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International Journal of Technology, Food and Agriculture (TEFA)

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Article

Manufacturing Non Adhesive Biobriquettes With Main Ingredients From Cow Manure Waste at Dairy Cows Teaching Factory

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Citation: R. E. Rachmanita, M. Aminullah, Y. Susmiati, S. D. A. Febriani, and B. Rudiyanto, "Manufacturing Non Adhesive Biobriquettes With Main Ingredients From Cow Manure Waste at Dairy Cows Teaching Factory", *tefa*, vol. 1, no. 1, pp. 23–32, Jan. 2024.

Received: 13-12-2023
Accepted: 25-01-2024
Published: 01-02-2024

Abstract: Biobriquettes are solid energy source that comes from biomass that is compressed under a certain pressure. The development of non-adhesive biobriquettes has not been widely carried out. Teaching factory (TEFA) Dairy Cows Politeknik Negeri Jember have 51 cows and products ± 18-20 kg/day of cow manure which have not managed optimally. On the other side of district Jember produces 1,945 tons of coconut shell waste per year which is pill up, thrown away and used as stove fiel or simply burned. This research was conducted with an experimental method using composition variations of raws material and mixed material to obtain the best mixture ratio for biobriquettes, 4KS6AR (40% : 60%), 5KS5AR (50% : 50%), 6KS4AR (60% : 40%). The raw material for cow dung is cleaned from grass fibers. The coconut shells raw material that has been dried in the sun, then pyrolyzed at a temperature of approximately 200-250ºC for 6-7 hours, then ground to size of 40, 60 and 100 mesh. From the tests that have been carried out, the most optimal value to quality standards of National Standard of Indonesia (SNI) 01-6235-2000 is with a water content of 2,382 %, calorific value of 6.650 cal/g.

Keywords: briquettes, cow manure waste, non-adhesive

1. Introduction

The dominance of fossil fuel usage, such as oil, as an energy source has led to global climate change, environmental pollution, and various other problems [1], [2]. Fossil fuels are non-renewable sources of energy. The energy used in Indonesia as well as in other countries of the world generally increases rapidly in line with population growth and technology developments [3]. Indonesia, as a petroleum producing country, estimates that national oil reserves will only last for the next 18 years, while on the consumption side there will be an increase [2]. Several steps to reduce dependence on kerosene, the government is converting kerosene to LPG gas, but this step turns out to be less effective in use from a security perspective, including the problem of not being properly targeted at recipients of subsidized LPG gas. Apart from that, this election still shows dependence on non-renewable energy. The two problems above require efforts to find alternative energy sources that can be renewed, are abundant, cheap and easy to use. One that has potential is biomass [4]. Biomass is used to supply energy, including power generation, fuel vehichle and industrial facilities. Biomass production in Indonesia is approximately 146.7 billion tones/year [5].

Biomass is organic material produced through the photosynthesis process in the form of products or waste. Apart from being used for primary purposes such as fiber, food, animal feed, vegetable oil, building materials and so on, biomass is also used as a source of energy (fuel) [5], [6], [7]. Generally, what is used as fuel is biomass which has low economic value or is waste after the primary product is taken. Biomass energy sources have several advantages, including being a renewable energy source so that it can provide sustainable energy [8], [9], [10]. Apart from that, biomass can be found almost all over the earth's surface without requiring high investment costs for exploration [11]. One alternative conversion that can be carried out in the use of biomass is bio briquettes. Bio briquettes are a solid energy source that comes from biomass that is compressed under a certain pressure [12], [13]. Good quality briquettes include properties such as a smooth texture, not easily broken, hard, safe for humans and the environment and have good ignition properties [14], [15]. The characteristics of this ignition include being easy to ignite, the ignition time is quite long, it does not produce soot, there is little smoke and it dissipates quickly and the heating value is quite high [16]. How long it burns will affect the quality and efficiency of combustion, the longer it burns with a constant flame, the better. In the process of making briquettes, adhesive is usually needed [17], [18]. The adhesive commonly used is tapioca flour. It's just that using tapioca flour as an adhesive has several disadvantages, including colliding with food ingredients so that production costs increase. Apart from that, the use of tapioca also causes smoke due to the starch content in tapioca. So innovation is needed in making briquettes using natural adhesives or also making briquettes without bio-adhesives, as well as making bio-briquettes that produce little smoke.

The development of non-adhesive briquettes has not been widely carried out. Innovation is usually carried out through high emphasis. The problem of using high pressure makes bio briquettes difficult to ignite. Based on this problem, it is necessary to innovate in the type of material and pressure used. One of the developments being carried out is bio briquettes from cow dung and charcoal. It is hoped that the use of cow dung (feces) that has just come out of the cow's stomach will be able to replace tapioca flour adhesive. One of the contents of cow dung is methane gas, where this gas is an element in increasing the calorific value in briquette production. The content of cow dung is carbon (29.35%), hydrogen (4.38%), oxygen (22.87%), nitrogen (1.85%) and sulfur (0.37%), calorific value 10.90821 MJ /kg. Meanwhile, the use of coconut shell charcoal, apart from the relatively abundant amount of coconut shell waste, in terms of chemical and physical characteristics, has quite high calorific value (Table 1). It is hoped that the use of coconut shell charcoal as the main ingredient for biobriquettes can function as an absorbant to absorb CH_4 (methane) from cow dung so as to reduce emissions from cow dung waste. Another hope is that the carbon content in the cow dung absorbed by the charcoal will react thereby increasing the calorific value of the bio briquettes.

Table 1. Chemical and physical of coconut shell [19]

Parameters	Properties	Description
Proximate Analysis	Moisture Content	5.56%
	Volatile Matter	70.82%
	Fixed Carbon	21.80%
	Ash	1.80%
	C	40.08%
	H	5.22%
Ultimate Analysis	N	0.22%
	S	0.17%
	O	54.31%

Parameters	Properties	Description
	Porosity	24.39%
Potential as Energy Source	Compressible Index	40.24%
	Calorific Value	19.4 MJ/kg
	Fuel Value Index	4441

2. Materials and Methods

2.1 Material Preparation

The raw materials used for the briquettes in this study are a mixture of coconut shell charcoal and cow dung. The study does not use any binder; however, the cow dung used is freshly excreted from one-day old cattle. The study begins by cleaning the raw material (coconut shells) and subjecting them to a pyrolysis process. On the other hand, the cow dung raw material does not undergo a pyrolysis process. The resulting coconut shell charcoal from the pyrolysis process was then ground to a specific size (passing through a 60-mesh sieve). It was then mixed evenly with cow dung. The percentage of the coconut shell charcoal-cow dung mixture is as follows:

Table 2. The composition of the bio briquette mixture of cow dung and coconut shell charcoal

Composition	Briquette mixture of cow dung (%)	Coconut shell charcoal (%)
4KS6AR	40	60
5KS5AR	50	50
6KS4AR	60	40

The following are the stages of preparing materials for briquettes:

a. Sorting: The first step in preparing the raw materials for biobriquettes is sorting. This involves separating any impurities or unwanted materials from the main raw materials. For example, in the case of cow manure, any grass fibers or large debris should be removed.
b. Drying: After sorting, the raw materials need to be dried to reduce their moisture content. This can be done through natural drying or using mechanical drying methods. For natural drying, the raw materials are spread out in a well-ventilated area and exposed to sunlight. Mechanical drying involves using equipment such as dryers or ovens to remove moisture.
c. Grinding: Once the raw materials are dried, they may need to be ground or pulverized to achieve the desired particle size. This is typically done using a grinder or mill. Grinding helps to increase the surface area of the raw materials, making them easier to compress into briquettes and improving the overall quality of the final product.
d. Mixing: After grinding, the raw materials are ready for mixing. The purpose of mixing is to achieve a homogeneous blend of the different components. In the case of biobriquettes, it will involve combining cow dung with coconut shell material. The mixing process can be done manually using a shovel or mechanically using a stirrer or blender.

Figure 1. Mixture of cow dung and coconut shell charcoal

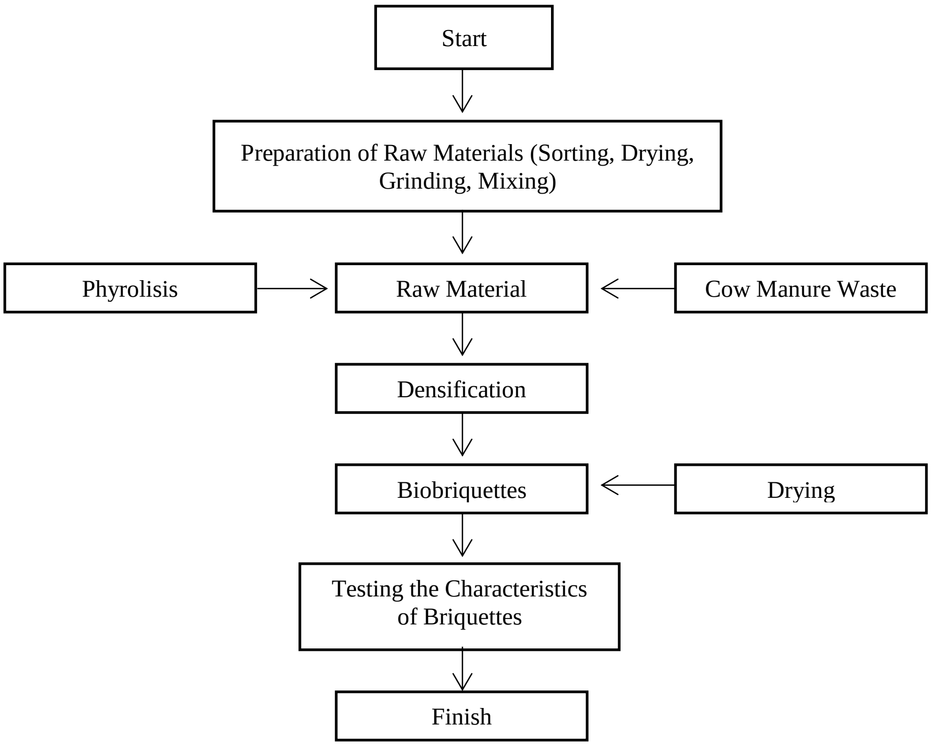

Figure 2. Research Diagram

2.2 Briquette Production

The briquette production process involves filling the mixture into a cylindrical iron pipe mold with a diameter of 5.4 cm and a height of 5 cm. After filling, the mixture is compacted from a height of 5 cm to 2.5 cm. The next step is weighing the initial weight of each bio briquette sample. The following process is drying the briquettes to reduce the moisture content. Drying is done by exposing the bio briquettes directly to sunlight for 5-6 days. The next step, after the bio briquettes are dry, is to conduct moisture content and calorific value tests. The moisture content test is conducted to determine the water content in the samples, which affects the ignition process and the resulting combustion temperature. The calorific value test is conducted to measure the heat generated by the bio briquettes.

2.3 Data Analysis

Data obtained from the testing is further analyzed using a Completely Randomized Design. Three treatments with three replications are used in the study. The data obtained is processed using ANOVA method with the following parameters:

a. Moisture content of the bio briquettes

In this study, the moisture content test is conducted using the ASTM D 1762-84 2007 method, specifically the wet bulb method. The equipment used includes a cup, a digital scale, and an oven.

The moisture content value can be calculated using the following formula:

$$\text{Moisture Content} = \frac{(a-b)}{a} \times 100\% \quad (1)$$

where:

a = initial mass of the briquette before drying (g)

b = final mass of the briquette after drying (g)

b. Calorific Value

The calorific value of the briquettes can be determined based on the literature values for the calorific value of the raw materials used. The formula to calculate the calorific value is as follows:

$$\text{HHV} = \text{P X HHV}^{*} \quad (2)$$

where:
HHV = Calorific value of the component (cal/g)
P = Percentage of the component (by weight)
HHV* = Data of the calorific value for each component (cal/g)

Figure 3. Bio briquette preparation schematic diagram

3. Results and Discussion

Briquette is a type of combustible biomass fuel that is formed from the pressing or compression process by using an adhesive to increase the fuel value [20]. The process of making briquettes involves converting biomass residue into a solid block using either a high-pressure or low-pressure process. During this process, an adhesive is added to the biomass material to bind it together and create a cohesive briquette. The use of an adhesive helps increase the fuel's calorific value, making it a more efficient and valuable source of energy. The burnt charcoal is mixed with the main raw material, cow dung, and a mixture of coconut shell charcoal to create the briquette mixture. The briquette mixture is then formed into uniform-sized briquettes using a Paralon mold with a pressure of 0.00928 bar, resulting in briquettes with a height of 2 cm and a diameter of 5.2 cm, as shown in the following:


Figure 4. Briquette

3.1 Moisture Content

The moisture content test of the briquettes aims to determine the percentage of water content present in the briquettes. Moisture content is a factor that affects the quality of the briquettes. A low moisture content indicates that the briquettes have a high calorific value, making them easily combustible. On the other hand, briquettes with a high moisture content will result in a decrease in calorific value. This is because the energy produced by the briquettes will be absorbed to evaporate the water [21]. In addition to affecting the calorific value, a high moisture content can also cause difficulties in ignition, produce smoke during combustion, and reduce the quality of the briquettes during storage due to microbial growth. The results of the briquette characterization test are as in Table 3.

Based on Table 3, it can be observed that the mixture with a higher composition of cow dung shows an increase in the higher water content of the bio briquettes. The composition with the lowest water content value was found in the 4KS6AR composition, which is 2.769%, while the composition with the highest water content value was found in the 6KS4AR composition, which is 4.961%. Water content is the ratio of the water content lost during the drying process to the initial water content of the material. The decrease of mass from component such as water and low molecular weight solvent and some physical transition also occur such as vaporization and evaporation.

Table 3. Water content test results.

No.	Treatment	Water Content (%)
1	4KS6AR	3,265
2	4KS6AR	2,381
3	4KS6AR	2,663
4	5KS5AR	2,410
5	5KS5AR	3,300
6	5KS5AR	3,676
7	6KS4AR	6,137
8	6KS4AR	5,376
9	6KS4AR	3,371

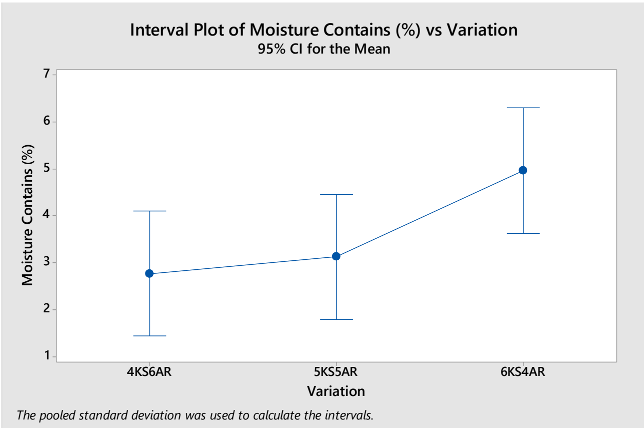

Figure 5. Interval plot of water content for each biobriquette treatment

Table 4. Analysis of variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Treatment	2	8,291	4,1457	4,66	0,060
Error	6	5,339	0,8899		
Total	**8**	**13,631**			

Composition	N	Mean	Group
6KS4AR	3	4,961	A
5KS5AR	3	3,129	A
4KS6AR	3	2,770	A

Based on the ANOVA test results for water content at α=0.05, it can be stated that the briquettes made from a mixture of coconut shell charcoal and cow dung show a level approaching significance. The p-value is less than 0.05. Supported by the graph in Figure 5, this result is further reinforced by the high R-square value of 60.83%. This means that the model generated from the experiment explains 60.83% of the variation in the response variable, which is the water content. The high water content in the 6KS4AR mixture is due to the trapped moisture in the bio briquettes that has not evaporated. On the other hand, the water absorbed by the coconut shell charcoal has not been able to escape during the 4-5 day drying process. The water content in the briquettes affects the quality of the briquettes in terms of calorific value and combustion rate. Briquettes with low water content produce high calorific value and combustion rate, and vice versa [22].

The moisture content can be measured by taking a small sample and oven drying it at 105^{0}C until the required consistency the sample mass is obtained. During combustion, the moisture in the biomass will absorb heat from the burning fuel to form vapor due to heat of vaporization. The moisture content in briquettes plays a significant role in their heating value and combustion properties. It is desirable to have a low moisture content in briquettes as it leads to higher heat values and easier ignition. When briquettes have a lower water content, they tend to burn more efficiently and produce higher calorific values, resulting in more heat output. On the other hand, briquettes with high moisture content can decrease the overall calorific value and combustion power, making them less effective as a fuel source. Therefore, it is important to ensure that the moisture content in briquettes is kept as low as possible to optimize their energy efficiency. This is because the energy produced will be absorbed a lot to evaporate water [23]. Briquettes with high water content will result in low calorific value and combustion rate because more energy is needed to evaporate the water contained in the briquettes. Based on the calculated data of water content in the three variations of briquette compositions, it can be concluded that the cow dung briquettes with a mixture of coconut shell charcoal can be considered good because they meet the quality standards of briquettes according to SNI 01-6235-2000, which is ≤ 8%. The particle size of the biomass material used in briquettes can indeed affect the water content. Coarser particle sizes tend to absorb less water compared to finer particle sizes. This could be due to the larger surface area available for water absorption in finer particles. Additionally, if the drying process is incomplete or insufficient, it can result in higher moisture content in the briquettes [24].

3.2 Calorific Value Test

The calorific value needs to be determined in the production of briquettes to assess the heat value that can be generated by the briquettes as a fuel. The calorific value is the standart measure of the energy content of fuel. When the latent heat of condensation of water is included in the calorific value, it is refereed to as the gross calorific value or higher heating value. The higher the calorific value produced by the briquette fuel, the better its quality. The difference in particle size gives a different supply of oxygen which affects combustion. Factors that influence the burning of solid fuels include particle size, velocity of air flow, type of fuel, and combustion air temperature [25]. The following table shows the results of the calorific value.

Table 5. Calorific value test

No.	Treatment	Calorific Value (cal/gr)
1	4KS6AR	6388
2	4KS6AR	6495
3	4KS6AR	6317
4	5KS5AR	6447
5	5KS5AR	6494
6	5KS5AR	6650
7	6KS4AR	6071
8	6KS4AR	6685
9	6KS4AR	6091

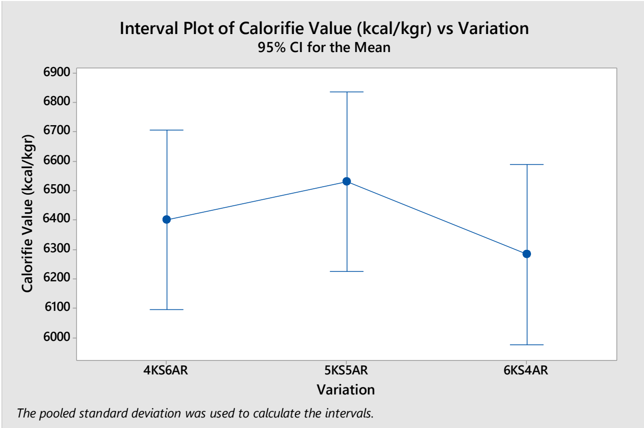

Figure 6. Interval plot of calorific value for each bio briquette treatment

Table 6. Analysis of variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Treatment	2	11,6209	5,81043	392,89	0,000
Error	6	0,0887	0,01479		
Total	**8**	**11,7096**			

Composition	N	Mean	Grouping
6KS4AR	3	13,1700	A
5KS5AR	3	11,763	B
4KS6AR	3	10,3867	C

Based on Table 6, the results of the calorific value test show that the 6KS4AR composition has the lowest calorific value, which is 6,282 kcal/g, while the highest calorific value is found in the 5KS5AR composition, which is 6,530 kcal/g. A higher calorific value of briquettes indicates a higher heat output, and vice versa, a lower calorific value means less heat generated.

Based on the ANOVA test results, the calorific value test has a significant p-value at $\alpha = 0.05$. This means that the composition treatment of cow dung and coconut shell charcoal mixture has a significant influence on the calorific value of the bio briquettes. Supported by the graph in Figure 6, this result is further reinforced by the high R-square value of 99.24% and the adjusted R-square value of 98.99%. This means that the model generated from the experiment explains 99.59% of the variation in the response variable, which is the calorific value. Factors that affect the calorific value of briquettes include the water content in the briquettes, the drying process applied to the raw materials, and the inherent calorific value of each material. Briquettes with low water content result in higher calorific values because the heat generated during combustion is not used to evaporate a significant amount of water. Based on the data in Table 6, the calorific value test conducted on the three compositions of bio briquettes, it can be concluded that the cow dung and coconut shell charcoal bio briquettes meet the quality standards for briquettes according to SNI 01-6235-2000, which is > 5000 kcal/g. This study contributes to a greater understanding of the implementation, constraints, and challenges, as well as regulations associated with converting biomass to renewable energy and meeting the 2025 energy mix target [26]. Further research needs to carry out additional tests on other quality parameters such as compressive strength and kamba density tests.

4. Conclusions

Based on the results of the research that has been done, it can be seen that the use of coconut shells as raw material for briquettes has a good ability to become a renewable energy source in the form of biomass. Based on water content calculation data and testing the calorific value contained in three variations of briquette composition, it can be concluded that the water content of dairy cow dung briquettes mixed with coconut shell charcoal can be said to be good because it meets the briquette quality standards based on SNI 01-6235-2000, namely ≤ 8% and the calorific value also meets the briquette quality standards based on SNI 01-6235-2000, namely > 5000 cal/gr. The compositions of 6KS4AR, 5KS5AR and 4KS6AR are not significantly different in water content, but are significantly different in heating value and the highest is the composition 5KS5AR. This means that with a balanced ratio, you will get a mixture of the right masses that bond together so that the calorific value is high.

Author Contributions: Conceptualization, R E Rachmanita, B Rudiyanto and M Aminullah.; methodology, R E Rachmanita, B Rudiyanto, Y Susmiati; validation, Y Susmiati and S D A Febriani; formal analysis, B Rudiyanto; investigation, R E Rachmanita and M Aminullah; resources, M Aminullah and S D A Febriani; data curation, Y Susmiati and B Rudiyanto; writing—original draft preparation, M Aminullah and B Rudiyanto; writing—review and editing, R E Rachmanita and S D A Febriani.

Funding: This research was funded by PNPB 2023 Politeknik Negeri Jember.

Acknowledgments: We sincerely thank to the Director of Politeknik Negeri Jember and Pusat Penelitian dan Pengabdian Masyarakat (P3M) for the PNBP 2023 funding support so this script can be carried out well. This script would hopefully give a positive contribution to the educational development or those are willing to conduct further research.

Conflicts of Interest: The authors declare no conflict of interest.

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