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Potential of Corn Stover And Coconut Shell as Environmentally Friendly Biomass Alternative Fuel

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Abstract: Energy sources from non-renewable materials such as petroleum are limited and will continue to decrease. Meanwhile, efforts to find renewable energy sources as reserves require quite expensive costs with a relatively long duration. Therefore, it is necessary to research renewable energy sources, such as corn stovers and coconut shells. This study is generally carried out by making charcoal or carbonization, briquetting, and testing the quality of briquettes. The variables used in this study are the composition of corn cob charcoal and coconut shells. The composition of the mixture used consists of 5 comparative variables, namely sample A = 1: 1, sample B = 1: 2, sample C = 1: 3, sample D = 2: 1, and sample E = 3: 1 with a drying temperature of 100 oC. This study aims to produce biobriquettes from variations in the ratio of good and quality corn cob and coconut shell so that they can be used as environmentally friendly alternative fuels. This study concludes that the optimal mixture variation to produce good quality biobriquettes is found in sample C with a water content of 2.20%, ash content of 3.22%, sulfur content of 0.07%, and a calorific value of 7339 cal/gram because it has a lower optimization compared to other samples and meets the specified standards.

Keywords: Biobriquettes; Calorific Value; Moisture Content.

Introduction

Energy sources from non-renewable materials such as petroleum are minimal and will continue to decrease. While the search for renewable energy sources as a reserve requires quite expensive costs and takes a relatively long time [1], [2]. So, it is necessary to utilize environmentally friendly alternative energy sources such as biogas and biobriquettes. One of the energies that can be developed today is biomass energy, or what is known as biobriquettes [3]. The development of biobriquettes is not without reason, considering that Indonesia, as an agricultural country, produces the most underutilized biomass, especially in the *Batang-Batang* area of Sumenep, Madura. *Batang-batang* Village is famous for its vast agricultural sector, including rice, peanuts, corn, and coconut. However, the livelihoods of most people come from corn and coconut. Corn and coconut cultivation are still popular and are the main economic activities in the *Batang-batang* area, thus affecting the livelihoods of farmers and changing the socio-economic situation. However, corn stover and coconut shell waste are still waste that has not been resolved, so recycling is needed.

Biobriquettes are carbon fuels made from organic waste or its derivatives and contain a certain amount of energy. Producing biobriquettes also does not require too much cost in its manufacture and can be developed in mass [4] [5]. Research on biobriquettes has been widely conducted with various types of organic and inorganic waste but with different characteristics. Each biobriquette has good characteristics and requires further research to ensure its success. In the study of Mangkau et al. [2011], the use of corn stovers was 75%, rice husks 25%, and the highest calorific value was obtained at 22343 kJ/kg or 5336.536 cal/gram and the highest fixed carbon at 46.34% [6]. The study of Hamidi et al. [7] stated that adding 15% corn stovers in the combustion of filter cake bio briquette fuel produced a calorific value of 2726.588 cal/gram [8]. In addition, there are many other studies with different variations and characteristics. The selection of corn cobs and coconut shells is thought to be able to replace wood fiber, which can affect the quality of water content and has heat stability of up to 195ºC [9]

The difference in this study is in the raw materials and variations of the comparison used, namely corn stovers and coconut shells. This will undoubtedly be tested for content, ash content, and calorific value, where one of the characteristics of a good bio briquette is that it has a high calorific value so that it can facilitate the combustion process [9]. Based on this, this study aims to modify the composition of corn stovers and coconut shells to produce good biobriquettes so that they can be used as environmentally friendly alternative fuels.

Research Methods

The materials used in the study were corn stovers, coconut shells, standard benzoic acid powder ($C_7H_6O_2$), distilled water, tapioca flour, nickelin burning wire, oxygen gas, purified water, methyl red solution indicator, 500 ppm K_2SO_4 stock solution, 0.0725N Na_2CO_3 solution, 2M HCl solution, $BaCl_2.2H_2O$ powder.

The tools used are an Ohous analytical balance with an accuracy of 0.01 grams, a 20-hole Klin drum, a panic furnace, a hot place, a desiccator, a crucible, a mortar/grinder, a pounder, 10 mm glass, a dropper, an ASTM Standard Test Sieve MBT 50 mesh (525 mm) sieve, a mattress/mold (diameter 3.2 cm, height 3 – 4 cm, and thickness 5.5 mm), a 100 psi hydraulic press, and other tools.

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Making Biobriquettes

Making bio briquettes includes preparing raw materials, carbonation, pounding, filtering, mixing, starch glue and moulding.

Carbonization or Charcoalization

The raw materials needed for the kiln process are cleaned biomass, namely corn stovers and coconut shells, then put into a kiln drum with holes at the top and bottom and burned alternately. Please wait for the raw material burning process until it is thoroughly cooked. Sprinkle water drop by drop to produce maximum charcoal. The charcoal process is carried out for 4 – 6 hours at a temperature of 300 – 500ºC [10]

Refining and Sifting

The charcoal is ground using a coffee grinder to make the treatment easier and faster. Then, it is ground and sieved using a 50 mesh sieve, little by little, until it becomes carbon powder.

Making Starch Glue

Mix tapioca flour with distilled water as needed to make starch glue. Then boil on a hot plate at a temperature of 250 –300°C for ± 15 minutes. During heating, the flour is continuously stirred until homogeneous to prevent the formation of lumps. The flour, which was initially white, changes color to slightly transparent. Then, the glue is cooled by airing it and left for a few minutes [11]

Mixing Carbon Powder with Starch Glue

Mix the carbon powder from the ground raw materials with starch glue, starting with 1:1, 1:2, 1:3, 2:1, and 3:1. Put in the carbon powder first, then add starch glue and stir until a relatively dry dough is formed. This is done alternately.

Printing and Pressing of Biobriquette Dough

This study used low-pressure bio briquettes with strong binders. The bio briquette mold was made with a diameter of 3.2 cm, a height of 3-4 cm, and a thickness of 5.5 mm. It was equipped with two handles, the upper and lower press tools. Two handles make it easy to remove the bio briquette from the mold. Then, a cloth was made and placed on the mold, and it was pressed using a hydraulic press tool with a pressure of 100 psi.

Drying of Biobriquettes

Biobriquettes are dried in an oven for approximately 6 hours with a drying temperature of ± 80 ºC – 120 ºC. The dried biobriquettes are packed in plastic clips and tightly closed so that the biobriquettes remain dry [12]

Biobriquette Characterization

1. Water content
   The lower the water content obtained, the better the quality produced with Indonesian National Standard (SNI) ≤ 8%.
2. Ash content
   Ash content The lower the ash content obtained, the better the quality obtained with Indonesian National Standard (SNI) ≤ 8%.
3. Determination of Calorific value
   The higher the calorific value obtained, the better the quality of the bio briquettes produced with an Indonesian National Standard (SNI) ≥ 500 cal/gram standard value.

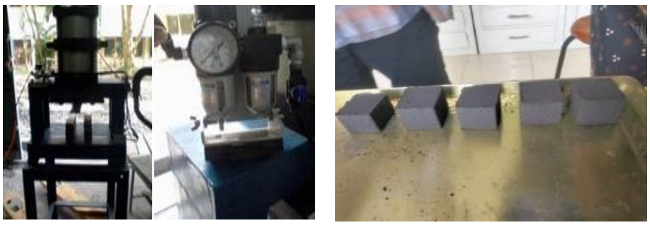
Data Analysis Techniques

The water content is calculated based on the sample weight data before and after ovening, and the ash content is calculated from the sample data before and after ashing. At the same time, the determination of the heat of combustion is measured using a Parr oxygen tube calorimeter. Determination of the heat of combustion with a Parr oxygen bomb calorimeter and determination of sulfur content with the turbidimeter method [12]. To determine the optimal composition for biobriquette production more clearly. Therefore, the data is summarized in a diagram for each biobriquette characteristic.

Result and Discussion

Printing, pressing, and drying

The biobriquette mixture is put into a mould and then pressed using a hydraulic press with a pressure of ± 100 Psi. In the research, it takes a long time to make the mould. The mould with a small thickness cannot withstand the pressure of the hydraulic press. In the briquetting process with medium pressure, 100 Psi is equivalent to 7 kg/cm^2. However, the briquetting process or press tool generally is more than 1000 Psi or equivalent to 100 kg/cm2 and above (Figures a and b). Biobriquette adhesive can affect the quality of the briquettes produced, both the type of adhesive used and the quantity [13], [14].



(a). Pressing (b) Printing

(c). drying

Figure 1. The process of moulding and pressing Biobriquettes until drying

Biobriquettes are dried in an oven for ± 6 hours. First, put in the oven for 2 hours at a temperature of 100ºC and the next day for 4 hours at 100ºC. Furthermore, the biobriquettes are left in a laboratory cabinet for ± 24 hours to produce perfect biobriquettes (Figure C) until a constant weight is obtained.

Theoretically, adding adhesive, in general, will increase the calorific value of the briquettes due to the addition of carbon elements in the adhesive. If the amount of adhesive is too little, the raw materials cannot be combined and do not have good density, making it difficult to use as fuel. Conversely, if the amount of adhesive is too much, the resulting briquettes will be too dense, so the flammability level is low. The differences in composition and physical properties of biomass waste used as raw materials for making briquettes will require different levels of adhesive [15].

Water content

The lower the water content, the better the quality of the biobriquette. Conversely, high water content makes the biobriquette difficult to ignite [16]. If the water content is high, the energy produced is largely absorbed to evaporate the water so that the calorific value will decrease. This study produced a relatively low water content value, which correlates with the calorific value. The lower the water content, the higher the calorific value and combustion absorption power, and vice versa. The higher the water content, the lower the calorific value and combustion power will be [8].

The following is the measurement data for the water content produced, which can be presented in the table below:

Table 1. Measurement of Water Content of Corn stover and Coconut Shell Combination

Sample code	Weight composition of charcoal		Water content (%)
	Corn Stovers	Coconut shell	Result
A	1	1	2.53
B	1	2	2.56
C	1	3	2.20
D	2	1	3.47
E	3	1	2.95

The results of this study obtained the results of water content in biobriquettes with variations in sample comparison, namely in sample A = 2.53%, sample B = 2.56%, sample C = 2.20%, sample D = 3.47% and in sample E obtained a result of 2.95%. The low water content value is in sample C = 2.20%, while the highest is in sample D = 3.47% with the same drying temperature of 100ºC for approximately 2 hours. From the lowest to the highest results obtained, both have met the SNI standard, namely ≤ 8%. This is because the water content test has a different composition or variation. However, the water content value decreases if the composition of the raw materials increases. High water content is caused by the number of pores still being quite large so that they can absorb water. High water content will cause a decrease in calorific value and combustion efficiency [17]

Ash Content

The higher the ash content, the lower the biobriquettes' quality. This study produced a low ash content, so the briquettes' quality was excellent. This affects adhesive composition because ash contains silica [18]. If the silica contained in the ash is high, then more ash will be produced. Of course, a suitable adhesive composition will affect the absorption of silica and make silica a little [19]

the ash content of biobriquettes with a comparison of raw materials between corn stovers and coconut shells with various variations and different weight factors of biobriquettes. The resulting ash content measurement data are presented in the following table:

Table 2. Measurement of Ash Content of Corn stover and Coconut Shell Combination

Sample code	Weight composition of charcoal		Ash content (%)
	Corn stovers	Coconut shell	Result
A	1	1	4.54
B	1	2	3.98
C	1	3	2.99
D	2	1	4.05
E	3	1	3.00

The table above shows that the results of the lowest ash content are in the comparison of sample C, which is 2.99%, while the results of the highest ash content are in the comparison of sample A, which is 4.54%. Both can be said to meet the SNI standard, which is ≤ 8%. This is never separated from the ashing temperature and the variation in the comparison of the raw materials mixed so that it will affect the ash content produced. The carbonization of biobriquette materials dramatically affects the ash content of the biobriquettes produced. High ash content is due to the imperfect carbonization of biobriquette materials [20]. The content of heat-absorbing components such as silica causes high ash content. High ash content will cause a decrease in calorific value and combustion efficiency.

Determination of Calorific Value

Calibration Curve

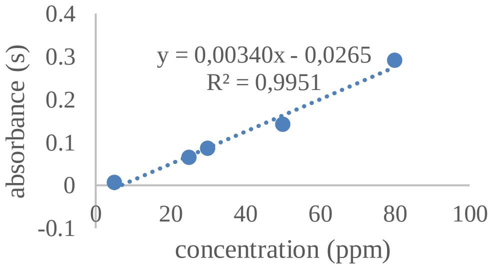


Figure 1. Calibration curve of $BaSO_4^{2-}$ solution turbidity

Calibration Curve of Turbidity of $BaSO_4$ Solution and Turbidity of Bomb Calorimeter Rinse Solution from Combustion of Briquette Samples.

Table 3. Turbidity Data for Each Biobriquette Sample

Concentration ion SO_4^{2-} (ppm)	Preaction $BaCl_2.2H_2O$ (mg)	Transmittance	Turbidans (S)
A	150	90.00	0.018
B	150	90.33	0.016
C	150	96.33	0.007
D	150	89.00	0.021
E	150	89.68	0.027
Benzoic acid	150	94.17	0.012

The determination of sulfate ion levels in bio briquettes is obtained from the combustion results, which are then determined based on the measurement of the calibration curve and multiplied by the dilution factor. The calibration curve is obtained from the equation y = 0.0034x – 0.0265. Then, the sulfur content value in sulfate ions is determined in percentage units through the formula

$$\text{Sulfur content} = \frac{\text{sulfur ion content (ppm)x 0.1x0.33}}{\text{sample (mg)}} \text{ x } 100\%$$

From this formula, the sulfur content of benzoic acid and each bio briquette sample can be obtained, which is presented in Table 4 below:

Table 4. Sulfur content of each Biobriquette sample

Code	Weight composition		Sulfate ion content (ppm)		
	Corn stovers	Coconut shell	y = 0.0034x – 0.0265	dilution 3x	Sulfur content (%)
A	1	1	13.08	39.26	0.12
B	1	2	12.50	37.50	0.24
C	1	3	7.80	23.40	0.07
D	2	1	13.97	41.91	0.13
E	3	1	15.73	47.20	0.15
Benzoic acid			9.89	49.45	0.16

Determination of sulfur content in bio briquettes needs to be done because sulfur compounds are in the form of gas that can be in the air. Combustion of briquettes will produce SOx gas emissions (SO_2 and SO_3). SOx emissions are formed from the sulfur content in briquettes through the oxidation process of the S element in briquettes as follows:

$S + O_2 \longrightarrow SO_2$ + heat .... (1)
$SO_2 + ½O_2 \longrightarrow SO_3$ + heat .... (2) [21]

The table above shows a low sulfur content, which indicates that the bio briquette results are very good for use as a basic material for environmentally friendly energy.

Calorific Value

Calorific value is one of the parameters determining the quality of bio briquettes. If the calorific value is higher, the quality of the bio briquette will be better so that the bio briquette is suitable for use as an environmentally friendly alternative fuel [22]. The water and ash content will influence the calorific value of the biobriquette. If the water and ash content are lower, the calorific value of the biobriquette will be higher. Conversely, if the water and ash content are higher, the calorific value of the biobriquette will be lower [23]. The results of this study obtained the calorific value results with variations in the comparison of raw materials from corn stovers and coconut shells can be seen in the following graph:

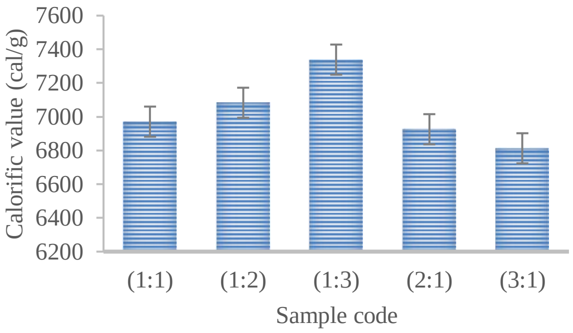


Figure 3. Comparative Calorific Value Diagram of Biobriquettes (Corn stover: Coconut shell).

Based on the diagram above, the results of the calorific value obtained are above the minimum Indonesian Nasional Standart (SNI) quality value of 5000 Cal/gram. Of course, the factor that significantly influences calorific value in biobriquettes is the type of raw material selected [24]. Raw materials with low water and ash content will be directly proportional to the calorific value obtained [25]. If the calorific value obtained is very low, it will inhibit heat production in biobriquettes [26]. The higher the calorific value produced by the briquette fuel, the better its quality [27].

The most widely used adhesive is starch adhesive [28]. Mixing the adhesive is so that the supercarbon does not break easily when burned. Adding starch adhesive at a specific concentration for making bio briquettes will increase the calorific value of bio briquettes compared to bio briquettes without adhesive. Previous research stated that the adhesive should not be too high, in addition to causing cracks, and can also reduce the quality of bio briquettes, often producing a lot of smoke when burned [29]. According to research by Sudrajat, the type of adhesive used in making briquettes affects the density, water content, ash content, and calorific value of combustion. Indriyanti's research also produced the same result, that a ratio of 1:3 between rice husks and coconut shells had a high calorific value, reaching 6021.65 cal/g [30].

Conclusion

Based on the results of the research conducted above, it can be concluded that sample C's test results have the best value among other sample codes, with a water content of 2.20%, ash content of 2.99%, sulfur content of 0.07%, and calorific value of 7339 Cal/gram, with a ratio of 1 : 3 to the variation of the comparison of corn stover and coconut shell bio briquettes, all of which meet the Indonesian National Standard (SNI).

Author's Contributions

Ratno Budiyanto: as a researcher and data compiler; Titin Setiawati: as research data analysis; Abd. Rahem: as a manuscript reviewer and manuscript writing correction

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