**Jurnal Agrotek UMMAT**
**p-ISSN 2356-2234 | e-ISSN 2614-6541 | SINTA accredited**
Volume 12, issue 4, 2025

# Effect of adhesive concentration on briquette characteristics from a mixture of cocoa shells and groundnut shells as an alternative fuel

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Received: 15th August, 2025 | accepted: 15th November, 2025

***ABSTRACT***

Agricultural wastes such as cocoa shells and groundnut shells hold significant potential as environmentally friendly alternative energy sources, particularly in West Nusa Tenggara Province, where these commodities are produced in abundance. However, their utilization as biomass energy materials remains limited and underdeveloped. In response to this potential, this study aims to evaluate the effect of varying tapioca starch adhesive concentrations on the characteristics of briquettes made from a mixture of cocoa shell charcoal and peanut shells. The research was conducted experimentally using three adhesive concentrations (10%, 20%, and 30%), with tests performed on calorific value, moisture content, ash content, and flame duration. The results revealed that increasing the adhesive concentration tended to decrease the calorific value and increase both the moisture and ash contents, although it extended the flame duration. The briquettes with 10% adhesive concentration exhibited the best performance, achieving a calorific value of 5,310 cal/g, a moisture content of 7.57%, an ash content of 7.56%, and a flame duration of 73 minutes. These values comply with the Indonesian National Standard (SNI) for charcoal briquettes, which require a minimum calorific value of 5,000 cal/g, a maximum moisture content of 8%, and a maximum ash content of 8%. These findings highlight the importance of proper adhesive formulation to improve the quality of local biomass-based briquettes and support the transition toward clean and sustainable energy..

***Keywords:*** ***agricultural waste; charcoal briquettes; cocoa husk; peanut shell; renewable energy;***

## INTRODUCTION

Indonesia is one of the largest cocoa producing countries in the world, with total production reaching more than 650 thousand tons per year (BPS, 2023). Cocoa plantations are spread across various provinces such as Aceh, Sumatra, Sulawesi, Nusa Tenggara and Papua. The existence of this

*How to cite*: Huda, A.A., Tawakal, A., Hidayatulah, S., Wiresansir, G.(2025). *Effect of adhesive concentration on briquette characteristics from a mixture of cocoa shells and groundnut shells as an alternative fuel*. *Jurnal Agrotek Ummat*, 12(4), 197-211

commodity not only contributes economically, but also leaves a large amount of biomass waste, especially in the form of cocoa pods. This huge potential has not been fully utilized as a raw material for alternative energy that is environmentally friendly (Andini et al., 2021).

West Nusa Tenggara (NTB), as one of the regions that helped develop the plantation sector, also recorded growth in land area of more than 7600 ha and cocoa production of more than 2600 tons (BPS NTB, 2024). Dompu, Bima and Sumbawa districts are the center of development of this commodity. With favorable geographical and agro-climatic characteristics, NTB is a strategic area for sustainable cocoa development (Dinas Pertanian dan Perkebunan, 2024). However, as in other regions, cocoa shell waste management in NTB is still minimal, especially at the farmer and MSME levels (Syarif et al., 2019). Without proper management, it may contribute to environmental pollution and represent a significant loss of potential energy resources. (Brunerová et al., 2017).

Cocoa shells as solid waste account for approximately 70–75% of the total weight of cocoa pods (Syarif et al., 2019). At the national level, this waste can amount to hundreds of thousands of tons annually. Without proper management, this waste can be a source of environmental pollution and waste of potential energy. However, utilizing cocoa shell waste as a raw material for charcoal briquette production offers not only an environmentally friendly solution but also notable economic benefits. Based on the average market price of biomass briquettes, the conversion of cocoa shells into briquettes could generate additional income for local farmers and small industries, with an estimated value reaching several million rupiahs per ton of processed waste. Furthermore, when used as household or industrial fuel, cocoa shell briquettes can reduce energy costs by up to 30–40% compared to kerosene or LPG (Brunerová et al., 2017). This highlights the substantial economic and environmental potential of cocoa shell waste utilization as part of sustainable energy development strategies in Indonesia.

In West Nusa Tenggara (NTB) most cocoa shells are still discarded without proper management often being openly burned, left to decompose around plantations, or used as limited animal feed. Such practices not only waste potential energy resources but also contribute to air pollution and greenhouse gas emissions. In fact, if processed into briquettes, cocoa shells could serve as an alternative fuel to replace firewood and LPG, particularly in rural areas. The utilization of local biomass, including agro-industrial waste for briquette production, aligns with the Indonesian government's vision to increase the share of renewable energy in the national energy mix to 23% by 2025 and to reduce greenhouse gas emissions by 29% (unconditional) or up to 41% with international support (conditional) (Millatie et al., 2024). This approach also supports the principle of circular economy by processing waste into energy, and contributes to the reduction of carbon emissions, as implemented through the biomass co-firing program by PLN (PT PLN, 2025).

Despite its potential, previous studies have shown that briquettes made from cocoa husk still have some shortcomings in terms of physical and chemical characteristics. The calorific value produced generally does not meet the SNI 01-6235-2000 standard. Several studies reported that the calorific value of cocoa shell briquettes only ranged from 3,000-4,500 kcal/kg, far below the minimum standard of high-quality briquettes, which is around 5,000-6,500 kcal/kg (Suprapti & Ramlah, 2013; Sinaga & Hasibuan, 2017; Iskandar et al., 2019; Laondi, 2021).

To overcome these weaknesses, a strategy is needed to strengthen the briquette raw materials by adding more thermally stable materials. One potential material is peanut shell charcoal, which is proven to have a high heating value (±6,500 kcal/kg) and characteristics that are in accordance with national briquette standards (Wahyusi et al., 2012; Febriani et al., 2022; Kusyanto et al., 2023). The addition of peanut shell charcoal has been investigated to increase fixed carbon content, reduce water and ash content, and strengthen the compressive strength of biomass briquettes.

The selection of peanut shell charcoal as an ingredient is also based on its abundant availability in Indonesia, including in NTB. Groundnut production in NTB reaches more than 3,000 tons per year, leaving a large amount of shell waste that has not been optimally utilized (BPS NTB, 2020). Therefore, the integration of cocoa shell and peanut shell waste can provide a dual solution: agricultural waste management and the provision of locally-based alternative fuels.

In addition to the charcoal base material, another factor that determines the quality of briquettes is the type and concentration of adhesive used. Tapioca starch is a commonly used natural adhesive because it is environmentally friendly and economical. However, an improper proportion of adhesive can cause a decrease in calorific value or low compressive strength (Huda et al., 2023). Therefore, this study aims to examine the effect of variations in the concentration of tapioca adhesive on the characteristics of briquettes made from a mixture of cocoa shells and tenah nut shells, in order to obtain the optimal formulation as an alternative fuel that meets SNI standards.

## METHODOLOGY

This research is an experimental study aimed at evaluating the effect of adhesive concentration on the characteristics of briquettes made from a mixture of charcoal waste cocoa shells and peanut shells. The treatment given in this study is the concentration of adhesive where the concentration of adhesive concentration (tapioca starch) in three levels: 10%, 20%, and 30%, while the test parameters are briquette characteristics including calorific value, moisture content, ash content, and burning time. Each treatment was repeated three times to obtain reliable data and can be analyzed statistically.

**1. Research tools and materials**

The raw materials used in this study include: 1) Dried cocoa pods; 2) Dry peanut shells; 3) Tapioca flour as adhesive material; 4) Water.

The equipment used include: 1) Pyrolysis furnace for carbonization process; 2) Digital scales; 3) 40 mesh size sieve; Mold; 4) Drying oven; 5) Bomb calorimeter; 6) Furnace; 7) Flame time test burner; 8) Analytical balance; 9) cup.

**2. Stages of research**

**a. Preparation of raw materials**

The cocoa pods and peanut shells were first cleaned to remove residual pulp and dirt, then cut into smaller pieces of approximately 2–3 cm to ensure uniform heating during carbonization. The materials were sun-dried for about four days. Carbonization was then carried out in a closed-type pyrolysis furnace equipped with a limited air inlet to maintain low-oxygen conditions. The process was conducted at a temperature range of 400–500 °C for approximately 2–3 hours, with visual monitoring of color change and smoke emission used to determine completion. The resulting charcoal was allowed to cool inside the furnace to prevent oxidation.

After cooling, the charcoal was manually pulverized using a traditional mortar and pestle (alu) until a fine and uniform powder was obtained. The crushed charcoal was then sieved through a 60 mesh screen to achieve consistent particle size suitable for briquette production. This manual pulverization process ensured adequate particle uniformity while maintaining the natural carbon structure, which is important for stable briquette density and combustion performance.

**b. Briquette formulation and molding**

Cocoa shell charcoal and peanut shell charcoal were mixed in a 1:1 ratio (based on dry weight) to balance the fixed carbon and volatile matter content. Tapioca starch adhesive was then added at concentrations of 10%, 20%, and 30% of the total dry weight of the charcoal. The mixture was thoroughly blended until a uniform, dough-like texture was obtained to ensure even distribution of the binder.

The homogeneous mixture was then molded using a cylindrical briquette mold with a diameter of 1 inch (≈ 2.54 cm). The compaction was performed manually by applying firm hand pressure using a simple mechanical mold press, ensuring that each briquette had a relatively consistent density and shape. To maintain uniformity, the same amount of mixture and pressing duration were applied for all samples.

After molding, the briquettes were sun-dried for four days until a constant weight was achieved, indicating stable moisture content. The dried briquettes were then stored in airtight containers to prevent moisture absorption prior to testing their physical and combustion characteristics.

**c. Testing the characteristics of briquettes**

Briquette characteristics testing was conducted for five main parameters, namely: 1) Calorific value (cal/g): measured using a bomb calorimeter according to ASTM D5865 method; 2) Moisture content (%): determined using the gravimetric oven method at 600°C for 3 hours; 3) Ash content (%): measured through complete combustion at 600°C for 3 hours in a burner furnace; 4) briquette flame duration (minutes): measured from the time the briquette starts to ignite until it is completely extinguished in free air conditions.

The analysis carried out includes analysis of water content and ash content while the calorific value is tested using a bomb calorimeter.

**1. Moisture content analysis**

According to (Putra & Hidayat, 2022) the analysis of briquette moisture content can be found using the following equation:

$$\text{Moisture content} = \frac{a-b}{a} x100\% \ldots\ldots..(1)$$

Description:

a = sample mass before drying (grams)

b = sample mass after drying (grams)

**2. Ash content analysis**

According to (Dewi et al., 2022) the analysis of briquette ash content can be found using the following equation:

$$\text{Ash content} = \frac{wo}{wd} x100\% \ldots\ldots\ldots..(2)$$

Description:

wo = mass of sample after ashing (grams)

wd = mass of sample before ashing (grams)

Measurement data were analyzed using analysis of variance (ANOVA) to evaluate whether variations in adhesive concentration (10%, 20%, and 30%) had a statistically significant effect on each briquette characteristic parameter, including calorific value, moisture content, ash content, and flame duration. ANOVA was chosen because it allows comparison among multiple treatment means simultaneously, reducing the probability of Type I errors compared to separate pairwise tests.

When ANOVA indicated significant differences among treatments, Duncan's Multiple Range Test (DMRT) was performed as a post-hoc analysis to identify which specific treatment levels differed significantly. DMRT was selected for its sensitivity in distinguishing treatment means in small experimental samples, making it suitable for laboratory-scale studies. A 5% significance level ($p < 0.05$) was used to ensure a balance between statistical rigor and practical interpretability — a standard threshold commonly adopted in agricultural and energy material research to minimize false-positive conclusions while maintaining analytical reliability.

## RESULTS AND DISCUSSION

The results of testing and analyzing each parameter of the briquette characteristics of the mixture of charcoal from cocoa fruit shells and charcoal from peanut shells at each variation of adhesive concentration are described as follows.

### 1. Calorific value

Calorific value is one of the primary indicators that determine the quality and performance of briquettes as solid fuels. It represents the total amount of heat energy released per unit mass of briquette during complete combustion. In addition to being influenced by moisture and ash content, the calorific value also reflects the overall efficiency and suitability of briquettes for use as an alternative energy source — the higher the calorific value, the greater the combustion efficiency achieved.

The calorific value of the briquettes was determined using a bomb calorimeter in accordance with the ASTM D5865 standard method. testing, approximately 1 gram of finely ground briquette sample was placed in the combustion crucible inside the bomb chamber, which was then filled with pure oxygen at a pressure of 30 atm. The sample was ignited using a fuse wire with an ignition energy of approximately 10 J, and the resulting heat was transferred to a known mass of water surrounding the bomb. The initial and final water temperatures were precisely monitored using a digital thermistor with a sensitivity of ±0.001°C, ensuring accurate thermal measurement. The calorific value was then calculated automatically by the instrument based on the temperature rise, heat capacity calibration, and correction for fuse wire and acid formation.

The results of the calorific value test for briquettes made from a mixture of cocoa shell charcoal and peanut shells at various adhesive concentrations are presented in **Figure 1,** which illustrates how different adhesive levels affect the heat energy output of the briquettes.

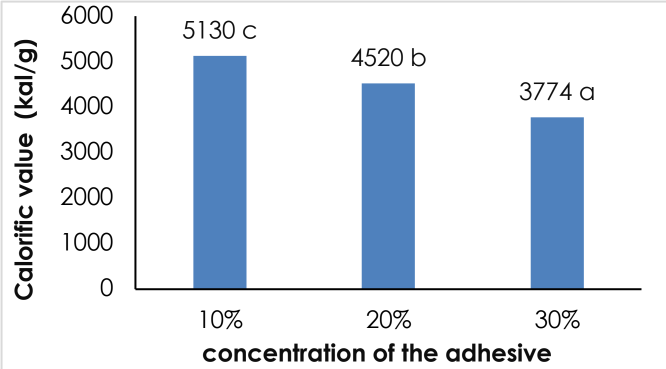


**Figure 1.** Graph of the calorific value of briquettes of cocoa shell charcoal and peanut shell mixture at different concentrations of adhesive.

Based on **Figure 1**, the calorific value of briquettes made from cocoa pods and groundnut shells showed a decreasing trend with increasing adhesive concentration. The highest heating value was achieved at 10% adhesive concentration, which amounted to 5310 cal/g, which was significantly higher than the 20% (4520 cal/g) and 30% (3774 cal/g) concentrations. Statistical analysis showed significant differences between treatments, as indicated by different letter notations at the top of the bar graph.

This decrease in heating value is in line with a common phenomenon in briquetting, where increasing the content of non-carbon adhesives, such as flour, will reduce the proportion of high-carbon raw materials in the briquette. This causes the heat energy released during combustion to decrease (Velusamy et al., 2022). Similar conditions were reported by Nurkholis & Rizaldi (2023) on bagasse charcoal briquettes with glutinous rice flour adhesive, where the highest heating value was obtained at 20% adhesive and decreased at higher concentrations. The heating value at 10% concentration in this study has met the Indonesian National Standard which requires a minimum of 5000 cal/g (National Standardization Agency, 2000). However, the heating values at 20% and 30% adhesives are below this standard, so the optimal proportion of adhesives can be considered to maintain the quality of briquettes as an alternative fuel in this mixture of cocoa shell and peanut shell charcoal briquettes.

**2. Moisture content test**

The high intensity of smoke produced during the briquette combustion process is generally caused by high moisture content, which ultimately reduces the quality of the briquettes (Chusniyah et al., 2022). Excessive moisture content causes most of the heat generated during combustion to be used to evaporate the water contained in the briquette, resulting in a decrease in calorific value and combustion rate (Priyanto et al., 2018). Based on the results of this study, the moisture content of briquettes made from a mixture of cocoa shell charcoal and peanut shells with variations in adhesive concentration was obtained as shown in **Figure 2.**

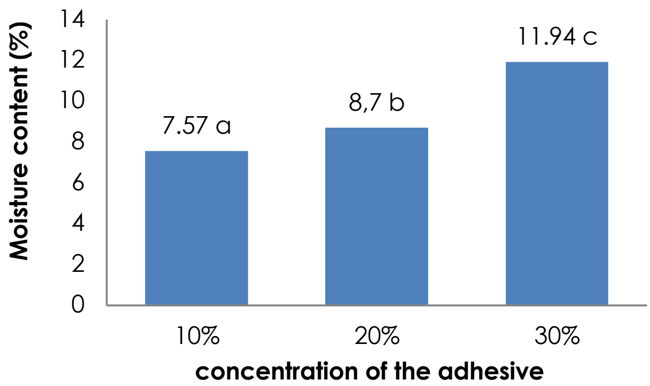


**Figure 2.** Graph of moisture content of briquettes of cocoa shell and peanut shell charcoal mixture at various adhesive concentrations

**Figure 2.** illustrates that the variation in adhesive concentration had a statistically significant effect on the moisture content of briquettes made from a mixture of cocoa shell charcoal and peanut shells. The one-way ANOVA test confirmed a significant difference among treatments ($F = 66.384$, $p < 0.01$), and further analysis using Duncan's Multiple Range Test (DMRT) revealed that each treatment group (10%, 20%, and 30% adhesive concentration) was significantly different from one another at the 5% significance level ($p < 0.05$), as indicated by distinct letter notations on the bar graph.

The lowest moisture content was obtained at a 10% adhesive concentration (7.57%), followed by 8.70% at 20%, and the highest at 11.94% for the 30% adhesive concentration. The results clearly show that increasing the adhesive concentration tends to increase the moisture content of the briquettes. This increase is primarily attributed to the hygroscopic nature of tapioca starch, which absorbs and retains ambient moisture. Moreover, higher adhesive concentrations tend to form a denser matrix structure within the briquette, reducing internal pore connectivity and hindering the diffusion of water vapor during drying. As a result, some residual moisture remains trapped in the micro-pores, even after extended sun drying. According to Elfiano et al., (2014), in the pore structure that is not completely evaporated during drying contributes to a higher final moisture content. Similarly, Bot et al., (2023) reported that excessive moisture content can reduce the calorific value and slow down the combustion process because part of the heat energy is consumed for water evaporation. In contrast, Huda (2023) noted that higher briquette density can restrict moisture reabsorption from the environment.

Based on the Indonesian National Standard (SNI 01-6235-2000), the maximum allowable moisture content for charcoal briquettes is 8%. The results of this study show that briquettes with 10% and 20% adhesive concentrations meet this requirement, whereas the 30% concentration exceeds the standard limit, indicating that excessive adhesive addition adversely affects drying efficiency and product quality.

### 3. Ash content test

Ash is the residue of combustion in the form of inorganic material that remains after the briquette is burned and heated in the furnace (Adeleke et al., 2022). Ash content is one of the important parameters in determining the quality of briquettes, because it affects combustion efficiency. Dewi (2021) explains that the higher the ash content, the lower the heating value produced. This happens because the part of the fuel that should produce heat actually becomes residue that does not burn completely.

The results of the ash content analysis of briquettes made from a mixture of cocoa shell charcoal and peanut shells with various adhesive concentrations are shown in **Figure 3.** This data is important to understand how the composition of the adhesive affects the combustion residue, while ensuring that the products produced meet the applicable quality standards.

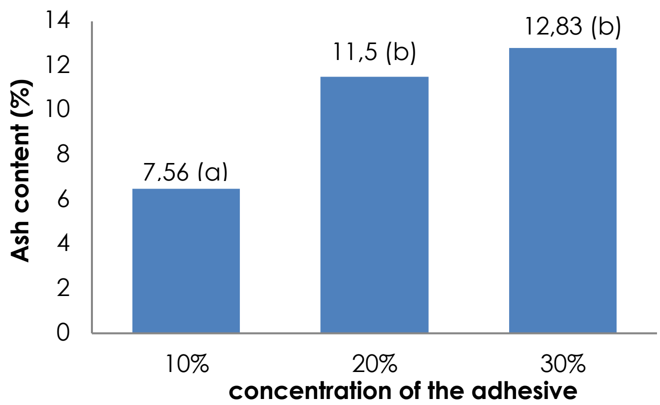


**Figure 3.** Graph of ash content of briquettes of cocoa shell and peanut shell charcoal mixture at various adhesive concentrations

**Figure 3.** shows that the use of tapioca starch adhesive at various concentrations significantly affects the ash content of briquettes made from a mixture of cocoa shell and peanut shell charcoal. The lowest ash content was recorded at 10% adhesive concentration at 7.56%, while 20% and 30% concentrations showed higher ash content at 11.50% and 12.83%, respectively.

The increase in ash content as the adhesive increases is due to two main factors: first, the presence of natural mineral content in the raw material that becomes residue after combustion; second, the incomplete carbonization process that leaves inorganic materials in greater quantities (Dewi et al., 2022; Nugraha & Mirwan, 2022). High ash content not only reduces the calorific value of briquettes, but can also accelerate the formation of scale in furnaces or combustion equipment (Sunnu et al., 2023).

Referring to the Indonesian National Standard (SNI), the recommended ash content for briquettes is ≤ 8%. In this study, only briquettes with 10% adhesive met this criterion, while 20% and 30% adhesives exceeded the threshold. This finding is consistent with the results of a study Wahyudi (2022) which showed that increasing the amount of adhesive can trigger an increase in ash content due to the increase in organic residues remaining after the combustion process.

Based on the Indonesian National Standard (SNI), the recommended ash content for briquettes is ≤ 8%. The results of this study show that only briquettes with 10% (7.56%,) adhesive concentration meet this standard, while 20% (11.50%) and 30% (12.83%) concentrations exceed the set limit.

### 4. Briquette flame duration

This test is conducted to find out how long the briquettes run out until they become ash. The results of the duration of the briquette flame of the mixture of cocoa husk charcoal and peanut shells at various adhesive concentrations can be seen in **Figure 4.**

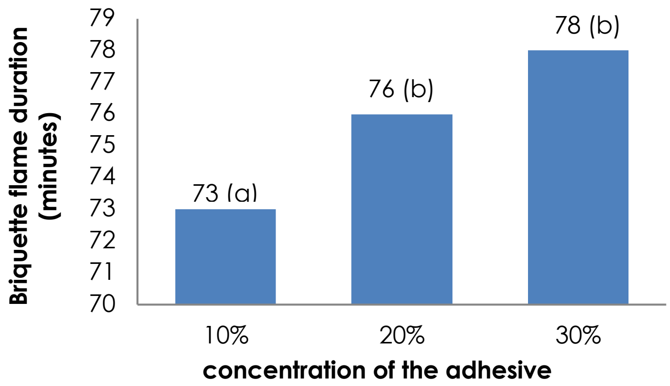


**Figure 4.** Graph of burning time of briquettes of cocoa husk and peanut shell charcoal mixture at various adhesive concentrations

**Figure 4.** shows that variations in the concentration of tapioca starch adhesive have a significant effect on the ignition time of briquettes made from a mixture of cocoa shell charcoal and peanut shells with a volume dimension of ± 25.34 $cm^3$. Briquettes with 10% adhesive concentration have the shortest ignition time, 73 minutes, while at 20% and 30% concentration the ignition time increases to 76 minutes and 78 minutes.

The increase in the flame duration of the briquettes as the adhesive concentration increases can be explained by the adhesive properties of tapioca starch which acts as a binder between charcoal particles, thus forming a denser and more homogeneous structure. Denser briquettes have a slower rate of oxygen diffusion into the pores, so the combustion process takes place more controlled and does not burn out quickly (Ashar et al., 2020).

In addition to the density factor, the volatile matter content also affects the flame duration. Volatile matter represents the fraction of organic compounds that easily vaporize upon heating and contribute to the initial ignition and flame stability of the briquette. In this study, the volatile matter content of briquettes ranged from 17.86% at 10% adhesive concentration, 19.42% at 20%, to 21.08% at 30%. These values fall within the optimal range of 15–25%, which generally supports stable combustion with minimal smoke (Tomen et al., 2023). The observed increase in volatile matter at higher adhesive concentrations indicates that the addition of binder not only enhances cohesion among particles but also introduces more organic compounds that volatilize during combustion. However, the tighter internal structure at higher adhesive levels may slow the release of these volatile gases, causing a more gradual burning process and resulting in a longer flame duration. This relationship suggests that flame duration is governed by both the physical compactness and the chemical composition of the briquette.

From a usage point of view, briquettes with longer flame times are highly desirable as they provide better energy efficiency and reduce the frequency of adding fuel during use. Thus, consideration needs to be given to choosing the right concentration of adhesive, which can be a simple yet effective strategy to improve the performance of briquettes in household and small industrial applications..

## CONCLUSION

The results showed that the concentration of adhesive has a significant effect on the quality of briquettes made from a mixture of cocoa shell charcoal and peanut shells. The use of 10% adhesive proved to provide optimal results, with calorific value and ash content that meet SNI standards, low moisture content, and adequate flash time. Increasing the adhesive concentration to 20% and 30% resulted in a decrease in quality, especially in calorific value and ash content that exceeded the standard limits. Therefore, the proportional formulation of adhesives is a crucial factor in the briquetting process, not only to ensure combustion efficiency, but also to guarantee the feasibility of use on a household and small industry scale.

Further research is recommended to explore combinations of other natural adhesives as well as modification of production techniques to improve the physical and chemical characteristics of the briquettes.

## ACKNOWLEDGEMENT

The authors express their highest appreciation and gratitude to the Institute for Research and Community Service (LPPM) of the University of Mataram for the support and funding assistance through the PNBP Research Grant in 2025 that has been provided. This assistance is one of the important factors that allow this research to be carried out well and produce findings that are useful for the development of science and the sustainable use of local resource potential.

## REFERENCES

Adeleke, A. A., Odusote, J. K., Ikubanni, P. P., Olabisi, A. S., & Nzerem, P. (2022). Briquetting of subbituminous coal and torrefied biomass using bentonite as inorganic binder. *Scientific Reports*, *12*(1), 1–11. https://doi.org/10.1038/s41598-022-12685-5

Andini, R. P., Asra, R., & Adriadi, A. (2021). Pemanfaatan limbah kulit buah kakao terhadap pertumbuhan tanaman tomat (Lycopersicon esculentum Mill.). *Agrovigor: Jurnal*

*Agroekoteknologi*. https://doi.org/10.21107/agrovigor.v14i2.10205

Ashar, Muh., Sahara, S., & Hernawati, H. (2020). PENGARUH KOMPOSISI DAN UKURAN PARTIKEL TERHADAP KUALITAS BRIKET KULIT DURIAN DAN TEMPURUNG KELAPA. *JFT : Jurnal Fisika Dan Terapannya*. https://doi.org/10.24252/jft.v7i1.13964

Bot, B. V., Axaopoulos, P. J., Sosso, O. T., Sakellariou, E. I., & Tamba, J. G. (2023). Economic analysis of biomass briquettes made from coconut shells, rattan waste, banana peels and sugarcane bagasse in households cooking. *International Journal of Energy and Environmental Engineering*. https://doi.org/10.1007/s40095-022-00508-2

BPS, B. P. S. I. (2023). *STATISTIK KAKAO INDONESIA (Indonesian Cocoa Statistics) 2022*. https://web-api.bps.go.id/download.php?f=IGnQ+iPyjKU4YRXYNWrj9lEzclpQOTVJTWwzY2NwalpZVGx3RjRXUzRMYktMNERjZElhdERwQnpxZ1NRTVpERFpyTG9odCtpbkdkOHFLZC85TUFZdHNNcmNnTmloc3VCWUpwaGtaZGRleXEvWmZBSEh0ZFgvbVVlWVpDNSs3TFpGS2krR2NlbHhFNGNpaDJORVRycEZ1c2d6TGg5NUFKeH

BPS NTB. (2020). *Luas Panen, Produksi, dan Produktivitas Kacang Tanah, 2015*. Badan Pusat Statistik Provinsi Nusa Tenggara Barat. https://ntb.bps.go.id/id/statistics-table/2/MTg0IzI=/luas-panen-produksi-dan-produktivitas-kacang-tanah.html

BPS NTB, P. (2024). *Produksi Perkebunan Menurut Kabupaten/Kota dan Jenis Tanaman di Provinsi Nusa Tenggara Barat (ribu ton), 2024*. Badan Pusat Statistik Provinsi Nusa Tenggara Barat. https://ntb.bps.go.id/id/statistics-table/3/ZWxKek1URkRaV0kwYlM5T2NHcHRNVkZXTkVkaGR6MDkjMw==/produksi-perkebunan-menurut-kabupaten-kota-dan-jenis-tanaman-di-provinsi-nusa-tenggara-barat--ribu-ton---2020.html?year=2024

Brunerová, A., Roubík, H., Brožek, M., Herák, D., Šleger, V., & Mazancová, J. (2017). Potential of tropical fruit waste biomass for production of bio-briquette fuel: Using Indonesia as an example. *Energies*. https://doi.org/10.3390/en10122119

Chusniyah, D. A., Pratiwi, R., Benyamin, B., & Suliestyah, S. (2022). Uji Kualitas Briket Berbahan Arang Ampas Kelapa Berdasarkan Nilai Kadar Air. *JURNAL PENELITIAN DAN KARYA ILMIAH LEMBAGA PENELITIAN UNIVERSITAS TRISAKTI*. https://doi.org/10.25105/pdk.v7i1.9778

Dewi, R. P., Saputra, T. J., & Purnomo, S. J. (2022). *Analisis karakteristik briket arang serbuk gergaji dan tempurung kelapa*. *17*(1), 1–5.

Dewi, R. P., Saputra, T. J., & Widodo, S. (2021). STUDI POTENSI LIMBAH KULIT KOPI SEBAGAI SUMBER ENERGI TERBARUKAN DI WILAYAH JAWA TENGAH. *Journal of Mechanical Engineering*, *5*(1). https://doi.org/10.31002/jom.v5i1.3946

Dinas Pertanian dan Perkebunan, N. (2024). *Produksi, Luas Panen dan Produktivitas Kakao berdasarkan Kabupaten/Kota*. Dinas Pertanian Dan Perkebunan, NTB. https://data.ntbprov.go.id/dataset/9d31548c-3405-4b5b-80bb-c699d06168c1/show

Elfiano, E., Subekti, P., & Sadil, A. (2014). Analisa Proksimat dan Nilai Kalor pada Briket Bioarang Limbah Ampas Tebu dan Arang Kayu. *Jurnal Aptek*, 6(1).

Febriani, S. D. A., Kusuma, F. W., Rahmanto, D. E., & Prasetyo, D. A. (2022). Analisis Kualitas Briket Arang Kulit Kacang Tanah Dengan Perekat Biji Nangka. *Jurnal Teknik Terapan*, *1*(2), 42–46. https://doi.org/10.25047/jteta.v1i2.19

Huda, A. A., Fathoni, A., & Aldi, M. J. (2023). Karakteristik Briket Limbah Cangkang Kemiri dengan Perekat Beras Ketan Karakteristik Briket Limbah Cangkang Kemiri dengan Perekat Beras Ketan. *R.E.M. (Rekayasa Energi Manufaktur) Jurnal*, *8*(2), 81–86. https://doi.org/http://doi.org/10.21070/rem.v 8 i2.1 6 7 5

Huda, A. A., Karyanik, K., Muliatiningsih, M., Fathoni, A., & Hakim, A. (2023). Effect of adhesive concentration and particle size on the quality of hazelnut shell briquettes with glutinous rice adhesive. *Jurnal Agrotek Ummat*. https://doi.org/10.31764/jau.v10i4.19663

Iskandar, N., Nugroho, S., & Feliyana, M. F. (2019). UJI KUALITAS PRODUK BRIKET ARANG TEMPURUNG KELAPA BERDASARKAN STANDAR MUTU SNI. *JURNAL ILMIAH MOMENTUM*. https://doi.org/10.36499/jim.v15i2.3073

Kusyanto, K., Rahim, M., Subakir, M. Y., Rahayu, I. E., & Fitriyana, F. (2023). Pemanfaatan Kulit Kacang Tanah Dan Bambu Sebagai Bahan Baku Pembuatan Biobriket Dengan Metode Karbonisasi. *DISTILAT: Jurnal Teknologi Separasi*, *8*(4), 1031–1039. https://doi.org/10.33795/distilat.v8i4.504

Laondi, M. A. (2021). Pengaruh Variasi Ukuran Partikel Arang Terhadap Karakteristik Briket Arang Kulit Kakao. *Skripsi*.

National Standardization Agency. (2000). Standar Nasional Indonesia Briket Arang Kayu. *Badan Standardisasi Nasional Indonesia*, 1–4.

Nugraha, R. A., & Mirwan, M. (2022). PEMANFAATAN LIMBAH KULIT BUAH DURIAN DAN SERBUK GERGAJI MENJADI BRIKET SEBAGAI BAHAN BAKAR ALTERNATIF. *Jurnal EnviroUs*, *2*(2), 1–6.

Nurkholis, M. F., & Rizaldi, L. H. (2023). Karakteristik briket ampas tebu ( bagasse ) dari bahan perekat tepung beras ketan Characteristics of bagasse briquettes using glutinous rice flour as adhesive. *Agrotek Ummat*, *10*(1), 1–8.

Priyanto, A., Hantarum, H., & Sudarno, S. (2018). Pengaruh Variasi Ukuran Partikel Briket Terhadap Kerapatan, Kadar Air, dan Laju Pembakaran Pada Briket Kayu Sengon. *Prosiding Seminar Nasional Sains Dan Teknologi Terapan*.

PT PLN, (Persero). (2025). *Co-Firing Biomassa di PLTU PLN Hasilkan 1,67 Juta MWh Listrik Hijau Sepanjang 2024*. PT PLN,(Persero). https://web.pln.co.id/media/siaran-pers/2025/02/co-firing-biomassa-di-pltu-pln-hasilkan-167-juta-mwh-listrik-hijau-sepanjang-2024

Putra, B. S., & Hidayat, A. A. (2022). BRIKET DARI CANGKANG KELAPA SAWIT MENGGUNAKAN PEREKAT DAUN BELIMBING WULUH. *J-TETA (Jurnal Teknik Terapan)*, *1*(1), 1–6.

Putri Azmi Millatie, Rahmat Hidayat, Suyono Thamrin, & Lailatul Fajriyah. (2024). Evaluation of Biomass Energy Policy Implementation in Indonesia to National Defense Support. *International Journal Of Humanities Education and Social Sciences (IJHESS)*. https://doi.org/10.55227/ijhess.v3i4.889

Rosta Natalia Sinaga, & Rosdanelli Hasibuan. (2017). PEMBUATAN BRIKET DARI KULIT KAKAO MENGGUNAKAN PEREKAT KULIT UBI KAYU. *Jurnal Teknik Kimia USU*. https://doi.org/10.32734/jtk.v6i3.1585

Sunnu, A. K., Adu-Poku, K. A., & Ayetor, G. K. (2023). Production and Characterization of Charred Briquettes from Various Agricultural Waste. *Combustion Science and*

*Technology*. https://doi.org/10.1080/00102202.2021.1977803

Suprapti, & Ramlah, S. (2013). Pemanfaatan kulit buah kakao untuk briket arang. *Jurnal Biopropal Industri*, *4*(2), 65–72.

Syarif, S., Cahyono, R. B., & Hidayat, M. (2019). Pemanfaatan Limbah Kulit Kakao Menjadi Briket Arang sebagai Bahan Bakar Alternatif dengan Penambahan Ampas Buah Merah. *Jurnal Rekayasa Proses*. https://doi.org/10.22146/jrekpros.41517

Tomen, W. T., Diboma, B. S., Bot, B. V., & Tamba, J. G. (2023). Physical and Combustion properties investigation of hybrid briquettes from tropical Sawdust: Case study of Iroko (Milicia excelsa) and Padouk (Pterocarpus soyauxii). *Energy Reports*. https://doi.org/10.1016/j.egyr.2023.02.006

Velusamy, S., Subbaiyan, A., Murugesan, S. R., Shanmugamoorthy, M., Sivakumar, V., Velusamy, P., Veerasamy, S., Mani, K., Sundararaj, P., & Periyasamy, S. (2022). Comparative Analysis of Agro Waste Material Solid Biomass Briquette for Environmental Sustainability. *Advances in Materials Science and Engineering*. https://doi.org/10.1155/2022/3906256

Wahyudi, Y., Amrullah, S., & Oktaviananda, C. (2022). Characteristics of Briquettes Made from Corn Cobs Based on Variations Amount of Adhesive. *Jurnal Pengendalian Pencemaran Lingkungan (JPPL)*.

Wahyusi, K. N., Dewati, R., Ragilia, R. putri, & Kharisma, T. (2012). Briket Arang Kulit Kacang Tanah Dengan Proses Karbonisasi. *Jurnal Teknik Kimia*, 6(2), 70–73.