Eksergi
Jurnal Ilmiah Teknik Kimia
Vol 21, No. 2. 2024

ISSN: 1410-394X
e-ISSN: 2460-8203

A Comparative Study of Coconut Shell and Melinjo Shell as Carbon Sources for Bio-Briquette Production

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Artikel histori :

Diterima 15 Juli 2023
Diterima dalam revisi 15 Februari 2024
Diterima 26 Februari 2024
Online 10 Maret 2024

ABSTRAK: Penelitian ini bertujuan untuk mengetahui pengaruh penambahan cangkang melinjo terhadap kualitas dan efisiensi bio-briket berbasis arang. Studi ini menggunakan kombinasi tempurung kelapa dan cangkang melinjo dengan rasio yang berbeda. Pembuatan briket ini dengan proses karbonisasi pada suhu 300°C selama 60 menit dan menggunakan tepung tapioka sebagai perekat. Kemudian, briket ini diuji untuk menentukan kadar air, kadar abu, zat volatil, dan nilai kalor. Hasil penelitian menunjukkan bahwa semua briket memenuhi persyaratan nilai kalor yang ditetapkan oleh Standar Nasional Indonesia (SNI), yaitu lebih dari 5.000 kal/g. Penambahan cangkang melinjo mengakibatkan penurunan kadar abu dan zat volatil, namun juga menyebabkan penurunan nilai kalor. Berdasarkan analisis, komposisi optimal yang diperoleh adalah 90gram tempurung kelapa dan 10gram cangkang melinjo. Komposisi ini menghasilkan briket dengan nilai kalor sebesar 5.582 kal/g, kadar abu sebesar 3,76%, dan kadar zat volatil sebesar 6,65%. Oleh karena itu, disarankan untuk melakukan penelitian lebih lanjut untuk mencari jenis komponen yang mudah terbakar (combustible) yang terkandung dalam cangkang melinjo untuk memastikan potensinya dalam mengurangi jumlah abu yang dihasilkan saat briket tersebut dibakar.
Kata Kunci: bio-briket; cangkang melinjo; kadar abu; nilai kalor; tempurung kelapa

ABSTRACT: The aim of this research was to investigate the influence of adding Melinjo shells on the quality and efficiency of charcoal-based bio-briquettes. A combination of coconut shells and Melinjo shells in various ratios was utilized in the study. The briquettes were produced through a carbonization process at a temperature of 300°C for 60 minutes, with tapioca flour used as a binder. Subsequently, the briquettes underwent testing to determine moisture content, ash content, volatile matter, and calorific value. The research findings indicated that all briquettes met the calorific value requirements set by the Indonesian National Standard (SNI), exceeding 5,000 cal/g. The addition of Melinjo shells resulted in a reduction in ash and volatile matter content but also led to a decrease in calorific value. Based on the analysis, the optimal composition obtained was 90 grams of coconut shells and 10 grams of Melinjo shells, producing briquettes with a calorific value of 5,582 cal/g, ash content of 3.76%, and volatile matter content of 6.65%. Therefore, further research is recommended to identify easily combustible components in Melinjo shells to ensure their potential in reducing the amount of ash produced when the briquettes are burned.
Keywords: bio-briquette; coconut shell; melinjo shell; calorific value; ash content

1. Introduction

Amid mounting environmental challenges and energy security concerns, the criticality of sustainable energy sources surges. Fossil fuel combustion, our primary energy, harms climate, air quality, and resources. Urgently exploring alternative options becomes vital to mitigate these impacts effectively (Kabeyi & Olanrewaju, 2022; Rabbi et al., 2022). Biomass-derived briquettes have surfaced as a feasible answer for sustainable energy production. Due to guarantee their lasting fuel viability it is essential to understand their fundamental characteristics (Mohd-Faizal et al., 2022).

Bio-based briquette production has undergone extensive research. Several studies have conducted to assessed the feasibility, characteristic, and quality by examining biomass sources, binders, and compositions. Here are some studies related Bio-based briquette conducted in the last 3 years. Putra et al. studied utilizations of sludge ash pond as alternative fuel using pyrolysis process and the heating value was obtained at 700-870 kcal/kg (Putra et al.,

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2023) Nikiforov et al. (Nikiforov et al., 2023) studied the eco-friendly manufacturing of bio-coal briquettes using a blend of sunflower husks, leaves, coal, and coke dust. They found significant enhancements in briquette properties by combining biomass and coal, underscored the potential of this approach. Panjaitan et al. (Panjaitan et al., 2022) explored bio-briquettes fabricated using teak tree branch charcoal and tapioca binder, examining the impact of charcoal size and binder ratio on heating value and water content.

Unzilatirrizqi and Wadli (2022) researched bio-briquette production using coffee grounds and onion waste. They aimed to achieve energy and waste utilization goals through optimal ingredient ratios. Murni et al. (Murni et al., 2021) studied briquette from different type of raw materials (palm shells, corncob, and soybean stem) using pyrolysis process at 500°C. The results showed that the best charcoal briquette was achieved from palm shells which resulted 4,1% moisture content, 3,4% ash content, and 15% volatile matter content. Anyanwu et al. (2022) investigated blended bio-coal briquettes from Nigerian agro-wastes. These briquettes, made by blending coal, biomass, and binders, serve as fuel and kindling. This study employed of corn cob and palm mesocarp fiber as biomass materials and cassava starch as the binder material. Widodo et al. (2021) explored raw material composition's impact on caloric value using canary shell, coal, tapioca starch, and water.

Firdaus and Octavianus (2021) produced bio-briquettes from cassava skin waste, banana plastic glue, and water hyacinth, promoting renewable energy and reducing pollution. The study found by Ifa et al. (2020) found that making bio-briquettes from cashew nut shell waste is economically viable and offers a sustainable and eco-friendly energy option for Indonesian households. Switching from LPG to cashew seed bio-briquettes could reduce yearly expenses for an average household in Muna Regency by 37.00%. The study underscored the significant influence of these parameters on the overall quality of the bio-briquettes, shedding light on their substantial importance. Based on the research described, it is interesting to conduct a study to evaluate the calorific value of Gnetum gnemon, that popularly referred as melinjo in Indonesia. This plant species is extensively cultivated in Indonesia and various other tropical regions in Southeast Asia (Khaira Ummah & Susanti, 2022; Qori Nur Fauziah & Siti Susanti, 2022).

The impressive nutritional worth and versatile applications of Gnetum gnemon have attracted the attention of researchers. A study conducted by Lelifajri et al. (Lelifajri et al., 2021) transformed Gnetum gnemon shell waste into high-quality activated carbon, unveiling its remarkable carbon source potential. Similarly, Slamet et al. (Slamet et al., 2020) revealed the significant carbon potential of this plant. They developed activated charcoal from Melinjo shells through carbonization, chemical activation, and physical activation. The resulting activated charcoal comprised 87-97% carbon, while the remaining portion encompassed hydrogen, oxygen, sulfur, and various other substances.

These findings support the notion that melinjo shells have the potential to serve as a carbon source for bio-briquettes. Chairina et al. (2022) also acknowledged this potential, focusing their investigation on utilizing biomass waste from melinjo seed husks to create biopelets, a type of compacted fuel. The procedure involved gathering, desiccating, and sieving the raw materials. Subsequently, the researchers amalgamated these substances with a starch binder, shaped the resultant mixture into briquettes, and subjected them to a drying procedure. The optimal composition consisted of 50 grams of melinjo seed shells and a starch binder comprising 5% of the total weight. The resulting biopelets exhibited a moisture content of 3.1%, volatile matter of 10.6%, ash content of 4.3%, fixed carbon content of 82%, and a calorific value of 1,7302 J/g or 4,1352 cal/g.

This study was aimed to optimize the compositions of melinjo shells in charcoal-based bio-briquettes for improved quality and efficiency. Different ratios of coconut shells and melinjo shells are examined: 100:0 grams, 90:10 grams, 80:20 grams, 70:30 grams, and 60:40 grams. Carbonization is conducted at 300°C for 60 minutes. The calorific value, which indicates the briquette's heat energy, is influenced by factors such as binder properties, moisture content, and drying duration. Enhancing the overall quality contributes to environmental conservation and the utilization of agricultural residue (Jaswella et al., 2022).

2. Material and Method

The investigation involved an eight-stage methodology as following steps: material pre-treatment, carbonization, size reduction and sieving, adhesive preparation, briquette production, and analysis.

2.1 Pre-treatment

This begins with prepping coconut shells and melinjo shells to eliminate contaminants that could impact briquette quality. The coconut shells are then cut into small pieces measuring 9 - 16 cm^2 to expedite drying. The materials are dried in an oven at 60°C for 30 minutes to reduce moisture content and ensure briquettes meet standards.

2.2 Carbonization

The carbonization process was carried out by burning the raw material at operating temperature 300°C for 60 minutes in a furnace which have specification maximum capacity of 3 kg and operating temperature range 30 - 3000 °C.

2.3 Reduction and sieving

To obtain a fine powder, coconut shell and melinjo shell were finely ground then sifted through using a 60-mesh sieve.

ISSN: 1410-394X
e-ISSN: 2460-8203

2.4 Adhesive preparation

The adhesive is prepared by combining 21 grams of tapioca flour with 70 mL of water to create a homogeneous mixture. The adhesive ratio used is 21%.

2.5 Briquette production

This step consists of three subsequent stages: First, the briquettes are formed by thoroughly blending the carbonized material with the adhesive, ensuring complete incorporation. Next, the mixture is shaped using a cylindrical mold with a diameter of 5 cm and a height of 12.3 cm. Careful compaction is achieved under a pressure of 1 ton/cm^2. Finally, the molded briquettes are placed in an oven and undergo a drying process at 60℃ for 20 hours, effectively reducing their moisture content.

2.6 Briquette analysis

To assess the quality and performance of the briquettes, a comprehensive set of tests is must be conducted to measure essential characters such as moisture content, ash content, density, and calorific value in accordance with SNI 01-6235-2000 standards. These tests are gives valuable insights about the characteristics and performance of the briquettes.

3. Results and Discussion

The calorific value of a briquette plays a crucial role in its quality as it indicates the amount of heat energy present in the briquette. The calorific value is also influenced by the duration of the drying process of the material. A longer drying time leads to a decrease in moisture content and an increase in calorific value. Fuels with a higher calorific value are considered to have better quality (Jaswella et al., 2022). Based on Table 1 and Figure 1, all briquette samples meet the Indonesian National Standard (SNI) requirement of having a calorific value greater than 5,000 cal/g. Sample A yielded the highest calorific value at 5,795 cal/g, but this sample was solely made from coconut shells. For the addition of melinjo shells in coconut shell briquettes, the calorific value was recorded at 5,582 cal/g in sample B.

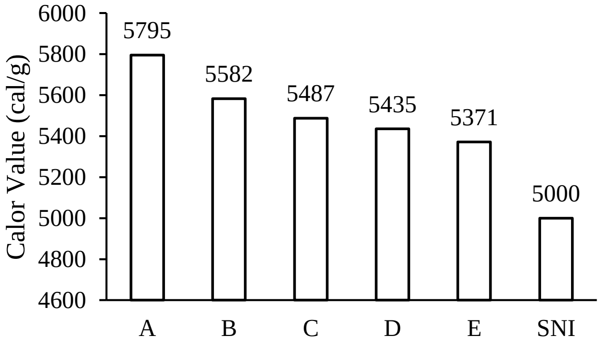

Figure 1. Calorific Value of Various Briquette Composition Variations

Figure 2 illustrates that bio-briquette samples incorporating a mixture of carbon from melinjo shells demonstrated reduced ash content compared to samples composed of 100% carbon from coconut shells. Notably, sample B, comprising 90 grams of coconut shells and 10 grams of melinjo shells, exhibited the lowest ash content at 3.76%. These findings are consistent with the research conducted by Rahmawati et al. (2013) which reported ash content ranging from 7.49% to 9.94% for samples composed solely of 100% coconut shell carbon.

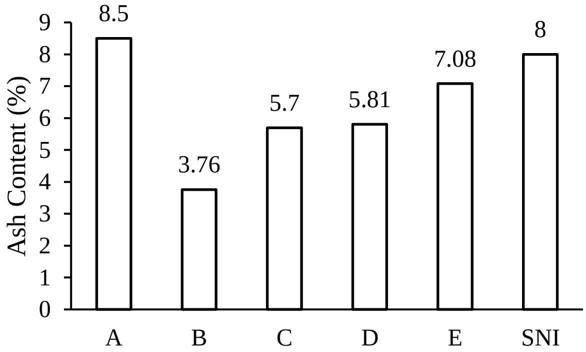

Figure 2. Ash Content Values of Various Briquette Composition Variations

Figure 2 reveals that incorporating melinjo carbon into coconut shell-based bio-briquettes reduces the ash content compared to briquettes composed solely of 100% coconut shell carbon. This suggests that the inclusion of melinjo carbon fibers enhances combustion efficiency. However, when the melinjo carbon composition prevails over 10%, the ash content begins to rise. This signifies a decline in combustion efficiency, resulting in incomplete combustion and the generation of ash containing inorganic impurities and unburned carbon residues. This decrease in combustion efficiency may be attributed to the higher proportion of binder, which reduces efficiency due to the water content present in the composite material.

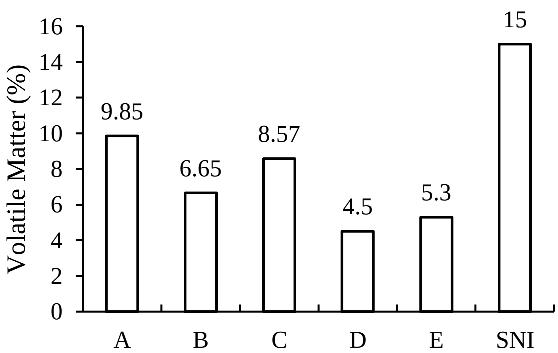

Figure 3. Volatile Matter Values of Various Briquette Composition Variations

In Figure 3, the volatile matter values of all briquette samples produced comply with the requirements set by SNI 01-6235-2000, which states that volatile matter should be less than 15%. The highest volatile matter content was observed in sample A at 9.85%, while the lowest was found in sample D at 4.5%. It is evident from the figure that the addition of melinjo shells can decrease the volatile matter content in the briquettes. In a study conducted by Fariadhie (2009), the volatile matter content of the produced briquettes was relatively high at 16.53%. The briquettes made in this research have lower volatile matter content compared to that study, and the addition of melinjo shells can further reduce the volatile matter content. Based on the analysis results, the briquette with the best quality, considering only the volatile matter content, is sample D. This is because a lower volatile matter content can increase the fixed carbon value in the briquettes and result in less smoke production during combustion.

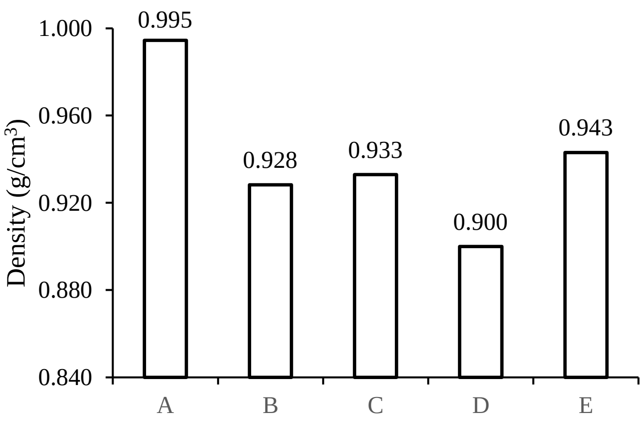

Figure 4. Density Values of Various Briquette Composition Variations

The volatile matter content of briquettes is crucial factor on determining their calorific value. It consists of hydrocarbon compounds such as aliphatic and aromatic compounds, that easily to evaporate. These compounds contribute to the briquettes' ignitability and high combustibility (Gazali & Tang, 2021). The choice of raw materials is a significant factor in the volatile matter content. Raw materials with higher moisture content tend to have lower volatile matter content, which can result in a slower burning rate for the briquettes.

The previous study conducted by Sirajuddin on the production of briquettes using coconut shell as a raw material yielded briquette with densities ranging from 0.78 g/cm^3 to 1.05 g/cm^3 (Sirajuddin, 2021). Based on Figure 4, sample A has the highest density, which is 0.99 g/cm^3, while sample D has the lowest density, which is 0.90 g/cm^3. When compared to previous research, the produced briquettes have a density that is not significantly different from briquettes made solely from coconut shells. Therefore, the resulting briquettes exhibit similar characteristics, including combustion efficiency, burning rate, and ease of handling.

Table 1. Analysis Results of Briquette Testing for Various Compositions of Coconut Shell and Melinjo Shell with 60 Minutes Carbonization Time

Characteristic	**Comparison of the Composition of Coconut Shell and Melinjo Shell — Carbonization Temperature of 300ºC and Carbonization Time of 60 minutes**					**SNI**
	100:0	**90:10**	**80:20**	**70:30**	**60:40**	
	A	**B**	**C**	**D**	**E**	
Density (g/cm^3)	0,995	0,928	0,933	0,900	0,943	-
Water Content (%)	6,08	6,09	6,73	6,72	6,19	< 8%
Ash Content (%)	8,5	3,76	5,7	5,81	7,08	< 8%
Volatile Matter (%)	9,85	6,65	8,57	4,5	5,3	< 15%
Calor Value (cal/g)	5.795	5.582	5.487	5.435	5.371	> 5000

4. Conclusion and recommendation

All briquette samples in the study meet the calorific value requirement set by the Indonesian National Standard (SNI) of being greater than 5,000 cal/g. Sample A, made solely from coconut shells, yielded the highest calorific value at 5,795 cal/g. Sample B, which included a mixture of coconut shells and melinjo shells, had a slightly lower calorific value at 5,582 cal/g. The addition of melinjo shells in coconut shell briquettes reduced the ash content compared to briquettes made solely from coconut shells. Sample B, comprising 90 grams of coconut shells and 10 grams of melinjo shells, exhibited the lowest ash content at 3.76%. Incorporating melinjo carbon fibers into coconut shell-based bio-briquettes enhances combustion efficiency, leading to reduced ash content. However, when the proportion of melinjo carbon exceeds 10%, the ash content starts to increase, indicating a decline in combustion efficiency. The decrease in combustion efficiency with a higher proportion of melinjo carbon may be attributed to the higher proportion of binder, which reduces efficiency due to the water content present in the composite material.

Acknowledgments

The research funding for this project was obtained from the Pusat Penelitian dan Pengabdian kepada Masyarakat (P3M) of Politeknik Negeri Bandung (POLBAN).

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ISSN: 1410-394X
e-ISSN: 2460-8203

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