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# Proximate Analysis of Bio-Coke from Sago Dregs and Patchouli Waste

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**ABSTRACT**– Bio-coke organic waste Sago dregs and Patchouli waste are produced by the pyrolysis method. In this study, proximate analysis of bio-coke was carried out with different comparisons of the composition of sago dregs and patchouli waste. Making bio-coke begins with cleaning and then drying the sago pulp and patchouli waste under direct sunlight. The pyrolysis process uses an initial temperature of 1100C which is maintained for 15 minutes. Then the temperature was set at 6000C maintained for 15 minutes and cooled at room temperature. The quality of bio-coke was obtained from a proximate analysis consisting of the value of water content, ash, volatile matter, fixed carbon, and calorific value. The results showed that the highest calorific value was a composition ratio of 5:1, which was 8,727.84 Cal/gr, with the lowest moisture content, volatile matter, and ash content, namely 2.24%; 30.74%; and 3.69%, and the highest bound carbon content is 63.3%.

KEYWORDS : *sago dregs, patchouli waste, pyrolysis, bio-coke, proximate*

## INTRODUCTION

In recent years, attention to the use of environmentally friendly renewable energy sources has increased. This occurs due to the reduced availability of fossil fuels and fluctuations in world energy prices. One of the most commonly used renewable energy sources is biomass, due to its low cost and high availability. Biomass waste a wide range of materials, and their availability is advantageous. Waste is a source of environmental pollutants due to improper disposal methods. There are many sources of biomass waste from both the agricultural/plantation sector and industry, including sago dregs and patchouli waste.

Apart from being a renewable energy source, the use of various types of biomass will have a positive impact on the economy and the environment. One type of biomass is bio-coke which is produced from the carbonization of biomass. The production and utilization of biocoke are very important because it contributes to the efficient management of agricultural residues and municipal solid waste (Mansor, Theo, Lim, Ani, Hashim, & Ho, 2018). This renewable energy source has been widely used because of its low production cost, abundant availability, and low sulfur content (Xianai, Duygu, S., & Dipankar, 2016). Bio-coke production also requires moderate temperatures of 120 – 200$^0$C and at a pressure of about 10 MPa and is cheaper than biomass briquettes (Fuchigami, Hara, Kita, & Uwasu, 2016). Bio-Coke has advantages such as high calorific value, high mechanical strength, and a high density of about 1.4 g/cm$^3$, compared to ordinary pellets having a density range of 0.63 - 0.85 g/cm$^3$ and a calorific value range of 18 - 31 MJ/kg (Mansor, Theo, Lim, Ani, Hashim, & Ho, 2018).

There are several ways to increase biomass into biofuels either by thermochemical or biochemical methods (Zhang, Xu, & Champagne, 2010). The thermochemical processes of biomass include combustion, pyrolysis, carbonization, co-combustion, gasification, and liquefaction

(Patel, Zhang, & Kumar, 2016). This process begins by applying heat to the decomposition of organic matter by breaking the hydrocarbon bonds to convert it into a richer form of energy. Various thermal conversion technologies have been developed for the production of biocoke from biomass raw materials, such as slow pyrolysis, intermediate pyrolysis, fast pyrolysis, hydrothermal carbonization, microwave pyrolysis, and pressure-assisted carbonization.

Research on the manufacture of bio-coke has been carried out with a variety of different constituent materials. Bio-coke from empty fruit bunch (EFB) material shows density and calorific value with superior quality (Baharin, et al., 2020). Jahiding et al, 2021, analyzed the quality of bio-coke from cocoa shells. The results showed that the bio-coke produced by liquid volatile matter (LVM) injection had a moisture content of 7.16%; volatile matter 20.93%; ash content 18.86%; fixed carbon 53% and calorific value of 7,007 cal/g (Jahiding, Lestari, Mashuni, & Devi L Oktaviani, 2021). Sago dregs and patchouli waste contain sufficient lignin cellulose content, making it possible to use bio-coke as an alternative energy source (Lestari, et al., 2022; Sahupala & Kakerissa, 2022). In this study, the manufacture of bio-coke using the pyrolysis method by varying the composition ratio of the ingredients, namely sago dregs and patchouli waste. This variation of composition was carried out to evaluate the composition of the bio-coke constituents which resulted in a good calorific value. Pyrolysis is a promising conversion technology to produce renewable fuels from biomass (Das, Sreelathab, & Ganesh, 2004). Biocoke production by pyrolysis is an irreversible process in which organic matter undergoes thermochemical decomposition at high temperatures in the absence of oxygen (Sanna, Ogbuneke, & Andresen, 2009).

**RESEARCH METHODS**

The materials used to make bio-coke are sago pulp and patchouli waste from Sangia Tiworo Village, South Tiworo District, West Muna Regency, Southeast Sulawesi, Indonesia. The preparation of bio-coke materials was carried out by cleaning the sago pulp and patchouli waste with water, then the samples were dried to minimize the moisture content. Chop the sago pulp and patchouli waste into small pieces and grind them with a blender. The method used to manufacture bio-coke of sago dregs and patchouli waste is the pyrolysis method. Put sago dregs and patchouli waste into the mold, then put it into the pyrolysis reactor at the initial temperature of 110°C for 15 minutes and simultaneously pressed with a mass of 1 kg (Jahiding, Lestari, Mashuni, & Devi L Oktaviani, 2021). Raise the temperature to 600°C for 15 minutes, then lowered to about 100 0C. The sample was cooled at room temperature and removed from the mold. The comparison of the composition of sago pulp and patchouli waste used was 1:5, 1:2, 1:1, 2:1, 3:2, and 5:1 using the same pyrolysis temperature for each comparison is a temperature of 600°C.

The bio-coke samples were characterized for proximate and calorific value analysis. The water content contained in the sample is calculated using Equation (1).

$$\text{MC}\ (\%) = \frac{\left(M_S - \left(M_C + S_P(105^0C)\right) - M_{CK}\right)}{M_S} \times 100\% \qquad (1)$$

where $M_S$ is the mass of the sample (grams), $M_{CK}$ is the mass of the empty cup (grams), $M_C + S_P(105^0C)$ is the mass of the cup and the mass after heating at a temperature of 105°C (grams). The volatile matter contained in the sample is calculated using Equation (2).

$$\text{VM}\ (\%) = \frac{\left(M_S - \left(M_C + S_P(750^0C)\right) - M_{CK}\right)}{M_S} \times 100\% - \text{MC} \qquad (2)$$

where $M_C + S_P(750^0C)$ is the mass of the cup and sample after heating to a temperature of 750$^0$C. Ash content, is calculated using Equation (3).

$$\text{Ash}\ (\%) = \frac{\left(M_C + S_P(750^0C)\right) - M_{CK}}{M_S} \times 100\% \qquad (3)$$

where $M_C + S_P(750^0C)$ is the mass of the cup and sample after heating to a temperature of 7500C. Fixed carbon is determined by equation (4) (Amer & Elwardany, 2020),

$$\text{Ash}\ (\%) = \frac{\left(M_C + S_P(750^0C)\right) - M_{CK}}{M_S} \times 100\% \qquad (4)$$

The calorific value is determined using a calorimetry bomb.

## RESULTS AND DISCUSSION

The results of the proximate analysis carried out on samples of Bio-Coke from Sago Dregs (SD) and Patchouli Waste (PW) which include water content, volatile substances, ash, and bound carbon. In the process, the composition ratios used are 1:5, 1:2, 1:1, 2:1, 3:2, and 5:1 at a temperature of 600°C. This is done to find the right composition for making bio-coke with good quality.

Moisture content indicates the amount of water in the bio-coke, which is expressed as a percentage of the weight of the raw material and affects the calorific value. High water content has a much lower rate of carbon combustion. The presence of high water content causes the resulting calorific value to decrease. This is because the energy produced will be absorbed a lot to evaporate the water contained in the material. Figure 1 is a graph of the dependence of the composition of SD: PW on the percentage value of the water content of bio-coke.

Based on Figure 1, it can be seen that the higher the content of patchouli waste used in bio-coke, the higher the water content in bio-coke, while the higher the sago pulp, the lower the water content in bio-coke. The highest water content was found in composition 1 (SD): 5 (PW) which was 3.49%, and the lowest was obtained at composition 5 (SD): 1 (PW) which was 2.24%. This is because the texture of the sago pulp is also fragile so it can absorb more water. The high water content is thought to be due to a large number of pores and the ability to absorb water. This is still higher than that of bio-coke RSM (rapeseed meal) and WSG (wheat spent grain) which only contain 0.89% and 1.77%, respectively (Sanna, Ogbuneke, & Andresen, 2009).This result also meets the SNI standard, namely 8%.

The greater the temperature and time of composing, the more volatile substances are wasted so that at the time of testing the levels of volatile substances will be obtained low levels of volatile substances. This level will also provide an inverse relationship to the calorific value. Figure 2 is a graph of the dependence of the composition of Sago Dregs: Patchouli Waste on the percentage value of volatile matter.

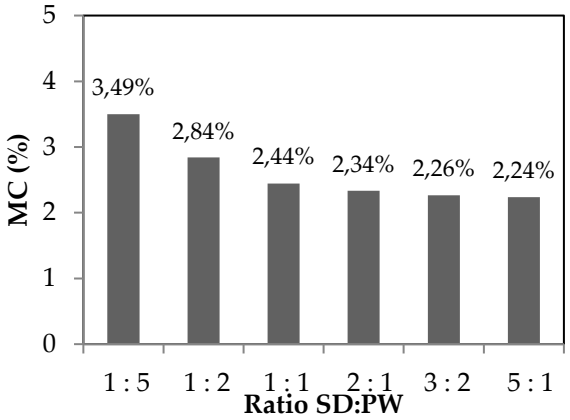


**Figure1. Moisture Content Value of Bio-Coke From Sago Dregs and Patchouli Waste.**

Based on Figure 2, it can be seen that the higher the level of patchouli waste used in pyrolysis, the higher the volatile matter content contained in bio-coke, while the higher the sago pulpcontent, the lower the volatile matter content. From this it can also be seen that the lowest volatile material content is found in a composition ratio of 5:1 and the highest volatile material content is found in a composition ratio of 1:5. This is still lower compared to coconut shell bio-coke and rice husk at 69.47% and 63.75% respectively (Azeta, Ayeni, Agboola, & Elehinafe, 2021)and higher than that of RSM (rapeseed meal) and WSG (wheat spent grain) bio-coke, which are 32 % and 28.6% (Sanna, Ogbuneke, & Andresen, 2009). Bio-coke must have a volatile matter content of less than 15% (Amer & Elwardany, 2020)andthe SNI standard set for this parameter is a maximum of 15%.

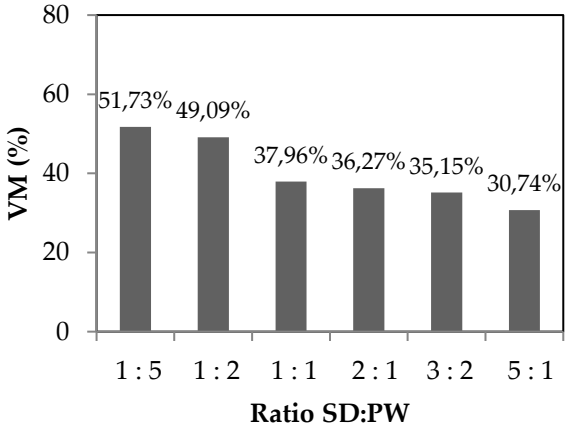


**Figure 2. Volatile matter value of bio-coke from sago dregs and patchouli waste.**

Figure 3 is a graph of the dependence of the composition of Sago Dregs: Patchouli Waste on the percentage value of ash content.

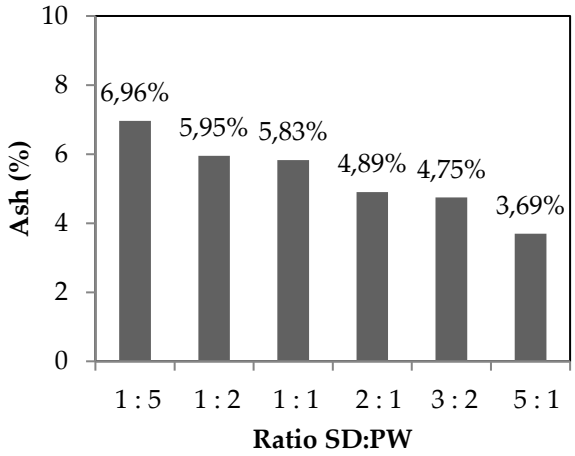


**Figure 3. Ash value of bio-coke from sago dregs and patchouli waste.**

Composition 1 (SD): 5 (PW) contains an ash content of 6.96%, which is greater than the samples with other compositions, due to differences in the particle size of the material used in the manufacture of bio-coke which affects the heat distribution. In this study, the particle size of the patchouli waste was larger (100 mesh) than that of sago pulp (60 mesh), which caused its density to be low and the inorganic matter to evaporate quickly. Bio-coke must have an ash content of between 0.5 and 5% (Amer & Elwardany, 2020), and The ash content analysis results obtained were smaller than the maximum SNI ash content requirement of not exceeding 8%.

The presence of bound carbon in bio-coke is influenced by the value of ash content and volatile matter content. Bonded carbon is a flammable solid residue that remains after the heating process and the volatile matter is removed, excluding ash and moisture content (Cai, He, Yu, Banks, Yang, & Zhang, 2017).

Based on Figure 4, it can be seen that bio-coke fixed carbon decreases with increasing sago dregs content, and increases with the addition of patchouli waste used. If the ash content, volatile matter content and water content are high, the fixed carbon will be low. From the analysis obtained, it can be seen that the lowest fixed carbon is found in a composition ratio of 1:5 and the highest fixed carbon is found in a composition ratio of 5:1. This is still lower than that of bio-coke RSM (rapeseed meal) and WSG (wheat spent grain) which are 67.8% and 70.8%, respectively (Sanna, Ogbuneke, & Andresen, 2009).

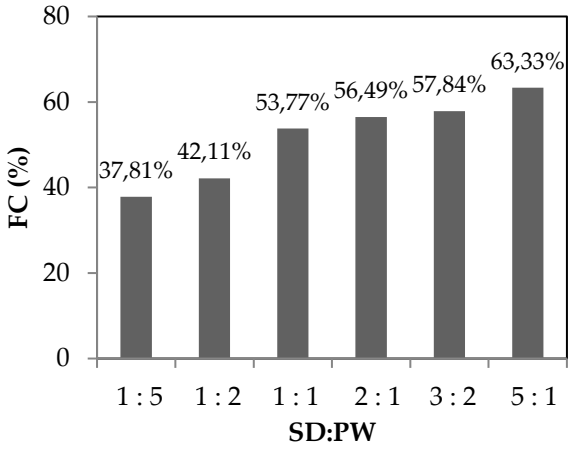


**Figure 4. Fixed carbon value of bio-coke from sago dregs and patchouli waste.**

The calorific value is a parameter that greatly determines the quality of the bio-coke produced and this value depends on the raw materials for which it is made. The composition of raw materials for bio-coke also affects the calorific value. In this study, the calorific value of the bio-coke produced was different with different compositions of raw materials and from the same type of material, as shown in Figure 5.

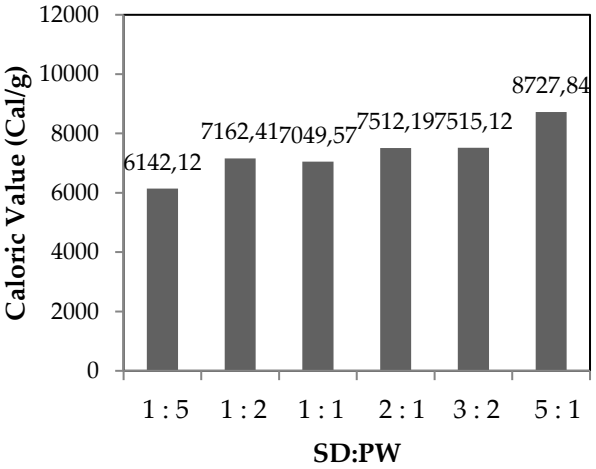


**Figure 5. Calorific value of bio-coke.**

Based on Figure 5, shows that the highest calorific value is obtained in comparison with the content of the dominant sago pulp composition. Meanwhile, at high levels of patchouli waste, the calorific value of bio-coke decreases. This happened because the lignin

content of sago pulp (27%) was higher than that of patchouli waste (6%). Lignin has a high proportion of carbon and energy. This causes the sago dregs to have a higher bound carbon content compared to patchouli waste. In addition, high ash content, volatile matter, and water content can also reduce the calorific value. From the results of the analysis, it appears that the lowest heating value is found in a composition ratio of 1:5 and the highest heating value is found in a composition ratio of 5:1. The calorific value obtained is greater than that of bio-coke Empty Fruit Bunch (EFB) which is 4,573.9009 Cal/gr; bio-coke from coconut skin, namely 4,566.73552 Cal/gr; bio-coke from oil palm fronds is 4,346.9972 Cal/gr (Baharin, et al., 2020). The calorific value can also be influenced by the lignin content of the biomass fuel, which increases with the lignin content (Demirbas, 2003)**.** The calorific value of bio-coke in this study is also still higher than that of bio-coke from olive branches (ranging from 6,472.7266 – 6,926.534 Cal/gr (Adrados A. , Marco, Lopez-Urionabarrenechea, Solar, & Caballero, 2015). Bio-coke with a ratio of 2:1 and 3:2 indicates a higher calorific value. almost the same as eucalyptus wood bio-coke, ranging from 7,404.226 – 7,547.5336 Cal/gr (Adrados A. , Marco, López-Urionabarrenechea, Solar, Caballero, & Gastelu, 2016).The resulting calorific value is greater than the SNI minimum standard, namely 5000 Cal/g.

## CONCLUSION

The results showed that the composition of sago dregs and patchouli waste influenced the proximate characteristics of bio-coke.The higher the content of sago dregs used in the process of making bio-coke, the lower the water content, volatile matter and ash content produced, while the fixed carbon decreases. The calorific value of the bio-coke produced tends to increase with decreasing levels of patchouli waste used. On the other hand, if the sago dregs content is high, the calorific value produced is also high. The water content, ash content and calorific value of the bio-coke produced have met the specified SNI standards.

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