Evaluation of Carbonization Process and Physicochemical Characteristics in Peanut Shell Briquettes Production

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Abstract: Briquettes were formed from peanut shells using starch as a binder with different formulations processes. Their physic-chemical properties evaluated the briquettes product includes caloric value, ash and moisture content, and fixed Carbon to consider an option for a potential application. As a result, the carbonized briquette sample has a higher caloric value than the non-carbonization briquette. However, the former is a relatively high moisture content that does not accept, where the latter was required for the Indonesian Standards (SNI) of Wood Briquette. Furthermore, their ash contents were standard and qualified in the production of further briquettes. The results will be considered to produce the peanut shell briquettes from agricultural waste and developed for a green energy source for households and small industries.

1 INTRODUCTION

Agricultural and plantation solid waste or biomass have a prospective alternative energy source, generally made in charcoal briquettes (Napitupulu, et al., 2020). There is a different process to formulate raw materials into briquettes form. Some reports produced briquette from biomass by densification [(Oyelaran, et al., 2015), (Kalo, et al., 2020), (Oni K, et al., 2020)] or carbonization [(Krylova & Zaichenko, 2018), (Chiaramonti, et al., 2014), (Aguko, et al., 2018)]. Densification offers the conversion of biomass waste with low energy characteristics and high bulk density (Kalo, et al., 2020). In contrast, the carbonization process proposes obtaining a high carbon content, decreasing or removing moisture, and decomposing the highly reactive organic matter components to increase the caloric value (Krylova & Zaichenko, 2018). These processes are still challenging because of their advantages or disadvantages on a specific agricultural waste like peanut shells. Besides, it may need improvement and evaluation of particular conditions on potential users.

Peanut shells waste is one of the most agricultural wastes, and it has been produced throughout the year in our region, especially in the district of Barru, Indonesia. This biomass source has potential sustainability for a green and renewable energy source to supply households or small industries. However, the peanut shells that had just been thrown and burned will cause problems for the environment. It may need an approach to improve the processing and utilizing the peanut shell waste for more valuable and valuable economic. This research aimed to compare the different processes of briquette production with their Physico-chemical characteristics. This evaluation was proposed to convert the initial biomass into solid fuel for the essential (Krylova & Zaichenko, 2018) and efficiency.

2 RESEARCH METHODS

2.1 Materials

The peanut shell charcoal briquette raw materials were taken from agricultural waste at the Bacu-Bacu village, district of Barru, South Sulawesi Province, Indonesia. Starch was selected as a binder agent and available at a traditional market. Starch was commonly used (Aguko, et al., 2018), and the previous report found that the starch can power output and the burning rate (Ugwu & Ago, 2013).

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2.2 Preparation of Briquettes

The peanut shells briquettes were formulated in two different processing. The first was produced from charcoal that was carbonized at 250 0C for 2.5 hours, called PSCB, and the second was fabricated thoroughly for briquette productions PSPB. These samples were respectively milled and filtered with a particle size of around 100 mesh. The starch was dissolved by the concentration of 24.6 wt% and mixed with briquette samples in the ratio of 1:7. Briquette samples mixture loaded into a cylindrical mould (size 3/4 inch length 5 cm compression 276.8 Pa) to construct the briquettes at room temperature. A simple apparatus was manually used to compress the briquettes for 2 hours. The densified briquette was pushed out and dried to obtain the briquettes (Moki, et al., 2018) then characterized.

2.3 Determination of Physico-chemical Characteristics

The samples that have been dried are then characterized. The Physico-chemical parameters of the briquette samples were volatile matter, caloric value, ash content, moisture content, and fixed Carbon. The calorific value was calculated using a bomb calorimeter (AC-500) at the Laboratory of Energy and Mineral Resource (ESDM), South Sulawesi Province. The volatile matter (VM) and ash contents (AC) were calculated using one gram of briquette sample in a crucible and heated at the furnace. The VM and AC were burned at a temperature of 900°C for 7 minutes and 850°C for 2 hours. Similarly, the moisture content (MC) was conducted at temperature 105°C in oven drying until the sample's mass was constant. The weight change determine the volatile matter (%VM), ash content (%AC), and moisture content (%MC) using Equation 1 [(Moki, et al., 2018), (Nazari, et al., 2019)]:

$$\%VM, \%AC, \text{and } \%MC = (W_i - W_f)/W_i \times 100\ \% \quad (1)$$

where Wi is the initial weight, and Wf is the final weight of the sample after processing the briquette treatments. Furthermore, the percentage fixed Carbon (%FC) was analyzed by the substitution of the value of %VM, %AC, and %MC to Equation 2 [(Moki, et al., 2018), (Nazari, et al., 2019)]:

$$\%FC = 100\ \% - (\%VM + \%AC + \%MC) \quad (2)$$

3 RESULTS AND DISCUSSIONS

The conversion of peanut or groundnut shells into the briquette as fuel was successfully done, as reported in many previous works [(Oni K, et al., 2020), (Wibowo & Lestari, 2020), (Oyelaran, et al., 2015)] with carbonization processing or directly into a pellet form. The carbonization process of briquette is the way to formulate the briquette from the charcoal by thermal treatment. It was called in some definitions, such as pyrolysis, torrefaction, and hydrothermal carbonization, depending on the thermal transformation of biomass (Krylova & Zaichenko, 2018). Meanwhile, the others have been processed by compacting the groundnut shell biomass briquettes with waste paper (Oyelaran, et al., 2015). This process was proposed to define the improvement of handling properties and volumetric with uniform shape and sizes at a low cost (Oyelaran, et al., 2015). However, considering the advantages and disadvantages of these two different processes is an important option to select and suitable for users. Figure 1 shows the different processes of peanut shell briquette production.

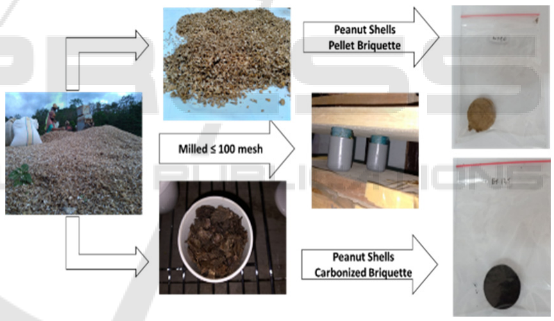

Figure 1: The Process of Production Briquette Samples

As shown in Figure 1, the briquette of peanut shells formulated without carbonization is a yellowish colour and has been called the Peanut Shells Pellet Briquette (PSPB). Others with carbonization processes have been famously named Peanut Shells Charcoal Briquette (PSCB) is blackish. According to the previous report, changing the colour caused the heating process to obtain the charcoal of peanut shells (Wibowo & Lestari, 2020), which mainly contained solid Carbon (Krylova & Zaichenko, 2018). The visual investigation by touching the briquettes showed that both were smooth; the PSPB has produced an odour and no black mark in hand than the PSCB.

Furthermore, the comparison of the Physico-chemical parameters has shown in Table 1. The parameters are caloric value, moisture content, ash content, volatile matter, and fixed Carbon, confirmed by the Indonesian National Standard (SNI) quality of briquettes.

Table 1. The Characteristics of Peanut Shell Waste Briquettes

No.	Para meters	Briquettes of Peanut Shells		Indonesian National Standards of Briquette Wood Bio-Pellet (SNI 8021-2014) [11]
		Carbonization Process (PSCB)	Non-Carbonization Process (PSPB)	
1	Calorific value (cal/g)	3736.82	3535.77	Min. 4000
2	Moisture content (%)	14.44	6.28	Max. 12
3	Ash Content (%)	2.72	3.05	Max. 1.5
4	Volatile matter (%)	57.14	68.93	Max. 80
5.	Fixed Carbon (%)	25.70	21.74	Min. 14

Table 1 shows that the caloric value and the percentage of fixed Carbon of PSCB are higher than the PSPB. These results confirm that the briquette, which has contained more Carbon, could utilize the caloricity, similar to the previous report (Wibowo & Lestari, 2020). The caloric value means how much heat can be released from the briquette (Oyelaran, et al., 2015), and when the caloricity is high, it will deliver a product less prone to rotting and spontaneous combustion (Krylova & Zaichenko, 2018). Also, both samples closely meet with minimum caloric value requirements in Indonesia. It is higher than other calorific values in equivalent compared to rice husk briquette 12,600 kJ/kg, cowpea 14,372.93 kJ/kg, and soybeans 12,953 kJ/kg (Oyelaran, et al., 2015).

The percentage of ash content and the volatile matter was lower than the PSPB briquettes. It means the temperature treatment affected the mineral content and volatilization of organic compounds. The low ash content and the volatile matter showed a good quality of the briquettes. Both samples showed the ash content was necessary reduced while their volatile value was acceptable for the SNI. According to the report (Philippe, et al., 2018), the ash content of the peanut shells briquette is very high than wood, affecting the briquette combustion. Whereas the volatile matter content functioned as a starter (igniter) to quickly burn in the initial ignition, their burning rate would be faster.

PSCB's moisture content was higher than the PSPB briquettes sample. It was because the concentration of the binder was relatively high. Hence, the presence of the water on the PSCB might be trapped and its hygroscopic characteristics. It should be dried or more evaporated; consequently, the PSCB may not consider Indonesia's commercial briquettes. In contrast, the PSPB has qualified. One of the most considerable disadvantages of biomass for consuming as fuel is high moisture content [5]. The moisture content is essential for briquettes' physical conditions during storage and transport [3].

4 CONCLUSIONS

The evaluation of the carbonization process in the production of briquettes made from the peanut shells waste has been successfully done by comparing their Physico-chemical characteristics. The briquette formulation process illustrated an option to enhance households' briquettes' production as a potential alternative energy resource. As a result, the peanut shells' charcoal briquette showed a higher caloric value than the peanut shells' without carbonization or pellet of peanut shells. On the other hand, the percentage of the briquette's moisture content made without the carbonization process confirmed acceptable for the Indonesian Standard of Wood Briquettes (SNI 8021-2014). In sum, the peanut shells briquettes could be used as fuel for households and reduce environmental problems.

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