Interdisciplinary School of Management and Technology
Institut Teknologi Sepuluh Nopember

JURNAL TEKNOBISNIS
20xx Vol. 0(0), pp-pp

Received 1 Jan, 2023; Revised 1 Feb, 2023; Accepted 1 Apr, 2023 | DOI: xxxx

The Effect of Variations on Raw Materials and Biobriquette Forms of Candlenut Shells (Aleurites moluccana) and Corn Cobs (Zea mays) on the Quality of Bio briquettes

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ABSTRACT

Biobriquettes are a fuel that is in solid form and comes from the remains of organic matter that undergoes a compression process with a certain compressive power. Bio briquettes can be used as an alternative fuel in everyday life. Besides being cheap and easy to obtain, using bio briquettes as fuel can help reduce the negative impact of environmental pollution. Factors that affect the quality of bio briquettes are raw materials, the final form of bio briquettes, the type of adhesive and carbonization temperature. In this research, the variations used were the raw materials and the final form of bio briquettes. The raw materials used were candlenut shells and corn cobs, while the final forms of bi briquettes used were cylinders, hollow cylinders and rectangles. Not only raw materials but also adhesive materials affected the quality of the bio briquettes produced. The adhesive used was tapioca flour (5% w/w). The combustion method used was the conventional method using a drum-kiln with a burning time of 3 hours for candlenut shells and 1 hour for corn cobs. The stages in the manufacture of bio briquettes included preparation, composting, mixing with adhesives as well as molding and drying. The resulting bio briquettes were then tested using proximate analysis. In this research, data processing was performed using R software. The results of the study showed that the variation of raw materials and the final form of bio briquettes influenced the quality of the bio briquettes produced in which candlenut shell had better quality with low ash content and volatile matter (3.01% and 5, 2433%, respectively) and high fixed carbon content (89.7433 %). In terms of the variations in the form used, hollow cylindrical bio briquettes were better than other variations because the presence of air cavities could facilitate the combustion process.

Keywords : Bio briquettes; candlenut shell, conventional, proximate, corn cobs

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1. INTRODUCTION

Candlenut shells and corn cobs are agricultural wastes that are quite large in Indonesia, especially in East Nusa Tenggara (NTT), Sumatra, and Sulawesi. According to Central Statistics Agency of Indonesia, candlenut production increased by 2.91% from 2017 to 2019 (Central Bureau of Statistics, 2019), and according to the North Sumatra Plantation Service, corn production increased by 8.95% from 2014 to 2018 (North Sumatra Plantation Service, 2018).

The increase in the production of candlenut shells and corn cobs is of course proportional to the waste generated. If the waste cannot be utilized, it will result in waste buildup and it will damage the aesthetic value of the environment. One alternative to treat this waste is to use it as an alternative fuel by converting it into bio-briquettes. Bio briquettes are solid fuels derived from organic materials that have been compressed with a certain compressive power. Biobriquettes can function as an alternative use of firewood where consumption has increased and can damage the forest ecology (Supriyadi, 2015).

Bio briquette has the advantage that it has a high economic value. Compared to wood charcoal, bio briquettes have relatively high heat, do not produce odors, and are non-toxic. In addition, cook utensils are kept clean because burning this fuel does not produce smoke or soot (Tarigan, 2018).

2. LITERATURE REVIEW

2.1 Preparation Stage

Candlenut shells and corn cobs were obtained from Nainggolan Village, Nainggolan District, Samosir Regency, North Sumatra Province. At the preparatory stage, the candlenut shells and corn cobs were cleaned of impurities using water and then dried in the sun for 1 day to reduce the water content by $\pm$ 15 %.

2.1.1 Charcoal Making

The dried hazelnut shells and corn cobs were roasted in drum kilns respectively. This burning process lasted for 3 hours for candlenut shells and 1 hour for corn cobs. Next, the charcoal was crushed and filtered to obtain pecan shell charcoal and corn cobs with a size of 60 meshes.

2.1.2 Adhesive Mixing process

The adhesive used in this study was tapioca flour. Candlenut shell charcoal and corn cobs that have gone through the cooking stage were then weighed as much as 300 grams and mixed with 5% w/w (sample ratio: adhesive) and sufficient water and then stirred until evenly distributed and ready to be molded into bio briquettes.

2.1.3 Molding and drying Stage

The charcoal that has been mixed with the adhesive was then molded and pressed into the mold according to the shape that has become a variation. The purpose of this stage was to obtain bio briquettes with raw materials and varied forms, the bio briquettes are dried under direct sunlight for 3-4 days. This was done so that the water content of the bio briquettes produced is by SNI 01-6235-2000.

2.2 Analysis Stage

Charcoal that had been molded was then tested for quality using proximate analysis. This test was conducted at the Mineral and Coal Analysis Laboratory, Faculty of Mining and Petroleum Engineering, Bandung Institute of Technology. The analysis was carried out in accordance with SNI 01-6235-2000.

2.2.1 Moisture Content

The moisture content of the bio briquettes was determined by weighing the porcelain cup, and then 2 grams of each sample was placed on the porcelain cup. The sample was put into the oven. The sample was heated at a temperature of 105^{o}C for 1 hour and put in a desiccator for 30 minutes and then the sample was weighed until a constant weight is obtained.

The formula to determine the water content is as follows:

$$\text{The water content (\%)} = \frac{M_1 - M_2}{M_1}\, x\ 100\ \%$$

M1 = Mass of the initial sample (gr)

M2 = Mass of the sample is constant after being in the oven (gr)

2.2.2 Ash Content

Determining the ash content in bio briquettes was performed using a porcelain cup. The porcelain cup was cleaned and then placed in an oven at a temperature of 105^{o}C for 1 hour, then put in a desiccator for 15 minutes and weighed until a constant weight was obtained. A total of 2 grams of each of the existing variations were put into a cup and heated at a temperature of 850^{O}C for 4 hours, then put in a desiccator for 30 minutes and then weighed.

The formula to determine the ash content is as follows.

$$\text{Ash Content }(\%) = \frac{C - A}{B} x\ 100\ \%$$

A = Weight of empty cup (gr)

B = Weight of sample before oven (gr)

C = Weight of ash and weight of cup after oven (gr)

2.2.3 Levels of Evaporative Substances

The porcelain dish was placed in an oven at a temperature of 1050C for 1 hour. Then the sample was cooled in a desiccator for 30 minutes and then weighed. A total of 2 grams of the sample was added to a porcelain dish, then heated using an oven at a temperature of 950^{o}C for 7 minutes and then in a desiccator for 30 minutes and then weighed.

The formula for determining volatile substances is as follows.

$$\text{Levels of Evaporative Substances}(\%) = \frac{Z_1 - Z_2}{Z_1} x\ 100$$

Z_1 = Mass of the initial sample (gr)

Z_2 = Mass of a sample after heating (gr)

2.2.4 Calorific Value

The calorimeter circuit was prepared and then 2 grams of the sample was put into an iron cup in the calorimeter circuit. Next, as much as 2 mL of water was inserted into the calorimeter vessel. The bomb calorimeter circuit was inserted into a hermetically sealed vessel. The bomb calorimeter was filled with 250 mL of water and put into the calorimeter and the engine was started. The initial temperature was recorded. After 5 minutes, the button was pressed for 7 minutes to get the final temperature, and then the engine was turned off.

The formula to determine the calorific value is as follows:

$$\text{HHV}\left(\frac{cal}{gr}\right) = \frac{(TA - TM)x\ 2458}{weight}$$

TA:Final temperature of bomb calorimeter calculation

TM: Initial temperature before the bomb calorimeter is ignited

2458: Coefficient of bomb calorimeter

2.2.5 Fixed Carbon

Fixed carbon content was the carbon fraction found in materials other than water, ash, and volatile matter.

The fixed carbon value in bio briquettes was calculated using the equation below (Saputro et al., 2012).

$$Fixed\ Carbon\ (\%) = 100\% - water\ content - volatile\ matter - ash\ content$$

3. RESULTS

3.1 Moisture Test

In this test, the moisture of 6 biobriquette samples was measured. The results of the test are shown in Table 3.1.

Table 3.1 Moisture Content Test Results

Raw Material	Shape	Moisture Content (%)
Candlenut shells	Cylinder	3,9233
	Hollow cylinder	2,0033
	Rectangular	4,9867
Corn Cobs	Cylinder	3,0233
	Hollow cylinder	1,0033
	Rectangular	3,8933

Based on the test results, the lowest moisture content in corn cob bio briquettes with holes was 1.0033 %. This can happen because the water content of bio briquettes is influenced by the type of raw material. The drier the raw materials used, the lower the water content and vice versa (Chitedze, 2012). The water content contained in corn cobs is 1.7% on a dry basis (Kaliyan, 2010) while in candlenut shells it is 12.05% on a dry basis (Sinaga, 2016).

When compared with the provisions of SNI for wood charcoal briquettes, this moisture content has met the standard of SNI 01-6235-2000, which is < 8. Based on comparison of water content possessed by each variety of bio briquettes, perforated cylindrical corn cobs bio briquettes have lower water content than other bio briquettes. . The low water content in a bio briquette will cause the bio briquette to burn quickly because the existing heat will be used to evaporate the water first and then followed by burning the bio briquette (Rahmadani et al., 2017).

3.2 Ash Content Test

In this test, the ash content of 6 biobriquette samples was measured. The results of the test are shown in Table 3.2.

Table 3.2 Ash Content Test Results

Raw Material	**Shape**	Ash Content **(%)**
Candlenut shells	Cylinder	3,4
	Hollow cylinder	3,01
	Rectangular	4,1867
Corn Cobs	Cylinder	7,0167
	Hollow cylinder	4,1933
	Rectangular	7,0567

High ash content can reduce the quality of bio briquettes because the calorific value of bio briquettes will be of low value (Mokodompit, 2011). Based on the test results, the lowest ash content in perforated cylindrical candlenut shell bio briquettes was 3.01%. This is because at high temperatures, the ash will evaporate and there will be less ash left in the charcoal whereas, in the research conducted, the temperature of the candlenut shell was higher than that of corn cobs (Mokodompit, 2011). When compared with the provisions of SNI for wood charcoal briquettes, this ash content has met the standard of SNI 01-6235-2000, which is < 8.

3.3 Evaporative Substance Test

In this test, the evaporative substance rate of 6 biobriquette samples was measured. The results of the test are shown in Table 3.3.

Table 3.3 Test Results for Evaporative Substances

Raw Material	Shape	Evaporative Substances (%)
Candlenut shells	Cylinder	6,9333
	Hollow cylinder	5,2433
	Rectangular	7,8033
Corn Cobs	Cylinder	9,03
	Hollow cylinder	8,8633
	Rectangular	9,9133

The content of highly volatile substances in a bio briquette will produce more smoke due to the reaction between CO and alcohol derivatives such as methanol, ethanol, ethylene glycol, and glycerol (Hendra and Pari, 2000). A lot of smoke is not good for health and the environment because it can interfere with the respiratory system (Miskah et al., 2014).

Based on the test results, the lowest volatile substance content was obtained in the hollow cylinder candlenut shell bio briquette (5.2433 %). This is because the low fiber content of raw materials will produce low volatile substances as well. The fiber content of candlenut shells is 2.7 grams per 100 grams, while the fiber content in corn cobs is 90 grams per 100 grams (Anita, 2009). When compared with the provisions of SNI, the content of this volatile substance has met the standard of SNI 01-6235-2000, which is <15% and is suitable for use.

3.4 Calorific Value Test

In this test, the calorific value of 6 samples of bio briquettes was measured. The results of the test are shown in Table 3.4

Table 3.4 Calorific Value Test Results

Raw Material	Shape	Calorific Value (cal/gr)
Candlenut shells	Cylinder	5978
	Hollow cylinder	7149,2
	Rectangular	6100
Corn Cobs	Cylinder	7466,4
	Hollow cylinder	8540
	Rectangular	6124,4

Based on the test results, the highest calorific value of corn cob bio briquettes with holes is 8540 cal/gr. This can happen because the water content in corn cobs is lower than the water content in candlenut shells, where the lower the water content of raw material, the higher the calorific value of the bio briquettes produced (Rahmadani, 2017).

The low water content will increase combustion efficiency because the heat of combustion is used first to evaporate the water (Borowski and Jan 2013). When compared with the provisions of SNI for wood charcoal briquettes, this calorific value has met the SNI standard 01-6235-2000, namely > 5000.

3.5 Fixed Carbon Value Test

In this test, the fixed carbon value of 6 samples of bio briquettes was measured. The results of the test are shown in Table 3.5

Table 3.5 Test results for fixed carbon.

Raw Material	Shape	Test results for fixed carbon (%)
Candlenut shells	Cylinder	85,7433
	Hollow cylinder	89,7433
	Rectangular	83,0233
Corn Cobs	Cylinder	80,93
	Hollow cylinder	85,94
	Rectangular	79,1367

Fixed carbon is influenced by water content and volatile matter content (Sudiyani et al., 2019). Based on the test results, the highest fixed carbon content was obtained in perforated cylindrical candlenut shell bio briquettes at 89.7433 %. This is because the high fixed carbon content is influenced by the low water content and volatile matter content of bio briquettes (Sudiyani et al, 2019).

Based on the test results, the moisture content and volatile matter content of hollow cylinder candlenut shell bio briquettes are of low value compared to other variations. When compared with the provisions of SNI for wood charcoal briquettes, this fixed carbon content has met the standard of SNI 01-6235-2000, which is > 77%.

4. CONCLUSIONS

The conclusions of this study are:

- Bio briquette of Candlenut shell has a better quality than that of corn cob, with low ash content and volatile matter rate (3.01% and 5.2433 %) and high fixed carbon (89.7433 %).
- Hollow cylinder bio briquettes have better quality than other forms because they have larger cavities so that combustion can occur easily.
- Biobriquettes produced are in accordance with SNI 01-6235-2000.

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