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Utilization of Livestock Waste (Cow Manure) and Household Waste (Waste Cooking Oil) as Briquettes to Substitute Alternative Fuels

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ABSTRACT

As the global population continues to grow, there is a corresponding increase in energy consumption annually. The need for alternative energy sources is evident in light of the finite reserves of oil. Briquettes are a renewable energy option that can help decrease reliance on oil. Briquettes can be produced through the utilization of organic waste materials. This research was carried out from 19 September to 18 October 2023, at the Faculty of Agriculture, University of Palangka Raya, and the Analytical Laboratory, Muhammadiyah University, Palangka Raya. The aim of this research is to determine the quality of briquettes made using cow dung charcoal and cooking oil as an adhesive. The parameters of this research are water content, ash content, burn rate, and colorific value. This research used a Completely Randomized Design (CRD) model with 4 treatments and each treatment was repeated 5 times so that there were 20 experimental units. The composition of the briquettes consists of (P1) = 90% cow dung and 10% used cooking oil, (P2): 87.5% cow dung and 12.5% used cooking oil, (P3): 85% cow dung and 15% used cooking oil and (P4): 82.5% cow dung and 17.5% used cooking oil. The results of variance analysis showed that the parameters of water content, ash content, burn rate, and colorific value did not show a significant influence between treatments (P>0.05) although there was a trend that P1 and P3 were better than the other treatments. It was concluded that the best quality of briquettes in terms of water content and ash content was in the P1 treatment (Briquettes with a composition of 90% cow dung and 10% used cooking oil), whereas if viewed from the burning rate and calorific value of the best briquettes, it was the P3 treatment (Briquettes with a composition of 85 % cow dung and 15% used cooking oil).

Key words: energy; briquettes; cow dung; used cooking oil

INTRODUCTION

Indonesia is rich in natural resources. The natural resources we possess make us the biggest energy generator globally. The abundant natural resources possess a significant amount of energy, although it will deplete gradually in the long run. Even though petroleum is a non-renewable energy source, it continues to be the primary choice for fuel in daily life, leading to the depletion of petroleum reserves in Indonesia. Energy has become a critical concern in recent years, largely due to the growing population and the diminishing reserves of the earth's energy (Nugraha, 2020). If it continues to be consumed without new oil reserves being discovered, it is estimated that Indonesia's oil reserves will run out. Furthermore, the utilization of petroleum and natural gas as sources of energy has the potential to contribute to environmental contamination (Patil et al., 2021). In such a situation, the public and academics should look for new, renewable energy sources. One example of renewable energy is the use of briquettes from various material sources (Yanti et al., 2022).

Briquettes are an effort to replace appropriate fuel as alternative fuel source to reduce the use of kerosene which can be used for daily needs. Briquettes are a solid fuel formed from mixing organic waste with adhesives and other substances so that they are useful in burning (Sugiharto and Firdaus, 2021). There are various types of briquettes and one of them is bioarang briquettes. Bioarang briquettes are lumps or sticks of charcoal made from bioarang (soft material) which comes from biological material or biomass (Lestari, 2023).

Utilizing livestock waste as a component of alternative fuels is considered to be a highly efficacious method for mitigating the environmental harm resulting from untreated waste. A lot of livestock manure is thrown away in random places or left to pile up by breeders, which can cause environmental pollution (Nahas et al., 2019). Each type of livestock is capable of producing varying amounts of waste depending on the type, number, and size of the livestock. On average, cattle generate feces that amount to approximately 5.5% of their live body weight per day (Guntoro et al., 2016). The content of livestock manure varies depending on the amount of feed consumed. Livestock manure contains CH_4, CO_2, N_2, and CO so it provides the opportunity to be used as fuel such as briquettes. Briquettes must meet specified standards so that they can be used according to their needs. The quality of briquettes can be seen from the ingredients that form them, burning time, size, particle distribution, and hardness of the material (Berek, 2019). In addition, high-quality briquettes should also be convenient to manage and store (Patil et al., 2021). The objective of this study is to evaluate the effectiveness of utilizing cow dung charcoal and household waste, specifically waste cooking oil, as adhesive in the production of briquettes. The study seeks to assess the overall quality of the briquettes produced through this process.

RESEARCH METHODS

Location and Time of Research

This research was carried out from 19 September to 18 October 2023, at the Faculty of Agriculture, University of Palangka Raya, and the Analytical Laboratory, Muhammadiyah University, Palangka Raya.

Tools and Materials

The tools used in this research are kiln drums, cauldrons, stirrers, furnaces or stoves, firewood, mortars or wood crushers for making briquettes, sieves, buckets, briquette presses, plastic trays, plastic cups, porcelain cups, aluminum cups, oven, furnace, desiccator, pans, spoons, pens, books, matches, triplex, and weights. The materials used are cow dung charcoal and used waste cooking oil.

Research Methods

The research method used in this research was a Completely Randomized Design (CRD) with 4 treatments and each treatment was repeated 5 times. The composition of the briquettes has the same density, namely 100 grams. The treatments tested consisted of:

P1: 90% cow dung charcoal and 10% waste cooking oil
P2: 87.5% cow dung charcoal and 12.5% waste cooking oil
P3: 85% cow dung charcoal and 15% waste cooking oil
P4: 82.5% cow dung charcoal and 17.5% waste cooking oil

Procedure for Making Cow Dung Charcoal

Making charcoal from cow dung starts with cleaning the cow dung from other impurities and then putting it into the kiln drum (burning place) separately, then burning it with the help of a flame from the bottom of the tube until all the dung is burned into charcoal. After all the ingredients have burned to charcoal, the fire at the bottom of the tube is extinguished, and then the smoke hole is closed until the fire is completely extinguished.

Procedure for Making Briquettes

The procedure for making these briquettes is:

1) The results of the burning are ground into charcoal powder
2) The results of the collision are then sieved (40 mesh) to obtain a uniform size.
3) Measure the amount of cow dung charcoal powder and waste cooking oil.
4) Combine the cow dung charcoal powder with the waste cooking oil adhesive, ensuring that the mixture is thoroughly blended.
5) Produce the briquettes by filling a custom-made cylindrical molding tool with the mixture to create briquettes that are 5 cm in height and 6 cm in diameter. The molding tool has been designed by the researcher.
6) Remove the briquette mold and proceed to measure its weight to determine the initial weight of the briquettes prior to the commencement of the drying process.
7) Record data on briquettes.
8) Briquettes undergo a drying process for 4-5 days.

Data Collection Procedures

Following the production of the briquettes, the moisture content of the specimen is determined through the use of the oven method. This process involves weighing the material with a 5 g analytical scale in an aluminum cup, the dry weight of which has been previously measured. The specimen was subsequently subjected to a drying process in an oven maintained at 105°C for 120 minutes, to achieve a constant weight. Subsequently, the material underwent a cooling process in a desiccator for 60 minutes before being weighed once more. The water content will be determined four times. The test involved measuring the ash content by taking 5 grams of the sample and placing it in a porcelain cup. Next, the substance is heated in a kiln at 550°C for 120 minutes until it turns to ash. Following this, it is cooled in a desiccator and then promptly weighed once it reaches room temperature. The ash content was determined four times. The following step involves determining the burning rate of the briquettes, which is obtained by dividing the weight of the ignited briquettes by the time it takes for them to burn out or turn into ash. When determining the calorific value in the final stage of calculation, the procedure is as follows:

a. The briquette sample is crushed weighed and then placed into a burning cup positioned just below the curve of the wick wire, with both ends of the wire connected to the two electrodes.
b. The circuit is then inserted into a bomb that has previously been filled with 1 ml of distilled water, then closed tightly and supplied with oxygen gas through a valve of approximately 35 atm. The bomb is inserted into the calorimeter which has been filled with 2 liters of water, and connected to the burner unit.
c. Close the calorimeter and place the thermometer on the calorimeter lid so that the scale at the bottom reads 19°C. Then, turn on the constant temperature electric stirrer and let it run for 5 minutes before switching on the 23-volt current source to ignite the wick wire. At this time the temperature is observed, the temperature will rise quickly, after that it will be constant and finally it will fall slightly, then the burner and stirrer voltage sources are turned off.

Research Variables

The variables measured in this research are:

Water content

Water content calculation formula:

$$\% \text{ water content} = \frac{b-c}{b-a} \times 100\%$$

Information :
a = weight of empty cup (g)
b = weight of cup + briquette sample (g)
c = weight of the cup + briquette sample after being oven-dried until the weight is constant (g)

Ash content

Ash content is calculating using the formula:

$$\text{Ash content } \% = \frac{ash\ weight}{sample\ weight} x 100\ \%$$

Briquette burning rate

The briquette burning rate is calculating using the formula:

$$\text{Briquette burning rate} = \frac{\left(\begin{matrix}\text{briquette}\\ \text{weight}\end{matrix}\right)}{\begin{matrix}\text{time until the briquettes}\\ \text{are finished (minutes)}\end{matrix}}$$

Calorific value

Calor is a quantity or amount of heat that is either absorbed or released by an object. The calorific value is obtained from briquettes using laboratory data. The formula for calculating calorific value is as follows:

$$\mathbf{Q = m.c.\Delta T}$$

Information :
Q = Hot to raise the temperature
m = Fuel mass
c = Specific hot
ΔT = Temperature difference

Data Analysis

The information collected was analyzed using variance based on a Completely Randomized Design (CRD), and additional examinations were conducted using Duncan's Multiple Range Test (Steel and Torrie, 1991). The mathematical model is $Yij = \mu + \tau i + €ij$

Information :
Yij = Observation value with the jth replication
μ = General average (middle value of observations)
τi = Effect of treatment i (i = 1, 2, 3, 4, 5, 6)
€ij = Experimental error from the-i treatment on the-j observation (j = 1, 2, 3, 4)

RESULTS AND DISCUSSION

Water Content

Testing for water content was conducted to establish the amount of water present in livestock manure briquettes and the adhesive made from waste cooking oil. Tabel 1 illustrates that the briquettes with the highest water content are made from 82.5% cow dung and 17.5% waste cooking oil (P4), at 7.11%. Subsequently by briquettes made from 85% cow dung and used cooking oil (P3) at 6.83%, and the lowest water content is in briquettes made from 90% cow dung and 10% used cooking oil (P1) at 6.56%. The moisture level found in the briquettes generated in this study conforms to the Indonesian National Standard (SNI), specifically being less than 8%. The briquettes will be hard to ignite and will create a large amount of smoke due to their high water content during combustion. In addition to that, it will lower the ignition temperature and combustion strength (Sunnu et al., 2023).

Table1. Average moisture content

Group	Water Content (%)	Value
P1	6.56	>0.05
P2	6.77	>0.05
P3	6.83	>0.05
P4	7.11	>0.05

Information:
P1: 90% cow dung charcoal and 10% used cooking oil
P2: 87.5% cow dung charcoal and 12.5% used cooking oil
P3: 85% cow dung charcoal and 15% used cooking oil
P4: 82.5% cow dung charcoal and 17.5% used cooking oil

The statistical tests indicate that varying the adhesive concentration does not notably impact the percentage of water content produced. The increase in the number of pores in the briquettes led to a higher water content. Water content greatly influences the quality of the briquettes produced lower the water content, the higher the calorific value and combustion resistance (Athaillah et al., 2024). The more efficient the briquettes are when used, the lower their water content (Kaur et al., 2017). The factor that causes differences in the percentage of water content in each briquette sample is due to the uneven influence of the mixture of used cooking oil and cow dung briquette mixture when mixing is carried out so that water absorption has different values in each briquette sample. However, in this study, the percentage of water content met the Indonesian national standard (SNI), which was lower than 8% (Takapaha et al., 2022).

Ash Content

The ash content refers to the residue left over after combustion, specifically from the burning of briquettes in this case. Because fuels without ash, such as gas and oil, have better combustion properties, the level of ash concentration is an important consideration (Athaillah et al., 2024). Silica, a component of ash, negatively impacts the heat output of the charcoal briquettes. The calorific value and carbon content of the briquettes are influenced by the ash content. The lower the ash content value, the greater the calorific value and carbon content. Ash is a non-combustible mineral that remains after the combustion process and the changes or reactions that accompany it. The ash content should be kept low as it can decrease the heating efficiency and lead to equipment scaling (Lestari, 2023). The results of the ash content test can be seen in Table 2.

Table 2. Results of testing the ash content of cow manure briquettes.

Group	Ash Content (%)	Value
P1	4.11	>0.05
P2	5.03	>0.05
P3	4.67	>0.05
P4	5.17	>0.05

Information:
P1: 90% cow dung charcoal and 10% used cooking oil
P2: 87.5% cow dung charcoal and 12.5% used cooking oil
P3: 85% cow dung charcoal and 15% used cooking oil
P4: 82.5% cow dung charcoal and 17.5% used cooking oil

Table 2 shows the highest percentage of ash content in cow dung briquettes in a mixture of 82.5% cow dung and 17.5% waste cooking oil (P4) was 5.17%. Followed by 87.5% cow dung and 12.5% waste cooking oil (P2) was 5.03%. Followed by 85% cow dung and 15% waste cooking oil (P2) at 4.67% and the lowest ash content was 90% cow dung and 10% used cooking oil (P1), namely 4.11%. The statistical tests revealed that adding adhesives with varying concentrations does not cause a significant change in the percentage of ash content generated. The increased ash content is likely attributable to the combustion process of the briquettes reacting with air, leading to a secondary combustion process in which activated charcoal produced from the initial combustion process converts into ash. The ash content of the final product is impacted by a combination of materials with elevated levels of ash content (Saeed et al., 2021). The ash content of the produced briquettes is a result of the combination of the materials utilized. The elevated ash content found in briquettes can be attributed to suboptimal carbonation process. According to the

Indonesian national standard (SNI), a good ash content for charcoal briquettes is <8% (Takapaha et al., 2022). In general, the briquettes produced in this study have normal ash content values and are categorized as meeting the Indonesian National Standard (SNI) which has an ash content of <8%.

Burn Rate

The briquette burning rate is the weight of the briquettes that burn within a certain time interval. Combustion rate testing is carried out to determine the speed of effectiveness of a fuel. This test is carried out to determine the suitability of the fuel being tested so that it can be used in its application. The burning rate of briquettes is influenced by the factors of calorific value and water content. The faster the rate at which the briquette burns, the shorter its overall burning time will be (Bira et al., 2020). The burning rate test is shown in Table 3.

Table 3. Burning Rate Test Results.

Group	Burning RateTest (g/sec)	Value
P1	0.27	>0.05
P2	0.31	>0.05
P3	0.35	>0.05
P4	0.25	>0.05

Information:
P1: 90% cow dung charcoal and 10% used cooking oil
P2: 87.5% cow dung charcoal and 12.5% used cooking oil
P3: 85% cow dung charcoal and 15% used cooking oil
P4: 82.5% cow dung charcoal and 17.5% used cooking oil

Table 3 shows the process of burning the best cow dung briquettes with a mixture of 15% waste cooking oil at (P3), which is 0.35 g/sec, followed by 87.5% cow dung briquettes and 12.5% waste cooking oil (P2), which is 0.31 g/sec. Furthermore, cow dung briquettes with a mixture of 90% cow dung and 10% waste cooking oil (P1) were 0.27 g/sec and the lowest burning rate was 82.5% cow dung and 17.5% waste cooking oil (P4), 0.25 g/sec. The statistical test results showed that the treatment had no significant effect on the burning rate (P>0.05).

The pressure during pressing influences the burning rate, high pressing pressure makes the briquettes stick together and become denser so that little air is trapped in the briquettes and also makes the pores (porosity) of the briquettes smaller (Putri et al. 2019). This situation results in that when burning briquettes, most of the air used for burning briquettes is obtained from the outside of the briquettes and this is still blocked by ash covering the surface of the briquettes, thereby slowing down the burning rate of the briquettes (Tanko et al., 2021). In this research, no variation was observed in the amount of pressure applied while pressing the joint, which could explain why there was no significant difference in the burning rate.

Calorific Value

The quality of briquettes is largely determined by their calorific value, as a higher calorific value indicates better quality of the produced briquettes. The calorific value of a fuel represents the maximum quantity of heat energy that can be generated by the complete combustion of a unit mass or volume of the fuel. The purpose of analyzing the calorific value of a fuel is to gather information on the amount of heat energy that can be generated by the fuel during a chemical reaction or combustion process (Almu et al., 2014). Testing the calorific value obtained from cow dung briquettes with waste cooking oil can be seen in Table 4.

Table 4. Calorific Value Test Results.

Group	Calorific Value Test (cal/g)	Value
P1	2367	>0.05
P2	2503	>0.05
P3	2843	>0.05
P4	2741	>0.05

Information:
P1: 90% cow dung charcoal and 10% used cooking oil
P2: 87.5% cow dung charcoal and 12.5% used cooking oil
P3: 85% cow dung charcoal and 15% used cooking oil
P4: 82.5% cow dung charcoal and 17.5% used cooking oil

Table 4 shows the calorific value of briquettes of 85% cow dung with 15% waste cooking oil (P3) of 2843 cal/g followed by briquettes of 82.5% cow dung and 17.5% waste cooking oil (P4) of 2741 cal/g. Furthermore, briquettes of 87.5% cow dung and 12.5% waste cooking oil (P2) of 2503 cal/g and the lowest calorific value was 90% cow dung and 10% waste cooking oil (P1) of 2367 cal/g. The statistical analysis revealed that the inclusion of adhesive made from waste cooking oil did not have a considerable impact on the calorific output (P>0.05). Cow dung briquettes do not comply with the Indonesian National Standard (SNI) for calorific value, specifically 6914.11 cal/gram.

The low calorific value is caused by the relatively high ash content in cow dung (Yano, 2022).

CONCLUSION

From this research, it can be concluded that the best quality of briquettes in terms of water content and ash content is in the P1 treatment (briquettes with a composition of 90% cow dung and 10% waste cooking oil), whereas if viewed from the combustion rate and calorific value the best briquettes are in the P3 treatment (briquettes with a composition of 85% cow dung and 15% waste cooking oil).

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