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The Characteristic of Biobriquette from Shell Charcoal and Coconut Husk with Crude Palm Oil Liquid Waste as Adhesive

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ABSTRACT

The aims of this research were to determine the influence of crude palm oil liquid waste as an adhesive in the making of biobriquettes from coconut shell and husk charcoal and to determine the best treatment in the making of biobriquettes. This study used a completely randomized design. The treatments were the ratio of the liquid waste of crude palm oil, coconut shell, and husk charcoal, with a ratio of 10%: 90%; 20%: 80%; 30%: 70%; and 40%: 60%. The analyses carried out on the biobriquettes were moisture content, ash content, volatile matter, calorific value, and burning rate. The ratio of the liquid waste of crude palm oil, coconut shell, and husk charcoal had a significant effect on the biobriquettes. The analysis refers to the National Standard of Indonesia (SNI), and the best result was the ratio of 10%: 90% with moisture content 3.16%, ash content 15.66%, volatile matter 23.97%, calorific value 5,950 cal/gr, and burning rate 0.1744 gr/minute.

1. INTRODUCTION

Biobriquettes come from the remains of organic materials in solid form and are used as fuel. Biobriquettes have the advantage of being more economical because the processing can be done simply, the calorific value is high, and the raw materials are quite plentiful in Indonesia. Biobriquettes can be used as fuel for household cooking, electricity generation, heating, and for industrial cooking boilers to produce electricity from steam [1], [2]. Biobriquette processing can be done using simple technology. Compression of biobriquettes can be done with tools in the form of cylinders or boxes using adhesive. The amount and type of adhesive used in making biobriquettes can affect the quality of the biobriquettes produced [3].

The types of adhesives used in making biobriquettes are organic and inorganic. Examples of organic adhesives are starch, asphalt, tar, paraffin, starch, and molasses, while examples of inorganic adhesives are clay, cement, and sodium silicate [4]. Another type of adhesive that can be used as a binder in making biobriquettes is palm shell tar with optimal treatment, namely the use of 25% tar, which has a calorific value of 6607 kcal/kg [5].

Crude palm oil (CPO) waste can be used as an adhesive in the processing of biobriquettes from empty palm oil bunches [6]. The comparison of optimal CPO liquid waste with empty palm oil bunch charcoal is 30% to 70%, which produces a water content and calorific value in accordance with SNI standards. Palm oil mill liquid waste, also known as POME (palm oil mill effluent), comes from boiled condensate water (150–175 kg/ton FFB), clarified drab (sludge) water (350–450 kg/ton FFB), and hydrocyclone water (100–150 kg/ton FFB) [7]. POME has an organic content and contains carbohydrates, lipids, and proteins [8].

However, there has been no research regarding biobriquettes made from shell charcoal and coconut husk using CPO liquid waste adhesive. The aims of this research were to determine the influence of crude palm oil liquid waste as an adhesive in the making of biobriquettes from coconut shell and husk charcoal and to determine the best treatment in the making of biobriquettes.

2. METHODS

2.1 *Materials and Tools*

Coconut shells, coconut husks, and CPO liquid waste were used in this research. The instruments used in this study were: a carbonization container, stone mill, mixing container, digital scale, 60 mesh sieve, briquette mold, and biobriquette storage container.

2.2 *Research Design*

This study used a completely randomized design (CRD) with the addition of CPO liquid adhesive. There were 4 treatments and 5 repeats for each treatment. Comparative treatment of CPO liquid waste adhesive with coconut shells and husks, namely:

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P1 = 10% CPO liquid waste: 90% coconut shells and husks
P2 = 20% CPO liquid waste: 80% coconut shells and husks
P3 = 30% CPO liquid waste: 70% coconut shells and husks
P4 = 40% CPO liquid waste: 60% coconut shells and husks.

(a) (b) (c)

Fig. 1. Coconut husks (a), coconut shells (b), and CPO liquid waste (c).

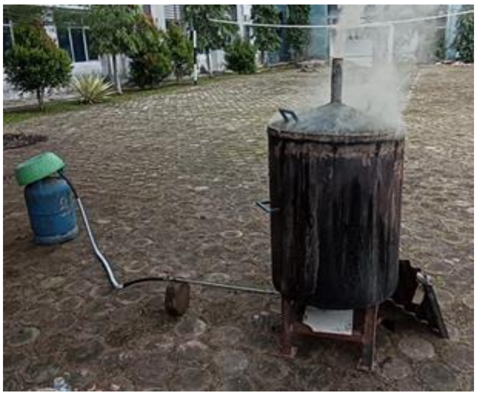

Fig. 2. Drum carbonation.

2.3 The Process of Making Biobriquettes

The coconut shells and husks were obtained from the coconut industry in Jambi city, and the ratio of raw materials used in this study was 50%: 50%. The CPO liquid waste was taken from the waste ponds in the palm oil factory [9]. Figure 1. a, b and c show coconut husks, coconut shells, and CPO liquid waste (sludge).

Raw material drying and carbonization

Drying is carried out under the sun. Before drying, raw materials are weighed first to determine the initial moisture content of the materials. Raw materials are then dried under the sun until the moisture content was 10–20%. This stage aims to reduce the material's moisture content, make the combustion process easier, and produce less smoke.

The carbonization process is carried out using a drum with a lid. This process is carried out for 4 hours; the coconut shells and husks are carbonized separately. Figure 2. shows the carbonation tool in the form of a drum.

Milling and sieving

Coconut shells and husks charcoal resulting from carbonization are ground into smaller pieces. The coconut shells and husk charcoal that have been ground are then sifted using a 60-mesh sieve.

Adhesive Mixing

The adhesive used is CPO liquid waste resulting from the processing of palm oil mills. Coconut shell and husk charcoal powder resulting from the grinding and sifting process are mixed with CPO liquid waste with an adhesive composition of: raw materials: 10%:90%, 20%:80%, 30%:70%, 40%:60%. Biobriquettes were formed in a rectangular mold with 4 cm in height, 3 cm in width, and 4 cm in length, then compacted with hydraulic pressure, and then let the mold stand for ± 5 minutes so that the adhesive and material were perfectly glued.

Drying of biobriquettes

Drying of the biobriquettes was carried out at temperature of 105^{o}C for 1 hour to reduce the water content contained in the biobriquettes, resulting in a higher calorific value and less cracking.

2.4 Biobriquette Quality Analysis

Moisture content

The method used for moisture content is American Society for Testing and Materials (ASTM) D.3137-11. The moisture content test was carried out by weighing the sample ± 1 gram and placing it in a cup. Then the cup is put into the furnace, which has been heated to 100°C for 1 hour. The cup is removed from the furnace and cooled in a desiccator. Then weigh the final mass. The procedure was repeated six times. The equation used to calculate the water content is:

$$M\ (\%) = \frac{(m2)-(m3)}{(m2)-(m1)}\ X\ 100\ \% \tag{1}$$

Information:
M = moisture content (%)
m1 = empty cup (g)
m2 = mass of the cup plus the mass of the sample (g) before heating
m3 = the mass of cup plus sample's mass after heating (g).

Ash content

The method used for ash content is ASTM D.3174-12. The ash content test is carried out by weighing (the sample ± 1 gram) and placing it in a cup. The cup is placed in a furnace at room temperature (±27°C) and then heated to a temperature of 800°C. This process takes ± 3 hours. The cup is removed from the furnace and cooled. Then weigh the final mass. The procedure was repeated twice. The equation used to calculate the ash content is:

$$AC\ (\%) = \frac{(m3)-(m1)}{(m2)-(m1)}\ X\ 100\ \% \tag{2}$$

Information:
AC = ash content (%)
m1 = mass of cup plus empty (g)
m2 = cup's mass plus the sample's mass before heating (g)
m3 = the cup's mass plus the sample's mass after heating (g).

Volatile matter

The method used for volatile matter is ASTM D.3175-11. The porcelain cup is first dried for 30 minutes at a temperature of 105 ºC and cooled in a desiccator for 15 minutes then the cup was weighed. The volatilization test was carried out by weighing 2 grams of sample and placing it in a cup. Then the cup containing the material was put into the furnace at (room temperature ± 27 ºC) and then heated to 900 ºC for 7 minutes. After that, the cup was removed from the furnace and cooled, and then the cup was weighed. Carry out the procedure to a constant weight using the equation below to calculate the volatile matter content.

$$VM\ (\%) = \frac{W1-W2}{W1}\ X\ 100\ \% \tag{3}$$

Information:
VM = volatile matter (%)
W1 = sample weight before heating (g)
W2 = sample weight after heating (g)

Calorific value

The method used for calorific value is ASTM D.5865-11a. Turn on the bomb calorimeter, water handling system, and cooler, then leave it until the jacket temperature reaches 30–35%. Fill the bucket with 2 L of distilled water, and then as much as ± 0.5000 grams of sample are weighed using a special cup. Place the cup in the hanger that has been installed with a wire (fuse wire) that connects the two poles of the bomb head. Ten centimeters of cotton burning thread should be attached to the wire connecting the bomb head's two poles. Turn the thread until the sample is touched by the tip. Turn it until it is closed and latched after inserting it into the bomb calorimeter. Once the bomb ID and bomb head code match, hit enter. Type the sample weight and press enter once more. Hit the star button, then press continue. Enter the code name or sample ID. The instrument will compute it and automatically analyze the sample. Wait until the analysis process is complete and the data comes out. After completion of the analysis, the bomb calorimeter is cleaned and dried.

The equation used to calculate the calorific value is:

$$\text{Calorific value} = \frac{(E * t) - e1 - e2 - e3}{M} \tag{4}$$

Information :
M = sample weight (gr)
E = energy equivalent value (Cal/C)
t = temperature rise (0 °C)
e1 = nitric acid correction
e2 = Conducting wire and burner thread corrections
e3 = sulphuric acid correction of sulphur assay

Burning rate

The biobriquette sample is weighed, and the biobriquette is burned. Time recording begins when the embers burn until the biobriquettes burn to ash [10]. The equation used to calculate the burning rate value is:

$$LP = \frac{A\ (gr)}{B\ (menit)} \tag{5}$$

Where: LP = burning rate (gram/second), A = Mass of briquettes before burning (gram), B = Burning time (minutes).

Data analysis

One-way analysis of variance (ANOVA) was used for the statistical analysis of the collected data. Duncan's New Multiple Range Test (DNMRT) at the 5% level should be performed if the computed F is larger than or equal to the F table at the 1% and 5% levels.

Determine the best treatment

Each parameter's value has a relative number of 0-1. The weight value depends on the importance of each parameter whose results are obtained as a result of the treatment. Water content is given a weight of 1; ash content is 0.9; volatile matter level (volatile matter) is 0.9; heating value is 0.9; and combustion rate is 0.9. After that, the analyzed parameters were grouped into 2 groups: group (A) consisted of parameters; the higher the average, the better, and group (B) consisted of parameters; the lower the average, the better.

Then find the parameter normal weight with the formula:Normal weight = weight value / total value weight.

Calculating the effectiveness value with the formula: effectiveness value = treatment value - worst value / best value-worst value.

For parameters with an average, the higher the better (A) is considered the best value, and the lowest value is considered the worst value. On the other hand, for parameters with a lower average, the better value (B) is considered the best value, and the highest value is considered the worst value. Then calculate the yield value of all parameters with the formula: yield value = effectiveness value x parameter normal weight. The combination with the highest value is declared the best treatment [11].

3. RESULT AND DISCUSSION

Moisture content

The analysis of variance showed that the use of CPO liquid waste as an adhesive in the manufacture of biobriquettes from coconut shells and husks significantly affected ($p \leq 0.05$) the average value of the resulting moisture content. The average value of biobriquette moisture content can be seen in Table 1.

The resulting moisture content ranges from 3.16% to 7.29%, where the highest moisture content is found in a ratio of 40% adhesive and 60% raw material with a value of 7.29% and the lowest is in a ratio of 10% adhesive and 90% raw material with a value of 3.16%. The high moisture content in biobriquettes is caused by the increasing concentration of adhesive. This is because the main content contained in CPO liquid waste is water, so when it is used as an adhesive for biobriquettes, it will affect the value of the water content of the biobriquettes. Biobriquettes with a high composition of CPO waste will increase the moisture content value [6].

Biobriquettes made from coconut husks and shells had a moisture content of 5.61% with tapioca adhesive [12]. A low moisture content produces a high calorific value, making it easier to ignite or burn initially. Conversely, a high percentage of moisture content will cause the calorific value of the resulting biobriquettes to decrease and also allow for the growth of fungi (microbes) [13]. The moisture content value produced in this study, compared with the biobriquette quality standard set by SNI 01-6235-2000, is still classified as meeting the standard because the maximum permissible moisture content requirement is 8%.

Table 1. Characteristic of biobriquettes with various treatments.

Sample	Parameters				
	Moisture Content (%)	Ash Content (%)	Volatile Matter (%)	Calorific Value (cal/gr)	Burning Rate (gr/min)
Coconut shell charcoal	4.42	11	4.3	6381.33	
Coconut husk charcoal	6.09	7.1	3.41	5421.08	
CPO liquid waste	56.33	9.6	67.98	2,303.36	
Comparison of Adhesives and Raw Materials					
10%: 90%	3.16 a	15.66 a	23.97 a	5,951 a	0.1744 a
20%: 80%	5.18 b	16.65 b	27.43 b	5,780 b	0.1691 a
30%: 70%	6.16 c	18.40 c	33.91 c	5,540 c	0.1427 ab
40%: 60%	7.29 d	19.25 d	37.44 d	5,491 c	0.1079 b

Note: The DNMRT test indicates that there is no significant difference at the 5% level between numbers that are preceded by the same lowercase letters (a, b, c, and d).

Ash Content

Analysis of variance shows that the use of CPO liquid waste as an adhesive in making biobriquettes from coconut shells and coconut husks has a significant effect ($p \leq 0.05$) on the average value of the ash content produced. The average ash content value of biobriquettes can be seen in Table 1. The ash content produced ranges from 15.66 to 19.25%, with the highest ash content found in the 40% adhesive treatment and 60% raw material, with a value of 19.25%, and the lowest in the treatment of 10% adhesive and 90% raw materials, with a value of 15.66%.

The increasing ash content is caused by the increasing adhesive concentration as well. This is due to the high water content and impurities in CPO liquid waste. Impurities in CPO liquid waste are minerals that cannot be burned or oxidized by oxygen, namely SiO2, Al2O3, Fe2O3, CaO, and alkali [4].

Ash content is related to the mineral content of a material; the higher the mineral content of a material, the higher the ash content of the material [14]. The ash content produced by CPO liquid waste is quite high, namely 14.10%. High ash content can also be caused by the high ash content contained in the raw material [15]. The ash content value produced in this study, compared with the Biobriquette Quality Standard set by SNI 01-6235-2000, still does not meet the standard because the maximum permitted ash content requirement is 8%.

Volatile matter content

The analysis of variance showed that the use of CPO liquid waste as an adhesive in the manufacture of biobriquettes from coconut shells and husks significantly affected ($p \leq 0.05$) the average value of volatile matter produced. The average value of volatile matter content in biobriquettes is shown in Table 1.

The levels of volatile substances produced ranged from 23.97 to 37.44%, where the highest levels of volatile substances were found in the treatment of 40% adhesive and 60% raw materials with a value of 37.44% and the lowest in the treatment of 10% adhesive and 90% raw materials with a value of 23.97%. The high levels of volatile matter present in this study were due to the high volatile matter content of the adhesive used. In the research on the thermal degradation of biomass wastes generated from palm oil milling plants, the volatile matter content of CPO liquid waste is quite high, namely 43.53%. This is because CPO liquid waste contains organics such as carbohydrates (29.55%), fat (10.21%), protein (12.75%), and a total content of 4-5% [16].

The raw material for charcoal derived from coconut husk contains a volatile matter of 22.11%, and the raw material for coconut shell charcoal is 23.09% [17]. The higher the amount of adhesive used, the higher the amount of volatile matter will also be [2], or, in other words, the higher the concentration of CPO liquid waste used, the higher the value of the volatile matter content in the resulting charcoal briquettes. The amount of volatile matter is affected by the amount of moisture and ash content; the higher the amount of moisture and ash content, the higher the amount of volatile matter [18], [19]. The value of the volatile matter content produced in this research is compared with the Biobriquette Quality Standards set by SNI 01-6235-2000, which still do not meet the standard because the maximum requirement for the volatile matter content that is allowed is 15%.

Calorific Value

The analysis of variance showed that the use of CPO wastewater as an adhesive in the manufacture of biobriquettes from coconut shells and husks had a significant effect ($p \leq 0.05$) on the average calorific value produced. The average value of the biobriquette calorific value is shown in Table 1. The calorific value produced ranged from 5.4910 to 5.9510 cal/gr, where the highest calorific value was found in the treatment of 10% adhesive and 90% raw material with a value of 5.9510 cal/gr and the lowest in the treatment of 40% adhesive and 60% raw materials with a value of 5.4910 cal/gr.

The low calorific value is caused by the higher concentration of adhesive used. The calorific value of CPO liquid waste is lower than the calorific value of coconut shells and coconut husks. The results of research [4] stated that the calorific value of CPO liquid waste was 2.303 cal/gr, and the results of research [20] stated that the calorific value of coconut shell was 6.862 cal/gr and the calorific value of coconut husks was 5.819 cal/gr.

The amount of ash and moisture content in the biobriquettes has an impact on their calorific value. The calorific value decreases with increasing water and ash content in the biobriquettes [21]. The calorific value produced in this study, when compared with the Biobriquette Quality Standards stipulated by SNI 01-6235-2000, is still classified as meeting the standard because the minimum requirement for the content of the allowed calorific value is 5000 kcal/gr.

Burning Rate

The analysis of variance showed that the use of CPO liquid waste as an adhesive in the manufacture of biobriquettes from coconut shells and husks significantly affected ($p \leq 0.05$) the average burning time produced. The average value of the biobriquette burning rate is shown in Table 1.

The resulting burning rate ranges between 0.1079 and 0.174 gr/minute, where the smallest burning rate is found in the ratio of 10% adhesive and 90% material, while the highest burning rate is found in the ratio of 40% adhesive and 60% material. The burning rate of biobriquettes is directly proportional to the percentage of adhesive used. This is in line with research results (22) which state that the higher the adhesive composition, the higher the moisture content of the briquettes. The consequences are increasing. A lot of water will be evaporated during the combustion process. This causes briquettes to lose a lot of mass in a short time, which results in the briquette having a high combustion speed and causes the briquette to burn out more quickly [23]. Figure 3. shows the burning of biobriquettes.

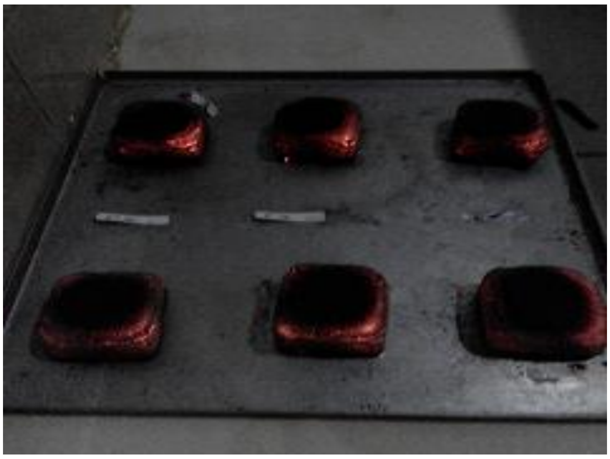

Fig 3. Biobriquettes burning.

Determination of the Best Treatment (Effectiveness Index)

The test value for the effectiveness of using CPO liquid waste as an adhesive in making biobriquettes from coconut shells and husks can be seen in Table 2.

Table 2. Test value for the effectiveness of using CPO liquid waste as an adhesive in the manufacture of biobriquettes from coconut husks and shells.

Comparison of Adhesives and Raw Materials	Yield Value
10%: 90%	1,000
20%: 80%	0.699
30%: 70%	0.281
40%: 60%	0.000

Note: The number that has the highest value is declared as the best treatment

Table 2 shows that the highest value based on the calculation of the effectiveness index is 10% Adhesive: 90% Raw Materials, with a value of 1,000. This is because the analysis results tend to be closer to SNI 01-6235-2000 compared to other treatments.

4. CONCLUSION

Making biobriquettes with CPO (crude palm oil) liquid waste adhesive made from coconut shell and husk significantly affects all the parameters analyzed, namely moisture content, ash content, volatile matter content, calorific value, and burning rate. In this study, the best treatment was obtained, namely the use of 10% adhesive: 90% raw material with a moisture content of 3.16%, an ash content of 15.66%, a volatile matter content of 23.97%, a calorific value of 5.9300 cal/gr, and a rate of burning of 0.1744 gr/minute. The biobriquettes produced from this research can be used as a source of energy generation in industry because they have quite high levels of ash and volatile matter. It is necessary to analyze parameters such as mass density, sharp index, and fixed carbon and apply other types of raw materials to get better results.

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