the process of forming charcoal with a furnace, each charcoal from coconut leaves and cassava peels is mashed using a blender separately. Mixing materials to produce bio-briquettes using variations in mass composition is shown in Table 1.

Table 1. Mass variation of bio-briquette composition

No	Ratio	TF (g)	W (g)	CL (g)	CP (g)
1	100:0	15	15	20	0
2	75:25	15	15	15	5
3	50:50	15	15	10	10
4	25:75	15	15	5	15
5	0:100	15	15	0	20

Annotation : **Ratio** is mass percentage ratio of coconut leaves charcoal and cassava peels charcoal, **TF** is tapioca flour, **W** is water, **CL** is coconut leaves charcoal, **CF** is cassava peel charcoal.

The bio-briquette sample molding process was carried out using a mold with hand pressure to produce a cube-shaped sample with dimensions of 2.5 cm x 2.5 cm x 2.5 cm. After the molding process is carried out, the sample is then dried in a room exposed to direct sunlight for 1 day so that the sample becomes hard and does not change its shape.

The analytical parameters tested on the sample include density, moisture content, ash content and calorific value. The density test is carried out by weighing the sample with dimensions 2.5 cm x 2.5 cm x 2.5 cm, then record the results of the weighing and calculate the density with the equation 1 [8], [9].

$$Density = \frac{briquette\ \ mass\ (g)}{briquette\ volume\ (cm^3)} \tag{1}$$

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Water content analysis was carried out by weighing the sample and recording the initial mass, heating it in an oven at 115^{o}C for 3 hours. After the heating time is complete, then place the briquettes in a desiccator until the sample reaches room temperature, weigh the sample after it has room temperature, then record the weighing results and calculate the water content with equation 2.

$$Water\ content = \frac{initial\ mass - final\ mass}{initial\ mass} \times 100\% \quad (2)$$

Ash content analysis was carried out by weighing the sample and recording the initial mass, then placing the sample in a furnace at 800^{o}C for 2 hours. After the time is over, the sample is placed in a desiccator at room temperature. Weigh the sample after it reaches room temperature and record the mass of the weighing result, then calculate the ash content using equation 3 [10].

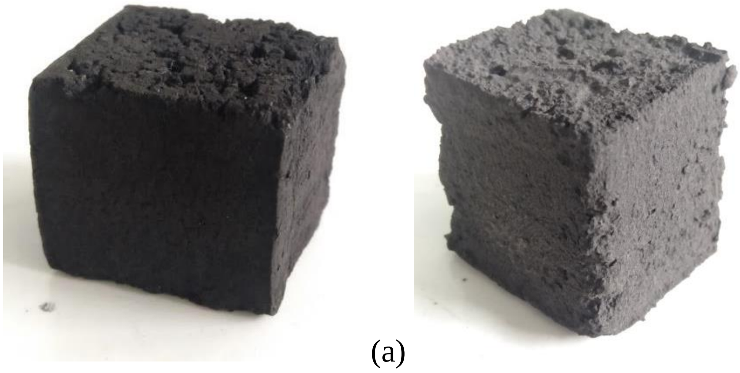
$$Ash\ content = \frac{final\ mass}{initial\ mass} \times 100\% \quad (3)$$

The method of calorie analysis with a calorimeter is done by putting the sample inside the combustion vessel, which is pressurized with oxygen. The sample is ignited and the temperature of the bucket and jacket water is measured by an electrical thermometer with a resolution of 0.0001 of a degree. A measurement of the water temperature inside the bucket and jacket is collected every second. Calorific values are determined by a simple maximum temperature rise of the bucket [11].

3 Results and Discussions

In the production of coconut leaf charcoal and cassava peel charcoal, temperature variations are carried out in the carbonization process at a temperature of 400 to 800^{o}C. The results showed that at a temperature of 400^{o}C the material was still in the form of black charcoal. There was a slight visible ash formed. Meanwhile, both coconut shells and banana peels turn into the form of completely gray ash at a temperature of 500, 600, 700 and 800^{o}C.

Based on the results of charcoal formation, a temperature of 400^{o}C was chosen to produce coconut leaf charcoal and cassava peel charcoal samples. Figure 1 shows the appearance of bio-briquettes produced from charcoal with a carbonization temperature of 400^{o}C compared to commercial bio-briquettes.



(a) (b)

Figure 1. The appearance of commercial bio-briquettes (a) and sample (b)

Based on its appearance, the commercial bio-briquettes look darker than the bio-briquettes samples from this study. This is due to the large amount of tapioca adhesive in the sample. Bio-briquette samples have been characterized to compare their properties with commercial sample properties, as shown in Table 2.

Table 2. Properties of bio-briquette made of coconut leaves and cassava peels compared to commercial sample

Parameter	Commercial sample properties	Mass percentage ratio of coconut leaves charcoal and cassava peels charcoal				
		100:0	75:25	50:50	25:75	0:100
Density (g/ml)	0.97	0.84	0.96	0.99	1.05	1.14
Burning rate (g/min)	0.136	0.307	0.190	0.357	0.441	0.318

The characteristics of the sample results from the study compared to commercial samples showed that the higher the content of cassava peel, the higher the density. The density value that is close to the value of the commercial sample is a ratio of 75:25 with a density of 0.96 g/ml and 50:50 of 0.99 g/ml.

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p-ISSN 2655-8564, e-ISSN 2685-9432

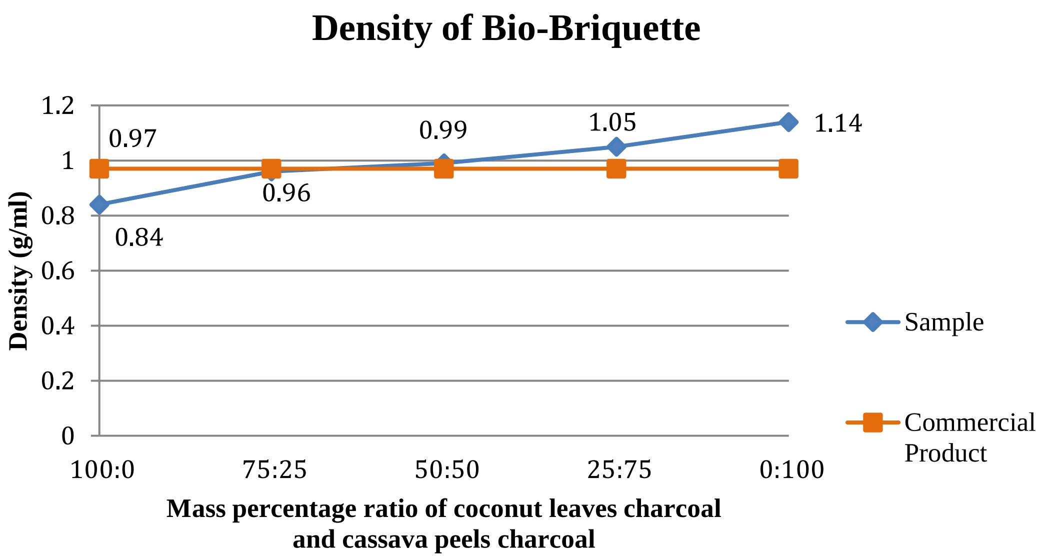

Figure 2. The effect of sample composition on density

The burning rate shows that the smaller the value, the longer the bio-briquette will burn. This is indicated by the commercial sample value as a reference of 0.136 g/min. Samples that are close to this value are in the composition of coconut leaves and cassava peels 75:25 with a burning rate of 0.190 g/min.

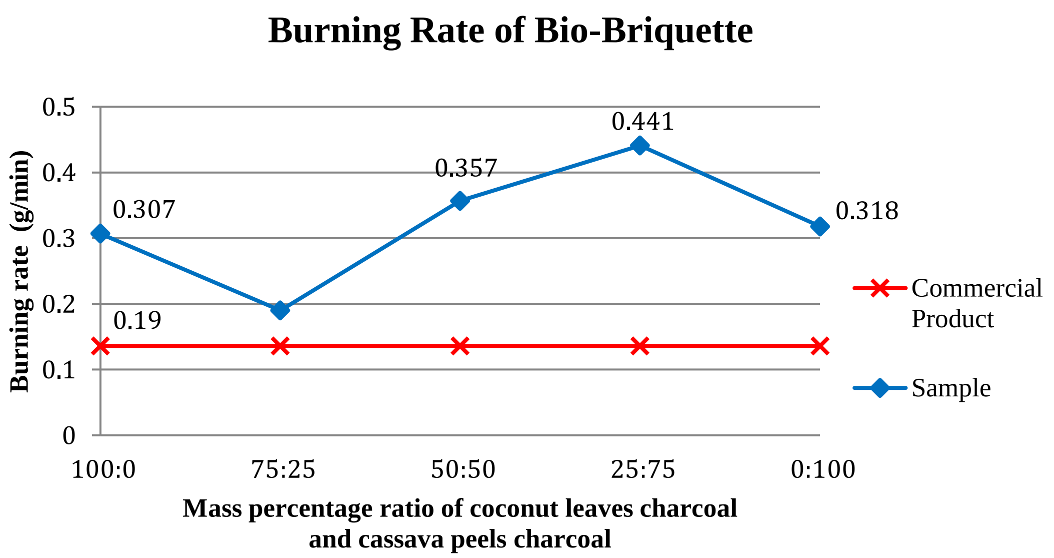

Figure 3. The effect of sample composition on burning rate

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The homogeneity and size distribution of the materials have an impact on the density of bio-briquettes. The density of a commercial bio-briquette has a value of 0.97 g/ml. If the density is greater than this value, it will require more raw materials for one piece of product [12]. The burning rate of a commercial bio-briquette has a value of 0.136 g/min. The higher the combustion rate, the faster the bio-briquette burn out. The lower the burning rate, the longer the bio-briquettes burn. Its impact on the increasing amount of heat generated.

So, for these two parameters, the sample with a mass percentage ratio of 75:25 gives the optimum analysis result. Further on Table 3, it shows bio-briquette samples properties compared with Indonesian national standards (SNI 01-6535-2000).

Table 3. Properties of bio-briquette made of coconut leaves and cassava peels compared to Indonesian national standards

Parameter	Indonesian national standard	Mass percentage ratio of coconut leaves charcoal and cassava peels charcoal				
		100:0	75:25	50:50	25:75	0:100
Water content (%)	8	11	3	3	3	3
Ash content (%)	8	18.01	18.81	18.32	19.35	17.02
Calorific value (Cal/g)	5000	3040.91	3521.47	3420.27	3199.28	3976.89

From Table 3, comparisons are made to the parameters water content, ash content, and calorific value. The results of the water content analysis show only samples with a ratio of 100:0 that do not meet the standards.

The ash content of the sample has a range of 17.03 to 18.81, where this value does not meet the standard. This can be caused by too much tapioca adhesive added in this study, which is around 40%. In several previous studies, the amount of tapioca that produced ash content values that met the standards was between 5 to 30% with an ash content range of 0.84% to around 6.42% [13]–[17].

Similar to the ash content, the calorific value of the bio-briquette sample did not meet the standard value. The optimum value obtained from the sample with a ratio of 0:100 is 3976.89 Cal/g. From several previous studies, bio-briquettes made from cassava peel charcoal have a fairly high calorific value, reaching 7669 Cal/g [16].

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The second highest calorific value was obtained from the sample with a ratio of 75:25 of 3521.47 Cal/g. The lower calorific value than the standard is due to the low amount of charcoal used in this research sample, which is around 60%.

Samples with a ratio of 0:100 have a high calorific value but have a weakness, namely a high burning rate compared to commercial samples. This can cause the bio-briquettes to burn out quickly.

Suggestions for further research are to experiment with the amount of adhesive between 5 – 30% so that a higher calorific value and lower ash content can be obtained. It is also hoped that the durability analysis of the sample will be carried out so that the results of the analysis are more comprehensive.

4 Conclusions

In this study, bio-briquette production was carried out using coconut leaves and cassava peel as raw materials, where the two materials are included in the category of agro-industry waste, which has the potential as waste-to-energy. This research was conducted to determine the characteristics of bio-briquettes from coconut leaves and their mixture with cassava peel. The optimum bio-briquette product from this research was found in variations of coconut leaves and cassava peels with a ratio of 75:25. The density is 0.96 g/ml, the burning rate is 0.190 g/min, the water content is 3%, the ash content is 18.81%, and the calorific value is 3521.47 Cal/g.

Acknowledgements

The author would like to thank LPPM Universitas Muhammadiyah Jakarta as the provider of research and publication of research papers funds with contract number 324/R-UMJ/VI/2022 dated June 24th, 2022. And thanks to the Chemical Engineering Department UMJ as a place for conducting research.

References

[1] J. D. Hunt, D. Stilpen, and M. A. V. de Freitas, A Review of the Causes, Impacts and Solutions for Electricity Supply Crisis in Brazil, (2022).

[2] O. Ellabban, H. Abu-Rub, and F. Blaabjerg, Renewable energy resources: Current status, future prospects and their enabling technology, Renew. Sustain. Energy Rev., 39 (2014) 748–764.

[3] D. Maradin, Advantages and Disadvantages of Renewable Energy Sources Utilization, Int. J. Energy Econ. Policy, 11(3) (2021) 176–183.

[4] International Energy Agency, Global Energy Review 2020 Renewables, (2020).

[5] K. E. Lorber and A. Ragoßnig, Solid recovered fuels 2.0 – ‘what’s new?’, Waste Manag. Res., 30 (4) (2012) 333– 334.

[6] P. K. Sadh, S. Duhan, and J. S. Duhan, Agro-industrial wastes and their utilization using solid state fermentation: a review, Bioresour. Bioprocess, 5 (1) (2018) 15.

[7] F. E. Hirniah, Analisis Energi dalam Pembuatan Briket Arang dari Kulit Singkong dengan Tepung Tapioka Sebagai Perekat, Jember, (2020).

[8] O.A. Oyelaran, O. Balogun, A.O. Ambali, and J. K. Abidoye, Characterization of Briquette Produced from Tannery Solid Waste, J. Mater. Eng. Struct., 4 (2017) 79–86.

[9] S. Anggraeni, S. N. Hofifah, A. B. D. Nandiyanto, And M. R. Bilad, Effects Of Particle Size And Composition Of Cassava Peels And Rice Husk On The Briquette Performance, J. Eng. Sci. Technol., 16 (1) (2021) 527–542.

[10] BSN, SNI 01-6235-2000 tentang Briket Arang Kayu. Badan Standar Nasional, Jakarta, (2000) 8.

[11] Leco, AC600 Isoperibol Calorimeter. Semi-Automatic Gross Calorific Content Analyzer, (2022). [Online]. Available: https://www.leco.com/product/ac600. [Accessed: 09-Sep-2022].

[12] D Nurba, M Yasar, Mustaqimah, R. Fadhil, S P Sari, and C V Mysa, Performance of Corncobs and Wood Charcoal Briquette as Heat Energy Sources in In-Store Dryer, IOP Conference Series: Earth and Environmental Science 365 (2019) 1–10.

[13] Ropiudin and K. Syska, Analisis Kualitas Biobriket Karbonisasi Tempurung Kelapa dan Kulit Singkong dengan Perekat Tepung Singkong, J. Agric. Biosyst. Eng. Res., 3 (1) (2022) 19–38.

[14] F. T. Aprilia, The Use of Sengon (Albizia Chinensis) Wood and Cassava Peel in Making Briquettes, Politeknik Negeri Jember, Jember, (2022).

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p-ISSN 2655-8564, e-ISSN 2685-9432

[15] J. T. Oladeji and O. R. Oyetunji, Investigations into Physical and Fuel Characteristics of Briquettes Produced from Cassava and Yam Peels, J. Energy Technol. Policy, 3 (7) (2013) 40–46.

[16] U. E. Terhider and O. E. Ediba, Investigation of The Combustion Characteristics of Briquettes Produced from Cassava Peels, Mango Nuts and Orange Peels, Int. Res. J. Mod. Eng. Technol. Sci., 3 (10) (2021) 736–742.

[17] L. Rumiyanti, A. Irnanda, and Y. Hendronursito, Analisis Proksimat pada Briket Arang Limbah Pertanian, J. Fis. dan Apl., 3 (1) (2018) 15–22.

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