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EFFECT OF BAGASSE PARTICLE SIZE AND CORNSTARCH COMPOSITION ON BAGASSE BRIQUETTE PRODUCTION AS COOKING FUEL IN SUMBUL VILLAGE

Tiara Nur Azizah, Christyfani Sindhuwati
Chemical Engineering Department, Politeknik Negeri Malang, Jl. Soekarno Hatta No. 9, Malang, Indonesia
tyazizah@gmail.com; [c.sindhuwati@polinema.ac.id]

ABSTRACT

Bagasse is one of the potential sources of biomass in Sumbul Village which is very abundant. This bagasse waste is accumulated on the side of the road which disturbs the aesthetics because it looks scattered and brings odor. The objective of this research was to make bagasse waste as briquettes for cooking fuel. This study used 2 variables, bagasse particle size (20, 40, and 60 mesh) and starch composition as an adhesive (10%, 20%, and 30% w/v). The parameters tested in this study were water content, ash content, calorific value, and ignition time. The results obtained were briquettes have a water content of 1.32% and ash content of 0.37%. Meanwhile, the best results were obtained on a variation of 60 mesh bagasse particles with 20% w/v corn starch composition which has a heating value of 3,215 J/g and an ignition time of 132 minutes.

***Keywords**: bagasse, briquette, particle size, cornstarch composition*

1. INTRODUCTION

Sumbul village is one of three villages in Klampok – Malang Regency with a lower population density among the other villages. This village consists of only 2 hamlets with the number of family heads only 56 people, who generally work as sugar cane farmers. This is because the village is at the foot of the mountain and is at the top of the two villages. Sumbul village is classified as an isolated area that has a problem in the provision of cooking fuel. They only rely on firewood as cooking fuel which takes more than 7 hours a week to find firewood in the forest.

This phenomenon is common in rural areas in Indonesia. Firewood as an energy source has an important role to play in rural communities in Indonesia to support the fulfillment of daily needs. Firewood is used to cook food, water, and heating (boiling). Firewood for rural communities will not yet be completely replaced by energy types such as kerosene and gas due to the low ability to purchase and difficulty to obtain alternative jobs outside of farming [1].

Corresponding author: Jurusan Teknik Kimia
Politeknik Negeri Malang
Jl. Soekarno-Hatta No.9, Malang, Indonesia
E-mail: c.sindhuwati@polinema.ac.id

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But it needs to be noted that using kerosene and gas will also increase environmental problems because they are classified as non-renewable energy and not environmentally friendly. Those energy sources can increase emissions of carbon dioxide and other harmful gasses that can lead to global warming, water and soil pollution that will harm all living things, and environmental balance [2]. Therefore, we need to tackle the problem of providing clean and affordable energy sources for cooking fuel in rural communities, especially in Sumbul village.

Sumbul village has potential biomass derived from sugar cane plants that thrive in the area. Sugar cane is cultivated as one of the plants that produce sweeteners (sucrose) which are stored in sugar cane stalks and are the material for producing crystal sugar through the process of industry [3]. Sugar cane is also very potential to be developed in Indonesia because the need for granulated sugar is increasing with time along with an increase in the population [4]. Among the 400 hectares of plantation land in Sumbul village, 345 hectares of them are used for sugar cane plantation areas. Sugar cane plants produce biomass in the form of bagasse. Bagasse is derived from the sequencing of sugar cane stems, in which the sugar cane water is used as raw material for sugar production and animal feed. There are more than 230 tons of bagasse produced from sugar cane plantations in Sumbul village each year [5]. These bagasses are only accumulated on the roadside which disturbs the aesthetics because it appears scattered and gives off an unpleasant odor.

When reviewed further, bagasse can be processed into briquette fuel for cooking purposes. Bagasse is a waste extracted from sugar cane stem which contains a lot of parenchymas and cannot be well stored because it is easily affected by fungi. Bagasse is in the form of fiber from the stem of sugar cane that has been damaged. Bagasse is usually disposed of in open dumping without further processing and causes environmental concern and unpleasant odors [6]. The chemical composition of bagasse can be seen in Table 1. below.

Table 1. Bagasse Composition

Contents	Setiawan, 2018 [7]	Shabiri, 2014 [8]
Water	48-52%	46-51%
Ash	3.82%	4.11%
Lignin	22.09%	13-22%
Cellulose	37.65%	26-34%
Pentose	27.97%	20-33%
Silica	3.01%	2.7-4.6%
Reducing sugar	3.3%	2.5-5.4%

From the reviewed composition, bagasse can be further processed as a briquette. Bagasse has the potential to be processed into briquettes because it is abundantly available and has a high cellulose content. The higher the cellulose content, the better the briquette quality obtained [9]. Briquette is a fuel made from materials that have high lignin and cellulose [10]. Usually found on cane stems, rice husks, corn cobs, etc. Briquettes are fuels that have a solid form and are produced from the remains of organic matter [11]. Briquettes are charcoal with a certain shape produced through the compression process with the addition of several adhesives. The utilization of briquettes as material fuel is capable of producing heat with a little smoke [12].

Biomass can be used directly without being processed. But, the benefits of biomass will be less efficient. One example is in the use of wood as fuel, the consumed energy is less than 10%. While in briquette can reach more than that. The energy produced from the burning of wood is only 2,300 kcal/g, while the energy from the combustion of briquette can be up to 5,000 kcal/g [13].

Briquette production from bagasse is an effort to obtain high carbon content and is well used as an alternative fuel. The change of material form from the original form to briquette is a way to obtain the desired shape and size to be used for certain purposes. The shape of briquettes usually varies, ranging from hollow cylinders to cubes, depending on the placement of briquettes to be used [14].

Briquette is considered a sustainable technology because it aims to maintain the environment, human safety, and increase economic value. In addition, bagasse briquette is one of the breakthroughs in renewable energy that is easy to produce, does not require much material, and has low operational costs [6]. It also considers that biomass like this can be used as a potential source for the development of renewable energy that is used as a substitute for petroleum [15]. Therefore, the briquette is very feasible to be developed further in Sumbul village to help provide clean and affordable cooking fuel.

While the production of briquettes using sugar cane bagasse is already being researched and developed by other researchers, they produce the briquettes by mixing them with other biomasses, such as coconut shells. This research offers the study of the usage of only sugar cane bagasse to make it easier if the villagers want to produce it in their area. That is what set this research apart from any other research that was done before. In this research, the researcher aims to understand the process of producing briquettes from sugarcane bagasse, their properties from their properties in moisture content, ash content, calorific value, and ignition time. This research was done with the hope to help utilize bagasse that's not utilized properly and make the citizen of Sumbul village get easier access for cooking fuel.

2. RESEARCH METHODS

The research was conducted through an experimental quantitative method with parameters standard refers to the regulation of the Minister of Energy and Mineral Resources no. 047 on the year 2006 and SNI 01-6235-2000 about briquette production and its quality. The tools and materials that are used in this research are furnace, oven, grinder, pan, analytics scale, sieves, desiccator, calorimeter, stopwatch, shaping tool, sugar cane bagasse, corn starch, and water. In this research, the briquette is made from sugar cane bagasse using 2 variables, bagasse particle size (20, 40, and 60 mesh) and starch composition as an adhesive (10%, 20%, and 30% w/v). The parameters tested in this study were water content, ash content, calorific value, and ignition time.

To produce the charcoal, water needs to be removed from the bagasse by drying. This process was conducted at the temperature of 105^oC until it was completely dry that was indicated by the constant mass of the bagasse. The following step was burning the sugar cane bagasse in a furnace with a temperature of 500^oC for 2 hours to convert them into charcoal and was repeated 2 times. Sizing was conducted to reduce the size of the charcoal using a grinder. This process aimed to make the mixing process of bagasse with other ingredients and to shape the briquettes easier. Particles obtained from the sizing process were screened to separate the particles based on their size according to the variable used in this research. The size used for the charcoal is sifted in 3 variations, listed as 20, 40, and 60 mesh, which was determined by using sieves.

All the existing ingredients were mixed to homogenize them so that the briquettes would be easily formed. Sifted charcoal mixed with adhesives, the corn starch solution, with the variations of 10%, 20%, and 30% of the corn starch solution(w/v). The mixture is then shaped into the form of briquettes according to the shape of the shaping tool used. Through the shaping process, it will be easier to carry and use the briquettes. After shaping the briquettes, water should be removed from them so that it will make it easier to burn and store the briquettes. The final process was to analyze four parameters of briquettes, listed as moisture content, ash content, calorific value, and ignition time. Further explanation of the analysis could be read below.

2.1. Drying.

A. Moisture content

Moisture content is a certain amount of water contained in an object [16]. The calculation of moisture content contained in briquette using ASTM standard D-3173-03. Based on the standards, adding the sample into a capsule serve as a tool during the heating process of the sample. The heating was done in a preheated oven at the temperature of 104 – 110°C for an hour. After that, put the capsule in the desiccant and weigh it as soon as it reaches room temperature. The calculation was done by dividing the mass differences between the initial mass (m_o) and the final mass (m_i) after drying with the initial mass (m_o). For better understanding, the mathematical form of the equation could be seen from equation 1.

$$\text{Moisture Content (\%)} = \frac{m_o - m_i}{m_o} \text{ x } 100\% \quad (1)$$

m_o = (g)

B. Ash Content

Ash content is a mixture of inorganic components or minerals contained in a material. Organic matter in the combustion process will be burned but its inorganic components will not be burned, therefore it is referred to as ash content [16]. The calculation of the percentage of ash content of briquette using ASTM standard D-3174-04. The calculation was done by dividing the mass of the ash with the mass of the sample (m_s) and multiplying it by 100% so that it becomes a percentage. The mass of ash could be obtained by calculating the differences in the mass of the empty crucible (m_c) and when it already had the ash on it (m_{ca}). The mathematical form of the equation could be viewed in equation (2).

$$\text{Ash Content (\%)} = \frac{m_{ca} - m_c}{m_s} \times 100\% \quad (2)$$

m_{ca} = (g)

C. Calorific value

The calorific value of briquettes is an important measure of the amount of energy released from every briquette when burned [17]. A calorimeter is used to measure the calorific value.

D. Ignition time

Ignition time is the length of time that takes for the briquettes until completely burned. Some amounts of briquettes were placed in a container and burned. The calculation of time was done from the beginning when the briquettes were burned until they were completely burned [18].

3. RESULTS AND DISCUSSION

Briquette qualities were tested in 4 parameters, which were moisture content, ash content, calorific value, and ignition time. The water content in briquettes greatly determines the quality of the briquettes produced. Briquettes with a low value of water content will have a high calorific value. Adhesive selection on briquette production is also very influential on the water content value of the briquettes produced, the higher the water content value, the lower the calorific value obtained [19]. This is due to the heat generated first being used to evaporate the water in the bagasse before producing heat that can be used as combustion [13].

Moisture content also affects the rate of combustion and briquette storage period [16]. The moisture content obtained from the briquette was 1.32% for all variables used. The moisture content was determined before it was made into each variable. Water content in briquettes based on SNI should not exceed 8% and this study has met the requirements. In addition to moisture content, ash content analysis was also carried out. Ash content influences the calorific value of briquettes. The higher ash content can reduce the heat calorific value [20]. The calorific value greatly determines the quality of the briquettes. The higher the calorific value, the better quality of the briquettes will be produced [13]. The average ash content obtained from briquette was 0.37%. Ash content in briquettes based on SNI should not exceed 8% and this research has met the requirements.

In addition to the analysis of water and ash content of bagasse, analysis of the calorific value and length of ignition of the briquettes were also conducted. The calorific value of the briquette can be seen in Table 2 and the ignition time of the briquette can be seen in Table 3.

Table 2. Calorific Value of Briquette (J/g)

Variation	20 mesh	40 mesh	60 mesh
10%	2,679	3,051	3,189
20%	2,882	3,S126	3,215
30%	2,885	3,107	3,193

From Table 2, the best result was obtained in variation with 20% (w/v) corn starch solution with the size of charcoal particles 60 mesh that has a calorific value of 3,215 J/g. The smaller the particle size, the larger the surface area, resulting in a better material to conduct and store heat [21]. A large area allows particles to bond better. Thus, the heat generated will be more evenly distributed and then produce a large calorific value [22]. In addition, the adhesive of the corn starch solution also affects the calorific value. If the amount of corn starch solution in the briquette is too large, it will inhibit the transfer of heat in the briquettes because the water content in them is too high [23]. The pores where the place to generate heat will be blocked due to the water contained in the adhesive. The heat will be absorbed first by the water, so it can reduce the calorific value [21].

In this research, the largest calorific value was obtained in 20% corn starch solution which value is not far from 10% cornstarch solution. This can be due to the drying quality of briquettes tends to be more maximal, so that the briquette content with 20% cornstarch variation has a smaller moisture content after the drying process.

Table 3. Ignition Time (minutes)

Variation	20 mesh	40 mesh	60 mesh
10%	46	97	128
20%	53	102	132
30%	42	96	119

From Table 3, it can be seen that the longest briquette ignition time in the variation of cornstarch solution is in variation 20% with the size particle 60 mesh which has an ignition time of 132 minutes. The length of this ignition is also affected by the amount of adhesive (cornstarch solution) in the briquette. If the amount of cornstarch solution in the briquette is too large, it will inhibit the transfer of heat in the briquettes [18], which causes a decrease in the ignition capability of briquettes.

Besides that, inter- and intra-particle porosity allows easy infiltration of oxygen and combustion briquette outflow. Finer particles having lower porosity can inhibit mass transfer, such as drying, devolatilization, and charcoal burning processes because less free space for mass diffusion (e.g. water vapor, volatiles, and carbon simultaneous outflow of dioxide and infiltration of oxygen). Thus, the larger the particle size, the faster the ignition time and vice versa. Saptoadi (2008) also investigated the effect of particle size, the largest particle size only burned for 19-25 minutes, while the smallest particle size ignited for up to 28 minutes [24]. Therefore, the most appropriate amount of corn starch solution is required to produce a good ignition duration.

4. CONCLUSION AND SUGGESTION

Conclusions that can be taken from this study are the best quality of briquette is obtained in variation 20% corn starch solution with the size of particles 60 mesh, which give the largest calorific value 3,215 J/g. The smaller the particle size, the larger the surface area will be, and a larger calorific value will be obtained. The appropriate amount of corn starch solution is also required to obtain a large calorific value. Therefore, these briquettes could be used as a cooking fuel for Sumbul villagers.

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