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Effect of rice flour binder concentration on the characteristics of peanut shell charcoal briquettes as an alternative fuel

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ABSTRACT

The use of peanut shell waste as briquettes is a renewable energy alternative with the potential to improve the quality of solid fuel. This study aims to analyze the effect of rice flour binder concentration on the quality of peanut shell charcoal briquettes based on quality parameters and their compliance with SNI standards. The method used was an experiment with a Completely Randomized Design (CRD) at binder concentrations of 10%, 15%, 20%, and 25%. The tested parameters included calorific value, moisture content, ash content, and burning rate. The results showed that an increase in binder concentration reduced the calorific value from 5,450 cal/g to 4,676 cal/g, and increased the moisture content to 7.9% and the ash content to 8.4%. All treatments met the SNI moisture content standard (<8%), but the ash content only met the standard up to a 20% concentration. The combustion rate decreased from 0.0042 g/s to 0.0031 g/s, while the burning time increased from 50.7 minutes to 68.8 minutes. Overall, the best briquette quality was obtained at a binder concentration of 10–20% because it met SNI standards, had a high calorific value, low moisture and ash content, and stable combustion. Therefore, controlling the binder concentration is crucial for producing briquettes of optimal quality.

Keywords: : biomass; ; briquette quality; charcoal briquettes; peanut shell; rice flour binder

INTRODUCTION

The massive use of fossil energy has increased greenhouse gas emissions, contributing to global climate change. Therefore, the development of sustainable and environmentally friendly alternative energy sources is necessary (REN21, 2023). One potential alternative energy source is biomass derived from agricultural waste, as it is renewable and abundantly available in agrarian countries such as Indonesia (IRENA, 2022). However, the utilization of this biomass remains suboptimal, and the waste is often burned or left to decay, causing environmental pollution.

Therefore, innovation is needed to process biomass waste into more valuable alternative fuels such as briquettes.

One type of agricultural waste with potential as a briquette raw material is peanut shells. Peanut shells contain 88.57% dry matter, 10.87% crude protein, 2.03% crude fat, 61.3% crude fiber, and 20.27% nitrogen-free extract (NFE), with a Total Digestible Nutrients (TDN) value of 31.7% (Praswanto & Setyawan, 2023). The high dry matter content indicates that peanut shells have good potential as a fuel due to their ability to produce stable energy. In addition, their high lignocellulosic content contributes to increased calorific value and combustion stability (Bot et al., 2023).

Several previous studies have shown that peanut shells have strong potential as briquette raw materials and are capable of meeting national quality standards. Wahyusi (2012) reported that carbonized peanut shell briquettes have a calorific value ranging from 5500 to 6000 cal/g. Febriani (2022) found that using jackfruit seed binder produced a calorific value of 5150 cal/g. Another study by Kusyanto (2023) demonstrated that a combination of peanut shells and bamboo could produce a calorific value of 5000–7000 cal/g. These findings indicate that peanut shells have great potential to be developed as an alternative fuel.

The quality of briquettes is influenced by several factors, one of which is the use of binders. Binders function to improve mechanical strength and maintain the structural stability of briquettes during storage and use (Uthman et al., 2026). Without binders, biomass particles are difficult to bind effectively, resulting in fragile briquettes. Therefore, the selection of binder type and concentration is a critical factor in briquette production (Mousa et al., 2022).

Natural binders are widely used in briquette production because they are more environmentally friendly and readily available compared to synthetic binders. One commonly used binder is tapioca flour, which has a high starch content that enhances the bonding between biomass particles (Olugbade et al., 2019). However, alternative materials need to be explored due to limitations in the cost and availability of tapioca flour in certain regions.

As an alternative, rice flour can be used as a binder in briquette production. Rice flour contains a high starch content of approximately 70–80%, consisting of amylose and amylopectin, which play important roles in particle binding. Amylose contributes to strength and rigidity, while amylopectin provides elasticity, thereby improving briquette compactness (Nagarajan & Prakash, 2021). In addition, rice flour is widely available as a staple food in Indonesia, making it more economical and sustainable. It also offers environmental advantages, as it does not produce harmful residues during combustion (Almirón et al., 2019).

However, the concentration of the binder must be carefully controlled, as it significantly affects the quality of the resulting briquettes. Insufficient binder concentration can lead to fragile briquettes with low mechanical strength (Aransiola et al., 2019). Conversely, excessive binder use can reduce calorific value and increase ash content due to the presence of non-carbon components (Nurkholis & Rizaldi, 2023). Therefore, further research is needed to determine the optimal binder concentration.

Based on the above background, this study aims to analyze the effect of rice flour binder concentration on the characteristics of peanut shell charcoal briquettes as an alternative fuel, in order to obtain the optimal composition for producing high-quality briquettes.

METHODOLOGY

1. Time and location of the study

This research was conducted from March to August 2025. The study took place at the Phenomena Laboratory, University of Mataram, and the Chemistry Laboratory, Faculty of Agriculture, University of Muhammadiyah Mataram.

2. Materials and equipment

The main raw material used in this study was peanut shells as the briquette feedstock, while rice flour was used as the binder. The equipment included a carbonization drum, a briquette mold with a diameter of 40 mm, an analytical balance, oven, furnace, bomb calorimeter, desiccator, porcelain crucible, mortar, 40-mesh sieve, stove, stopwatch, and other supporting tools.

3. Experimental design

This study employed an experimental method using a Completely Randomized Design (CRD). The experiment consisted of four treatments with three replications, resulting in 12 experimental units. The treatments were variations in rice flour binder concentration relative to the weight of peanut shell charcoal, as follows:

P1 = 10% binder

P2 = 15% binder

P3 = 20% binder

P4 = 25% binder

4. Research procedures

Raw material preparation

Peanut shells were collected, cleaned, and dried for approximately 3 days. Carbonization was then carried out using a pyrolysis drum for about 5 hours until charcoal was formed. The charcoal was crushed and sieved using a 40-mesh sieve.

Binder preparation

The binder was prepared from rice flour with a ratio of 1:10 (flour:water), then heated until a homogeneous gel was formed.

Briquette production

The charcoal powder was mixed with the binder according to each treatment variation until homogeneous. The mixture was then molded into cylindrical briquettes with a diameter of 40 mm and compacted. The briquettes were dried under sunlight for approximately 4 days.

Briquette characterization

Quality testing was conducted according to the methods specified in SNI 01-6235-2000. The parameters tested included moisture content, ash content, calorific value, and burning rate.

5. Data analysis

Data were analyzed using Analysis of Variance (ANOVA) and followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level if significant differences were observed.

To determine moisture and ash content, mathematical calculations were performed using the following equations:

Moisture content analysis

According to Putra & Hidayat (2022), moisture content is calculated using the following equation:

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

Where:

a = mass of sample before drying (g)

b = mass of sample after drying (g)

Ash content analysis

According to Dewi (2022), ash content is calculated using the following equation:

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

Where:

wo = mass of sample after ashing (g)

wd = mass of sample before ashing (g)

Burning rate

According to Ismayana (2021), the burning rate test (in g/s) is calculated using the following equation:

$$\text{Burning rate} = \frac{m}{t} \text{ ....(3)}$$

Where:

R = burning rate (g/s)

m = mass of briquette burned (g)

t = burning time (s)

Analisis kadar abu

Menurut analisis kadar abu briket dapat diketahui menggunakan persamaan berikut:

Keterangan:

wo = massa sampel setelah pengabuan (gram)

wd = massa sampel sebelum pengabuan (gram)

Lama menyala

Menurut untuk uji lama menyala (*burning rate)* dengan satuan gram/detik, rumus yang digunakan adalah:

Keterangan:

R = laju pembakaran (gram/detik)

m = massa briket yang terbakar (gram)

t = waktu pembakaran (detik)

RESULTS AND DISCUSSION

The results of testing and analysis for each parameter of peanut shell charcoal briquettes at various rice flour binder concentrations are presented as follows.

1. Calorific Value

The calorific value of peanut shell charcoal briquettes at different binder concentrations is shown in **Figure 1**.

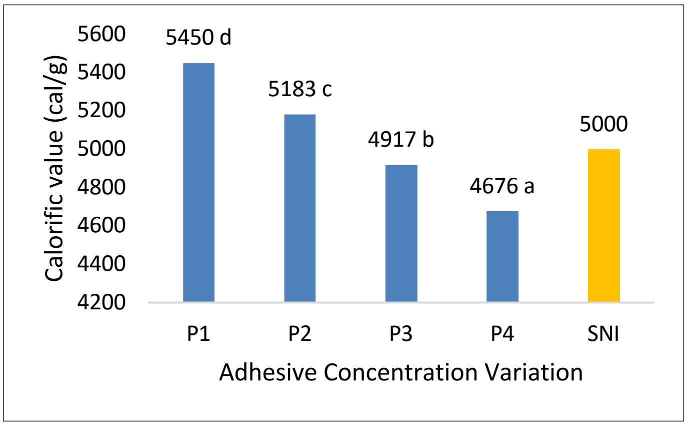

Figure 1. Calorific value of peanut shell briquettes at various adhesive concentrations

Figure 1 shows that variations in binder concentration have a significant effect on the calorific value of the briquettes, as indicated by differences in letter notations at the peak of the graph. The highest calorific value was obtained in P1 at 5450 cal/g, while the lowest was found in P4 at 4676 cal/g. These results indicate that increasing binder concentration tends to reduce the calorific value of the briquettes. This is due to the characteristics of starch-based binders, which contain more non-carbon compounds, thereby reducing the combustion energy (Walozi et al., 2026).

The decrease in calorific value from P1 to P4 occurred gradually. In P2, the calorific value was 5183 cal/g, which is still relatively high and meets the standard, while P3 decreased further to 4917 cal/g. Although the difference between P2 and P3 is not substantial, this trend indicates that increasing binder content begins to significantly affect the energy quality of the briquettes. This is attributed to the increase in moisture and ash content, which reduces combustion efficiency and lowers the fixed carbon fraction (Onukak et al., 2017).

The best result was obtained in P1 with a calorific value of 5450 cal/g, which exceeds the minimum SNI standard (≥ 5000 cal/g) (Badan Standardisasi Nasional, 2000). P2 also meets the standard with a value of 5183 cal/g, making both treatments acceptable in terms of energy quality. In contrast, P3 and P4 do not meet the SNI standard and are therefore less recommended as fuel. This indicates that excessive binder addition does not provide benefits in terms of energy performance (Kpelou et al., 2019).

Overall, binder concentration significantly affects the calorific value of briquettes. Low to moderate concentrations (P1–P2) are considered optimal as they produce high calorific values and meet SNI standards, while excessive binder content reduces energy quality and should be controlled.

2. Moisture Content

The moisture content of peanut shell charcoal briquettes at various binder concentrations is presented in **Figure 2.**

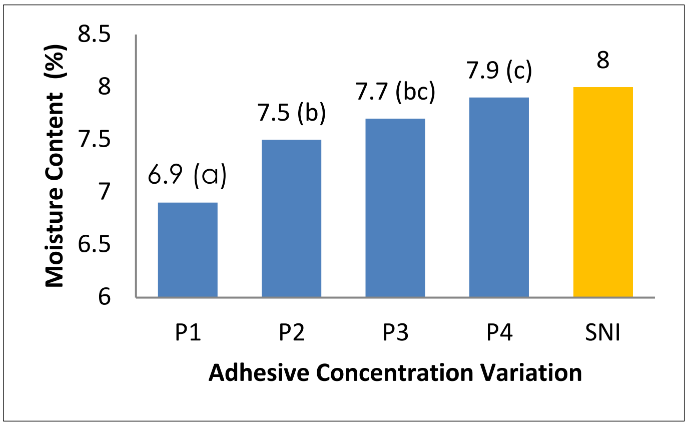

Figure 2. Moisture content of briquettes at different adhesive concentrations.

Figure 2 shows that variations in binder concentration have a significant effect on the moisture content of the briquettes, as indicated by differences in letter notations on the graph. The highest moisture content was observed in P4 at 7.9%, while the lowest was found in P1 at 6.9%. These results indicate that increasing binder concentration tends to increase the moisture content of the briquettes.

This increase is due to the hygroscopic nature of starch-based binders (rice flour), which can absorb and retain more water (Aransiola et al., 2019). The higher the binder concentration, the greater the amount of water retained within the briquette structure. As a result, moisture content in P2, P3, and P4 increased gradually compared to P1.

High moisture content negatively affects combustion quality, as initial heat energy is used to evaporate water before combustion can occur, thereby reducing efficiency and calorific value. Conversely, low moisture content facilitates ignition and improves combustion efficiency (Abdel Aal et al., 2023). Therefore, the recommended moisture content for high-quality briquettes is below 8%, in accordance with SNI standards (Badan Standardisasi Nasional, 2000).

In this study, all treatments were below the maximum SNI limit (8%) and can be classified as meeting quality standards. However, the best result was obtained in P1 with a moisture content of 6.9%, as it supports more efficient combustion. Thus, it can be concluded that increasing binder concentration increases moisture content, and its use must be controlled to achieve optimal fuel quality.

3. Ash content

The results of ash content analysis of briquettes at various adhesive concentrations are shown in **Figure 3.**

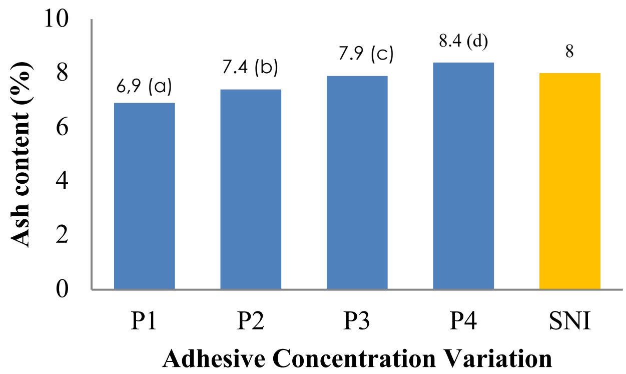

Figure 3. Ash content of peanut shell briquettes at various adhesive concentrations.

Based on the results, ash content showed significant differences across variations in rice flour binder concentration, as presented in **Figure 3.** The ash content of peanut shell charcoal briquettes increased with increasing binder concentration. The lowest ash content was obtained in treatment P1 at 6.9%, while the highest was observed in P4 at 8.4%.

This increase indicates that higher amounts of rice flour binder contribute to greater inorganic residue after combustion. Starch-based binders contain mineral components that do not burn completely and remain as ash after the combustion process (Muazu & Stegemann, 2017). Therefore, the higher the binder concentration added, the greater the amount of ash residue produced (Cahyono et al., 2017).

In addition, the increase in ash content may also be attributed to a reduction in the fixed carbon proportion in the briquettes due to binder addition. Lower fixed carbon content leads to higher combustion residue in the form of ash (Nwabue et al., 2017). This finding is consistent with previous research by Adeleke (2021), which reported that the addition of non-carbon materials such as binders can increase ash content and reduce the quality of solid fuels.

Ash content is an important parameter in determining briquette quality because it affects combustion efficiency. High ash content can hinder airflow during combustion and reduce combustion temperature, resulting in less efficient burning. Excessive ash may also cause slagging or deposits in combustion equipment (Wang et al., 2017).

According to SNI 01-6235-2000, the maximum allowable ash content for charcoal briquettes is 8% (Badan Standardisasi Nasional, 2000). In this study, treatments P1 (6.9%), P2 (7.4%), and P3 (7.9%) met this standard, while P4 (8.4%) exceeded the permissible limit. Therefore, the use of high binder concentration (25%) is not recommended as it reduces briquette quality in terms of ash content.

Overall, the results indicate that increasing rice flour binder concentration is directly proportional to the increase in ash content. Low to moderate binder concentrations (10–20%) are more optimal, as they maintain ash content within standard limits while preserving good combustion quality.

4. Burning rate of briquettes

This test was conducted to evaluate the burning duration of the briquettes. The results of the burning rate of peanut shell charcoal briquettes with different rice flour adhesive concentrations are shown in **Figure 4.**

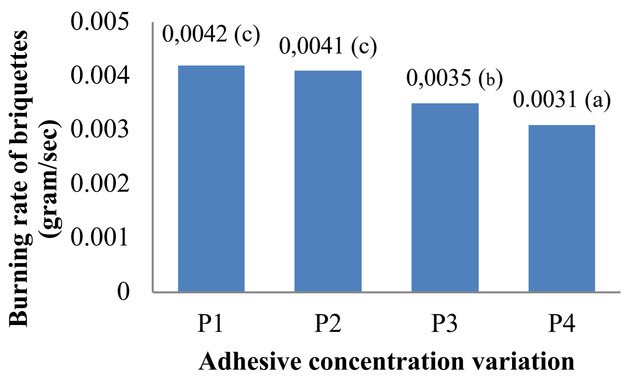

Figure 4. Burning rate of peanut shell briquettes at various adhesive concentrations.

Based on the research results, the burning rate and burning duration of peanut shell charcoal briquettes show a correlated and inversely proportional relationship. The highest burning rate was obtained in treatment P1 at 0.0042 g/s, followed by P2 at 0.0041 g/s, P3 at 0.0035 g/s, and the lowest in P4 at 0.0031 g/s. In contrast, the burning duration showed an opposite trend, where P1 had the shortest burning time of approximately 50.7 minutes, followed by P2 at 52.0 minutes, P3 at 60.9 minutes, and P4 had the longest burning time at approximately 68.8 minutes.

These results indicate that a higher burning rate leads to faster consumption of briquette mass, resulting in a shorter burning duration. Conversely, a lower burning rate slows down the combustion process, thereby extending the burning time. In this study, treatment P1 with the highest burning rate produced the shortest burning duration, while P4 with the lowest burning rate resulted in the longest burning duration.

The decrease in burning rate with increasing binder concentration is attributed to the increased density and compactness of the briquette structure, which limits oxygen diffusion into the fuel pores (Aulia et al., 2024). In addition, higher moisture and ash contents at higher binder concentrations also contribute to slower combustion (Huda et al., 2023). The increase in moisture content, from 6.9% in P1 to 7.9% in P4, causes part of the heat energy to be used for water evaporation before combustion occurs. Meanwhile, the increase in ash content from 6.9% in P1 to 8.4% in P4 can hinder contact between the fuel and oxygen, thereby slowing down the combustion reaction (Huda et al., 2025).

Although calorific value is an important parameter in determining fuel energy quality, the results of this study indicate that it does not directly determine the burning duration of briquettes. The highest calorific value was obtained in P1 at 5450 cal/g, while the lowest was found in P4 at 4676 cal/g. However, the briquettes with the highest calorific value actually exhibited shorter burning times. This indicates that the burning rate plays a more dominant role in determining combustion duration than calorific value (Mousa et al., 2022).

Thus, it can be concluded that the burning rate is the main factor influencing briquette burning duration, while calorific value determines the amount of energy produced. Therefore, a balance between burning rate and burning duration is essential to achieve optimal combustion performance. Based on this study, binder concentrations in the range of 10–20% provide the most balanced characteristics, as they exhibit moderate burning rates (0.0042–0.0035 g/s), sufficiently long burning durations (50.7–60.9 minutes), and still meet fuel quality standards.

SIMPULAN/CONCLUSION

Based on the results of this study, variations in rice flour binder concentration significantly affect the quality of peanut shell charcoal briquettes as an alternative fuel. Increasing the binder concentration led to a decrease in calorific value from 5450 cal/g to 4676 cal/g, as well as an increase in moisture and ash content up to 7.9% and 8.4%, respectively. Although all treatments met the SNI standard for moisture content, only treatments up to 20% binder concentration complied with the maximum ash content limit of 8%. In terms of combustion characteristics, increasing the binder concentration reduced the burning rate from 0.0045 g/s to 0.0031 g/s and increased the burning duration from 50.7 minutes to 68.8 minutes. These findings indicate that briquette quality is not determined solely by calorific value, but also by the balance between moisture content, ash content, and combustion performance. Overall, a binder concentration of 10–20% produced the best briquette quality, as it met quality standards, maintained relatively high calorific value, and exhibited stable and efficient combustion characteristics.

To improve the quality of briquettes as an alternative fuel, it is recommended to use binder concentrations in the range of 10–20%, as this provides the best balance among calorific value, moisture content, ash content, and combustion performance. Future research should focus on enhancing energy quality by reducing ash content while maintaining calorific value, for example through raw material modification or the use of binders with lower mineral content. In addition, further tests such as compressive strength, density, and combustion gas emissions are necessary to ensure that the briquettes are not only energy-efficient but also safe and practical for broader applications.

DAFTAR PUSTAKA/REFERENCES

Abdel Aal, A. M. K., Ibrahim, O. H. M., Al-Farga, A., & El Saeidy, E. A. (2023). Impact of Biomass Moisture Content on the Physical Properties of Briquettes Produced from Recycled Ficus nitida Pruning Residuals. *Sustainability (Switzerland)*. https://doi.org/10.3390/su151511762

Adeleke, A. A., Odusote, J. K., Ikubanni, P. P., Orhadahwe, T. A., Lasode, O. A., Ammasi, A., & Kumar, K. (2021). Ash analyses of bio-coal briquettes produced using blended binder. *Scientific Reports*. https://doi.org/10.1038/s41598-020-79510-9

Ahmad Akromul Huda, Tawaqqal, A., Hidayatullah, S., & Juniardi, N. (2025). The Effect of Variations in the Composition of Cocoa Shell Charcoal and Peanut Shell Charcoal on Briquette Characteristics. *R.E.M. (Rekayasa Energi Manufaktur) Jurnal*. https://doi.org/10.21070/r.e.m.v10i2.1777

Almirón, J., Roudet, F., & Duquesne, S. (2019). Influence of volcanic ash, rice husk ash, and solid residue of catalytic pyrolysis on the flame-retardant properties of polypropylene composites. *Journal of Fire Sciences*. https://doi.org/10.1177/0734904119867912

Aransiola, E. F., Oyewusi, T. F., Osunbitan, J. A., & Ogunjimi, L. A. O. (2019). Effect of binder type, binder concentration and compacting pressure on some physical properties of carbonized corncob briquette. *Energy Reports*. https://doi.org/10.1016/j.egyr.2019.07.011

Aulia, Y., & Akromul Huda, A. (2024). Karakteristik Briket Campuran Arang Kulit Kakao dan Arang Sekam Padi Terhadap Mutu Briket. *Rekayasa Energi Manufaktur) Jurnal |*.

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

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

Cahyono, R. B., Santoso, J., & Miliati, R. (2017). Biomass briquettes using Indonesia durian seeds as binder agent: The effect of binder concentration on the briquettes properties. *Chemical Engineering Transactions*. https://doi.org/10.3303/CET1756278

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

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

Hari Praswanto, D., & Yohanes Setyawan, E. (2023). Analisa Karakteristik Model BioBaterai dari Campuran Limbah Kulit Kacang dan Bambu Ori dengan Katalis Gel Elektrolit. *Prosiding SENIATI*. https://doi.org/10.36040/seniati.v7i1.8060

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

IRENA, I. R. E. A. (2022). *World Energy Transitions Outlook 2022: 1.5°C Pathway*. https://www.irena.org/publications

Ismayana, A. dan M. R. A. (2021). Pengaruh Jenis Dan Kadar Bahan Perekat Pada Pembuatan Briket Blotong Sebagai Bahan Bakar Alternatif. *J. Tek. Ind. Pert*.

Kpelou, P., Kongnine, D. M., Kombate, S., Mouzou, E., & Napo, K. (2019). Energy Efficiency of Briquettes Derived from Three Agricultural Waste's Charcoal Using Two Organic Binders. *Journal of Sustainable Bioenergy Systems*. https://doi.org/10.4236/jsbs.2019.92006

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

Mousa, E., Ahmed, H., & Söderström, D. (2022). Potential of Alternative Organic Binders in Briquetting and Enhancing Residue Recycling in the Steel Industry. *Recycling*, *7*(2), 1–17. https://doi.org/10.3390/recycling7020021

Muazu, R. I., & Stegemann, J. A. (2017). Biosolids and microalgae as alternative binders for biomass fuel briquetting. *Fuel*. https://doi.org/10.1016/j.fuel.2017.01.019

MUAZU UTHMAN, ZULKIFIL OGIRIMA KING SULE, & ABBATI IBRAHIM. (2026). EFFECT OF STARCH BINDER ON BRIQUETTES AT VARIOUS BINDER CONCENTRATIONS. *Harvard International Journal of Engineering Research and Technology*. https://doi.org/10.70382/hijert.v10i5.009

Nagarajan, J., & Prakash, L. (2021). Preparation and characterization of biomass briquettes using sugarcane bagasse, corncob and rice husk. *Materials Today: Proceedings*. https://doi.org/10.1016/j.matpr.2021.04.457

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.

Nwabue, F. I., Unah, U., & Itumoh, E. J. (2017). Production and characterization of smokeless bio-coal briquettes incorporating plastic waste materials. *Environmental Technology and Innovation*. https://doi.org/10.1016/j.eti.2017.02.008

Olugbade, T., Ojo, O., & Mohammed, T. (2019). Influence of Binders on Combustion Properties of Biomass Briquettes: A Recent Review. *Bioenergy Research*. https://doi.org/10.1007/s12155-019-09973-w

Onukak, I. E., Mohammed-Dabo, I. A., Ameh, A. O., Okoduwa, S. I. R., & Fasanya, O. O. (2017). Production and characterization of biomass briquettes from tannery solid waste. *Recycling*. https://doi.org/10.3390/recycling2040017

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.

REN21. (2023). *Renewables 2023 global status report*. https://www.ren21.net/reports/global-status-report/

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.

Walozi, R., Onep, G. S., Sanusi, Y. S., Babiker, O. E., Dennison, M. S., Candia, A., & Okurut, S. (2026). Critical review of biomass heterogeneity effects on briquette combustion. *Discover Applied Sciences*, *8*(3). https://doi.org/10.1007/s42452-025-08212-6

Wang, Q., Han, K., Wang, J., Gao, J., & Lu, C. (2017). Influence of phosphorous based additives on ash melting characteristics during combustion of biomass briquette fuel. *Renewable Energy*. https://doi.org/10.1016/j.renene.2017.06.018