Characteristics and performance of charcoal briquette from the sawdust of Sungkai (Peronema canescens Jack)

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Abstract. Sungkai wood (Peronema canescens Jack) is one of the prominent materials used for the production of furniture and other decorative elements in Kalimantan and Sumatra due to its beautiful fiber and colour, and also fairly smooth texture. Since massive production, the waste resulted from the processing of sungkai wood is very abundant. The utilization of sawdust or wood shavings of sungkai still generates a relatively low value. In order to increase the value of sawdust of sungkai, this research was aimed to identify the characteristics and performance of bio-briquette produced from the sawdust of sungkai. This research was performed by evaluating the characteristics and performance of bio-briquettes produced from three concentrations (10%, 15%, and 20%) of glue material made from tapioca starch. The results show that, except for the volatile matter, all parameters of the characteristics and performance of the tested briquettes comply with the Indonesian National Standard (SNI) of briquette products. The characteristics and performance of the tested briquettes at the lowest levels are follows: water content (4.52%; SNI: max 8%), ash content (4.36%; SNI: max: 8%), volatile matter (42%; SNI max: 15%), density (0.46 g/cm³; SNI: 0.45-0.85 g/cm³), combustion time (0.14 g/min), ignition time (2.5 second/g), and calorific value (5.889 kcal/kg; SNI: min 5000 kcal/kg). It requires the optimization of the carbonization process in order to reduce the volatile matter.

1. Introduction

Sungkai (Peronema canescens Jack) named as Jati Barang, ki sabrang, kurus, sekai, and sungkai, is included in the family of Verbenaceae. At the Dayak tribe, the barks and leaves of sungkai have been used as traditional medicines and other health care [1]. The leaves contain alkaloids, terpenoids, steroids, flavonoids, and tannin [2]. Sungkai is one of among species recommended for industrial forestry plantation (IFP) by the Ministry of Forestry of Republic of Indonesia due to some benefits offered by sungkai. Sungkai is able to be regenerated by vegetative propagation; therefore, it does not depend on flowering and fruiting seasons. Sungkai can be regenerated by cuttings, so it is easier and more effective [3]. In the last three decades, sungkai has become one of the most used woods in the production of furniture and other decorative elements in Kalimantan. Recently, it has also been used for making of the wood cabinet, veneer, molding, plywood, and handicraft [4]. Sungkai becomes popular due to its beautiful pattern of the fiber and also its warm color. The increasing demand for various products of sungkai wood leads to increasing demand for the wood itself.

Since the intensive demand for sungkai for furniture and handicraft production, the quantity of by-product resulted from the processing of sungkai wood is also very massive. However, the utilization of
sawdust or wood shavings of sungkai has not been optimized yet. Utilization of by-products of sungkai wood processing still generates a relatively low value such us for compost or the floor of the chicken farm. Briquette is one of the alternative energies for replacing fossil fuel energy [5]. Various solutions have offered to produce renewable energy made from bio-charcoal briquettes. It aims to develop renewable energy as a companion to limited fossil energy reserves and minimize negative environmental impacts by the use of fossil energy [6]. The purpose of making briquettes is to improve the quality of these materials as fuel. The briquette process or densification is also known as a method to enhance the characteristics of biomass waste [7]. Briquette production can be carried out through carbonized or uncarbonized densification and manufacture processes [8].

Fossil fuels throughout the world are both vulnerable in the short term and limited over the long term. Therefore, worldwide searches for renewable and sustainable energy resources have been explored to comply with a considerable part of the energy demand in the future. Increasing attention has been focused on biomass resources because they can be transformed into multifarious fuels [9]. Environmental problems, like air pollution and greenhouse gas emissions, also play a vital role in the utilization of renewable biomass resources, as biomass is considered to be environmentally friendly. The utilization of biomass has great potential for reducing the dependence on fossil fuels and alleviating the burden of environmental degradation [10]. Biomass in the form of wood and agricultural wastes constitute one of the third largest alternative source of primary energy in the world aside from coal and oil [8].

Briquette is environmentally friendly and material availability is abundant in Indonesia, mainly in South Kalimantan [5]. Sawdust waste has a big potential to be used as charcoal briquette [11]. In order to increase the value of the by-product of sungkai, this research was aimed to evaluate the technical feasibility (characteristics and performance) of briquette charcoal produced from the sawdust of sungkai.

2. Materials and methods

2.1. Materials

Sawdust of Sungkai wood was obtained from three furniture home industries in Banjarbaru City. All samples were removed from some impurities such as stones, plastics, or other woods, then mixed and dried under sunshine for two days to produce samples with uniform water content. Tapioca starch used to make binder was purchased from a traditional market in Banjarbaru.

2.2. Methods

The sawdust that has been dried was weighted (4 kg) and carbonized in a small-size of the metal kiln. The carbonization process was performed at 450 °C for two hours using closed system carbonization. The resulted charcoals then were crushed and filtered using a 30-mesh sieve. The powdered charcoals were weighted for yield determination and the density.

![Figure 1. Making process of briquette charcoal. where (a) Carbonization on a small-size kiln, (b) Powdered and sieved charcoal, (c) Briquette production on a presser.](image)
Briquette binder was made by mixing the tapioca starch with water and boiled until a semi-solid and transparent form was shown. The powdered charcoals then were mixed with the binder to produce a sticky mixture. Three ratios of charcoal and the binder (10%, 15%, and 20%) were tested to obtain some information especially the characteristics and performance of the resulted briquettes as the effect of the differences of concentration of the binder. The determination of three concentrations of the binder was considered from the study of Hamidah [12]. Each mixture (200 g) was loaded to the briquette maker and pressed to produce briquette charcoal. The briquette maker was a presser with eight holes that each hole has 4 cm of diameter and 3.5 cm of height. One hole can be loaded with 200 g of mixed charcoal.

The tube briquettes resulted by the presser then were unloaded and dried in an oven at 60 °C for 24 hours. The products were evaluated for their characteristics and performance, including water content, ash content, volatile matter, density, combustion time, ignition time, and calorific value (ASTM). The experiment was performed for three repetitions to ensure the data were obtained with minimum error. The data were analyzed for their variants using a statistical program (SPSS).

3. Results and discussion

This research tested the ability of sawdust of sungkai wood for bio-briquettes. The briquettes were made by pressing the mixture of powdered charcoal and tapioca binder on a presser with 10,000 kg/cm² of pressure. Tapioca flour was used as the adhesive agent following the method of Yuniarti [11]. We use 10,000 kg/cm² for the pressure clamp. Following the size of the holes of the presser, the volume of the resulted briquette was approximately 42 cm³. Each briquette was made from 200 g of powdered charcoal. After the molding and pressing process, the briquettes were dried in an oven at 60 °C for 24 hours to produce briquettes with dryness that comply with the national standard. Figure 2 shows the final product of the briquette resulted from the process.

![Figure 2. Charcoal briquette produces from sawdust of sungkai.](image)

In order to obtain some valuable information, especially the optimum characteristics and performance of the briquette, this research examined three different concentrations of binder (tapioca starch), 10%, 15%, and 20%. The different concentration of binder should affect the characteristic of the briquettes. The higher concentration of binder theoretically will produce briquette with higher density but lower in calorific value. To examine this hypothesis the three types of briquettes were tested for several quality parameters including water content, ash content, volatile matter, density, combustion time, ignition time, and calorific value. Characteristics represent the quality of the briquettes are shown in table 1.

| Treatment (ratio of binder) | Water content (%) | Ash content (%) | Volatile matter (%) | Density (g/cm³) |
|----------------------------|-------------------|-----------------|--------------------|----------------|
| SNI                        | max. 8            | max. 8          | max. 15            | 0.447 - 0.849  |
| 10%                        | 4.27 ± 0.12       | 4.29 ± 0.15     | 42,30 ± 0.23       | 0.48 ± 0.01    |

Table 1. Characteristics of briquettes produced from three ratios of charcoal and binder.
Generally, the characteristics of the three types of tested briquettes are quite similar. Analysis of variants also exhibited that among the tested briquettes were not significantly different in four parameters tested (water content, ash content, volatile matter, density). It suggests that the application of binder concentration in the range of 10% to 20% does not affect the quality of briquette in terms of physical characteristics. As shown in table 1, the water content of the briquettes is about 4.30%. It meets the national standard that water content should be under 8%. Briquette with lower water content will give some benefits, such as higher calorific value and lighter weight. To achieve such a lower level or water content, the drying process with adequate time and temperature is essential. In this study, we implemented the drying process at 60 °C for 24 hours.

In addition to the water content, the level of ash content of the tested briquettes also was relatively low comparing to the standard. It was almost half of the standard. It means that when the briquettes used, it will produce ash as residues at a lower level. This is a positive value of sungkai as charcoal as the material of briquette. Meanwhile, the number of volatile matters still at a higher level (42%) compare to the national standard (maximum 15%). It indicates that the carbonization process of the sawdust was not sufficient. It may require a longer time and higher temperature of the carbonization process. Two hours of carbonization was not enough to produce charcoal with the lower volatile matter. Therefore, this research also suggests performing the carbonization at least for three hours.

Table 2. Performance of briquettes produced from three ratios of charcoal and binder.

| Treatment (ratio of binder) | Performance of briquette |
|----------------------------|--------------------------|
|                            | Combustion time (g/min)  | Ignition time (second/g) | Calorific value (kcal/kg) |
| SNI                        | -                        | -                        | min. 5,000                 |
| 10%                        | 0.14 ± 0.01              | 2.51 ± 0.31              | 6,020 ± 120               |
| 15%                        | 0.15 ± 0.01              | 2.41 ± 0.37              | 5,950 ± 175               |
| 20%                        | 0.15 ± 0.01              | 2.47 ± 0.28              | 5,889 ± 210               |

Table 2 shows the performance of tested briquettes, in aspects of combustion time, ignition time, and also calorific value. Combustion time indicates the length or period that a gram of charcoal briquette can produce energy through the combustion process. Longer combustion time is required in the production of briquette. Longer combustion time correlates with the potential energy contained by briquette. On the other hand, briquetting pressure also needs to be increased. According to Nugraha [5], briquetting pressure affects the combustion characteristics of briquettes.

Of three types of briquettes, their calorific values were higher than the minimum standard (5,000 kcal/kg). Per kilogram sawdust charcoal briquette from sungkai wood can produce about 6,000 kcal of energy. These results exhibit the potency of sawdust of sungkai to be used or commercialized as briquette. One kilogram of the briquette can be combusted for more than 2.3 hours. While all the tested briquettes also exhibited an easy ignition process. Per gram briquette required around 2.5 seconds to ignite.

4. Conclusion
The sawdust of sungkai wood has a capability and feasibility to be processed and utilized as a charcoal briquette. Except for the volatile matter, all parameters of the characteristics and performance of the briquettes made from the sawdust of sungkai wood can meet the Indonesian National Standard (SNI) of briquette products. The characteristics and performance of the tested briquettes at the lowest levels are...
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