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The Effect of Briquette Shape Variation on the Combustion Quality of Rice Husk Waste Briquettes

Muhammad Ashhabul Kah'fi[1], Dwi Santoso[1]*, Nur Indah Mansyur[1], Titik Ismandari[1], Nur Jannah1, Saat Egra[1]

[1] *Department of Agrotechnology, Faculty of Agriculture, Universitas Borneo Tarakan, Tarakan, Indonesia*

* Corresponding author. E-mail address: dwis13170@gmail.com

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ABSTRACT

Rice husk waste has potential as a biomass feedstock for briquettes, but briquette shape may influence ignition behavior, combustion rate, density, residue formation, and overall fuel quality. This study aimed to evaluate the effect of briquette shape variation on the combustion quality of rice husk waste briquettes. The research was conducted at the Agricultural Engineering Laboratory, Universitas Borneo Tarakan, from July 2024 to April 2025. A quantitative descriptive approach was used with four briquette shapes: cylinder (P1), sphere (P2), cube (P3), and rectangular block (P4). All briquettes were prepared from rice husk charcoal and tapioca starch adhesive at an 80:20 ratio, with each briquette weighed at 40 g. Quality parameters included ash content, moisture content, gross calorific value, density, and combustion rate, and the results were compared with SNI 01-6235-2000. The results showed that ash content ranged from 7.649% to 8.115%, moisture content from 1.261% to 2.370%, calorific value from 2,796 to 3,314 cal/g, density from 0.60 to 0.66 g/cm3, and combustion rate from 0.867 to 1.015 g/min. Cylinder and rectangular block briquettes met the ash and moisture criteria, all treatments met the moisture criterion, and the spherical briquette was closest to the stated SNI density range. However, none of the briquette shapes met the minimum SNI calorific value of 5,000 cal/g. Overall, briquette shape affected specific combustion-quality indicators, but no treatment satisfied all SNI quality requirements.

INTRODUCTION

Briquettes are solid fuels produced from biomass and other organic residues that can be used as alternative energy sources to reduce dependence on petroleum and fossil-based fuels. Agricultural residues, including fruit shells, wood sawdust, corn cobs, and rice husks, can be converted into briquettes through carbonization, grinding, mixing with a binder, compaction, and drying [1],[2]. The conversion of agricultural waste into briquettes is also relevant for sustainable waste management because it can reduce the accumulation of solid residues while producing a useful renewable energy product [3].

Rice husk is one of the major by-products of rice milling. Although it can be used directly for several purposes, its loose structure makes storage, handling, and combustion less efficient. Densification into briquettes improves compactness, facilitates transport and storage, and increases the practical usability of rice husk as a fuel [4]. However, the quality of a briquette depends on several physical and chemical characteristics, including moisture content, ash content, calorific value, density, and combustion rate. In Indonesia, charcoal briquette quality is commonly evaluated using SNI 01-6235-2000, which specifies requirements such as maximum moisture content, maximum ash content, minimum calorific value, and density criteria [5],[6].

In addition to raw material composition, particle size, binder concentration, and compaction pressure, briquette shape may affect combustion performance. Briquette shapes may include cylinders, hollow cylinders, cubes, rectangular blocks, spheres, and hexagonal forms. Shape influences the contact area between the briquette and air, the distribution of oxygen during combustion, heat transfer, and the rate at which mass is lost during burning [5]. Cylindrical briquettes, especially when arranged with spaces between them, may allow better oxygen flow than more compact block-like forms, while porous or hollow structures may ignite more easily because oxygen can pass through a larger surface area [5],[7].

In practice, briquette shape is often selected based on market demand and the availability of molding machines rather than on measured combustion

performance. Consequently, there is a need to examine whether different shapes of rice husk briquettes produce different quality characteristics and whether they meet applicable quality standards. Therefore, this study aimed to evaluate the effect of briquette shape variation on the combustion quality of rice husk waste briquettes. The study focused on ash content, moisture content, calorific value, density, combustion temperature profile, and combustion rate and compared the results with SNI 01-6235-2000.

MATERIALS AND METHODS

Research Site and Time

This study was conducted at the Agricultural Engineering Laboratory, Universitas Borneo Tarakan, from July 2024 to April 2025. Laboratory analysis and performance evaluation were carried out to determine the quality of rice husk waste briquettes with different shapes.

Materials, Tools, and Experimental Design

The materials used were rice husk waste, tapioca starch as an adhesive, and water as the binder solvent. The tools included a milling machine, rice husk carbonization equipment, briquette press and molds, trays, buckets or basins, drying equipment, digital scales, labels, stationery, and measuring glassware. The study used a quantitative descriptive method, with briquette quality compared against SNI 01-6235-2000. Four shape treatments were used: P1 = cylinder, P2 = sphere, P3 = cube, and P4 = rectangular block. Each briquette was formed with a mass of 40 g. The tested parameters consisted of ash content, moisture content, gross calorific value, density, and combustion rate. Each parameter was measured with five replications.

Table 1. Briquette shape treatments used in the study

Treatment	Briquette shape	Briquette mass
P1	Cylinder	40 g
P2	Sphere	40 g
P3	Cube	40 g
P4	Rectangular block	40 g

Treatment codes follow the original experimental design.

Briquette Production Procedure

Rice husk waste was cleaned to remove impurities and then sun-dried to reduce moisture content and facilitate carbonization. A total of 20 kg of rice husk was prepared as the raw material. The dried rice husk was carbonized by burning it over the ground surface using a wire-mesh chimney placed in the rice husk pile. Carbonization was conducted for approximately 4-5 hours until the material became evenly blackened. The charcoal was then extinguished with water, air-dried, and ground using a milling machine.

The ground rice husk charcoal was mixed with tapioca starch adhesive at a ratio of 80% rice husk charcoal and 20% adhesive. The adhesive was mixed with hot water and stirred continuously until it formed a uniform paste without lumps. The charcoal and adhesive mixture was then placed into different molds to produce cylinder, sphere, cube, and rectangular block shapes. The briquettes were pressed to improve compactness and to allow the adhesive to enter the pores of the material, thereby reducing breakage. After molding, the briquettes were air-dried for three days to reduce moisture content before testing.

Observed Parameters and Data Analysis

Ash content was determined using the gravimetric method. A porcelain crucible was dried in a furnace at 600 deg C, cooled in a desiccator, and weighed. A 1 g briquette sample was placed in the crucible and heated in a furnace at 850 deg C for 4 hours until ash was formed. The crucible was cooled and weighed, and ash content was calculated as the percentage of ash mass to initial sample mass [8].

Moisture content was also determined gravimetrically. A 5 g sample was placed in a crucible and oven-dried at 105 deg C for 3 hours. The sample was then cooled in a desiccator and weighed. Moisture content was calculated from the difference between the sample mass before and after drying, following the principle of ASTM D-3173-03 [9].

Gross calorific value was tested by laboratory analysis using the bomb calorimeter method, following the standard method applied by the testing laboratory. Density was calculated by dividing dry mass by briquette volume. The volume of each briquette was calculated according to its geometry: cylinder, sphere, cube, or rectangular block. Combustion rate was determined by burning the briquette, recording the burning duration with a stopwatch, measuring the mass loss, and calculating the ratio of burned mass to burning time [10]. The combustion test was also conducted by heating 1 L of water and recording temperature changes over time for each treatment. Data were processed descriptively using Microsoft Excel and compared with SNI 01-6235-2000 criteria.

RESULTS AND DISCUSSION

Briquette Quality Compared with SNI Standards

The quality evaluation of rice husk waste briquettes with different shapes is presented in Table 2. The assessed parameters were ash content, moisture content, gross calorific value, density, and combustion rate. The results indicate that shape variation affected several quality indicators, although no treatment satisfied all SNI requirements simultaneously.

Table 2. Quality characteristics of rice husk waste briquettes with different shapes

Parameter	P1 cylinder	P2 sphere	P3 cube	P4 block	SNI criterion	Interpretation
Ash content (%)	7.649	8.024	8.115	7.766	<= 8	P1 and P4 met the criterion; P2 and P3 slightly exceeded it.
Moisture content (%)	1.957	2.370	1.758	1.261	<= 8	All treatments met the criterion.
Gross calorific value (cal/g)	3,123	3,314	2,796	2,857	>= 5,000	No treatment met the criterion.
Density (g/cm3)	0.63	0.60	0.66	0.61	0.5-0.6	P2 was within/closest to the stated range; others were slightly above the upper limit.

P1 = cylinder, P2 = sphere, P3 = cube, P4 = rectangular block. SNI criteria refer to SNI 01-6235-2000 as used in the thesis.

Ash content is the inorganic residue remaining after combustion. Lower ash content is generally preferred because high ash residue can reduce calorific value and may form crusts that cover the ember surface during combustion [11]. The lowest ash content was found in the cylinder-shaped briquette (P1), with 7.649%, while the highest was recorded in the cube-shaped briquette (P3), with 8.115%. Based on the SNI maximum ash criterion of 8%, P1 and P4 met the standard, whereas P2 and P3 slightly exceeded the limit. The differences among shapes may be related to density, compactness, and the degree of air movement through the briquette during combustion. More uniform and compact shapes may support more stable combustion and leave less residue, whereas shapes that burn less evenly may leave more ash.

Moisture content ranged from 1.261% to 2.370%, and all treatments were below the SNI maximum limit of 8%. The lowest moisture content was observed in the rectangular block briquette (P4), while the highest was observed in the spherical briquette (P2). Moisture content is an important quality indicator because high moisture reduces ignition ease and lowers the effective calorific value; part of the heat generated during combustion is first used to evaporate water before the fuel burns efficiently [12], [13]. The low moisture content observed in all treatments indicates that the drying stage was generally effective.

The calorific value ranged from 2,796 to 3,314 cal/g. The spherical briquette (P2) showed the highest calorific value, while the cube-shaped briquette (P3) showed the lowest. Nevertheless, all treatments were below the minimum SNI requirement of 5,000 cal/g. This result suggests that although rice husk briquettes can function as an alternative fuel, their energy quality was still insufficient to meet the national standard. The low calorific value may be associated with the intrinsic properties of rice husk, including relatively high silica and ash contents, as well as the carbonization condition, binder proportion, and compaction level [14]. Further optimization of carbonization temperature, particle size, binder ratio, and raw material mixture is therefore required.

Density values ranged from 0.60 to 0.66 g/cm3. Density affects compactness, storage durability, ignition, and combustion duration. Higher density can make briquettes more durable and capable of burning longer, but excessively dense briquettes may require more oxygen and may be more difficult to ignite [9]. In this study, the spherical briquette (P2) was within or closest to the stated SNI range of 0.5-0.6 g/cm3, while the other treatments were slightly higher than the upper limit. The cube-shaped briquette (P3) had the highest density, indicating that its compact structure may slow ignition but support a longer combustion process.

Combustion Temperature Profile and Burning Rate

The combustion test was conducted by heating 1 L of water and recording the water temperature over time. The resulting temperature profile is shown in Figure 1, and mass loss and combustion rate are summarized in Table 3.

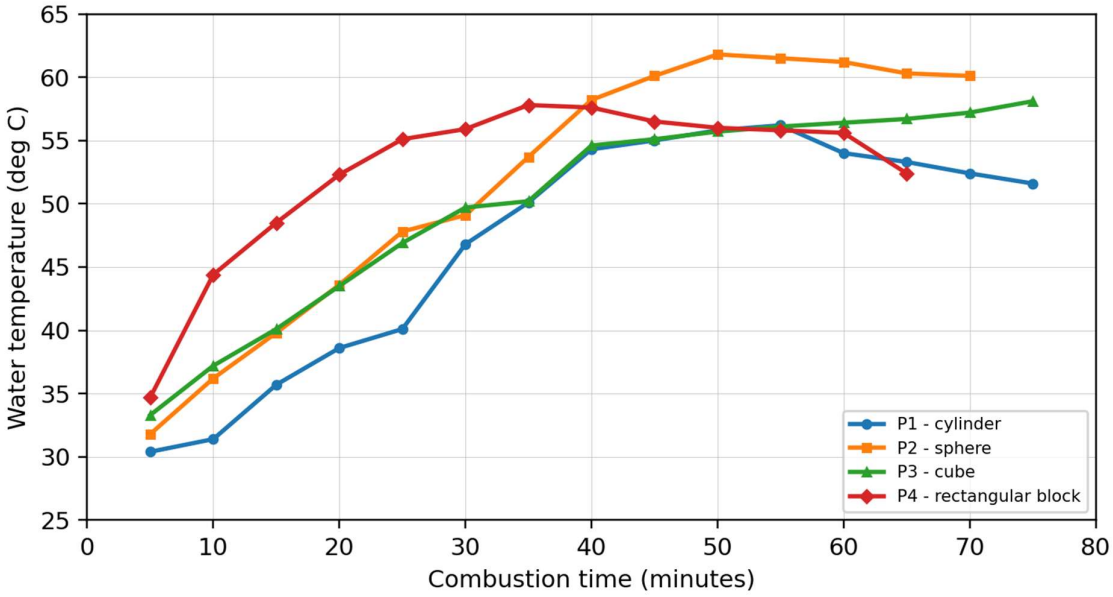


Figure 1. Temperature profile during combustion of rice husk waste briquettes with different shapes

Table 3. Briquette mass loss and combustion rate

Treatment	Mass before combustion (g)	Mass after combustion (g)	Mass loss (g)	Mass loss (%)	Burning duration (min)	Combustion rate (g/min)
P1 cylinder	103	38	65	63.1	75	0.867
P2 sphere	110	45	65	59.1	70	0.928
P3 cube	119	51	68	57.1	75	0.906
P4 block	112	46	66	58.9	65	1.015

Combustion rate was calculated as burned mass divided by burning duration.

The longest combustion durations were observed in P1 and P3, each lasting 75 minutes. The shortest combustion duration was observed in P4, which burned for 65 minutes. The highest peak temperature was recorded in P2, reaching 61.8 deg C at 50 minutes. P3 showed a gradual increase and reached its highest temperature of 58.1 deg C at 75 minutes, while P1 reached 56.2 deg C at 55 minutes and then decreased. P4 increased rapidly during the early phase, reached approximately 57.8 deg C at 35 minutes, and then declined. These patterns indicate that briquette shape influences oxygen access, heat distribution, and burning behavior.

The cylinder-shaped briquette (P1) had the lowest combustion rate, 0.867 g/min, and a long burning duration. This suggests that P1 burned more slowly and may be suitable for applications requiring longer heat release. The rectangular block briquette (P4) had the highest combustion rate, 1.015 g/min, indicating faster fuel consumption. The cube-shaped briquette (P3) had the largest mass loss at 68 g but a lower percentage mass loss because it also had the largest initial mass. Meanwhile, P2 generated the highest calorific value and peak water temperature, although its burning duration was shorter than that of P1 and P3.

The percentage mass loss was highest in P1 (63.1%). The cylinder geometry provides a relatively large surface area and, in this study, a central cavity that may improve airflow. Better oxygen flow can promote more complete combustion and greater mass loss. Previous studies have also reported that oxygen supply and surface area play important roles in combustion propagation and burning rate [5], [15]. However, faster or more complete mass loss does not necessarily indicate that all quality standards are met, because calorific value and ash content must also satisfy the required criteria.

Overall, the results show that each briquette shape had different advantages. P1 and P4 met the ash and moisture criteria, P2 produced the highest calorific value and peak combustion temperature, and P3 had the highest density. However, none of the shapes met the minimum SNI calorific value, and no single treatment met all quality indicators. For practical use, the best shape depends on the intended purpose. P1 may be preferred when longer burning duration and lower combustion rate are desired, P2 may be preferred when higher peak heat release is needed, and P4 may be useful where faster ignition and faster fuel consumption are acceptable. For standard-compliant briquettes, additional improvement is needed through optimization of raw material composition, carbonization conditions, adhesive concentration, particle size, and pressing pressure.

CONCLUSION

Briquette shape variation affected several combustion-quality characteristics of rice husk waste briquettes, including ash content, moisture content, density, calorific value, combustion temperature profile, and burning rate. Cylinder-shaped (P1) and rectangular

block-shaped (P4) briquettes met the SNI requirements for ash and moisture content, while all treatments met the moisture content requirement. The spherical briquette (P2) was within or closest to the stated density criterion and produced the highest calorific value and peak combustion temperature. Nevertheless, none of the treatments reached the minimum SNI calorific value of 5,000 cal/g, and no treatment satisfied all SNI quality parameters. Further research should optimize particle size, compaction pressure, binder concentration, carbonization conditions, and raw material mixtures to improve the calorific value and overall quality of rice husk briquettes as an efficient and sustainable alternative fuel.

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REFERENCES

[1] Arni, A., Labania, H. M., & Nismayanti, A. (2014). Study of physical characteristics of biochar briquettes as an alternative energy source. Natural Science: Journal of Science and Technology, 3(1). [in Indonesian]

[2] Ruslinda, Y., Husna, F., & Nabila, A. (2017). Characteristics of briquettes from fruit waste, HDPE plastic waste, and coconut shell composites as household alternative fuel. Jurnal Presipitasi, 14(1), 5-14. [in Indonesian]

[3] Saparin, & Wijianti, E. S. (2018). Utilization of organic waste for briquette production as alternative energy for communities in Kulur Ilir Village, Central Bangka Regency. Jurnal UBB, 18-19. [in Indonesian]

[4] Suryaningsih, S., Afandi, K. A., & Nurhilal, O. (2018). Analysis of particle size of rice husk and coffee shell mixed briquettes on combustion rate and carbon monoxide emissions. Jurnal Material dan Energi Indonesia, 8(01), 44. [in Indonesian]

[5] Asri, S., & Indrawati, R. T. (2018). Effect of briquette shape on combustion-rate effectiveness. Jurnal Penelitian dan Pengabdian Kepada Masyarakat UNSIQ, 5(3), 338-341. [in Indonesian]

[6] Ndraha, N. (2009). Test of biochar briquette material composition. Undergraduate thesis. [in Indonesian]

[7] Siregar, A. R., Harahap, L. A., & Panggabean, S. (2015). Utilization of rice husk and tea waste as charcoal briquette materials with molasses adhesive. Jurnal Rekayasa Pangan dan Pertanian, 3(3), 396-402. [in Indonesian]

[8] Ningsih, A., & Hajar, I. (2019). Quality analysis of coconut shell charcoal briquettes with tapioca starch and sago flour adhesives as alternative fuels. Seminar Nasional Industri dan Teknologi, 60-69. [in Indonesian]

[9] Masthura, M. (2019). Physical analysis and combustion rate of biochar briquettes from banana midrib material. Elkawnie: Journal of Islamic Science and Technology, 5(1), 58-66. [in Indonesian]

[10] Aljarwi, M. A., Pangga, D., & Ahzan, S. (2020). Combustion rate and calorific value test of rice husk wafer briquettes with pressure variation. ORBITA: Jurnal Pendidikan dan Ilmu Fisika, 6(2), 200-206. [in Indonesian]

[11] Saukani, M., Setyono, R., & Trianiza, I. (2019). Effect of rubber adhesive amount on the quality of palm shell briquettes. Jurnal Fisika Flux, special edition, 1(1), 159-162. [in Indonesian]

[12] Qistina, I., Sukandar, D., & Trilaksono, T. (2016). Quality study of biomass briquettes from rice husk and coconut shell. Jurnal Kimia VALENSI, 0(0), 136-142. [in Indonesian]

[13] Pohan, G. A., et al. (2024). Characteristics of calorific value and combustion rate of biomass briquettes with variations in bagasse and cassava peel composition. Jurnal Program Studi Teknik Mesin UM Metro, 13(1), 73-77. [in Indonesian]

[14] Ardiansyah, I., Putra, A. Y., & Sari, Y. (2022). Review: Calorific value analysis of various biomass briquettes using a calorimeter. Journal of Research and Education Chemistry, 120-133. [in Indonesian]

[15] Syarief, A., & Hakim, L. (2022). Effect of shape variation, particle size, and pressure on combustion characteristics of alaban wood charcoal and rice husk waste briquettes. [in Indonesian]