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The effect of particle size and adhesive on the ash content and volatile matter of organic waste bio-charcoal briquettes

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Abstract:*Householdwaste, whichoriginatesfromdailyactivitieswithinhouseholds, can accumulate over time and decompose if not managedproperly. Improperwaste management can lead to variousdiseasescaused by bacteria and viruses. To addresswastegeneration in households and provide an alternative fuel source to replace fossil fuels and LPG gas, one solution is to utilizehouseholdorganicwaste in the production of briquettes. In an experimentalapproach, the carbonization process isemployedusing a modifieddrum. The study examines the impact of adhesive concentration (at 5%, 10%, and 15% of 3 grams by weight of briquettes) as the dependent variable. Additionally, the independent variable consideredisparticle size, with sizes rangingfrom 30 mesh to 80 meshTheresultsshowedthat the lowestlevels of volatile substances wereobtained at an adhesive concentration of 15% and a meshparticle size of 80. Charcoal briquettes with a larger and non-uniformparticle size containmany compounds, such as minerals and gaseswhich are veryeasy to evaporate. This isbecause the largerparticle size has a lowdensity. Meanwhile, the lowestash content isobtainedfrom an adhesive content of 15% and a meshparticle size of 30. The addition of adhesive concentration increases the calorific value of the briquettes sothat the volatile matter content is high whichresults in lowash content.*

Keywords:*Household waste, Charcoal briquettes, Adhesives,Particles size, Organicwaste.*

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I. INTRODUCTION

Waste management in Indonesia faces significant challenges due to the lack of public awareness across various sectors, from households to industries. When waste is not properly managed, it accumulates over time and decomposes, potentially causing various diseases due to bacteria and viruses. Common illnesses include diarrhea, typhoid, dysentery, fungal infections, cholera, and skin diseases (anomim, 2012).To address waste generation, sorting and proper disposal are essential. By categorizing waste types, we can create useful products. For instance, household organic waste can be used to produce briquettes, which serve as an alternative renewable energy source. This approach not only reduces waste but also contributes to sustainable energy solutions.

Organic waste has the ability to decompose naturally with the assistance of microorganisms. However, inorganic waste, such as plastic food containers and mineral bottles, does not readily break down. One practical application for organic waste is its conversion into biomass briquettes(Saragih, et al, 2020), which can serve as an alternative energy source. These briquettes are produced using dry organic waste materials like leaves and twigs, along with inorganic waste such as plastic. The plastic waste acts as an adhesive during the briquette-making process(Mara et al, 2023). This approach not only reduces waste but also contributes to sustainable energy solutions.

Briquettes, obtained from pressing and compacting, are solid fuels with a uniform shape. They serve as an alternative energy source and are derived from various materials, including coal dust, charcoal, sawdust, wood chips, peat, or paper. These compressed blocks are relatively small or irregular in size (Hamzah, 2019).Briquettes are compressed blocks of coal dust or other combustible biomass materials, such as charcoal, sawdust, wood chips, peat, or paper. They are used for fuel and kindling to start fires. These briquettes serve as an efficient and convenient alternative energy source. They are typically obtained by pressing and compacting the raw materials into a specific shape, resulting in uniform blocks that can be easily handled and burned. Briquettes are commonly used for heating, cooking, and industrial processes (Desgira, 2020)

Study conducted by Priyanto, et al (2018) aims to determine the effect of pyrolysis temperature on the biochar produced and determine the effect of starch adhesive concentration (5%, 10%, 15%) on the characteristics of the research briquettes (water content, volatile matter, ash content, fixed carbon , calorific value and combustion rate). It can be concluded that the lower the adhesive concentration, the lower the water content of the briquettes, resulting in a high heating value. The higher the adhesive concentration, the higher the ash and volatile matter content, while the fixed carbon content is lower.

In a study conducted by Ristianingsih, et al (2015), the primary objective was to investigate the impact of pyrolysis temperature on the resulting biochar. Additionally, the study aimed to assess the influence of starch adhesive concentration (at levels of 5%, 10%, and 15% by weight) on various characteristics of the research briquettes. These characteristics included water content, volatile matter, ash content, fixed carbon, calorific value, and combustion rate.The study findings revealed that the lower adhesive concentrations correlated with reduced water content in the briquettes, leading to a higher heating value.Conversely, higher adhesive concentrations resulted in increased ash and volatile matter content, while the fixed carbon content decreased.

Virgiawan(2014) conducted tests using specimens with varying particle sizes of 30 mesh, 50 mesh, and 70 mesh. The research results indicate that bagasse charcoal briquettes with a particle size variation of 70 mesh exhibit a high heating value of 5238.58 cal/g and the lowest combustion rate of 0.00167 g/s.

Adhesive is a substance or material with the ability to bond two objects through surface attachment. Various terms refer to adhesives with specific functions, including glue, mucilage, paste, and cement. Glue, typically made from protein, finds common use in the woodworking industry (Seo, et al, 2015). Paste or starch adhesive results from heating a mixture of starch and water until it forms a paste. Meanwhile, the term cement is commonly associated with rubber-based adhesives that harden through solvent release(Alfajriandi et al, 2007; Jannah 2018).

Utilizing waste from vegetable scraps from households to make charcoal briquettes is one solution to overcome the generation of organic waste in household waste and can also be used as an alternative fuel to replace petroleum and LPG gas. The aim of this research is to determine the best adhesive concentration and particle size to meet the Indonesian National Standard (SNI) for wood charcoal briquettes.

II. MATERIAL AND METHODS

This research was carried out experimentally and followed several stages, namely the preparation stage, followed by the steps for making charcoal. The next stage is determining the size of the charcoal particles and determining the adhesive concentration according to what has been determined. Next, the charcoal bio briquettes are printed and dried.

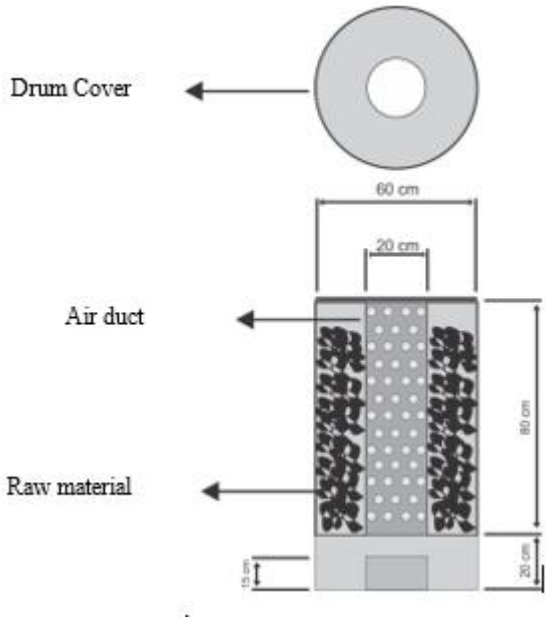

Figure1. Charcoal making drum

The variables tested in this research were analysis ofvolatile matter value and ash content. Meanwhile, variations in adhesive concentration used were 5%, 10% and 15% and particle sizes were 30 mesh, 60 mesh and 80 mesh.

2.1 Carbonization stage

The waste used is organic waste that has been dried in the sun to reduce the water content until it is dry so that the raw material does not produce smoke and is flammable. Organic waste is put into iron cans until they are full. The drum as a burning stove is lit with wood as fuel, then on top of the drum are placed 4 burning tins. The carbonization process is carried out for 20 minutes over a constant fire. The burning process is left until all the raw materials have become charcoal. It can be seen from the ventilation hole in the middle of the can that no smoke is emitted.

2.2 Adhesive formation stage

In this research it was use 75 grams of starch dissolved in 350 ml of water is heated using the stove provided, while stirring until it boils and becomes thick, shaped like glue.

2.3 Charcoal briquettes making Stages

Charcoal resulting from carbonization of organic waste raw materials is ground using a prepared tool, then filtered using a sieve with sizes of 30 mesh, 60 mesh and 80 mesh. The sifted charcoal powder is completely added with starch adhesive which has been made like glue and mixed in a ratio of 5%, 10% and 15% of the total weight of the charcoal powder mixture. The finished dough is ready to be molded into cylindrical briquettes by placing the dough into the mold and then pressing it with the tool provided.

2.4 Drying of charcoal briquettes Stages

The resulting charcoal briquettes were then dried in an oven at 100^{o}C for 2 hours. The water content drying stage was carried out to determine the evaporated water content in each specimen from variations in adhesive concentration and particle size.

Figure2. bio-Charcoal briquettes

III. RESULTS AND DISCUSSIONS

3.1 Volatile mattercontent

During the combustion process, the biomass contained in the bio-charcoal briquettes will evaporate in the form of volatile substances. The greater the biomass content, the faster the resulting volatile substances will burn. (Suryaningsih et al. 2019). The volatile matter content in a briquette is a substance that can evaporate as the decomposition of compounds that are still present in the charcoal other than water. (Faujiah, 2016)..

Tabel 1. Volatile mattercontent (%)

	M30	M60	M80
So5	38.73	32.86	26.66
S10	45.68	37.35	27.80
S15	40.65	34.65	21.57

In table 1, the calculation results for the volatile matter content of the So10-30 treatment with an adhesive concentration of 10% with a particle size of 30 mesh have the highest volatile matter content value of 45.675%. and the So15-80 treatment with an adhesive concentration of 15% with a particle size of 80 mesh had the lowest volatile matter content of 22.678%. Volatile substances in charcoal briquettes refer to compounds that easily turn into steam or evaporate during the combustion process. Volatile matter mainly consist of hydrocarbon elements, methane and carbon monoxide. The high content of volatile matter in charcoal briquettes can cause the production of more smoke during combustion. Therefore, controlling the levels of volatile substances in charcoal briquettes is important to produce efficient combustion and reduce smoke emissions.

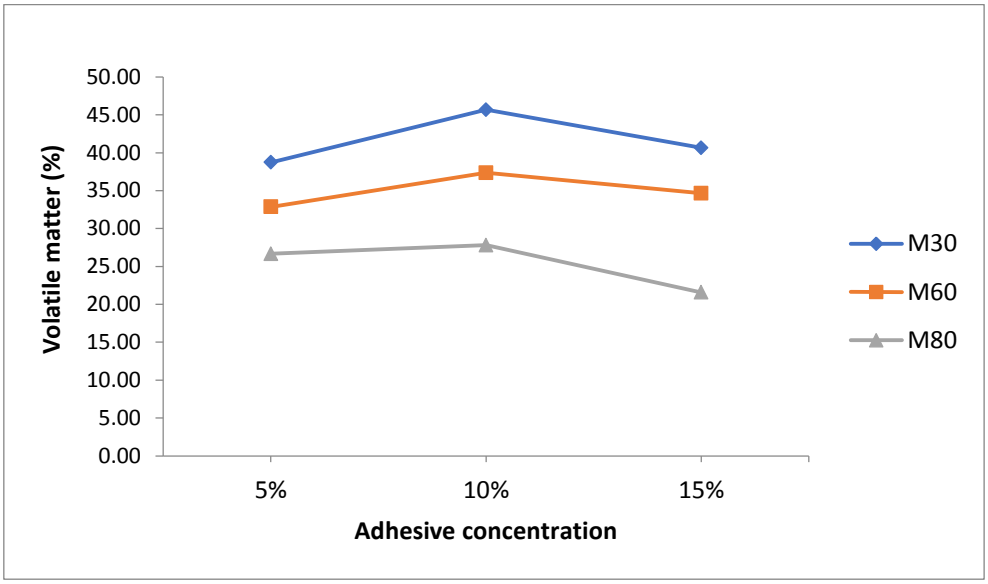

Figure 3. The relationship of adhesive concentration and particle size on the volatile matter of bio-charcoal briquettes

Figure 3 shows the relationship between adhesive concentration and particle size for volatile substances in biomass charcoal bio briquettes. Treatment with an adhesive concentration of 5% resulted in a low value of evaporating substances, with an adhesive concentration of 10% the value of evaporating substances was high and decreased at an adhesive concentration of 15%. One of the factors that causes the value of volatile substances to be unstable when varying adhesive concentrations is the water content that is still stored in the briquettes during the drying process and the uneven mixing of charcoal powder with adhesive. So that during the final calculation the value of the volatile matter level is unstable. In research by Ristianingsih, et al (2015), the high levels of volatile substances contained in briquettes were influenced by water content. The higher the water content, the higher the level of evaporating substances.

Moreover, figure 3 also shows that the larger the particle size in the briquette, the higher the volatile matter content. At a particle size of 30 mesh the content of volatile substances produces the highest value and at a particle size of 80 mesh the content of volatile substances produces the lowest value. There is a difference in density which causes the value to decrease as the particle size becomes smaller. The larger the particle size, the more pores the briquette has. Charcoal bio briquettes with large and non-uniform particle sizes still contain many compounds in them such as minerals and gases which are very easy to evaporate because the large particle size has a low density. In line with research conducted by Dewi, et al, (2020), the smaller the particle size of charcoal powder, the lower the volatile matter content of the charcoal briquettes produced.

Because the value of the volatile matter produced is high, the quality of the briquettes produced is low quality. One of the factors that influence the high levels of volatile matter is that the carbonization process

which is carried out conventionally, so that the resulting temperature does not reach the optimal temperature. The perfection of the carbonization process is also influenced by the temperature and time of combustion which can reduce the levels of volatile matter in charcoal briquettes. The high levels of volatile substances are also influenced by the chemical composition of the charcoal, such as the presence of impurities in the charcoal raw material. The higher the temperature and cooking time, the more volatile substances are removed, so that during the test a low level of volatile substances will be obtained. (Pane et al, 2015).This can happen because during the charcoal making process, the temperature setting is less stable so that the temperature set is not optimal. Therefore, in the value of volatile matter content, there is no treatment that meets the criteria of SNI 01-6235-2000, the maximum value of volatile matter content is 15%.

3.2 Ash content

Ash content is the remaining part of the combustion of charcoal bio briquettes. According to Saragih et al, (2020) one of the elements of ash content is silica and its effect is not good on the calorific value produced. High ash content can reduce the calorific value of charcoal briquettes so that the quality of the charcoal briquettes decreases. In the following table, the average value of ash content from the test results is displayed as shown in table 2 below.

Table 2. Calculation results of ash content in charcoal brio briquettes (%)

	M30	M60	M80
So5	42.79	44.78	48.52
S10	38.43	43.55	47.96
S15	38.28	41.27	44.64

Table 2 shows the calculation results for the ash content of the So5-80 treatment with an adhesive concentration of 5% with a particle size of 80 mesh which has the highest value of volatile matter content of 48.52%. Furthermore, the So15-30 treatment with an adhesive concentration of 15% with a particle size of 30 mesh had the lowest ash content, namely 38.28%. The ash content in charcoal briquettes refers to the amount of material remaining after the briquettes are heated to a constant weight. The higher the ash content in the briquettes, the lower the quality. This is due to the fact that ash has unburned contents and can affect the calorific value of the briquettes. The high ash content is caused by the many minerals contained in vegetables because minerals are inorganic elements in vegetables that cannot be completely burned, where the ash content of the raw material used indicates the mineral content in the material.

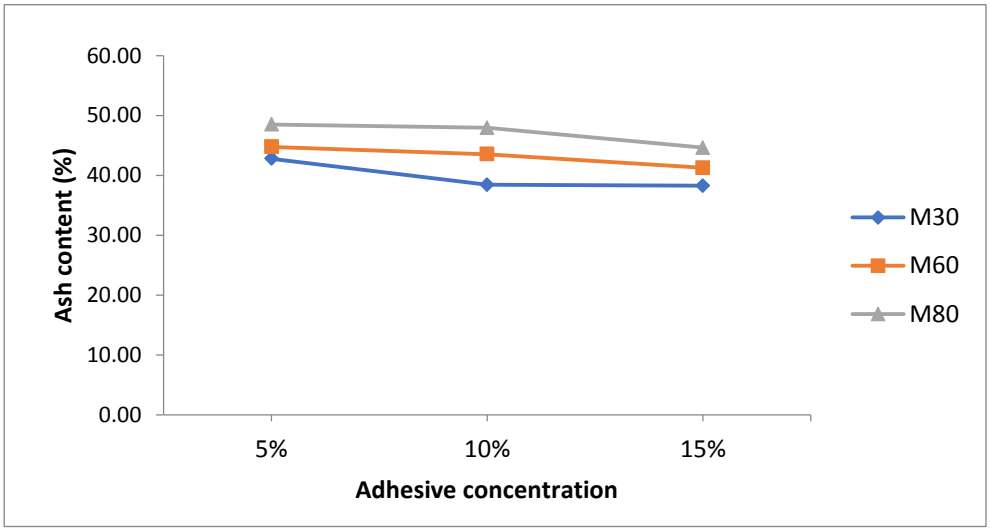

Figure 4. Relationship of particle size and adhesive concentration on ash content in bio-charcoal briquettes

In figure 4. the greater the adhesive concentration used in making charcoal bio briquettes, the lower the ash content produced. The lowest ash content resulted in an adhesive concentration of 15% and the highest ash content resulted in an adhesive concentration of 5%. The addition of adhesive concentration increases the calorific value of the briquettes so that the volatile substance content is high which results in low ash content.

The higher adhesive content in briquettes can cause the briquettes to burn out so that briquettes with a high adhesive concentration produce low ash content.

The results of this research are in line with research by Ulva et al., (2020), the lower the amount of adhesive used, the higher the ash content value produced by the briquettes. Conversely, the higher the amount of adhesive used, the lower the ash content produced.

Figure 4 shows that the larger the particle size, the lower the ash content produced. The lowest ash content resulted in a particle size of 30 mesh and the highest ash content resulted in a particle size of 80 mesh. The factor that causes increased ash content in small particle sizes is because small particle sizes are not good at absorbing adhesive. After the heating process produces a lot of ash due to the large amount of charcoal powder which is not bound by adhesive which has the property of being able to burn out. Another factor that causes small sized particles to have a high ash content value is because the value of the volatile matter content is low.

This is in line with research conducted by Alfajriandi et al, (2017), this is because the smaller the particle size apparently does not improve the quality of charcoal briquettes, because the smaller the particle size the higher the ash content.

These results indicate that the high ash content in household waste charcoal briquettes does not meet the SNI 01-6235-2000 standard, namely ≤ 8%. Higher than the ash content in the Setyaningtyas (2018) research, the results of the analysis of ash content values show that the largest ash content is in 100% fruit waste briquettes with an ash content value of 18.67%, while the lowest ash content value is in 100% vegetable waste briquettes with a value of 10.33%.

IV. CONCLUSION

Based on the results of the research and discussions carried out, a conclusion was drawn that household waste charcoal briquettes have the lowest levels of volatile substances at an adhesive concentration of 15% and a mesh particle size of 80. Household waste bio charcoal briquettes with a large particle size and it is not uniform, it still contains many compounds in it such as minerals and gases which are very easy to evaporate because the large particle size has a low density. Meanwhile, the lowest ash content is obtained from an adhesive content of 15% and a mesh particle size of 30. The addition of adhesive concentration increases The calorific value of bio charcoal briquettes means that the volatile matter content is high which results in low ash content.

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