AGRONES

JOURNAL OF AGRICULTURE, AGRIBUSINESS, WELFARE, TECHNOLOGY, HUMANITY, ENVIRONMENT, SOCIAL, AND ECONOMY

Volume 2 Nomor 1 April-Juni 2026 **E-ISSN: 3110-3405**

The Effect of the Biomass Weight Ratio of Patchouli Leaves and Sawdust on the Chemical Properties of Patchouli Briquettes

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ABSTRACT

The increasing depletion of fossil fuel reserves and rising global energy demand have accelerated the development of renewable energy sources, particularly biomass-based fuels. This study aimed to analyze the effect of biomass weight ratios of patchouli leaf waste and sawdust on the chemical properties and combustion rate of charcoal briquettes, and to determine the optimum composition for producing high-quality briquettes. The research was conducted in Wakumoro Village, Parigi District, Muna Regency, Southeast Sulawesi, from October to November 2025. A Completely Randomized Design (CRD) was applied with five treatment levels and three replications. The treatments consisted of different ratios of patchouli leaves and sawdust: P1 (100% patchouli leaves), P2 (75% + 25%), P3 (50% + 50%), P4 (25% + 75%), and P5 (100% sawdust). The observed parameters included moisture content, ash content, and combustion rate. Data were analyzed using Analysis of Variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) at a 95% confidence level. The results showed that biomass composition significantly affected moisture content, ash content, and combustion rate of briquettes. The best overall performance was obtained in P2, with moisture content of 1.57% and ash content of 7.48%, both meeting the Indonesian National Standard (SNI 01-6235-2000). The highest combustion rate was observed in P3 at 6.93 g/min. These findings indicate that the combination of patchouli leaf waste and sawdust has strong potential as an environmentally friendly alternative fuel and provides an effective solution for agricultural and wood waste utilization.

Keywords:, ***Biomass Briquette, Patchouli Leaf Waste, Sawdust, Moisture Content, Ash Content, Combustion Rate***

How to cite: Muliono, Oge, L., A., Danggi, E., Ari, R., Hastian, H, & Nurfatimah, W. O. N. S. (2026). *The Effect of the Biomass Weight Ratio of Patchouli Leaves and Sawdust on the Chemical Properties of Patchouli Briquettes*. Agrones: Journal of Agriculture, Agribusiness, Welfare, Technology, Humanity, Environment, Social, and Economy. Vol. 2 (1), 73-91

INTRODUCTION

Energy is currently one of the world's major challenges due to the increasing dependence on fossil fuels such as petroleum, natural gas, and coal. According to Kholiq (2015) the continuous rise in fossil energy consumption may lead to the depletion of global energy reserves and potentially trigger an energy crisis in the future. The availability of fossil energy sources is becoming increasingly limited as a result of ongoing exploitation. Meanwhile, energy demand continues to grow along with population growth and industrial activities. This condition creates an imbalance in energy supply and may contribute to a global energy crisis. In addition, fluctuations in fossil fuel prices directly affect the economy, particularly in developing countries such as Indonesia, which still heavily relies on fossil fuels as its primary energy source. Therefore, diversification of energy sources is urgently needed to ensure long-term energy security and sustainability.

Efforts to reduce dependence on fossil fuels can be achieved through the development of sustainable alternative energy sources. According to Addriani et al. (2024) one promising alternative energy source is biomass-based bioenergy because it can help reduce carbon emissions while utilizing organic waste. Biomass refers to organic materials derived from living organisms or biological residues that can be used as renewable energy sources. The utilization of biomass is considered a strategic solution for optimizing organic waste that has not been fully utilized. As an agricultural country, Indonesia possesses abundant and diverse biomass resources, making it highly supportive of locally based renewable energy development. This potential positions biomass as a key component in Indonesia's transition toward a low-carbon energy system.

Biomass plays an important role in the development of renewable energy, particularly through its utilization as fuel in biomass power plants. According to Prastyo et al. (2025) biomass power plants are electricity generation systems that use biomass combustion to produce steam for driving electricity-generating turbines. This system has become one of the government's strategies to accelerate the transition toward clean energy. Besides being environmentally friendly, biomass is also sustainable because it originates from renewable organic materials. Therefore, biomass utilization functions not only as an energy source but also as a solution for organic waste management. In addition, briquette production contributes to rural economic empowerment through the utilization of locally available waste resources.

Biomass generally originates from agricultural, forestry, and plantation waste that possesses relatively low economic value. These wastes can be processed into solid fuel in the form of briquettes, which are more efficient in terms of storage and utilization. According to Muhamadin et al. (2024) briquettes are alternative fuels produced from biomass through a process of mixing raw materials with binders, followed by compaction and drying. This process produces solid fuel with a more stable calorific value than raw biomass. Thus, converting waste into briquettes not only reduces environmental pollution but also provides added economic value to communities. Therefore, valorization of this waste represents an important step toward sustainable biomass utilization.

One type of biomass waste with significant potential as briquette raw material is patchouli leaf waste. Patchouli leaves contain coarse fibers such as lignin, which support the charcoal formation process. According to Shukla (2015) waste generated from patchouli oil distillation has not been optimally utilized and is mostly discarded, potentially causing environmental pollution. In fact, this waste has considerable energy potential. Furthermore, according to Isikgor and Becer (2016) lignocellulosic biomass has great potential as a sustainable alternative energy source due to its high cellulose and lignin content. The utilization of patchouli leaf waste as briquettes can increase its economic value while simultaneously reducing the environmental impacts of the patchouli oil distillation industry. Therefore, valorization of this waste represents an important step toward sustainable biomass utilization.

In addition to patchouli leaves, sawdust is another biomass waste with great potential as a briquette raw material. Sawdust contains high levels of cellulose, hemicellulose, and lignin, enabling it to produce a favorable calorific value. To date, sawdust is often discarded or burned without further utilization, despite still containing usable energy. According to Patabang (2013) sawdust-based briquettes possess several advantages, including good density, ease of packaging, and uniform size. Moreover, Suhartoyo et al. (2025) stated that wood biomass demonstrates good combustion performance and has strong potential as an alternative energy source to replace fossil fuels. Therefore, sawdust is highly suitable as a blending material in briquette production. Its continuous availability from wood-processing industries also ensures sustainability of raw material supply.

Based on several previous studies, various organic wastes have been utilized as briquette materials; however, studies combining patchouli leaves and sawdust remain limited. According to Anggoro et al. (2017) the combination of different types of biomass in briquette production can improve the physical and chemical characteristics of the resulting fuel. The combination of patchouli leaves and sawdust is expected to produce briquettes with improved quality, particularly in terms of moisture content, ash content, fixed carbon, and calorific value. Therefore, this study was conducted to analyze the effect of the biomass weight ratio of patchouli leaves and sawdust on the chemical properties of the resulting briquettes and to determine the best treatment for producing the most optimal briquette quality. This study also fills the research gap by providing empirical evidence on the optimal formulation of patchouli leaf and sawdust briquettes for improved fuel quality.

METHODS

2.1 Research Location and Time

This study was conducted in Wakumoro Village, Parigi District, Muna Regency, Southeast Sulawesi Province from October to November 2025. The research location was selected based on the abundant availability of raw materials in the form of patchouli leaf waste and sawdust, which supported the biomass briquette production process. In addition, the area is one of the patchouli oil-producing regions, making patchouli leaf distillation waste easily accessible. The research was carried out through several sequential stages to ensure standardized briquette production and testing procedures. The research was carried out through several stages, including raw material preparation, carbonization, briquette molding, drying, and testing of the chemical characteristics and combustion rate of the produced briquettes.

2.2 Tools and Materials

The tools used in this study included a 50-mesh sieve, digital scale, grinder, plastic bags, porcelain crucibles, briquette molds, carbonization furnace, oven, desiccator, tongs, stopwatch, and muffle furnace. These tools were used to support the briquette production process and the testing of briquette characteristics. Meanwhile, the materials used consisted of patchouli leaf waste, wood sawdust, tapioca flour as a binder, and water. Patchouli leaves and sawdust were used as the primary materials for biomass briquette production, while tapioca flour functioned as a binder to ensure that the charcoal particles adhered properly during the molding process. All materials were selected based on their availability and suitability for biomass briquette production.

2.3 Experimental Design

This study employed a Completely Randomized Design (CRD) with one treatment factor, namely the composition ratio of patchouli leaf biomass and sawdust. According to Gomez and Gomez (2010) a Completely Randomized Design is an experimental design used under homogeneous environmental conditions so that each treatment has an equal opportunity to be applied to the experimental units. The treatments consisted of five levels, and each treatment was repeated three times, resulting in 15 experimental units. The treatments were as follows:

P1 = 100% patchouli leaves (500 g)
P2 = 75% patchouli leaves (375 g) + 25% sawdust (125 g)
P3 = 50% patchouli leaves (250 g) + 50% sawdust (250 g)
P4 = 25% patchouli leaves (125 g) + 75% sawdust (375 g)
P5 = 100% sawdust (500 g)

This design was used to determine the effect of biomass ratio on the chemical properties and combustion rate of the resulting briquettes. The experimental design ensures controlled comparison among treatments under identical processing conditions.

2.4 Research Procedures

2.4.1 Charcoal Briquette Production

The production of charcoal briquettes was carried out through several stages, including raw material preparation, carbonization, grinding and sieving, binder mixing, and briquette molding. These stages were conducted systematically to produce briquettes with good and uniform quality for each treatment.

2.4.2 Raw Material Preparation

Patchouli leaf waste was cut into sizes of 5–10 cm and then dried under sunlight until the moisture content reached approximately 15–20%. Wood sawdust was also dried until it reached the same moisture level. According to Triono (2016) the drying process aims to reduce the moisture content of the material so that combustion can occur more easily and produce less smoke. Drying the raw materials also improves the efficiency of the carbonization process and the quality of the resulting charcoal. Uniform moisture content was maintained to ensure consistency in carbonization results.

2.4.3 Carbonization Process

The carbonization process was carried out by placing patchouli leaf waste and sawdust separately and gradually into the carbonization furnace to ensure even combustion. After ignition, the patchouli leaf waste and sawdust were removed from the furnace once they had turned into charcoal. According to Hendra and Winarni (2015) the carbonization process aims to increase carbon content and reduce volatile substances in biomass, thereby producing charcoal with better combustion quality. The process was controlled to minimize incomplete carbonization and ensure uniform charcoal quality.

2.4.4 Grinding and Sieving

The charcoal produced from carbonization was ground into fine powder and then sieved using a 50-mesh sieve. According to Tambaria and Serli (2019) finer particle sizes can improve the density and strength of briquettes, resulting in better combustion quality. The fine charcoal powder was then mixed according to the predetermined treatments.

2.4.5 Binder Mixing

The binder used in this study was tapioca flour. The tapioca flour was mixed with water at a ratio of 1:10 according to the method proposed by Sidiq in Darhani (2020). The binder was used at 10% of the total weight of the patchouli leaf and sawdust mixture. According to Sani in Darhani (2020) the use of a binder aims to improve the bonding strength between charcoal particles so that the briquettes are not easily broken. The tapioca flour and water mixture was heated while being stirred until it formed a gel adhesive, which was then mixed evenly into the charcoal powder until homogeneous. The binder was applied uniformly to ensure consistent briquette structure.

2.4.6 Briquette Molding

The charcoal powder mixed with the binder was then placed into a molding device and manually compacted to form briquettes. The molded briquettes were dried in an oven at 110°C for 4 hours. According to Yuliansyah et al. (2020) the drying process is essential for reducing moisture content so that the briquettes become denser, less fragile, and possess better combustion quality. After drying, the briquettes were packaged in plastic bags and stored in sealed conditions to maintain dryness before testing. Standardized drying conditions were applied to ensure comparable briquette quality across treatments.

2.5 Charcoal Briquette Testing

The charcoal briquettes were tested for their chemical properties, including moisture content, ash content, and combustion rate. The tests were conducted to determine the quality of the briquettes based on biomass testing standards. All tests were conducted under controlled laboratory conditions to ensure data reliability.

2.5.1 Moisture Content Analysis

According to AOAC International (2019) moisture content analysis was conducted using the oven method at 105°C until a constant weight was obtained. The petri dish was cleaned, heated in the oven, and cooled in a desiccator. A 5 g sample was placed into the dish and weighed as the initial weight. The sample was then dried in the oven for 30 minutes and cooled in a desiccator before being reweighed. The procedure was repeated until a constant weight was obtained. Moisture content was calculated using the following formula:

$$\text{Moisture Content (\%)} == \frac{W2-W3}{W2-W1} \text{ X } 100\%$$

Where:

W_1 = Weight of empty dish

W_2 = Weight of dish + sample before oven drying

W_3 = Weight of dish + sample after oven drying

2.5.2 Ash Content Analysis

According to AOAC International (2019) ash content analysis was performed using a muffle furnace at 600°C to determine the amount of mineral residue remaining after complete combustion. The porcelain crucible was heated in the oven, cooled in a desiccator, and weighed. A 5 g sample was placed into the crucible and heated in the muffle furnace for 4 hours. After the ashing process was completed, the crucible was cooled in a desiccator and weighed until a constant weight was obtained. Ash content was calculated using the following formula:

$$\text{Ash Content (\%)} == \frac{C-A}{B} \text{ X } 100\%$$

Where:

A = Weight of empty crucible

B = Sample weight

C = Weight of crucible + ash

2.5.3 Combustion Rate Test

The combustion rate test was conducted by burning the briquettes to determine burning duration and the amount of briquette mass consumed. According to Almu et al. (2014) the combustion rate indicates the speed at which fuel is consumed during combustion. Burning time was measured using a stopwatch, while briquette mass was measured using a digital scale. The combustion rate was calculated using the following formula:

$$\text{Combustion Rate} = \frac{\text{burning time}}{\text{mass of burned briquette}} \text{ gr/ minutes}$$

Where:

Mass of burned briquette = initial mass − remaining mass (grams)

Burning time = combustion duration (minutes)

2.6 Data Analysis

The data obtained from moisture content, ash content, and combustion rate tests were analyzed using Analysis of Variance (ANOVA). According to Gomez and Gomez (2010) analysis of variance is used to determine the effect of treatments on the observed variables. If the analysis showed significant effects, it was followed by Duncan’s Multiple Range Test (DMRT) at a 95% confidence level (α = 0.05) to determine differences among treatments. This statistical approach ensures objective evaluation of treatment effects on briquette quality parameters.

RESULTS AND DISCUSSION

RESULTS

The results of the charcoal briquette production study demonstrated the physical quality characteristics and combustion performance obtained through a series of tests, including moisture content, ash content, and combustion rate analyses. The moisture content test was conducted to determine the level of briquette humidity, which affects ignition ease and combustion efficiency. Meanwhile, the ash content test aimed to evaluate the inorganic residue remaining after combustion, which is related to the cleanliness and quality of briquettes as a solid fuel. In addition, the combustion rate test was used to evaluate the rate of briquette mass consumption during combustion as an indicator of energy performance and flame stability. These three parameters were collectively used to describe the quality of the produced charcoal briquettes and served as the basis for further analysis regarding the feasibility of briquettes as an alternative energy source.

Overall, the results indicate that the variation in biomass composition directly influences the physical and combustion characteristics of the briquettes, particularly in terms of moisture retention, inorganic residue formation, and burning behavior.

3.1 Results of Moisture Content, Ash Content, and Combustion Rate Analysis

The results of the analysis of variance for moisture content, ash content, and combustion rate tests are presented in Table 1.

Table 1. Analysis of Variance Results for Moisture Content, Ash Content, and Combustion Rate

Observation Component	Analysis of Variance Results
Moisture Content	**
Ash Content	**
Combustion Rate	**

Note: ** = Highly significant effect ($p < 0.05$)

Based on Table 1, the analysis of variance results for briquettes with different ratios of patchouli waste and sawdust showed highly significant effects on moisture content, ash content, and combustion rate. This indicates that the composition ratio is a determining factor in the quality performance of the briquettes produced.

3.2 Moisture Content Test

The average moisture content values and Duncan’s Multiple Range Test (DMRT 0.05) results are presented in Table 3, indicating that the briquette composition ratio had a highly significant effect on moisture content.

Table 2. Moisture Content Test Results of Briquettes

Treatment	Mean Value
P1	$4.33^{d} \pm 0.03$
P2	$1.57^{a} \pm 0.10$
P3	$2.07^{b} \pm 0.16$
P4	$2.76^{c} \pm 0.30$
P5	$4.62^{d} \pm 0.18$

Note: Values followed by different superscript letters indicate highly significant differences according to DMRT at the 5% significance level with 95% confidence.

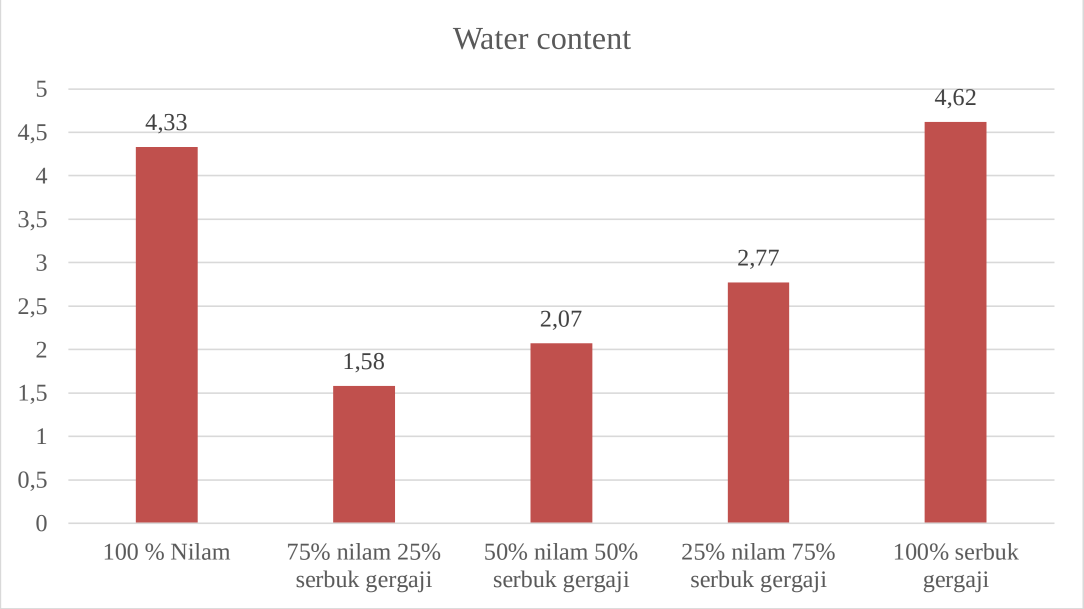

Figure 1. Moisture Content Test

Based on Table 2 and Figure 1, the moisture content test results showed that the highest moisture content was observed in treatment P5 (100% sawdust), reaching 4.62%, while the lowest moisture content was found in treatment P2 (75% patchouli leaves and 25% sawdust), reaching 1.57%. Overall, all treatments met the requirements of Indonesian National Standard Badan Standardisasi Nasional SNI 01-6235-2000 for charcoal briquettes, which specifies a maximum moisture content of 8%. The best treatment was P2 (75% patchouli leaves and 25% sawdust) with a moisture content of 1.57%, because lower moisture content generally results in a higher calorific value. This confirms that the addition of sawdust at an appropriate proportion improves drying efficiency and reduces water retention in briquette structure.

3.3 Ash Content Test Results

The average ash content values and DMRT (0.05) results are presented in Table 4, indicating that the briquette composition ratio had a highly significant effect on ash content.

Table 3. Ash Content Test Results of Briquettes

Treatment	Mean Value
P1	$19.80^{e} \pm 0.25$
P2	$7.48^{a} \pm 0.09$
P3	$10.52^{c} \pm 0.43$
P4	$9.43^{b} \pm 1.09$
P5	$19.23^{d} \pm 0.18$

Note: Values followed by different superscript letters indicate highly significant differences according to DMRT at the 5% significance level with 95% confidence.

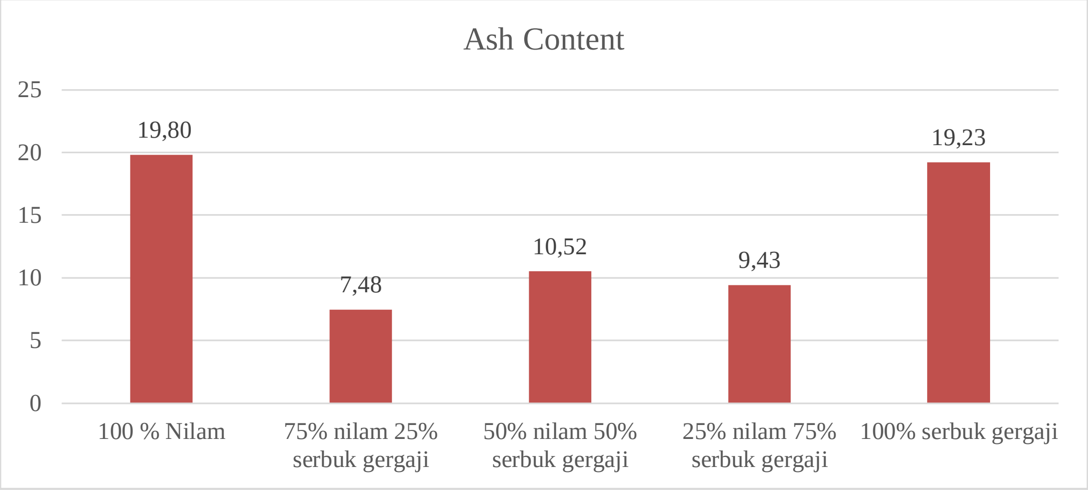

Figure 2. Ash Content Test

Based on Table 3 and Figure 2, the ash content test results showed that the highest ash content was found in treatment P1 (100% patchouli leaves), reaching 19.80%, while the lowest ash content was observed in treatment P2 (75% patchouli leaves and 25% sawdust), reaching 7.48%. The best treatment was P2 (75% patchouli leaves and 25% sawdust) with an ash content of 7.48%. Lower ash content generally indicates higher calorific value and carbon content. Treatment P2 also met the requirements of Indonesian National Standard Badan Standardisasi

Nasional SNI 01-6235-2000 for charcoal briquettes, which specifies a maximum ash content of 8%. This suggests that combining patchouli leaves with sawdust can reduce inorganic residue accumulation during combustion.

3.4 Combustion Rate

The average combustion rate values and DMRT (0.05) results are presented in Table 4, indicating that the briquette composition ratio had a highly significant effect on combustion rate.

Table 4. Combustion Rate Test Results of Briquettes

Treatment	Mean Value
P1	$4.21^{a} \pm 0.10$
P2	$5.42^{c} \pm 0.04$
P3	$6.97^{d} \pm 0.05$
P4	$6.51^{d} \pm 0.03$
P5	$5.09^{d} \pm 0.32$

Note: Values followed by different superscript letters indicate highly significant differences according to DMRT at the 5% significance level with 95% confidence.

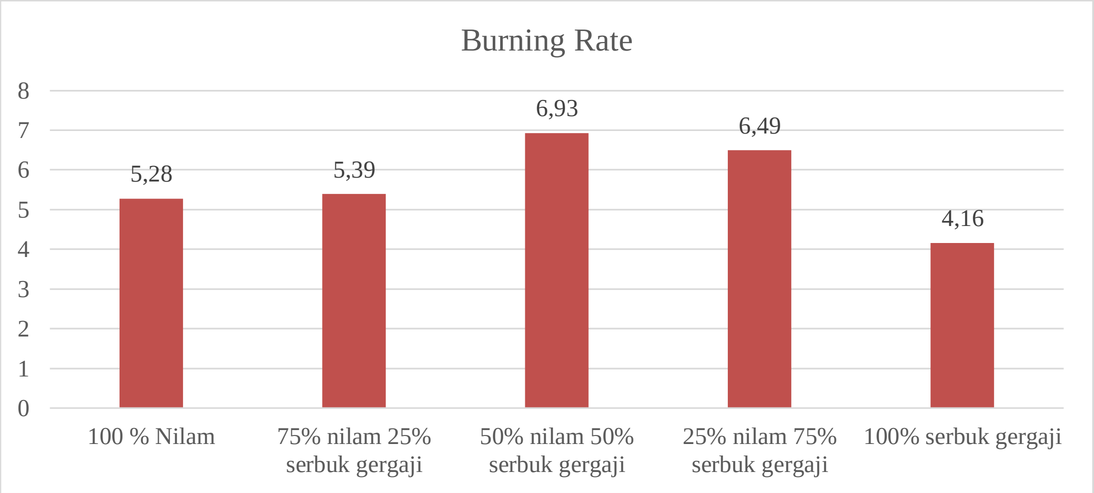

Figure 3. Combustion Rate Test

Based on Table 4 and Figure 3, the combustion rate values of the briquettes ranged from 4.16 g/minute to 6.93 g/minute. The slowest combustion rate was observed in sample P5 with a composition of 100% sawdust charcoal, while the highest combustion rate was found in sample

P3 with a composition of 50% patchouli leaves and 50% sawdust. These results indicate that a balanced composition of biomass can enhance combustion reactivity, while single-material briquettes tend to show less optimal burning performance.

DISCUSSION

4.1 Moisture Content

Moisture content in briquettes is defined as the ratio between the weight of water contained in the briquette and the dry weight of the briquette after oven drying. According to Firdaus et al. (2019) determining the moisture content of charcoal briquettes is very important because high moisture content can make ignition more difficult and reduce combustion temperature. Moisture content testing also aims to determine the hygroscopic properties of charcoal briquettes, as briquettes generally possess high hygroscopic characteristics according to Putri and Andasuryani (2017). Moisture content greatly affects the calorific value of briquettes. Lower moisture content generally results in higher calorific value and better combustion performance. The average moisture content values in this study ranged from 1.58% to 4.62%, which were still below the Indonesian National Standard Badan Standardisasi Nasional SNI maximum limit of 8%. This indicates that all treatments met the required standard. Compared with the study conducted by Putri and Andasuryani (2017) which reported a moisture content of 5.37% for biomass waste briquettes, the moisture content obtained in the present study was lower.

High moisture content is generally caused by the large number of pores present in the briquettes according to Wulandari et al. (2024). Moisture content strongly influences the quality of the produced briquettes because lower moisture levels increase calorific value and combustion efficiency. High moisture content causes briquettes to become difficult to ignite during combustion and produces more smoke. In addition, it reduces ignition temperature and combustion efficiency according to Widarti et al. (2016).

The highest moisture content in this study was found in treatment P5 (100% sawdust). This condition was likely caused by the large number of pores in sawdust charcoal, which allowed greater water absorption. This finding is consistent with Triono (2006) who stated that high moisture content in sawdust briquettes is related to the large pore structure of sawdust.

Furthermore, sawdust still contains chemical components such as cellulose, lignin, and hemicellulose, which contribute to its hygroscopic properties.

4.2 Ash Content

Ash content is the residue remaining after the combustion of briquettes. One of the components of ash is silica, which negatively affects the calorific value of charcoal briquettes. Ash content influences both calorific value and carbon content. According to Putri and Andasuryani (2017) lower ash content results in higher calorific value and carbon content. High ash content can form crusts and reduce briquette quality because it decreases calorific value and combustion rate. Therefore, charcoal briquettes should possess very low ash content according to Moeksin and Kunchoro (2015).

High ash content in biochar briquettes is caused by the large amount of raw material and high temperatures during the pyrolysis process, which leave combustion residues in the form of inorganic minerals and ash. According to Onukak et al. (2017) high ash content reduces combustion efficiency and lowers the calorific value of fuel. Lower ash content indicates better briquette quality and utilization potential, while higher ash content increases dust formation and negatively affects combustion efficiency. Koricho et al. (2017) also stated that higher ash content decreases the quality of biochar briquettes because it lowers their calorific value.

In this study, the highest ash content was found in treatment P1 (100% patchouli leaves), reaching approximately 19.80%, while treatment P5 (100% sawdust) produced an ash content of 19.23%. These findings are relatively consistent with the study conducted by Wulandari and Lestari (2025) in which the highest ash content of sawdust and coconut shell briquettes was obtained from 100% wood sawdust briquettes at 16.94%. The lowest ash content in the present study was observed in treatment P2 (75% patchouli leaves and 25% sawdust), reaching 7.48%. This treatment met the Indonesian National Standard Badan Standardisasi Nasional SNI 01-6235-2000 requirement, whereas treatments P1, P3, P4, and P5 did not meet the standard. Compared with the study conducted by Rumiyati et al. (2018) on cassava peel charcoal briquettes, which reported an ash content of 0.84%, the ash content obtained in this study was higher.

4.3 Combustion Rate

Combustion rate testing is conducted by burning briquettes to determine the burning duration of the fuel and measuring the mass of briquettes consumed during combustion. Combustion rate determines the quality and effectiveness of biobriquettes. Several factors influence briquette combustion rate, including volatile matter content, moisture content, particle size, airflow velocity, and combustion temperature. Combustion rate represents the speed at which briquettes are completely burned. Therefore, a higher combustion rate value indicates that the briquette burns out more quickly.

The combustion rate test was conducted to determine the burning duration of sawdust charcoal briquettes until they were completely converted into ash. Longer burning duration generally indicates better briquette quality. In this study, the slowest combustion rate was found in treatment P5 (100% sawdust), with a value of 4.16 g/minute. This result is consistent with the findings of Hidayat et al. (2022) where the slowest combustion rate was obtained in sample A3 containing 100% wood charcoal and 25 g molasses, with a combustion rate of 4.85 g/minute. Meanwhile, the highest combustion rate in the present study was observed in the treatment containing 50% patchouli leaves and 50% sawdust, reaching 6.93 g/minute. This finding is also consistent with Hidayat et al. (2022) who reported the highest combustion rate in sample D3 containing 50% wood charcoal and 50% teak leaf charcoal with 25 g molasses, reaching 7.05 g/minute.

The study conducted by Irbah et al. (2022) showed that briquette sample 6, composed of 10 g nyamplung shell charcoal and 90 g patchouli stem charcoal, produced the lowest combustion rate at 0.163 g/minute. In contrast, sample 1 containing 100 g nyamplung shell charcoal produced the highest combustion rate at 0.258 g/minute. The addition of charcoal powder from different biomass sources affects briquette combustion rate. Increasing the percentage of patchouli stem charcoal tends to increase the combustion rate because the volatile matter content of patchouli stem charcoal is higher than that of nyamplung shell charcoal.

CONCLUSION AND IMPLICATIONS

The biomass weight ratio of patchouli leaves and sawdust significantly affected the chemical properties and combustion rate of the produced briquettes. The moisture content values ranged from 1.57% to 4.62%, while ash content ranged from 7.48% to 19.80%, and combustion rate ranged from 4.16 to 6.93 g/minute. Treatment P2 (75% patchouli leaves and

25% sawdust) was identified as the best treatment because it produced the lowest moisture content and ash content, namely 1.57% and 7.48%, respectively, and met the Indonesian National Standard (SNI 01-6235-2000) requirements for charcoal briquettes. Meanwhile, treatment P3 (50% patchouli leaves and 50% sawdust) produced the highest combustion rate at 6.93 g/minute. Overall, the combination of patchouli leaf waste and sawdust has strong potential to be developed as an environmentally friendly alternative fuel while simultaneously increasing the economic value of biomass waste. This study demonstrates that the integration of agricultural and wood-processing waste can significantly improve briquette quality and provides an environmentally sustainable energy alternative for rural resource utilization.

Further research is recommended to evaluate additional quality parameters of patchouli leaf and sawdust briquettes, such as calorific value, fixed carbon content, density, and mechanical strength, in order to obtain more comprehensive information regarding briquette quality. Future studies should also investigate different types and concentrations of binders as well as alternative carbonization methods to improve briquette performance and combustion efficiency. In addition, future research is expected to focus on scaling up production and assessing the feasibility of industrial application to support wider adoption of biomass-based energy technologies.

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