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EFFECT OF VARIATION IN TAPIOCA ADHESIVE COMPOSITION ON QUALITY OF COCONUT PULP CHARCOAL BIO-BROQUETTE

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ABSTRACT

Energy needs and consumption are still increasing, while energy sources continue to decrease due to their non-renewable nature. Renewable energy sources are needed as a substitute for alternative energy that is renewable, cheap, and environmentally friendly. Making bio-broquettes from coconut pulp charcoal is one of the studies that need to be studied and developed at this time. The abundance of coconut pulp waste is still not optimally utilized in managing its potential as a material for making bio-broquette. The composition of the adhesive used determines the quality of the bio-broquettes. This study aims to determine the effect of variations in the composition of tapioca adhesive on the calorific value, moisture content, density, ash content, fly content, carbon content, and burning rate of bio-broquettes. The material used for making bio-broquettes is coconut pulp charcoal. While the composition of tapioca adhesive that is varied is 30%, 40%, and 50%. The research used an experimental method, with 3 test treatments for each sample. The results obtained with 30%, 40%, and 50% tapioca adhesive for all test parameters have met the quality standards of charcoal bio-broquettes based on SNI 01-6235-2000. The best composition of tapioca adhesive is bio-broquettes that have a ratio of coconut pulp charcoal with 70% tapioca adhesive: 30% which produces the highest calorific value of 6,825.79 cal/gram, the lowest moisture content of 5.66%, density of 2.25 grams/cm3, the lowest ash content of 2.82%, the lowest fly substance content of 3.17%, the highest carbon content of 88.35%, and the highest burning rate of 0.1032 grams/minute.

Keywords : Bio-broquettes, Bio-broquettes quality, Coconut pulp, Tapioca adhesive.

I. INTRODUCTION

Energy problems cannot be separated from human life, the increase in population, the improvement of human lifestyles and the growing number of industries have resulted in the demand for energy needs continuing to increase, while the availability of energy reserves is running low. This is because energy is one of the basic needs in human life. The increasing number of human activities that use fuel oil sourced from fossil animals and plants causes energy demand to increase every year. Renewable energy sources are needed as a substitute for alternative energy that is renewable, cheap, and environmentally friendly. One alternative energy that needs to be studied and developed at this time is the use of biomass energy by converting it into bio-broquettes. Bio-broquettes are a type of charcoal-shaped fuel made from various kinds of biomass waste or biological materials, such as twigs, leaves, grass, branches, straw obtained from market waste, households, and market waste which are very abundant in the environment but have not been optimally used or even not utilized properly. The use of bio-broquettes can minimize and save the use of fossil fuels [1].

One of the biomass opportunities that can be produced in the Padang city area is coconut pulp waste. Coconut pulp waste is very much found in the kampung jawa market, Padang Barat sub-district. Until now, the abundance of coconut pulp waste has not been optimally utilized, especially in the market environment sector. Coconut meat pulp is a biomass derived from organic substances from coconut milk that still contains fat and oil around 12.2 - 15.9% which can be converted into energy. Coconut meat pulp has a high content of cellulose, hemicellulose, and

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lignin [2]. Dried coconut pulp (fat-free) contains 93% carbohydrates consisting of: 61% galactomannan, 26% mannose and 13% cellulose. As for coconut pulp charcoal, it contains 12.2% fat, 18.2% protein, 20% crude fiber, 4.9% ash, and 6.2% moisture content. Due to the high content of lignin and cellulose, coconut pulp is very suitable to be used as the main raw material in the processing of bio-broquettes [3].

The quality of bio-broquettes depends on the type of biomass raw material used and operating conditions such as drying temperature and duration, burning temperature and duration, sieve size, mass of coconut pulp charcoal, volume ratio of water and adhesive, pressure strength, shape and size of the molding tool and type and composition of the adhesive used. The best bio-broquettes were cylindrical solids with a diameter of 2 cm and a height of 4 cm, which were studied by experimental methods [4]. The best drying temperature and duration of raw materials for making bio-broquettes is 1000 C for 3 hours [5]. The best temperature and duration of charring the raw materials for making bio-broquettes and burning bio-broquettes is 3000 C for 1 hour [6]. The best sieve size used during the charcoal pulverization process of coconut pulp is 80 mesh [7]. The best ratio of water volume to the mass of tapioca flour during the process of making tapioca adhesive material is 1: 1. With the best pressure strength when pressing the coconut pulp charcoal bio-broquettes sample is 100 N/cm2 [8].

Another factor that greatly influences the quality of bio-broquettes is the composition of the adhesive used. The role of tapioca adhesive on coconut pulp charcoal biobriquettes is to increase the calorific value, but in the research results obtained that the calorific value of biobriquettes decreased as the mixture of tapioca adhesive increased, so the addition of tapioca adhesive to biobriquettes should not be excessive. A large amount of adhesive causes the moisture content to increase so that the resulting calorific value will be lower. This is because the calorific value produced by the briquette is first used to evaporate the water trapped in the briquette before generating heat which is used as heat of combustion.One of the adhesives that can be used to glue the particles of substances in order to produce compact Bio-broquettes is tapioca starch. Tapioca starch has favorable properties in food processing, high solution purity, good gel strength and high adhesion so it is widely used as an adhesive material. The nutritional content of tapioca starch per 100 grams is 362 calories, 0.59% protein, 3.39% fat, 12.9% water and 6.99% carbohydrates. In addition, the advantages of tapioca as an adhesive increase the quality of Bio-broquettes such as low moisture content and ash content so that tapioca is very good as an adhesive [9].

The best variation of tapioca adhesive composition that meets the SNI standard is 30% of the mass of raw materials for making biobriquettes. Meanwhile, biobriquettes with more than 50% adhesive are classified as too much adhesive for biobriquette adhesive mixture. In accordance with previous research that suggests using a lower adhesive composition of the waste material used and not more than 50% of the mass of raw materials for making biobriquettes. This is so that the potential of the waste material used really show that it can be utilized as good and usable biobriquettes with good quality. Another reason is that the large amount of adhesive in biobriquettes usually causes the resulting biobriquettes to contain a lot of water, difficult to form, melting texture, and very low calorific value [10].

Based on the above problems and seeing the potential of coconut pulp as raw material in making biobriquettes that are appropriate, efficient, and zero waste. Encouraging me as a researcher to find out and research, how does the effect of variations in the composition of tapioca adhesive on quality of coconut pulp charcoal bio-broquette?

II. METHOD

This research is an experimental research with literature study. Experimental research is research that has a high level of accuracy or that has more accuracy than other types of research methods, to get a causal relationship. This study examines the effect of variations in the composition of tapioca adhesive on the quality of coconut pulp charcoal biobriquettes conducted at the Laboratory of Higher Education Service Institution Region X Padang for the process of making coconut pulp charcoal biobriquette samples and testing calorific value, moisture content, density, ash content, fly substance content, carbon content, and combustion rate. The research design in this study was carried out in 4 stages, namely: making coconut pulp charcoal, making tapioca adhesive, making coconut pulp charcoal briquette samples, testing the quality of coconut pulp charcoal briquettes.

The first step is the preparation of coconut pulp charcoal samples. The coconut pulp was cleaned and then weighed using a scale according to the sample needs, namely as many as 9 samples, then dried using an oven for 3 hours at 100 ° C for the drying process. After the drying process, the samples were put into the furnace for 1 hour at 300°C for the charring process, then grinding with a mortar and pestle to smooth the coconut pulp charcoal and then sieved with an 80 mesh sieve. The transformation of coconut meat pulp into coconut meat pulp charcoal as shown in Figure 1.

(a) (b) (c)

Fig. 1. Process of making coconut pulp charcoal
(a) Coconut pulp, (b) pulp after drying, (c) Coconut pulp charcoal

From Figure 1 above, it can be seen that the changes in coconut pulp initially still contain a lot of water content. After drying the coconut pulp looks dry and the water content is reduced, until finally the coconut pulp turns into coconut pulp charcoal after the charring process.

The second step is the manufacture of tapioca adhesive material. The tapioca adhesive is made by mixing tapioca flour with water which has a ratio of 1: 1 in a container, then the tapioca adhesive material is cooked and stirred until it is evenly distributed to form an adhesive mixture. The composition of tapioca adhesive produced is 30%, 40% and 50% of the weight of coconut pulp charcoal.

The third step is to make a sample of coconut pulp charcoal briquettes. The sifted coconut pulp charcoal was then weighed as much as 70%, 60%, and 50% of the mass of tapioca adhesive. Then the coconut pulp charcoal is put into a beaker glass, then the coconut pulp charcoal and tapioca adhesive are mixed into the same beaker glass. The biobriquette sample consists of coconut pulp charcoal and tapioca adhesive in the ratio of 7: 3, 3 : Next, the coconut pulp charcoal biobriquette sample dough is formed into a cylindrical biobriquette sample, with the help of a PVC pipe measuring 2 cm in diameter and 4 cm in height. Then the sample is pressed using a biobriquetting hydraulic press with a pressure of 100 N/cm2. The process of mixing tapioca adhesive with coconut pulp charcoal to become a biobriquette sample of coconut pulp charcoal can be seen in Figure 2.

(a) (b) (c)

Fig. 2. Process of making biobriquette samples
(a) Mixing of charcoal and adhesives, (b) Molds of coconut pulp charcoal biobriquettes, (c) Samples of coconut pulp charcoal biobriquettes

From Figure 2 above, it can be seen that the mixing of tapioca adhesive and coconut pulp charcoal causes the biobriquette samples to coalesce and form a cylindrical coconut pulp charcoal biobriquette sample that is molded using a cylindrical PVC pipe with a height of 4 cm and a diameter of 2 cm. With the shape and size of the coconut pulp charcoal biobriquettes have met the quality standards of SNI 01-6235-2000 charcoal biobriquettes.

The fourth step is testing the quality of coconut pulp charcoal biobriquettes. The resulting samples of coconut pulp charcoal biobriquettes were then tested for calorific value, moisture content, density, ash content, fly content, bound carbon content and burning rate. The calorific value was measured using a calorimeter bomb device by weighing the sample before testing, connecting the calorimeter bomb device with a platinum wire until it touched the briquettes to be tested, turning on the main switch then filling it with water in the jacket hole at the bottom of the cover, connecting the circulator with a water cooler with a hose that has been installed at 400ºC, position the calorimeter cover in the open position, then install the sample on the calorimeter bomb circuit that has been arranged into the bomb head, then the bomb head containing the sample is put into the bucket, turn on the timer

T1 for 10 minutes, record the temperature found on the display, turn on the combustion switch, turn on the timer T2 then record the temperature found on the display. The moisture content of the biobriquettes was determined by weighing the mass of the biobriquette sample using a scale, after which the biobriquette sample was dried using a laboratory oven at 100ºC for 3 hours until the weight was constant, then the material was cooled in a desiccator for 5 minutes after which the biobriquette sample was weighed again. The biobriquette density test was conducted by measuring the mass and volume of the coconut pulp charcoal biobriquette samples.

The coconut pulp charcoal biobriquette samples have been molded and oven dried and then tested for ash content by weighing the mass of the biobriquette samples using a scale, then the samples are put into a furnace at 300°C for 1 hour. After that, the biobriquette samples were cooled in a desiccator for 5 minutes and then weighed the ash produced after the combustion process. The fly content test was carried out simultaneously with the ash content test by weighing the mass of the biobriquette sample (M1) before the ignition process using a scale, then the sample was placed in a furnace at 300°C for 1 hour. After that, the coconut pulp charcoal biobriquette sample was cooled in a desiccator for 5 minutes then the remaining coconut pulp charcoal biobriquette sample from the furnace process was weighed again (M2). The bound carbon content contained in the biobriquettes was calculated by summing up the results of the moisture content, ash content, and fly content of the coconut pulp charcoal biobriquettes. The burning rate of the coconut pulp charcoal biobriquette sample is determined by calculating the mass of the biobriquette sample and then burning the biobriquette sample until the biobriquette stops burning or runs out, after which the time required in the process of burning the coconut pulp charcoal biobriquette until it runs out is calculated.

III. RESULTS AND DISCUSSION

This study was conducted to determine the effect of variations in tapioca adhesive composition on the quality of biobriquettes through 7 stages of testing including: calorific value, moisture content, density, ash content, fly content, carbon content, and combustion rate. The first test is the calorific value test. The heating value is the main characteristic in determining the quality of the biobriquettes produced. Good quality biobriquettes are those with the highest calorific value. Calorific value is the amount of heat energy produced or released by a fuel through the combustion reaction of the fuel. Calorific value can be interpreted as the amount of heat obtained from burning a certain amount of fuel in biomass biobriquettes, the higher the density of the fuel, the higher the calorific value obtained [11]. Data and the effect of tapioca adhesive composition on the resulting coconut pulp charcoal biobriquettes can be seen in Figure 3.

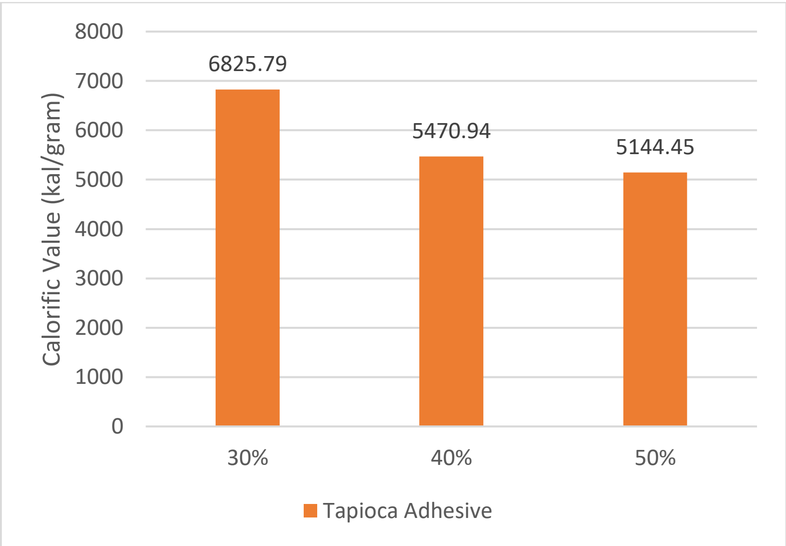
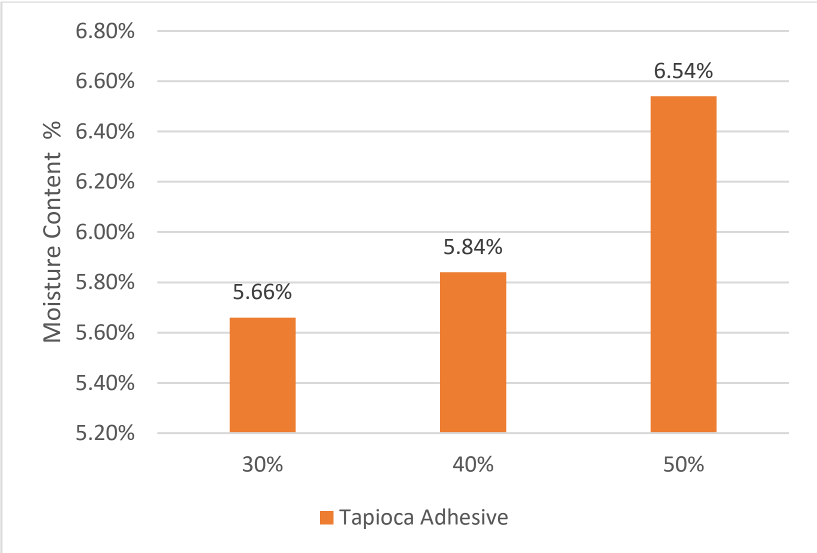


Fig. 3. Adhesive Percentage vs Calorific value

Based on Figure 3 above, it can be seen that variations in the composition of tapioca adhesive have a significant effect on the heating value of coconut pulp charcoal biobriquettes produced. If the composition of tapioca adhesive material is increasingly mixed in the manufacture of coconut pulp charcoal biobriquettes, the heating value produced will be lower. This is influenced by the cellulose and lignin content of the tea leaves. The higher the lignin content, the better the calorific value and vice versa. A high calorific value results in a high combustion rate. From the results of obtaining the water content of biobriquettes, it can be seen that the calorific value is inversely proportional to the value of water content and ash content obtained, where the higher the calorific value produced, the lower the value of water content and ash content contained in the biobriquettes. This is in line with Norman's research in 2019 which explains that the heating value is influenced by the moisture content and ash content of charcoal biobriquettes. The higher the moisture content and ash content of charcoal briquettes, the lower the heating value of the resulting charcoal briquettes [12]. Coconut pulp charcoal briquettes that have the highest calorific value are those with the addition of tapioca starch adhesive at 30%. While the lowest calorific value is biobriquettes with the addition of tapioca starch adhesive at 50% composition. The calorific value of biobriquettes obtained for all variations of tapioca adhesive composition ranged from 5,144.45 cal/gram - 6,825.79 cal/gram and met the quality standards of charcoal biobriquettes based on SNI 01-6235-2000 which requires a minimum calorific value of 5000 cal/gram.

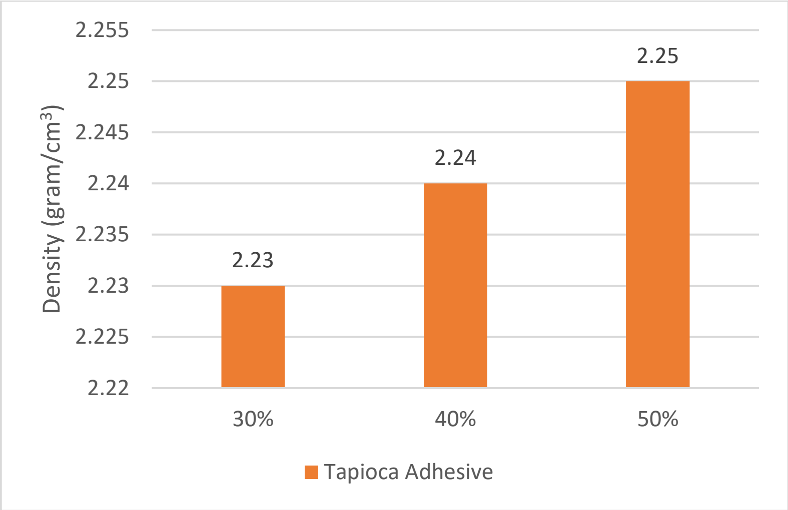
The second test is testing the water content of coconut pulp charcoal biobriquettes. water content is the amount of water content contained in the biobriquette sample. Data on moisture content and the effect of tapioca adhesive composition on the resulting coconut pulp charcoal biobriquettes can be seen in Figure 4.



Gambar. 4. Adhesive Percentage vs Moisture Content

Based on Figure 4 above, it can be seen that variations in the composition of tapioca adhesive have a significant effect on the water content of the resulting coconut pulp charcoal biobriquettes. If the composition of tapioca adhesive mixed in the manufacture of biobriquettes is more and more, the water content contained in the biobriquettes will also be higher. This happens because the moisture content of biobriquettes is influenced by the type of raw material, type and composition of the adhesive mixed in the manufacture of biobriquettes. Dian Asmaul Chusniyah in 2022 explained that high water content will reduce the calorific value and combustion rate because the heat provided is used first to evaporate the water contained in the briquette. Biobriquettes containing high water content will be easily destroyed and easily overgrown with mold. The addition of higher adhesives causes the water contained in the tapioca adhesive to enter and be bound in the pores of the briquette charcoal [13]. The moisture content of biobriquettes obtained ranged from 5.66% - 6.54%. biobriquettes that have the lowest moisture content are biobriquettes with the addition of tapioca starch adhesive material at 30% composition. While the highest water content is biobriquettes with the addition of tapioca starch adhesive material at 50% composition. From the results of the water content test for all tapioca adhesive compositions, it meets the criteria of SNI No. 01-6235-2000 which requires a maximum moisture content value of 8%.

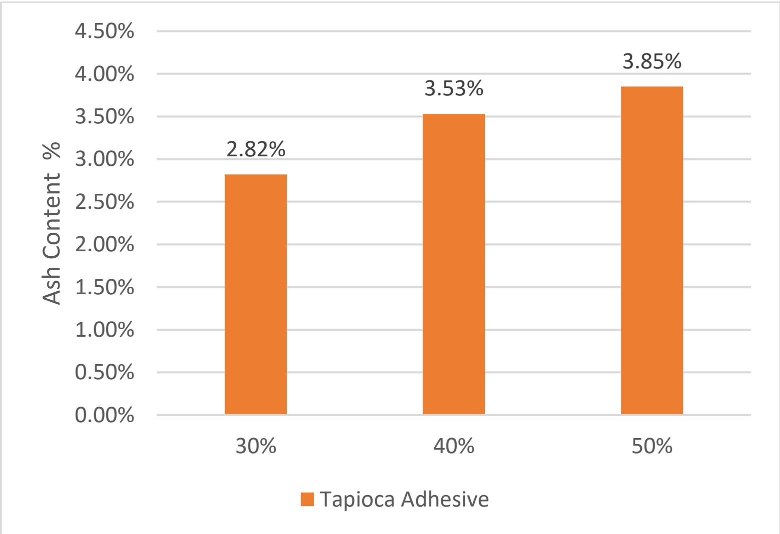
The third test is density testing of coconut pulp charcoal biobriquettes, density is the ratio between the mass of the briquette and the volume of the briquette. The density data and the effect of the type and composition of tapioca adhesive on the resulting coconut pulp charcoal biobriquettes can be seen in Figure 5.



Gambar. 5. Adhesive Percentage vs Density

Based on Figure 6 above, it can be seen that variations in the composition of tapioca adhesive have a significant effect on the density of the resulting coconut pulp charcoal biobriquettes. If the composition of tapioca adhesive is mixed in the manufacture of coconut pulp charcoal biobriquettes, the density or density of the resulting biobriquette sample will be higher. In line with Retnani's research in 2020 which states that the addition of high adhesives the density or density of biobricks is getting higher which results in the adhesive will enter the pores of the biobricks so that the spread of the adhesive will be evenly distributed which results in the high density or density obtained [14]. Density or density of biobriquettes obtained ranged from 2.23 grams / cm3 - 2.25 grams / cm3. biobriquettes that have the highest density or density are biobriquettes with the addition of tapioca starch adhesive material at 50% composition. While the lowest density or density is biobriquettes with the addition of tapioca starch adhesive material at 30% composition. From the results of density testing for all tapioca adhesive compositions, it meets the criteria of SNI No. 01-6235-2000 which requires a denitas value in the range of 0.44 - 2.5 gr/cm^3.

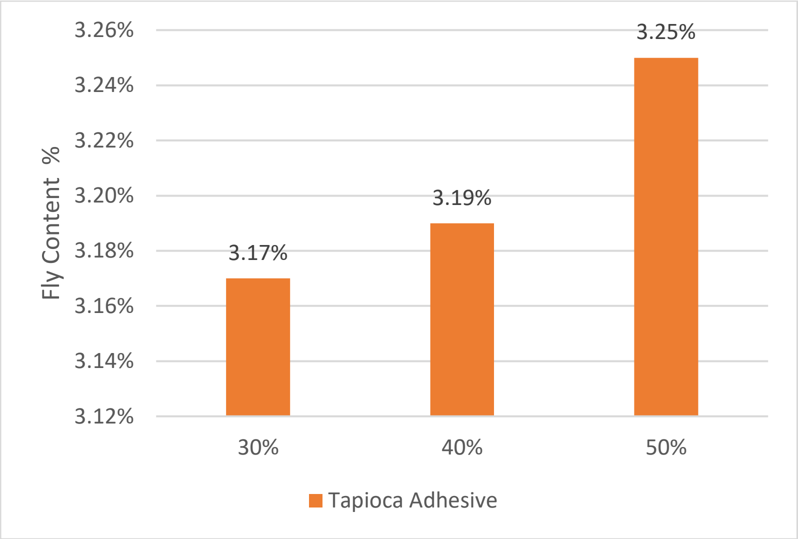
The fourth test is testing the ash content of coconut pulp charcoal briquettes. Ash content is the weight of briquettes after combustion in the form of inorganic substances that no longer have carbon elements. Briquettes with high ash content are poor quality briquettes because ash will form a crust that indicates the briquette cannot burn and only functions as an impurity in the briquette. Ash content greatly affects the quality of biobriquettes because it can reduce the calorific value, this is because the ash contains silica which can reduce the calorific value. Data on ash content and the effect of tapioca adhesive composition on the resulting coconut pulp charcoal briquettes can be seen in Figure 6.



Gambar. 6. Adhesive Percentage vs Ash Content

Based on Figure 6 above, it can be seen that the variation of tapioca adhesive composition has a significant influence on the ash content of the coconut pulp charcoal biobriquettes produced. If the composition of tapioca adhesive mixed in making coconut pulp charcoal biobriquettes is more and more, the ash content contained in coconut pulp charcoal biobriquettes will be higher. This is in accordance with the results of Eka's research in 2017 which showed that the tendency of increasing the adhesive used caused an increase in the ash content of the biobriquettes [15]. In this study, the ash content of the biobriquettes obtained ranged from 2.82% - 3.85%. The biobriquettes with the lowest ash content were those with the addition of tapioca starch adhesive at 30%. Meanwhile, the highest ash content was biobriquettes with the addition of tapioca starch adhesive at 50%. The results of the ash content test for all tapioca adhesive compositions have met the criteria of SNI No. 01-6235-2000 which requires a maximum ash content value of 8%.

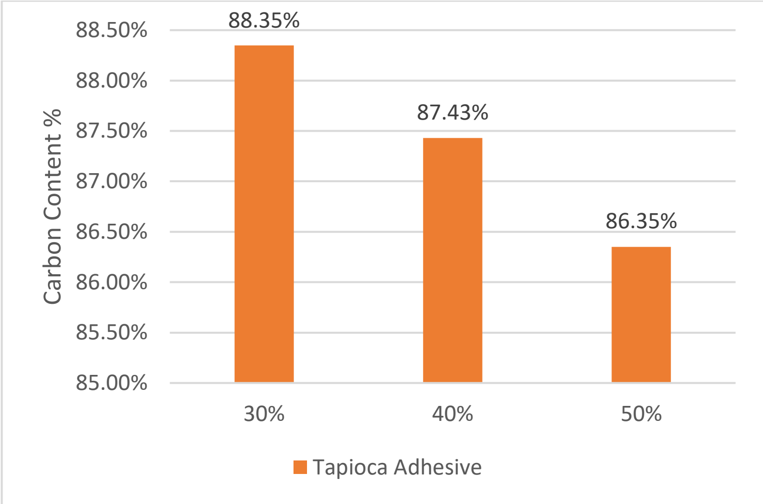
The fifth test is testing the flying substance content of coconut pulp charcoal biobriquettes. Fly substances are substances that can evaporate as a result of the decomposition of compounds that are still present in the briquette in addition to water, bound carbon and ash. Data on fly content and the effect of tapioca adhesive composition on the resulting coconut pulp charcoal biobriquettes can be seen in Figure 7.



Gambar. 7. Adhesive Percentage vs Fly Content

Based on Figure 7 above, it can be seen that variations in the composition of tapioca adhesive have a significant effect on the fly content of coconut pulp charcoal biobriquettes produced. If the composition of tapioca adhesive is mixed in the manufacture of coconut pulp charcoal biobriquettes, the level of fly substance produced in the biobriquettes will be higher. This is in line with research conducted by faujiah in 2021 which states in the results of his research that the high percentage of flying substance content indicates a high level of ignition. In addition, high levels of fly substances will produce a lot of smoke. Fly content is influenced by the chemical components of charcoal in the form of extractive substances from biobriquette raw materials. Therefore, the high fly content also indicates the proportion of organic matter in the biobriquettes [16]. The flying substance content of the biobriquettes obtained ranged from 3.17% - 3.25%. Coconut pulp charcoal biobriquettes that have the lowest flying substance content are biobriquettes with the addition of tapioca starch adhesive material at 30% composition. While the highest flying substance content is biobriquettes with the addition of tapioca starch adhesive material at 50% composition. In this study, the value of fly content obtained data for all variations of tapioca adhesive composition in testing fly content has met the criteria of SNI No. 01-6235-2000 which requires a maximum fly content value of 15%.

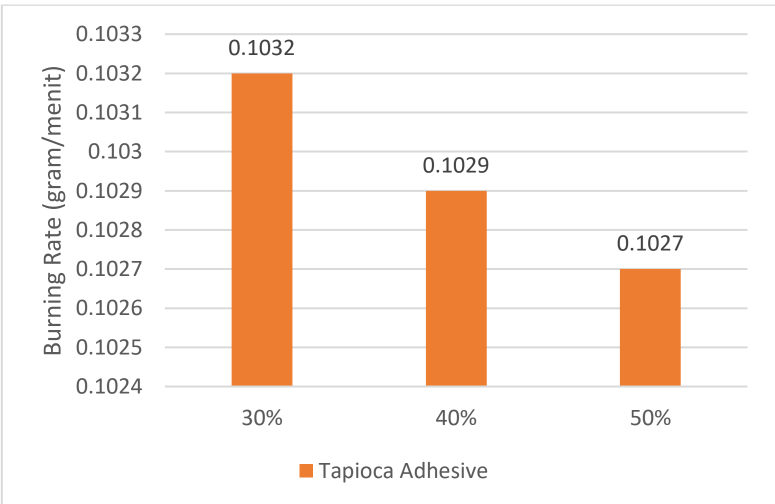
The sixth test is testing the carbon content of coconut pulp charcoal biobriquettes. Bound carbon content is the fraction of carbon (C) contained in biobriquettes other than water, ash fraction, and fly matter. Bound carbon content has an influence on the quality of biobriquettes, where biobriquettes that produce high bound carbon content are categorized as biobriquettes with the best quality. Data on carbon content and the effect of tapioca adhesive composition on the resulting coconut pulp charcoal briquettes can be seen in Figure 8.



Gambar. 8. Adhesive Percentage vs Carbon Content

Based on Figure 8 above, it can be seen that the variation of tapioca adhesive composition has a significant effect on the carbon content of the coconut pulp charcoal biobriquettes produced. If the composition of tapioca adhesive is mixed in the manufacture of coconut pulp charcoal biobriquettes, the carbon content contained in coconut pulp charcoal biobriquettes will be lower. This is in accordance with the results of research conducted by Sucipto in 2021 which states the results that the ability of the type of adhesive used in absorbing water in biobriquettes will affect the size of the carbon content produced in making biobriquettes [17]. In this study, the carbon content of coconut pulp charcoal biobriquettes obtained ranged from 86.35% - 88.35%. biobriquettes that have the highest carbon content are biobriquettes with the addition of tapioca starch adhesive material at 30% composition. While the lowest carbon content is biobriquettes with the addition of tapioca starch adhesive material at 50% composition. The carbon content obtained for all variations of tapioca adhesive composition in carbon content testing has met the criteria of SNI No. 01-6235-2000 which requires a minimum carbon content value of 77%.

The seventh test is testing the burning rate of coconut pulp charcoal biobriquettes. The burning rate is the speed at which the biobriquettes burn out. This means that the greater the combustion rate value, the faster the biobriquettes will burn out. The use of various compositions of tapioca adhesive has an influence on the burning rate of the briquettes produced. In general, based on the results, it can be seen that the use of tapioca adhesive with less composition gives a higher burning rate. The burning rate data and the effect of tapioca adhesive composition on the coconut pulp charcoal briquettes produced can be seen in Figure 9.



Gambar. 9. Adhesive Percentage vs Burning Rate

Based on Figure 35 above, it can be seen that variations in the composition of tapioca adhesive have a significant effect on the burning rate of the resulting coconut pulp charcoal biobriquettes. If the composition of tapioca adhesive is mixed in the manufacture of coconut pulp charcoal biobriquettes, the burning rate will be lower or reduced. This is because low density has a larger air cavity so that the amount of material burned is more than briquettes that have a large density. According to Mislaini's research in 2018, testing the combustion rate is carried out to determine the effectiveness of the use of a fuel in the form of briquettes [18]. So when compared to this study for the three compositions of tapioca adhesive, namely, 30%, 40% and 50% which can be applied to fuel applications, namely the use of tapioca adhesive with the composition of the ratio of charcoal and tapioca adhesive, namely 70%: 30% and this is in accordance with the results of Masthura's research which produces the best quality briquettes with the same adhesive composition of 30%. This is due to the longer burning time that occurs in biobriquettes with 30% tapioca adhesive mixing. The burning rate of biobriquettes obtained in this study ranged from 0.1027 grams/minute - 0.1032 grams/minute. biobriquettes that have the highest burning rate are biobriquettes with the addition of tapioca starch adhesive at 30% composition. While the lowest burning rate is biobriquettes with the addition of tapioca starch adhesive material at 50% composition. The combustion rate obtained for all variations of tapioca adhesive composition in the combustion rate test has met the criteria of SNI No. 01-6235-2000 which requires a combustion rate range of 0.05 - 0.7050 gr/min.

IV. CONCLUSION

Based on the research on the effect of variations in the composition of tapioca adhesive on the quality of coconut pulp charcoal biobriquettes, it can be concluded that the effect of variations in the composition of tapioca adhesive on the quality of coconut pulp charcoal biobriquettes is that the increasing content of tapioca adhesive will increase water content, ash content and fly substance content but reduce calorific value, density, carbon content, and combustion rate in biobriquettes.

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