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Potential of Biomass Briquettes from Tropical Fruit Waste (Study Case: Durian Skin)

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Abstract. The search for alternative and sustainable renewable energy sources has become necessary as the world faces growing concerns over climate change and depleting fossil fuel reserves. Biomass briquettes, derived from various organic materials, present a promising solution to this global energy crisis. This study explores the potential of utilizing tropical fruit, specifically durian (*Durio zibethinus*), as a renewable energy source by producing biomass briquettes. Durian is a widely cultivated tropical fruit, abundant in certain regions but often underutilized due to its strong aroma and perishability. By converting durian waste into biomass briquettes, we can address environmental challenges while creating a valuable energy resource that aligns with sustainability principles.

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1 Introduction

The search for alternative and sustainable renewable energy sources has become necessary as the world faces growing concerns over climate change and depleting fossil fuel reserves. Renewable energy (RE) sources provide energy services sustainably, particularly in mitigating climate change [1].

Biomass represents a cleaner alternative to coal and stands out as the sole renewable carbon source that can be directly transformed into fuel [2]. Briquettes are energy sources that undergo direct combustion and find application in heating and cooking for domestic and industrial purposes. They are ideally suited for fixed bed chambers thanks to their specific physical characteristics [3]. Biomass fuels usually have a low as-received fixed carbon value compared to coals, while the volatile matter values are higher; therefore, when co-gasifying coal and biomass, a low release of carbon-containing compounds such as CO2, CO, CH4, and other light hydrocarbons are expected in comparison, to gasifying coal [2].

Globally, the primary biomass energy sources are wood and wood residues, crops and their by-products, municipal solid waste, animal waste, fruit waste, food processing waste, aquatic plants, and algae [4]. In some developing countries, significant quantities of biomass wastes, encompassing agricultural residues and similar materials, are generated yearly. Unfortunately, these wastes are often utilized inefficiently or disposed of without proper consideration, posing a threat to the environment [5].

Waste briquettes are easy to handle and can be transported more efficiently than loose waste [6]. Residues exhibit various forms and characteristics that dictate their suitability as fuel. Woody residues are the most efficient cooking fuel in their natural state due to their excellent burning properties. Conversely, other crop residues are generally regarded as less optimal fuels, offering lower performance in combustion [7]. Waste can be an alternative fuel, contributing to a partial reduction in the environmental impact within the waste management sector. Waste briquetting is a treatment option for improving waste combustion efficiency, management, and handling [6].

Indonesia stands out for its extensive cultivation of tropical fruits, resulting in substantial fruit waste biomass. Undoubtedly, oil palm cultivation is the country's primary source of fruit biomass. Approximately four kilograms of fruit waste biomass, specifically empty fruit bunches, are estimated to be generated during one kilogram of crude palm oil [4].

One of the potential materials for producing briquettes involves utilizing waste from durian fruit skins combined with sawdust and molasses as an adhesive. Besides obtaining durian peels directly from durian fruit plantations, there is significant availability from numerous sources, including restaurants and seasonal street stalls offering some seasonal fruit, including durian. Additionally, urban areas often boast numerous eateries specialized in serving durian dishes and other processed durian items. Unfortunately, the optimal utilization of durian peel waste has not been achieved, as it is frequently discarded. However, by converting this waste into briquettes, it is possible to enhance the economic value of the material and simultaneously reduce environmental pollution [8].

The effective utilization of fruit waste biomass generated during the processing of the fruit above types is only sometimes carried out optimally (e.g., shown in Fig. 1) [4]. This study investigates the viability and energy value of durian biomass briquettes as a potential renewable energy source.

Fig. 1. Unused Durian fruit Skin [4]

2 Methodology

The Data used in this analysis was collected from an experimental study that involved creating biomass briquettes using durian skin waste and sawdust. Variables were controlled by setting the carbonization temperature at 450°C, removing moisture content at 105°C, and maintaining a total weight of 150 grams for the briquette mixture. The independent variable in the study from the composition variation ratio of durian skin waste and an admixture of sawdust. The anticipated outcomes in the briquette-making process involve the water content and ash content as the dependent variables.

After conducting a series of searches, additional data for this study was gathered by identifying a collection of scientific works that utilized Durian Skin as the same raw material for producing briquettes and some admixtures that are commonly used and easy to get (Coconut shell and sawdust).

These works also employed similar experimental methods in producing these solid fuels from the same raw material. To interpret the potential of renewable energy from durian skin, which possesses favorable energy characteristics, such as moderate to high calorific value, which makes it a potential energy source suitable for various applications, including domestic and industrial heating.

This study used descriptive analysis in the results of the data analysis, explaining the findings and their implications for the comparative outcomes of the

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Water content, Ash Content, and Calorific Value from Durian Skin Briquettes and Some Common Biomass mixtures

3 Result and Discussion

Durian, known as the "King of Fruits," is a tropical fruit native to Southeast Asia. It is widely cultivated for its rich flavor and unique texture. However, due to its aroma and relatively short shelf life, significant amounts of durian go to waste each year, leading to environmental issues and economic losses. This study delves into the extent of durian waste generation and the challenges associated with its proper disposal. Durian skin waste contains substantial amounts of lignocellulosic material, making it a suitable source for biomass briquettes. Properly processed and carbonized, the resulting briquettes can have a high calorific value, providing efficient and sustainable energy for cooking, heating, and other applications.

Biomass briquettes are compact, solid, and energy-dense fuel sources derived from organic materials. These briquettes are produced by compressing biomass waste under high pressure, resulting in a dense and uniform product. The advantages of biomass briquettes include their renewability, reduced greenhouse gas emissions compared to fossil fuels, and potential to utilize various organic residues. This section highlights the benefits of biomass briquettes from Durian Skin and their role in sustainable energy production. Biomass briquettes are solid fuel blocks made from compressed biomass materials, offering a cleaner and more sustainable energy source than traditional fossil fuels. Production involves densifying biomass to increase energy density and facilitate storage, transportation, and combustion.

Drying is the following energy-consuming process in biomass briquette making. Moreover, the quality of the briquette depends on the drying method. Drying refers to the removal of water from a solid by evaporation. This could be achieved through mechanical, thermal, or natural under atmospheric conditions [14]. Table 1 shows thermal and natural methods for the drying proses. Natural methods can dry some materials, but some must go through the drying and carbonization process.

Table 1. Water Content, Ash Content, and Calorific Value of Briquettes Made from Durian and Common Admixture used

Ref.	Raw Material	Temp ° C	Water content (%)	Ash content (%)	Calorific Value (cal/gr)
Research	Durian Skin and Sawdust	450	1,74 – 2,09	0,77 – 0,96	-
[9]	Durian Skin	450	0,01	18,18	6274,29
[10]	Durian Lai and Strach	400[1]	5,85	10,58	6016
[11]	Durian Skin and Durian Seed (Biochar)	400[1]	8,54	12,51	5196,5
[12]	Durian and Coconut Shell	400 Durian 450 Coconut shell	4,2-7,7	7,3	5710,43
[13]	Coconut Shell	450	4,74	-	7660,41
[14,15]	Sawdust	-	28% [2]	-	6603,4

[1] pyrolysis; [2] natural drying

The carbonization temperature can significantly impact the production and properties of briquettes. Carbonization is a crucial step in the briquette manufacturing process, where the raw biomass material undergoes thermal decomposition without oxygen. This process results in the removal of volatile compounds and moisture, leaving behind a carbon-rich residue that enhances the quality and energy content of the briquettes.

The composition of briquettes can be tailored by blending durian skin waste with other biomass materials or additives. This allows the creation of briquettes with specific characteristics and desired performance for different applications. Using sawdust as a mixture is by considering its high calorific content. The biomass from sawdust has a calorific value of up to 6603.4 cal/gr [15]. When processing the material into briquettes, the water and ash content are analyzed by controlling the briquette size, carbonation temperature, and water removal [8]. Both materials are sustainable choices as they utilize waste materials - sawdust from wood processing and durian skin from fruit processing, contributing to waste reduction and circular economy practices.

Biomass briquettes, on the other hand, represent a renewable and environmentally friendly alternative to conventional fossil fuels. Their calorific value is critical to determining their effectiveness as a sustainable energy source. These fuels can be used for cooking, heating, and electricity generation by converting agricultural and organic waste materials into compact and energy-dense briquettes.

Table 2. Standard Quality for Charcoal Briquettes in Indonesia [16]

No.	Raw Material	Standard
1	Water Content	≤ 8 %
2	Ash Content	≤ 8 %
3	Calorific Value	≥ 5000 Cal/gr

The quality of the briquettes is influenced by their water content, as a decrease in water content leads to increased calorific value and combustion power. Conversely, higher moisture content results in reduced heating value and combustion power. Briquettes with high water content may require more than ignite and lower the combustion temperature. On the other hand, briquettes with low water content will positively impact their quality, as lower water content translates to higher calorific value for the briquettes [17].

Calorific value is a crucial parameter when evaluating the energy potential of any fuel source, including both traditional combustible materials and modern biomass briquettes. It measures the amount of heat energy released during combustion and is a crucial indicator of a fuel's efficiency and suitability for various applications. Establishing a minimum calorific value standard helps maintain consistency and quality across different batches of briquettes.

Each data in Table 1 experimented with almost the same treatment and temperature in making briquettes. Every raw material using durian skin only or added mixture and other typical biomass mixture has to meet the standard minimum for calorific value to be used as briquettes (Fig. 2). The minimum calorific value of briquettes at 5000 cal/gram is often considered a standard or benchmark to ensure the effectiveness and efficiency of these biomass-based fuels. Lower calorific value briquettes may need more heat to meet the energy requirements of specific applications. A minimum value of 5000 cal/gram ensures that the briquettes offer practical and reliable energy output for everyday uses.

Durian Skin Briquettes generally have a high calorific value due to the lignocellulosic content of durian skin waste, providing efficient heat energy during combustion. On the other hand, coconut shell briquettes Possess a high calorific value as coconut shells have a high lignin content, contributing to an enhanced energy output which is why they are shown at 7.660 cal/gr. It also tends to have lower moisture content, facilitating easier ignition and sustained burning than durian skin briquettes requiring proper drying to achieve optimal combustion efficiency.

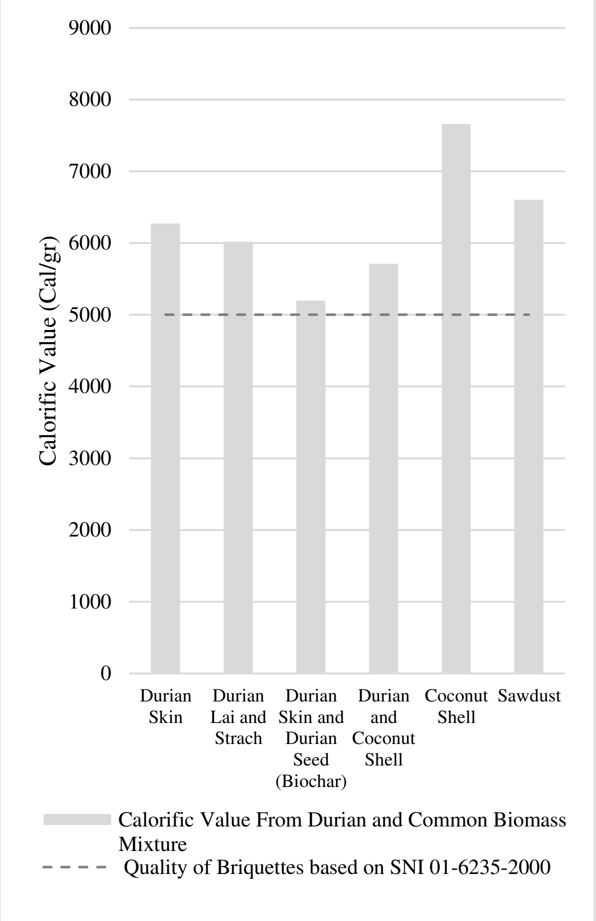

Fig. 2. Calorific Value From Durian and Common Biomass Mixture and Based on Standard

As shown in Table 1., compared to the standard of briquette in Table 2., all the data show that Durian has the potential and effectiveness for solid fuels from biomass waste because of the potential energy source. Durian Skin as raw material has an Ash content of around 18,18% which is 10,18 higher than the standard but has a shallow water content that affects the calorific value for about 6274,29 Cal/gr. Coconut shell, as tropical fruit, also has the potential to be utilized in briquette-making raw material. As a mixture with durian skin, it has shown potential and added some experimenting treatments to find the best ratio on both as briquette material.

As mentioned before, woody residues are the most efficient cooking fuel due to their excellent burning properties [7]; even the water content for sawdust is about 28%, and only using natural drying. Sawdust Briquettes typically have a high calorific value due to the dense and energy-rich nature of wood material, lower moisture content, and provide efficient heat energy during combustion, which is shown in a calorific value of more than 6000 Cal/gr,

So that it can be concluded that the calorific value of a mixture of durian and sawdust has good combustion potential and effectiveness when used as briquettes. Because lower calorific value briquettes may not generate sufficient heat to meet the energy requirements of specific applications, a minimum value of 5000 cal/gram ensures that the briquettes offer practical and reliable energy output for everyday uses. On the other hand, briquettes with higher calorific values tend to produce lower emissions during combustion.

It's important to note that the minimum calorific value can vary depending on the specific application and the intended use of the briquettes. Additionally, technological advancements and improvements in production processes may lead to higher calorific values in biomass briquettes, further enhancing their desirability as a renewable energy source. Ongoing research and innovation in briquette production from durian skin waste can lead to advancements in technology, processing techniques, and the improvement of calorific value, further enhancing its potential as a renewable energy source. The conversion of durian skin waste into briquettes can create economic opportunities for local communities and businesses. It can lead to developing small-scale briquette production units, providing employment and income generation.

4 Conclusion

This study concluded that biomass briquettes from Durian Skin and some of its mixture meet the standard of SNI 01-6235-2000 for the calorific value >5.000 cal/gram. So, it has potential because the calorific value and efficiency were good for combustion. The calorific value standard is to make sure the briquette can ignite and that the heat stored in the briquettes won't lower the temperature because of utilized to evaporate the inherent moisture present in them before being employed as combustion heat. Calorific value is a critical parameter for traditional combustion fuels and biomass briquettes. Biomass briquettes offer a promising and sustainable alternative with higher calorific values and reduced environmental impact. As research and innovation continue to advance, biomass briquettes' calorific value will improve, making them an indispensable component in the journey towards a greener and more sustainable energy future.

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