Bio-briquettes production from coconut shell and corn cobs as a renewable energy alternative and climate change mitigation strategy

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Abstract. Climate change represents a major global issue, primarily driven by the overreliance on fossil fuels. Agricultural activities produce numerous byproducts that can negatively impact the environment if not managed effectively. The production of bio-briquettes represents a method to enhance the added value of agricultural waste materials. Bio-briquettes provide effective applications for reducing fossil fuel consumption and mitigating climate change. This study aimed to produce bio-briquettes utilizing corncob and coconut shell waste with varying particle sizes. The experimental methodology involved briquette production utilizing two raw materials: corn cob and coconut shell, along with three particle sizes of 45, 60, and 80 mesh. The calorific value is between 6,249 and 7,061 cal/g, moisture content ranges from 4.05% to 5.78%, ash content varies from 14.39% to 28.6%, volatile matter is between 25.07% and 31.63%, fixed carbon ranges from 38.78% to 48.5%, and density is between 0.60 g/cm³ and 1.17 g/cm³. The data on bio-briquettes properties indicates that bio-briquettes produced from corn cob with a particle size of 60 mesh exhibit the closest alignment with the Indonesian National Standard (SNI), though further enhancements are necessary. All produced bio-briquettes can serve as an alternative energy source; however, they generate a lot amount of ash residue.

Keywords: agricultural waste, bio-briquettes, corn cobs, particle size

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1 Introduction

Climate change is a global problem, and our heavy use of fossil fuels exacerbate it. This is because when we burn the fossil fuels, they produce a lot of greenhouse gases into our atmosphere [1]. Climate change has adverse impacts including rising sea levels and extreme weather that harm people and ecosystems [2]. Climate change also impacts people's health, including increased respiratory and cardiovascular disease, malnutrition, and the spread of diseases through insect vectors [3]. To combat climate change new long time energy source is very necessary like bio-briquettes comes from farm waste [4,5].

The shift from fossil fuel-based energy to other renewable forms of energy will lead to decreased greenhouse gas emissions and is essential for combating the greenhouse effect and protecting the environment [5]. This method solves both energy demand and waste management problems for biowaste, such as biowaste of agricultural residues (coconut shells and corn cobs). The transformation of the agricultural residues to bio-briquettes is one method to replace conventional fossil fuels with bio-based or renewable energy sources, which beneficial both for economy and environment rather than letting them unused [4,5].

Bio-briquettes quality is largely affected by the characteristics of raw materials, the binders used and particle size of the biomass [6]. For example, raw materials namely coconut shells and corn cobs consist of varieties of constituents that play role in carbonization efficiency and end properties of the briquettes they form after briquette formation [4]. Various types of binders, such as cassava starch and molasses, are added to the mixture to enhance physical and thermal properties of bio-briquettes which in turn influence their conversion. Besides, the particle size of biomass is required for optimization before briquetting in order to produce identical compaction and higher calorific value that would make efficient and clean combustion [7]. This research aimed to identify the characteristics of bio-briquettes fabricated from coconut shells and corn cobs with different particle sizes based on Indonesian Standard for Briquette. To investigate which is better between coconut shells and corn cobs as material for bio-briquettes and which particle size is best for making bio-briquettes.

2 Methods

2.1 Material Collection and Sample Preparation

The main components used in this study were coconut shell and corn cobs waste. The coconut shells were obtained from local markets, while the corn cobs were obtained from local farmers around Cibinong Sub-District, Bogor Regency, Indonesia. Bio-briquettes were made from coconut shells and corn cobs because they are abundant, environmentally friendly, and meet energy requirements. The collected coconut shells and corn cobs are then dried under the sun for three days, reducing the water content and making them easier to burn during the carbonation process. Larger coconut shells are then whacked with a hammer to reduce their size to under 10 cm the burn for carbonation process. The dried corn cobs can be burned directly for the carbonation process.

2.2 Carbonation and Bio-briquette Fabricating Process

The carbonization process begins with finding an open area and gathering firewood. The raw materials, coconut shells and corn cobs, are carbonized for approximately four hours using a kiln measuring 60 cm in diameter and 50 cm in height. The carbonization process is considered a slow combustion process, also known as slow pyrolysis. Once the material has

carbonized, the entire combustion process is stopped by sprinkling it with water. The material is then dried for three to five days until completely dry.

The carbonized and dried samples were then manually ground with a mortar and sieved. The samples were sieved using three different sieves: 40, 60, and 80 mesh. After the samples were sieved, the briquette-making process proceeded. The charcoal flour, separated according to the sieve mesh size, was mixed with 10% tapioca starch adhesive. Ten grams of tapioca starch was heated on a hotplate with 50 ml of water added. Mixing the tapioca starch with the charcoal flour was done while the adhesive was still warm, then 25 ml of water was added to soften the briquette mixture.

Briquette-making was done manually using a briquette mold, string, a wooden pusher, and manual by hand. The molded briquettes were dried in an oven at 70°C for 24 hours. Briquette drying is intended to reduce the water content and so that the briquette material is evenly distributed into the gaps in the charcoal surface, so that the bonds between charcoal particles will be stronger and produce briquettes that are not easily brittle. There are 6 types of bio-briquettes, namely CC-45, CC-60, CC-80, CS-45, CS-60, CS-80. CC = Corn Cobs. CS = Coconut Shell. Then, 45, 60, 80 are the mesh sizes used to sieve the sample.

2.3 Characterization of Bio-briquette

The properties of the dried briquettes were then examined. The testing assisted in assessing the briquettes' quality and performance to make sure they fulfilled the requirements needed to be used as an alternative energy source. A bomb calorimeter was used to test a calorific value. Additionally, the ASTM D3172-13 technique was employed for proximate analysis, including percentages of moisture content, volatile matter, ash content, and fixed carbon. Additionally, the density value was calculated by dividing the briquettes' weight by their volume (briquette size). The measures' results were then compared with one another to provide a descriptive discussion.

3 Result and Discussion

3.1 Calorific Value

Calorific value is one of the most important characteristics of a fuel [4]. The resulting calorific value ranges from 6249 to 7061 cal/g (Fig. 1). The test results show that the calorific value meets the SNI standard, which is ≥ 5000. The calorific value meets the standard and the one with the highest value is coconut shell mesh size 80 (CS80), which is 7061.73 cal/g.

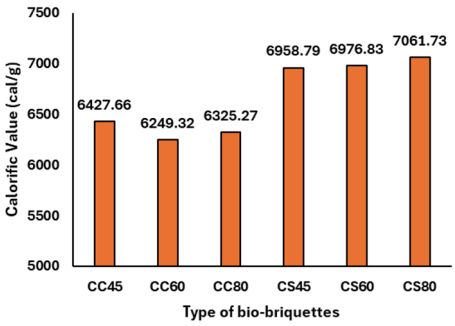

Fig. 1. Calorific value of corn cob and coconut shell briquettes.

In average coconut shell briquette have higher calorific value compared to corn cobs briquette. With the high calorific value, coconut shell briquettes have the advantage of heating up faster, this is proven by the fact that coconut shell briquettes can heat up water faster than briquettes from corn cobs [4]. Optimized calorific value is in line with green energy initiatives, advancing a greener path towards energy security [8].

3.2 Moisture Content

The moisture content ranged from 4.05% to 5.78% (Fig. 2). The moisture content of all charcoal briquette samples in this study was within the maximum limit set by the Indonesian National Standard (SNI), which is 8%. The results showed that the moisture content of briquettes from coconut shells was lower than that of briquettes from corncobs. This is in line with the research of Sabo *et al.* [4] corncob briquettes have a higher moisture content, namely 24.24%, and coconut shell briquettes have a moisture content of 14.02%.

The low water content is due to the characteristics of coconut shells, such as their high lignin content. Lignin itself is hydrophobic and therefore poorly absorbs air. Conversely, corn cobs contain a high cellulose content of up to 40%, making them readily water-retaining [9]. Controlling moisture content is very important to ensure energy efficiency during briquette use [10].

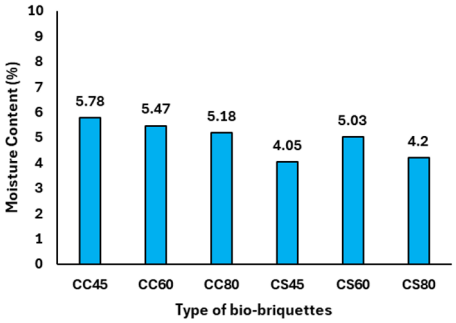

Fig. 2. Moisture content of corn cob and coconut shell briquettes.

3.3 Density

Density ranges from 0.6 to 1.17 g/cm³ (Fig. 3). Briquettes made from corn cobs with a 45-mesh size have a density of 0.6 g/cm³ and the highest briquettes made from coconut shell with a 45-mesh size have a density of 1.17 g/cm³.

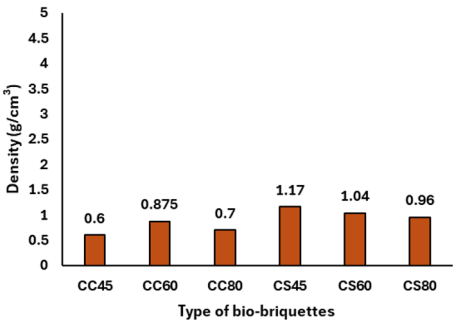

Fig. 3. Density of corn cob and coconut shell briquettes.

The density from corn cobs was similar with previous research, that the density 0.7 g/cm³ with the smallest mesh size of 40 mesh [11]. Briquettes with lower density (0.7 g/cm³) are more porous and contain more holes in which oxygen may enter, faster flame propagation through the material. This speeds both mass loss and burnout time. The denser ones (1.7 g/cm³) feature tighter packing, slowing oxygen access and heat dissipation across the material for longer burning time.

3.4 Ash Content

Ash content ranged from 14.39% to 28.6% (Fig. 4). The highest ash content on the 60-mesh sieve was found in coconut shell briquettes. The lowest found in corn cobs briquettes under 60 mesh sieves. Similar results showed that the ash content in corn cobs briquettes was 30.39% and 25.79% for coconut shell briquettes [4].

This ash content is very high, exceeding the SNI standard's maximum allowable limit of 8%. High ash content can be a challenge in the combustion process. The high ash content indicates that using the briquettes as fuel will produce significant amounts of ash.

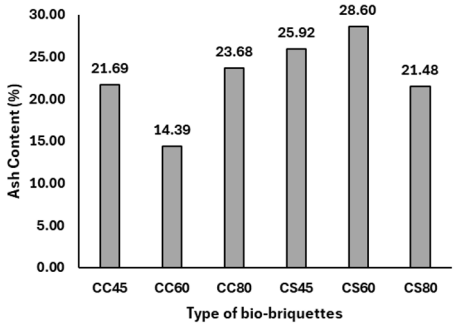

Fig. 4. Ash content of corn cob and coconut shell briquettes.

3.5 Volatile Matter Content

Volatile matter content ranged from 25.07% to 31.63% (Fig. 5). The highest volatile matter content was found in corn cob briquettes with a 60-mesh sieve (31.63%), and the lowest was found in corn cob with a 45-mesh sieve (25.07%). Meanwhile, volatile matter content in coconut shell briquettes ranged from 27-28%.

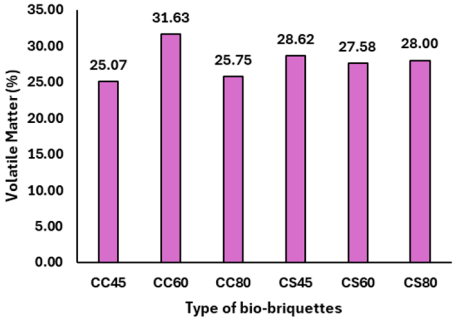

Fig. 5. Volatile matter of corn cob and coconut shell briquettes.

Volatile matter refers to the gases released during the initial stages of combustion, which affect the briquette's combustion rate and the resulting emissions. High volatile matter

content tends to accelerate combustion but can also lead to increased smoke and emissions [12].

3.6 Fixed Carbon

The fixed carbon content ranges from 38.78% to 48.5% (Fig. 6). The highest fixed carbon content was found in corn cob briquettes with a 60-mesh sieve (48.50%), and the lowest was found in coconut shell briquettes with a 60-mesh sieve (38.78%). This fixed carbon data is in line with the fixed carbon from briquettes made from a mixture of rice husk and coconut shell where the fixed carbon content is 38-49% [13], in other research the fixed carbon from corn cob briquettes can reach 57.58% -68.52% [11].

The fixed carbon levels obtained from this investigation did not meet the Indonesian National Standard. The fixed carbon content refers to the amount of carbon contained in the briquettes after the combustion and processing process. The fixed carbon content will affect the combustion process; the higher the fixed carbon content, the more suitable it is for fuel.

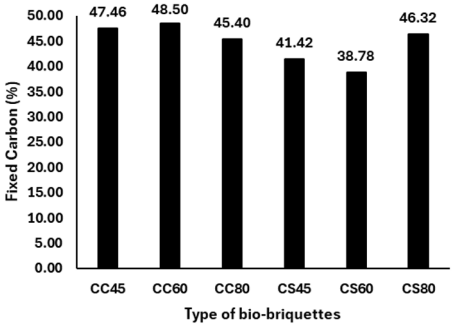

Fig. 6. fixed carbon of corn cob and coconut shell briquettes.

4 Conclusion

Briquettes, both corn cobs and coconut shells, have a high calorific value (6,249-7,062 kcal/kg), with the average calorific value of coconut shells higher than that of corn cobs. The low moisture content of the briquettes (4.05–5.78%) indicates that all samples meet general quality standards. However, the relatively high ash content (14–29%) poses a challenge as it can increase combustion residue and particulates. Fixed carbon values around 39–49%, requiring carbonization optimization to increase carbon retention. Furthermore, coconut shell briquettes have a higher density, potentially extending the burning duration. In general, although some parameters do not fully comply with the SNI 01-6235-2000 standard, both corn cobs and coconut shell briquettes can still be applied as alternative energy sources with good potential to support global climate change mitigation, with the consequence of producing ash residue and producing smoke during use.

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