The Effect of Variations in The Composition of Coffee Grounds And Cocopeat Powder on The Characteristics of Briquettes With Tapioca Flour As A Binder

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ABSTRAK

Energi biomassa bisa jadi sebuah sumber energi alternatif yang dapat menggantikan bahan bakar fosil dikarenakan memiliki berbagai sifat yang punya keuntungan yakni relatif tidak memiliki sulfur hingga tidak bisa menimbulkan polusi udara, serta bisa diambil manfaatnya dengan berkesinambungan dikarenakan sifatnya yang bisa diperbarui (renewable resources). Pada penelitian ini pembuatan briket biomassa dilakukan dengan bahan dasar ampas kopi dan serbuk cocopeat. Metode yang dilakukan dalam pembuatan briket dari ampas kopi serta serbuk kayu yang punya rasio persentase bahan 80%+20%, 60%+40%, 40%+60%, 20%+80% dengan menggunakan bahan perekat tepung tapioka. Menggunakan pengepresan 50 kgf/cm2, dengan karbonisasi pada ampas kopi dan serbuk cocopeat dengan temperatur 180℃ selama 60 menit. Apabila memperhatikan pada hasil pengujian yang sudah diselenggarakan didapat variasi yang terbaik adalah variasi ampas kopi 60% dan serbuk cocopeat 40% dengan nilai kalor 5196,25 kal/g, kadar air 9,62%, kadar abu 8,11%, kadar karbon 50,2%, kadar zat terbang 67,4% juga laju pembakaran 0,1978 gram/menit.

Kata kunci: Energi, Briket, Ampas Kopi, Serbuk Cocopeat

ABSTRACT

Biomass energy can be employed as a substitute for fossil fuels in energy systems: it is relatively sulfur-free, so it does not cause air pollution, and it can be used continuously due to its renewable nature. In this study, the production of biomass briquettes were carried out using coffee grounds and cocopeat powder as the base materials. The method involved making briquettes from coffee grounds and cocopeat powder with percentage ratios of 80%+20%, 60%+40%, 40%+60%, also 20%+80% using tapioca flour as a binder. The pressing was done at 50 kgf/cm², with carbonization of coffee grounds and cocopeat powder at 180°C for 60 minutes. Based on the testing results, the best variation was 60% coffee grounds and 40% cocopeat powder with a calorific value of 5196.25 cal/g, moisture content of 9.62%, ash content of 8.11%, carbon content of 50.2%, volatile matter of 67.4%, and a burning rate of 0.1978 grams/minute.

***Keywords**: Energy, Brickets, Coffee Grounds, Cocopeat Powder*

1. INTRODUCTION

The demand for energy in the industrial, transportation, and commercial sectors continues to increase year after year, in line with the growing human population and economic development. The extensive exploitation of fossil fuels occurs due to society's heavy dependence on them, leading to further deterioration of the Earth's condition **(Kamal, 2022)**. The availability of fuels, especially fossil fuels like coal, is decreasing year by year as coal consumption increases across various sectors of life. Indonesia's coal reserves in 2022 reached 38.84 billion tons, spread across various regions in the country. With an annual coal production of around 600 million tons, the coal supply is estimated to last only 65 more years unless new reserves are discovered. **(Pratama & Praswanto, 2022)**.

One way to reduce society's dependence on fossil fuels is by producing bio-briquettes from the utilization of biomass, which is a renewable natural resource. Biomass energy can serve as an alternative energy source to replace fossil fuels because it has several advantages, such as containing almost no sulfur, thus not causing air pollution. It can be used sustainably because it is a renewable resource, and it can enhance the efficient use of agricultural and forest resources. One of the products that can be derived from biomass is briquettes.

Briquettes are solid fuel used as an alternative energy source to replace oil-based fuels, typically made through a carbonization process and then shaped under specified pressure. Generally, bio-briquettes are made from agricultural biomass charcoal, either from parts intentionally used as briquette fuel or from waste produced by agro-industrial processes **(Lukman & Vegatama, 2023)**. Materials with potential to be used as raw materials for making briquettes are coffee grounds and coconut coir (cocopeat).

Coffee grounds are solid biomass waste that is the byproduct of the coffee brewing process. The lifestyle of the millennial generation, with its high coffee consumption today, has led to the rise of coffee shops in urban areas, and even in rural regions. As coffee consumption increases, the amount of coffee ground waste also rises proportionally. **(Aprilliani et al., 2023)**.

Indonesia is the country with the largest coconut plantation area in the world, covering 3.712 million hectares **(Armina Rianti Lubis & Saiful Bahri, 2022)**. ith 96.9% of the plantations owned by smallholders, 2.7% by private companies, and 0.7% by the state. Coconut fiber or coconut shells are the largest byproduct of the coconut fruit, accounting for around 35% of the total weight of the coconut, with a production potential in Indonesia estimated at around 6.4 tons. **(Ramadan et al., 2023)**. If extracted, it will produce coconut coir dust (cocopeat) and coconut fiber (coco fibre).

The underutilization of coffee grounds and cocopeat presents an opportunity to turn them into renewable energy sources . In his regard, a solution is needed to utilize coffee grounds and cocopeat waste as renewable energy sources to address the issues associated with them. Given the potential and challenges of coffee grounds and cocopeat, both of these biomass materials are suitable to be used as raw materials for briquette production.

In briquette production, several factors can influence the quality of a briquette, such as carbonization temperature, type of charcoal powder or fuel, and the pressure during the molding or compaction process. **(Haurissa et al., 2021)**. In addition to the factors mentioned earlier, another factor that affects the quality of briquettes is the additives or supporting materials used as binders. These binders function to hold together the particles of the main material in the briquette production process.

Briquette production using binders will yield better results compared to briquette production without binders **(Ramadhan et al., 2020).** In briquette production, adding binders aims to ensure that charcoal particles are bonded together and do not easily break apart **(Zaenul amin et al., 2017)**. Binders are additional or supporting materials used in the briquette production process. Binders can come from inorganic or organic sources. Organic binders produce better results and generate lower ash content during the combustion process. Generally, an effective and commonly used binder is tapioca flour (starch). Tapioca flour has several advantages as a binder, including the ability to create high dry pressure, its low cost and easy availability, and its ease of use **(Alfianolita, 2018)**.

Currently, there has been extensive research on briquettes, and many developments related to briquette research have been carried out. Previous researchers have conducted several experiments with various briquette production methods to achieve the best quality. One of the earlier studies is the research conducted by **(Umar, 2021)**, The study used coffee grounds as the main material and added cocopeat, with variations of 100% coffee grounds + 0% cocopeat, 75% coffee grounds + 25% cocopeat, 50% coffee grounds + 50% cocopeat, 25% coffee grounds + 75% cocopeat, and 0% coffee grounds + 100% cocopeat. Tapioca starch was used as a binder, mixed with aquades. The best result for the highest calorific value was found with the 100% coffee grounds + 0% cocopeat variation, which had a calorific value of 5292.443 cal/g. This result met the SNI 01-6235-2000 standard for briquette quality and specifications. However, on the other hand, the moisture content for the 100% coffee grounds + 0% cocopeat variation was high, at 20.66%. Adding cocopeat reduces the moisture content of the briquettes, as demonstrated by the 75% coffee grounds + 25% cocopeat variation, which had the lowest moisture content among all variations, at 20.55%.

Research related to briquettes has also been conducted by **(Pratama & Praswanto, 2022)** Research related to briquettes has also been conducted by using a mixture of coffee grounds and wood powder with palm oil, along with a binder made of botanical flour. The variations included 30 g coffee grounds + 0 g wood powder, 20 g coffee grounds + 0 g wood powder, 15 g coffee grounds + 15 g wood powder, 10 g coffee grounds + 20 g wood powder, and 0 g coffee grounds + 30 g wood powder. The best results from this research were found in the 30 g coffee grounds + 0 g wood powder variation, which had the highest calorific value compared to other variations, at 8180.517 cal/g. Additionally, it had the lowest moisture content among the variations, at 4.57%.

The next briquette research was conducted by **(Kambey et al., 2022)** The next briquette research was conducted regarding the quality testing of coconut coir briquettes as an alternative biomass source. In this study, the quality of the briquettes was tested for moisture content, calorific value, burning rate, and flame duration, using coffee grounds as the main material and tapioca flour as the binder. The binder variations included 5%, 7.5%, and 10%. The research results showed that the highest calorific value was achieved with the 7.5% binder variation. The study also found that adding more binder increased the burning rate and flame duration, but it negatively affected the calorific value of the briquettes. As the binder amount increased, the calorific value of the briquettes decreased.

In accordance with several previous studies, the title "The Effect of Variations in Coffee Grounds and Cocopeat Composition on Briquette Characteristics with Tapioca Flour Binder" was chosen. This research aims to determine the moisture content, ash content, carbon content, calorific value, and volatile matter content using coffee grounds and cocopeat as the main materials. The variations used are 80% coffee grounds + 20% cocopeat, 60% coffee grounds + 40% cocopeat, 40% coffee grounds + 60% cocopeat, and 20% coffee grounds + 80% cocopeat.

2. METHODOLOGY

This research falls into the category of quantitative research using experimental methods. This method is used to investigate cause-and-effect relationships resulting from the influence of various compositions in briquettes. The research design is carried out in 2 stages, namely:

2.1 Stage of Briquette Production

A B

Figure 1. a) Coffe Ground, b) Cocopeat Powder

Coffee grounds and cocopeat powder are cleaned of any adhering impurities. The materials are then dried under the sun to reduce their moisture content. Coffee grounds are dried for 3 days with 6 hours of drying each day, while cocopeat is dried for 4 days with 6 hours of drying each day. Once dried, the coffee grounds and cocopeat are subjected to a carbonization process using a drum placed on a stove. They are burned until the materials no longer produce smoke. The drum is closed and air holes are added around the top of the drum to accelerate the carbonization process. This carbonization process lasts for 1-2 hours at a temperature of around 180°C, followed by cooling for 30-45 minutes

The charcoal formed after the carbonization process is then ground using a 40-mesh sieve until a fine charcoal powder is obtained. The next step is mixing the briquette ingredients with ground peanut shells and coffee grounds, which are then combined with a binder at a ratio of 85% raw materials to 15% binder of the total mass. The mixture is then molded using prepared molds and pressed with a pressure of 50 kg/cm². Subsequently, the briquettes are dried in an oven at 100°C for 1 hour. After drying, the briquettes are tested to determine the quality of the finished product.

2.2 STAGE OF BRIQUETTE TESTING

The produced briquettes are then subjected to tests for moisture content, ash content, carbon content, volatile matter, calorific value, and burning rate. The methods used for testing the briquettes are:

2.2.1 Moisture Content Testing

Moisture content testing aims to determine the amount of moisture in the charcoal briquettes. The testing procedure begins by weighing a 1 g sample. The sample is then placed into a moisture analyzer, which has been set to a temperature of 115°C ± 5°C for 3 hours. The formula for moisture content testing can be seen in Equation 1.

$$\text{Moisture Content (\%)} = \frac{B-C}{B-A} X\ 100\% \quad (1)$$

Description :

A = Mass of the Empty Cup (gram)
B = Mass of the Empty Cup + Sample (gram)
C = Mass of the Empty Cup + Sample after Oven Drying (gram)

2.2.2 Ash Content Testing

Ash content testing aims to determine the residue left after the combustion process, such as the remaining ash in charcoal briquettes. The testing begins by weighing 2 g – 3 g of the sample into a pre-weighed cup. The test is conducted using a furnace at 800°C for 2 hours. Once the sample has turned into ash, the cup is cooled in a desiccator and then weighed. If necessary, the ash is weighed again until a constant weight is achieved. The formula for ash content testing can be seen in Equation 2.

$$\text{Ash Content (\%)} = \frac{C-A}{B} X\, 100\% \quad (2)$$

Description :
A = Mass of the Empty Cup (gram)
B = Mass of the Empty Cup + Sample (gram)
C = Mass of the Empty Cup + Sample after Oven Drying (gram)

2.2.3 Carbon Content Testing

Carbon content testing aims to indicate the amount of charcoal remaining after the briquette burning stage. The formula for carbon content testing can be seen in Equation 3.

$$\text{carbon (\%)} = 100\% - (\%\ \text{zat terbang} + \%\ \text{abu}) \quad (3)$$

2.2.4 Volatile Matter Testing

This test aims to measure the amount of components that evaporate during the briquette combustion process. The formula for testing volatile matter content can be seen in Equation 4.

$$\text{Volatile Matter} = \frac{a-b}{b} \times 100\% \quad (4)$$

Description :
a = Mass of Briquette Sample (gram)
b = Mass of Briquette Sample after Heating (gram)

2.2.5 Calorific Value Testing

Calorific value testing aims to measure the amount of heat energy produced by a briquette. The formula for calorific value testing can be found in Equation 5.

$$\text{Calorific Value} = \frac{\Delta TW - I_1 - I_2 - I_3}{a} \quad (5)$$

Description :

Hg = Heat energy of combustion
t = Corrected net temperature rise
W = 2426 calories/°C (according to the conversion of the tool used)

e1 = Correction in caloric value is made to calculate the heat generated during the formation of nitric acid (HNO3)
e2 = 13.7 x 1.02 x sample weight
e3 = 2.3 x length of burning fuse wire
m = Mass of briquette sample (gram)

Figure 2 is a flowchart depicting the stages of the experimental research on the production and testing of briquettes made from coffee grounds and cocopeat with varying compositions.

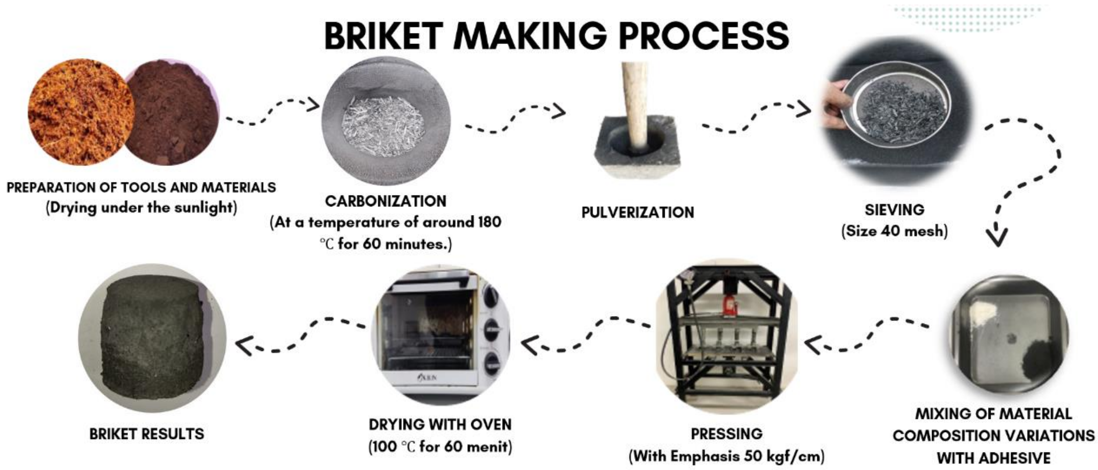

Figure 2. Briket Making Process

3. RESULTS AND DISCUSSION

The results of the briquette research with variations in the composition of coffee grounds (CG) and cocopeat powder (CP), using tapioca flour as a binder, are presented in tables and figures. This study includes testing for moisture content, ash content, carbon content, calorific value, volatile matter, and burning rate. The results of the briquette testing are analyzed and compared to determine whether the briquette quality meets the SNI briquette standards and is classified as high quality. Below, Figure 3 shows the briquette products molded using various compositions of coffee grounds and cocopeat powder.

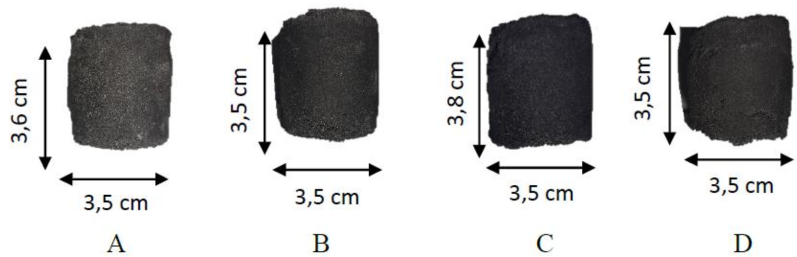

Figure 3. Briquettes with variations in composition of CG :CP. a) 80%:20%, b) 60%:40%, c) 40%:60%, d) 20%:80%

3.1 Moisture Content

Moisture Content Testing aims to determine the amount of moisture present in the charcoal briquettes. The equipment used for moisture content testing is a Moisture Analyzer. Before the test, the briquettes to be tested are crushed into a powder. The sample mass is then weighed, with an average weight of 2 grams per sample. During moisture content testing, the time and temperature are monitored until the moisture content value becomes constant. The results of the moisture content testing can be seen in the graph shown in Figure 4 below.

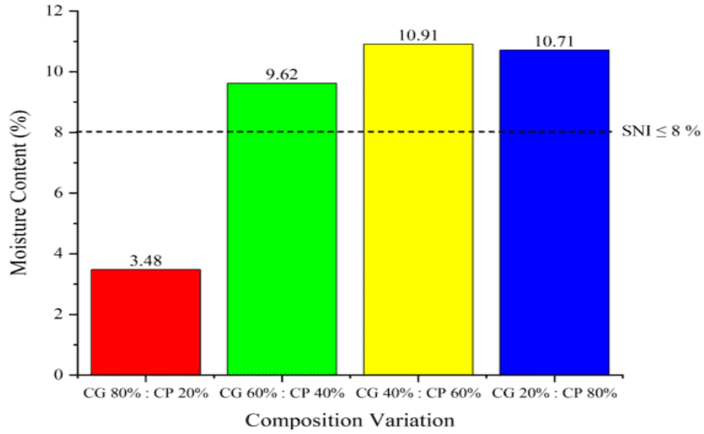

Figure 4. Moisture Content Graph

According to the results of the moisture content testing shown in Figure 4 above, the results for sample 1 with the first composition variation of 80% coffee grounds and 20% cocopeat were 3.48%. For sample 2 with the composition variation of 60% coffee grounds and 40% cocopeat, the moisture content was 9.62%. For sample 3 with the composition variation of 40% coffee grounds and 60% cocopeat, the moisture content was 10.91%. Finally, for sample 4 with the composition of 20% coffee grounds and 80% cocopeat, the moisture content was 10.71%.

From the data of the moisture content testing conducted, it can be observed that as the percentage of cocopeat powder increases, the moisture content in the briquettes also tends to increase. This is likely due to the hygroscopic nature of cocopeat powder, which has a high ability to retain and absorb moisture effectively **(Kuntardina et al., 2022).** From the data of the moisture content testing conducted by the author, it was found that sample 1 with a composition of 80% coffee grounds and 20% cocopeat had a result of 3.48%, which does not meet the SNI moisture content standard of 8% specified in SNI 01-6235-2000.

3.2 Ash Content

The ash content value indicates how much residue remains after burning the charcoal briquettes. The equipment used for this testing is a furnace. The quality of charcoal briquettes decreases with an increase in ash concentration. The analysis of ash content in this test can be seen in figure 4 below.

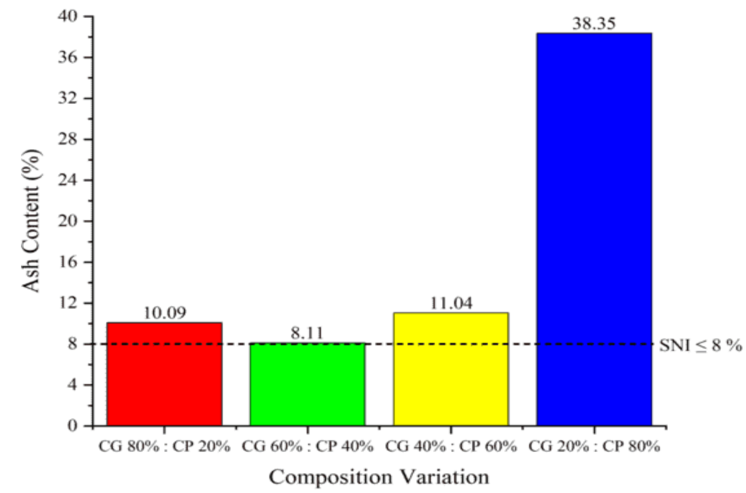

Figure 5. Ash Content Graph

From the figure above, it can be observed that the sample with the lowest ash content is sample 2, with a composition of 60% coffee grounds and 40% cocopeat, having an ash content of 8.11%. Next, in second place, is sample 1 with a composition of 80% coffee grounds and 20% cocopeat, with an ash content of 10.09%. In third place is sample 3 with a composition of 40% coffee grounds and 60% cocopeat, which has an ash content of 10.91%. Lastly, in fourth place is sample 4 with a composition of 20% coffee grounds and 80% cocopeat, which has the highest ash content at 39.35%.

None of the four tested samples met the SNI 01-6235-2000 standard. Several factors can contribute to high ash content in briquettes. One factor affecting ash content in a briquette is the conventional carbonization process, which does not reach the torrefaction temperature of 200°C or the pyrolysis temperature of 500°C. Carbonization during pyrolysis produces lower ash content compared to conventional carbonization. This is because materials burned in traditional burning processes tend to interact with the surrounding air, breaking down biomass into ash **(Anizar et al., 2020)**. Additionally, impurities in the raw materials can contribute to high ash content in briquettes by increasing the mineral content of the charcoal and leaving a significant amount of ash as a residue from the burning process **(Ristianingsih et al., 2015)**.

3.3 Carbon Content

Carbon content indicates how much material remains after burning the charcoal briquettes. A furnace is the equipment used for testing carbon content. The amount of bound carbon in the briquette fuel affects its quality; the higher the concentration of bound carbon, the higher the quality of the briquette produced. The amount of bound carbon in the mixture results in a higher calorific value. When this happens, briquettes with high bound carbon content will burn with less smoke. **(Anizar et al., 2020)**.

From the results of the carbon content testing conducted by the author, it was found that the sample with the highest carbon content is sample 2, with a composition of 60% coffee grounds and 40% cocopeat, having a carbon content of 50.2%. The second highest carbon content is found in sample 1, with a composition of 80% coffee grounds and 20% cocopeat, which has a carbon content of 47.93%. Following this, sample 3 with a composition of 40% coffee grounds and 60% cocopeat has a carbon content of 43.93%. The sample with the lowest carbon content is sample 4, with a composition of 20% coffee grounds and 80% cocopeat, which has a carbon content of 18.9%. The carbon content analysis for this test can be seen in Figure 5 below.

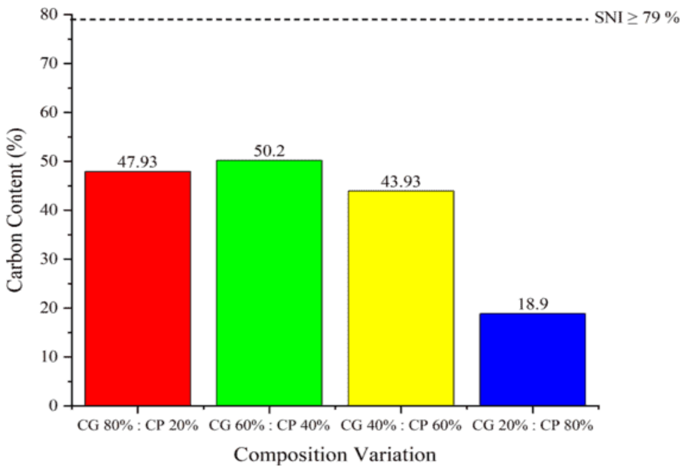

Figure 6. Carbon Content Graph

3.4 Volatile Matter

When analyzing the concentration of volatile matter, it refers to substances other than water that can evaporate during the decomposition of compounds remaining in charcoal or briquettes. A furnace is used for testing the volatile matter content. The results of the volatile matter testing can be seen in Figure 6 below.

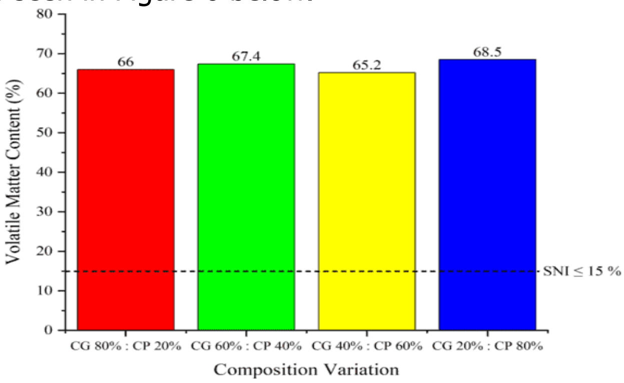

Figure 7. Volatile Matter Content Graph

According to the results of the volatile matter testing conducted by the author, the following findings were obtained: Sample 1, with a composition of 80% coffee grounds and 20% cocopeat, had a volatile matter content of 66%. Sample 2, with a composition of 60% coffee grounds and 40% cocopeat, had a volatile matter content of 67.4%. Sample 3, with a composition of 40% coffee grounds and 60% cocopeat, had a volatile matter content of 65.2%. Lastly, Sample 4, with a composition of 20% coffee grounds and 80% cocopeat, had a volatile matter content of 68.5%.

From the testing data conducted by the author, it can be observed that none of the four samples tested meet the SNI 01-6235-2000 standard. The SNI 01-6235-2000 specifies a maximum volatile matter content of 15%. Several factors can contribute to the low volatile matter content in the tested briquettes. One such factor is the testing process itself. A limitation of using a furnace for testing is that the presence of oxygen can lead to partial combustion of the material, producing additional gases from incomplete combustion, which increases the volatile matter results. Since furnaces often operate in an oxygen-rich atmosphere, they can cause partial combustion of organic materials, resulting in higher volatile matter readings due to the inclusion of gases formed from burning. In contrast, volatile matter machines are designed to work in inert conditions (without oxygen), usually using nitrogen to prevent sample combustion. Additionally, the amount of volatile matter in briquettes can vary during the carbonization process. The volatile matter content is correlated with the carbonization temperature, meaning that as the temperature increases, the volatile matter content tends to decrease **(Fachry et al., 2010)**.

3.5 Calorific Value

The most important factor in evaluating the use of briquettes as fuel is their calorific value. Improved quality of briquettes is indicated by an increase in calorific value. Before conducting tests using a bomb calorimeter, the briquettes are first ground into powder, weighing an average of 0.3 grams per sample, with testing carried out over a period of 20 minutes per sample to measure the temperature of the test material before and after the bombing. During the first five minutes, the temperature is recorded before bombing, and from five minutes and 45 seconds to seven minutes, the temperature continues to rise. By the 11th or 12th minute, the temperature stabilizes, and the testing concludes by the 20th minute. Following this, an analysis and calculation are performed

According to the results of the calorific value tests conducted by the author, the first sample with a composition of 80% coffee grounds and 20% cocopeat yielded a value of 5108.06 cal/g. The second sample, with a composition of 60% coffee grounds and 40% cocopeat, had a calorific value of 5196.25 cal/g. The third sample, composed of 40% coffee grounds and 60% cocopeat, resulted in a calorific value of 4909.69 cal/g. Finally, the fourth sample with a composition of 20% coffee grounds and 80% cocopeat had a calorific value of 4842.52 cal/g. The data analysis results from the calorific value tests can be seen in Figure 7 outlined below.

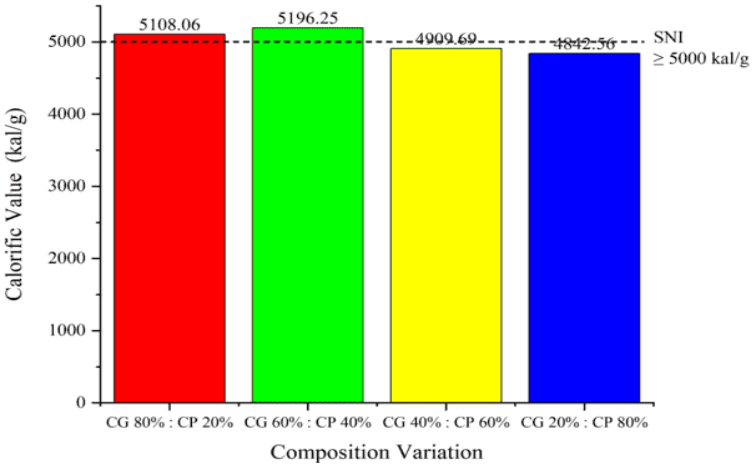

Figure 8. Calorific Value Graph

he calorific value of briquettes can vary depending on several factors. The calorific value is directly proportional to the carbon content, which affects the quality of the briquette. Additionally, the quality of the briquette can also be influenced by the ash content. The relationship between ash content and calorific value is inversely proportional; thus, if the ash content in a briquette is higher, its calorific value will be lower **(Faijah, Fadilah Ratnawaty, 2020)**. From the results of the research conducted by the author, it was found that sample 1 with a composition of 80% coffee grounds and 20% cocopeat, and sample 2 with a composition of 60% coffee grounds and 40% cocopeat, met SNI 01-6235-2000, which has a minimum calorific value limit of 5000 cal/g. Sample 1 had a calorific value of 5108.06 cal/g, while sample 2 had a calorific value of 5196.25 cal/g.

3.6 Burning Rate

The burning rate is a testing process for the fuel, namely the briquette, to determine how long the fuel will burn and to observe the mass loss over time. The briquette being tested is made from coffee grounds and cocopeat powder with varying compositions, using tapioca flour as a binder. By separating the mass of the briquette from the amount of time it takes for the charcoal to completely burn, one can calculate the burning rate of the briquette. Figure 8 below presents the findings from the analysis.

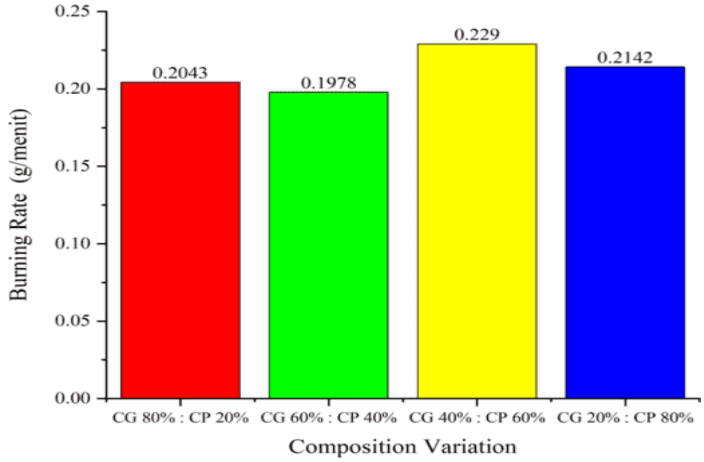

Figure 9. Burning Rate Graph

Based on the results of the burning rate test conducted by the author, as observed in Figure 4.7 above, the first sample with a composition of 80% coffee grounds and 20% cocopeat has a burning rate of 0.2043 grams/minute with a burning duration of 1 hour and 33 minutes, or 93 minutes. Next, the second sample with a composition of 60% coffee grounds and 40% cocopeat has a burning rate of 0.1978 grams/minute with a burning duration of 1 hour and 31 minutes, or 91 minutes. For the third sample with a composition of 40% coffee grounds and 60% cocopeat, the burning rate is 0.229 grams/minute with a burning duration of 1 hour and 23 minutes, or 83 minutes. Lastly, for the fourth sample, the burning rate is 0.2142 grams/minute with a burning duration of 1 hour and 24 minutes, or 84 minutes

The magnitude of the burning rate value will affect the quality of a briquette; if the burning rate of a briquette is low, the quality of that briquette is better. This is because the briquette will last longer when used **(Pratama & Praswanto, 2022)**. From the results of the burning rate tests conducted by the author, different outcomes were obtained for each variation of coffee grounds and cocopeat. The magnitude of the values obtained in the burning rate tests can be influenced by the calorific value. A higher calorific value leads to a better burning rate, indicating good energy efficiency in the briquettes **(Yoisangadji & Pohan, 2022)**.

4. CONCLUSION

The conclusions of this study are as follows

1. Based on the research conducted by the author, the best result was found in the second sample with a composition of 60% coffee grounds and 40% cocopeat. This sample had a calorific value of 5196.25 cal/g, moisture content of 9.62%, ash content of 8.11%, carbon content of 50.2%, volatile matter content of 67.4%, and a burning rate of 0.1978 grams/minute. This indicates that variations in the composition of materials can influence the characteristics of briquettes made from coffee grounds and cocopeat.
2. According to the research conducted by the author, there are two parameters that meet the SNI 01-6235-2000 standards, namely the moisture content parameter with a maximum value of 8%. In the composition variation of 80% coffee grounds and 20% cocopeat, the moisture content is 3.48%. The second parameter is the calorific value test, with a minimum calorific value threshold of 5000 cal/g. In the variation of 80% coffee grounds and 20% cocopeat, the calorific value test result is 5108.06 cal/g, and in the variation of 60% coffee grounds and 40% cocopeat, the calorific value test result is 5196.25 cal/g.

3. According to the research conducted by the author, the variation in composition between coffee grounds and cocopeat powder can influence the characteristics of a briquette. It was found that each sample variation resulted in different characteristic values for each variation.

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