

BRIQUETTES FROM BIOMASS WASTE

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Briquettes from Biomass Waste

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Abstract. This research made three kinds of briquettes from various biomass waste, including alaban wood charcoal and rubber seed shells mixed with coal bottom ash and coal fly ash. The purpose of the study was to obtain the characteristics and quality of briquette combustion. Making briquettes is by drying, grinding, and sifting raw materials then mixed with adhesive, printing and drying. Briquettes were made with variations in composition and pressure and the particle size of the material passing through the 50 and 250 mesh sieves. Briquettes produced from alaban wood charcoal and coal bottom ash, or fly ash, obtained more bottom ash or fly ash composition characteristics. The moisture content and calorific value would be lower while the ash content was higher. While the initial ignition time, the combustion duration is getting longer, but the burning rate would decrease. Briquettes made from rubber seed shells and coal bottom ash obtained variations in composition and pressure that affect the characteristics and quality of combustion. The higher the rubber seed shell composition and pressure, the lower the water and ash content, but the calorific value increased.

1. Introduction

Humans always need energy in carrying out their activities. Non-renewable energy sources such as petroleum, if used continuously, will run out in a short time, so that alternative renewable energy is needed [1]. There are many alternative sources of renewable energy, including biomass or organic waste materials. Biomass includes wood waste, agricultural/plantation/forest waste, organic components from industry and households, which could be reused as the source of alternative energy. The utilization of biomass waste as alternative energy can be produced using simple technology such as briquettes. The use of briquettes, especially briquettes produced from biomass, can replace fossil fuels [2]. Some biomass has considerable potential as a material for making briquettes, including rubber seed shells, coal waste in the form of bottom ash and fly ash and alaban wood charcoal waste.

Several studies of briquettes have been carried out using a mixture of coconut shell and sawdust; oil palm shells with variations in particle size of 7 mesh, 16 mesh, 25 mesh; peat and palm frond charcoal; bamboo; hazelnut skin and tamarind peel with various sizes of 20 mesh, 40 mesh, 60 mesh; rice husk and teak wood powder with size variations of 40 mesh, 60 mesh, 100 mesh [3 - 8]. From several studies, no one has used coal bottom ash, coal fly ash, alaban wood charcoal, and rubber seed shells to make briquettes. In addition, research on briquettes using a particle size of 250 mesh has not been carried out.

Coal bottom ash still has a carbon content value that can be reused by increasing the heat value using biomass mixture [9], [10]. Alaban wood charcoal has several advantages: its quality is equal to briquette charcoal and does not emit smoke [11]. The large number of rubber seeds produced from rubber plants causes the rubber seed shells that have not been utilized optimally to become one of the potential biomass that can produce briquettes as alternative energy. [12]. Several factors need to be considered in the



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11 manufacture of briquettes, including raw materials, adhesive materials, the particle size of the material, the pressure of the printing machine.

The particle size of different briquette materials will determine the value of compressive strength, moisture content, and calorific value. The smaller the particle size of the material, the stronger the adhesion between the particles when an adhesive is added and the higher the calorie [13-15]. In the manufacture of these briquettes, in addition to using alaban wood charcoal, bottom ash and coal fly ash and rubber seed shells, a small particle size of 250 mesh are also used, and this is a novelty of this research.

Some of the benefits of using briquettes are the immense potential of biomass in Indonesia which is a source of raw materials. In addition, briquettes can be increased in density, adjust the shape and size, are not dirty, are easy to transport and are practical as fuel [16]. Briquettes have an economic advantage in manufacturing because they can be produced with simple technology and high calorific value. The price of briquettes is lower and is a renewable alternative energy source. In this study, alaban wood charcoal biomass waste, rubber seed shells, bottom ash, and coal fly ash were used to make briquettes. This study aimed to obtain the characteristics and quality of briquette combustion made from biomass waste. The attributes of briquettes include moisture content, ash content, calorific value, while the rate of briquette combustion has initial ignition time, duration of combustion and combustion speed.

2. Method

This research is experimental research conducted in a laboratory. The raw material used in the manufacture of briquettes is alaban wood charcoal waste obtained from the charcoal company Citra Utama (Ltd) in Banjarbaru, while coal bottom ash and fly ash was obtained from the Asam-Asam power plant located in Jorong District, Tanah Laut Regency, South Kalimantan Province. Meanwhile, rubber seed shell waste was taken from rubber farmers' plantations in Pengaron Village, Simpang Empat District, Banjar Regency, South Kalimantan Province. In this study, three kinds of briquettes made from biomass waste were made with different mixed materials, namely briquettes made from alaban wood charcoal and coal bottom ash, briquettes made from alaban wood charcoal and coal fly ash, briquettes made from rubber seed shells and coal bottom ash. The three kinds of briquettes were made with various compositions, and three samples were made for each composition.

Making briquettes made from alaban wood charcoal and bottom ash and coal fly ash is carried out by drying, grinding and sieving the raw materials. The raw materials are crushed and sieved using a sieve to pass a 250 mesh sieve to obtain a more petite and uniform size. When making powdered raw materials from rubber seed shells, the waste process of rubber seed shell is first cleaned of dirt, then dried for three days in the sun, that it is carbonized at a temperature of 300°C. After the carbonization process is complete, the charcoal is then pulverized and sieved to obtain 50 mesh rubber seed shell waste charcoal powder to manufacture briquettes.

The process of making briquettes includes mixing raw materials with adhesives, molding and drying. Making briquettes is by mixing alaban wood charcoal powder and coal bottom ash until homogeneous with composition variations of 100%:0%, 90%:10%, 80%:20% and 70%:30%. In contrast, the variations in the compositions used in alaban wood charcoal briquettes and coal fly ash are 100%:0%, 90%:10%, 80%:20%. In the process of mixing raw materials for charcoal, rubber seed shell waste and coal bottom ash, with variations in the material composition of 60%:40%, 70%:30%.

It was making adhesive by cooking tapioca flour with water to form a gel. Tapioca flour was chosen as an adhesive because it has a higher carbon content than other flour types. The content of carbon content in tapioca flour is 85.20%. Meanwhile, alaban wood charcoal was 76.69%, and coal bottom ash was 41.87%. [17].

The adhesive that has formed a gel is then mixed with alaban wood charcoal powder, bottom ash, coal fly ash, rubber seed shell charcoal as much as 5%. The results of the mixing of the samples were put into a mold with a size of 2 cm x 5 cm and compacted using a hydraulic pump with a pressure of 150 kg/cm². Meanwhile, briquettes made from rubber seed shell charcoal and coal bottom ash were molded with pressure variations of 100, 150, and 200 kg/cm². The molded briquettes were dried in the oven at 120 °C for 4 hours and cooled at room temperature for 24 hours. Furthermore, the dried briquettes were tested for characteristics and combustion quality tests.

Characteristic tests include moisture content, the ash content² accordance with SNI 06-3730-1995, while the calorific value is in accordance with ASTM D₆15. The calorific value test uses the Bomb Calorimetric method. The quality standard of briquettes is based on SNI 01-6235-2000, namely moisture content (< 8%), ash content (< 8%), calorific value (> 5000 cal/g). The quality test of briquette combustion includes initial ignition time, duration of combustion and combustion speed.

3. Results and Discussions¹

3.1 Briquettes Made from Alaban Wood Charcoal and Coal Base Ash²

The average moisture content, ash content, and calorific value of briquettes made from alaban wood charcoal biomass waste and coal bottom ash from 3 samples for each material composition are as shown in Table 1.

Table 1. The characteristics of briquettes made from alaban wood charcoal and coal ash[18]

	Alaban charcoal + bottom ash				Alaban charcoal + fly ash		
	100%:0%	90%:10%	80%:20%	70%:30%	100%:0%	90%:10%	80%:20%
Moisture (%)	3.91	4.10	2.95	3.86	3.91	4.31	3.96
Ash content (%)	0.38	8.32	18.28	26.67	0.38	8.18	17.39
Calorific value (cal/g)	6.621.07	5,871.53	5,349.03	4,749.60	6,621.07	5,858.73	5,283.93

The highest average water content is 4.10% in 90%:10% briquettes composition, and the lowest average water content is 2.95% in 80%:20% composition. The water content affects the rate of briquette burning. High moisture³ content will inhibit the ignition rate so that it will reduce the rate of combustion [19]. In this study, the moisture content¹ of the briquettes obtained did not exceed the SNI because the moisture content test results were 8%. It can be seen that the more composition of coal bottom ash used, the lower the moisture content.

In Table 1, it can be seen that the highest average ash content of 26.67% was obtained in 70%:30% briquettes and the low⁶ average ash content was 0.38% in 100%:0% briquettes. The more coal bottom ash composition used, the higher the ash content of the briquettes. The ash content in this study that met the SNI was briquettes with a composition of 100%:0% and 90%:10%, with an ash content value of 8%¹.

The calorific value is the amount of heat released by each kilogram of briquettes if burned completely [19]. Table 1 shows that the highest average calorific value of 6,621.07 cal/g is 100%:0% briquette, and the lowest is 4,749.60 cal/g 70%:30% briquette. In this study, only one briquette did not meet SNI with an average calorific value of 4,749.6 cal/g, SNI for briquettes was 5,000 cal/g. It can be seen that the more composition of alaban wood charcoal waste used, the greater the calorific value of the briquettes.

The briquette combustion quality test includes initial ignition time, duration of combustion and combustion speed, as shown in Table 2.

Table 2. Briquette Combustion Quality Results.

	Alaban charcoal + bottom ash				Alaban charcoal + fly ash		
	100%:0%	90%:10%	80%:20%	70%:30%	100%:0%	90%:10%	80%:20%
Ignition time (mins)	1.32	2.02	2.13	2.22	1.32	2.20	2.52
Burning duration (mins)	74	79	80	84	74	77	84
Burning speed (g/min)	0.34	0.26	0.24	0.22	0.34	0.33	0.21

From Table 2, the quickest initial ignition time of briquettes, 1.32 minutes, were briquettes with a composition of 100%:0%, briquettes with the longest ignition time of 2.22 minutes were briquettes with a composition of 70%:30%. It is because 70%:30% of briquettes have¹ the lowest calorific value of 4,749.6 cal/g, making them difficult to ignite. At the initial ignition time, it can be seen that the higher the composition of the coal bottom ash used, the longer the initial ignition time of the briquettes.

Based on Table 2, the briquettes that ignite the fastest to become ash are briquettes with a composition of 100%:0%, which were 74 minutes and the longest¹ briquettes with a composition of 70%:30%, which was 84 minutes. In the duration of combustion, it can be seen that the higher the composition of the coal bottom ash used, the longer the period of burning the briquettes.

In Table 2, the highest burning rate of briquettes was 0.34 g/mins with a composition of 100%:0%, and the lowest burning rate was 0.22 g/minute of briquettes with a composition of 70%:30%. At the searing speed of briquettes, it can be seen that the higher the composition of the coal bottom ash used, the lower the briquette burning speed. It is because briquettes with a high coal bottom ash composition have tiny pores, and high ash content will make it difficult for outside air to enter because the ash covers the surface of the briquettes, making the combustion speed slow. In research [6] with variations in the composition of peat and palm frond charcoal, it was found that the initial ignition and the fastest briquette burning speed were briquettes with a composition of 90%:10%.

3.2. Briquettes Made from Alaban Wood Charcoal and Coal Fly Ash

The average moisture content, ash content, the calorific value of briquettes made from alaban wood charcoal biomass waste and coal fly ash from 3 samples for each material composition are shown in Table 1. Table 1 shows the average moisture content of briquettes; the lowest was 3.91% in briquettes with a composition of 100% alaban wood charcoal, while the highest is 4.31% in briquettes with a composition of 90%:10%. The value of the moisture content of all samples of briquettes meets SNI No. 01-6235-2000 ($\leq 8\%$). The moisture content affects whether or not the briquettes are easy to burn [20]. The higher the moisture content, the more complex the briquettes to burn, so the calorific value produced will also be lower.

The results in Table 1 show the highest average ash content of 17.388% in briquettes with 20% coal fly ash composition and the lowest average ash content of 0.383% in 100% alaban wood charcoal briquettes. Briquettes with 100% alaban wood charcoal composition are still below SNI, but briquettes with 10% and 20% coal fly ash composition exceed SNI. The higher the ash content in a briquette, the lower the quality of the briquettes because the high ash content means the lower calorific value of the briquettes.

The calorific value dramatically determines the quality of the briquettes. The higher the calorific value, the quality of the briquettes produced would be better. The results in Table 1 show the highest average calorific value of 6,621.067 cal/g in briquettes with a composition of 100% alaban wood charcoal and the lowest 5,283.933 cal/g found in briquettes with a composition of 20% coal fly ash. The average calorific value of all samples of briquettes according to SNI No. 01-6235-2000, the calorific value of briquettes is 5,000 cal/g. From the study results, the higher the composition of coal fly ash causes the calorific value of the briquettes to decrease.

The initial ignition timing of the briquettes can be seen in Table 2. It can be seen that the briquettes with 100% alaban wood charcoal composition have the fastest initial ignition of 1.32 minutes. In contrast, the briquettes with the longest ignition of 2.52 minutes were briquettes with a 20% coal fly ash composition. The more the addition of coal fly ash, the more difficult it is to ignite the briquettes. [21].

The results in Table 2 show that briquettes with a composition of 100% alaban wood charcoal have the fastest burning duration of 74 minutes. At the same time, the briquettes with the most extended burning duration of 84 minutes were briquettes with a composition of 20% coal fly ash. It was found that the more coal fly ash composition caused the duration of the briquettes to be burned to become longer. The longer the duration of combustion, the more efficient the use of briquettes can be.

The burning rate of briquettes is the speed at which the briquettes run out to ashes. The results in Table 2 show that briquettes with 100% alaban wood charcoal composition have the highest burning rate of 0.34 g/mins. In comparison, the briquettes with the lowest burning rate of 0.21 g/minute were briquettes with a composition of 20% coal fly ash. It seems that the more coal fly ash composition, the lower the burning rate of the briquettes.

3.3. Briquettes made from rubber seed shell and coal bottom ash

The results of the average moisture content, ash content, calorific value of briquettes made from rubber seed shell biomass waste and coal bottom ash from 3 samples for each material composition are shown in Table 3. A2 and A3 samples with a composition of 60%: 40% and 70%: 30% pressure 100 kg/cm², B2 and B3 samples with composition 60%:40% and 70%:30% pressure 150 kg/cm², C2 and C3 samples with composition 60%:40% and 70%:30% pressure 200 kg/cm².

Table 3. Rubber seed shell biomass waste and coal bottom ash briquette characteristics [22]

Sample	Moisture (%)	Ash content (%)	Calorific value (cal/g)	Ignition time (mins)	Burning Duration (mins)	Burning rate (g/ mins)
A2	10.65	16.78	4,018.66	10.35	80.56	0.62
A3	9.43	12.53	4,536.23	10.55	81.20	0.62
B2	7.57	16.73	4,578.32	12.02	90.21	0.55
B3	6.49	12.94	4,549.88	12.06	91.13	0.55
C2	5.86	17.26	3,909.81	12.19	94.21	0.53
C3	4.35	12.63	3,597.59	12.21	94.22	0.53

In Table 3, the highest moisture content is 10.65% in briquettes with a composition of 60%: 40% pressure of 100 kg/cm², while the lowest moisture content is 4.35% in briquettes with a composition of 70%:30% pressure of 200 kg/cm². High moisture content in the briquettes will cause the briquettes to be difficult to ignite. The briquetting pressure of 100 kg/cm² resulted in high water content for briquettes mixed with rubber shells and coal bottom ash. In contrast to the pressure of 150-200 kg/cm², the water content of the briquettes meets the SNI 01-6235-2000 standard. In testing the moisture content, the higher the biomass composition used, the higher the moisture content produced [23]. From the results of the moisture content, it can be seen that the moisture content decreases as the pressure is applied; this is in accordance with other research [24].

In Table 3, the addition of coal bottom ash to the briquette mixture tends to increase the ash content. The ash content of briquettes is much influenced by the chemical composition of the briquette raw materials. One of the constituent elements of ash is silica; the silica content in coal bottom ash is almost 60%. The mineral content of coal bottom ash is SiO₂ 61.92%, Al₂O₃ 16.00%; Fe₂O₃ 6.47%; CaO 6.85%; MgO 7.90% and several other compounds in relatively small amounts [25]. Increasing briquette ash content in the composition variation is due to the silica content in the coal bottom ash. The ash content of the briquettes produced is relatively low compared to mixed biomass briquettes (coffee shells, kapok shells, coconut shells) and coal bottom ash. [23]. In testing the ash content, it can be seen that the higher the pressure, the lower the ash content; this is in line with other research [8].

Based on Table 3, the calorific value is still below SNI 01-6235-2000. The highest calorific value is 4,578.32 cal/g in the composition of 60% rubber seed shell briquettes and 40% coal bottom ash with a pressure variation of 150 kg/cm². While the lowest calorific value in briquettes with a composition of 70% rubber shell and 30% coal bottom ash with a pressure variation of 200 kg/cm². The greater the pressure applied, the more the calorific value of the briquettes produced [24]. However, the tests' results obtained varied calorific values, an indication of the homogeneity factor at the time of mixing briquettes made the briquette mixture not mixed evenly [26].

Each variation in the composition of briquettes shows an initial ignition time that is not much different but tends to be slow, the initial ignition time is in the range of 10-12 minutes, with other pressures given to each briquette, namely 100 kg/cm², 150 kg/cm², and 200 kg/cm².

In Table 3, the higher the briquetting pressure, the longer the initial ignition time. Besides that, the composition of different materials with the same pressure difference in combustion duration is not too long. Still, it can be seen that the pressure difference gives a significant combustion duration. The greater the pressure applied, the denser the cavities in the briquettes, making it difficult for oxygen to enter the pores of the briquettes so that combustion tends to be slower and lasts longer until the briquettes turn to ash. Good briquettes are briquettes that have a long burning duration. The longer the flame period, it will save the use of briquettes as fuel [28]. The briquettes with the most extended burning duration of 94.22 minutes have a composition variation of 70% rubber shell: 30% coal bottom ash.

The rate of combustion is influenced by the structure of the material, the content of bound carbon, and the level of hardness of the material [29], [30]. The burning rate of briquettes in all compositions is not too far between 0.53-0.62 g/mins. Based on Table 6, it can be seen that the greater the pressure applied to the briquettes, the lower the combustion speed. Because the denser the briquettes, the smaller the pores formed, making less oxygen available so that the combustion process is hampered.

4. Conclusion

The characteristics of the briquettes obtained that the higher the composition of bottom ash and coal fly ash, the lower the moisture content and calorific value. In contrast, the ash content would be higher.

While the quality of briquette combustion, the higher the composition of bottom ash and coal fly ash, the longer the initial ignition time and duration of discharge and the lower the combustion speed. The recommended composition is 90% (alaban wood charcoal): 10% (bottom ash or coal fly ash) because the moisture content, ash content and calorific value are in accordance with the provisions of SNL. Variations in the composition and pressure of briquettes affect the characteristics and quality of combustion of rubber seed shells and coal bottom ash briquettes. The more the composition of the rubber seed shell gave lower moisture and ash content, while the calorific value was higher. Higher pressure on briquetting yielded lower moisture and ash content but higher calorific value, increasing the quality of briquette combustion. Briquettes with good combustion quality are easy to ignite, long burning duration, and have a slow combustion speed. The long burning time of a briquette will affect the quality and efficiency of combustion. A better briquette has a longer burning duration with a constant flame.

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