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A Feasibility Study of Bio-Briquettes Production from the Skin and Epidermis Layer of Cassava (*Manihot esculenta*) as An Alternative Energy

Neda Prasiska Kusumawati[1*], Dodyk Pranowo[2], Dian Siswanto[3], Wresti L. Anggayasti[1]

[1] Graduate School of Universitas Brawijaya, Malang, Indonesia.
[2] Faculty of Agricultural Technology, Universitas Brawijaya, Malang, Indonesia.
[3] Faculty of Mathematics and Natural Sciences, Universitas Brawijaya, Malang, Indonesia.

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Corresponding Author:
Neda Prasiska Kusumawati
nedaprasiska@student.ub.ac.id

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Abstract: Unprocessed leftover cassava wastes from the home industries in Pomahan Village in Bojonegoro, East Java, has become a serious problem as a pollutant to the environment. This study examined the quality of bio-briquettes made from cassava skin waste with its epidermis starch as an adhesive agent, or binder. The aim is to assess the quality of the bio-briquettes for alternative energy sources and their suitability from an economic point of view. The utilized research method was a descriptive quantitative approach by measuring water and ash content, calorific value test, and economic feasibility calculation. The results indicated that the highest calorific value of 5337.83 cal/g was obtained from a bio-briquette mix of 50 g cassava skin with 5% epidermis starch binder. This bio-briquette also possesses the lowest water and ash contents of 2.75 and 8%, respectively, compared to other mixtures. The economic feasibility calculation showed a BEP value of 423 kg/ month, B/C Ratio of 6.14-fold, ROI of 30%, and PBI of 0.2 years. In conclusion, cassava-based bio-briquettes are economically promising and environmentally friendly due to their biomass property and help to tackle the environmental problem due to the cassava waste.

Keywords: Cassava briquette; Economic feasibility; Organic waste; Promising alternative energy

Introduction

Organic waste in Indonesia has become a big problem that needs serious handling and management efforts (Gerda, 2023). Based on the *Sistem Informasi Pengelolaan Sampah Nasional* (SIPSN), an information system of national waste management of the Ministry of Environment and Forestry of Indonesia (KLHK) in 2022, there are 19.45 million tons of organic waste pile in Indonesia. Organic waste is commonly found from leftover foods, vegetables, peels, and fruit seeds (Prarikeslan et al., 2023, Taqiyyah et al., 2023), and as a byproduct of domestic activities such as *Usaha Mikro Kecil dan Menengah* (UMKM) or home industries that use paddy rice, cassava, corn, and other crops (Nugrahani & Listyarini, 2023).

Pomahan Village is a village situated in Baureno District. This district is in the easternmost part of Bojonegoro Regency, on the close border with the Babat District of Lamongan Regency. Both regencies are in the East Java Province of Indonesia. In Pomahan Village, 15 craftsmen of the UMKM made processed food products with cassava (*Manihot esculenta*) as the main ingredient. Each craftsman can use 50 kg of cassava to produce tape, a traditional fermented cassava-based food (Herminingrum, 2019; Anggayasti et al., 2022). Thus, all

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craftsmen utilize an average of 750 kg of cassava to make tape. Such process will result in 150 kg of cassava skin waste. However, the cassava skin waste from tape production usually gets dumped anywhere near the village's housing area, leading to air pollution due to the decomposition process (Linggi & Pawarangan, 2018) and taking up free spaces.

Cassava skin has high levels of carbohydrates that reach 72.49-85.99% of its total mass (White et al., 2022) possibly in form of linamarin (Anggayasti et al., 2022). This property makes it likely to be an alternative energy source candidate. Therefore, this study will attempt to process cassava skin waste as bioenergy to avoid burdening the environment, as previously reviewed in cases of African countries (Oghenejoboh et al., 2021; Veiga et al., 2016). The increasing popularity of bioenergy is considering the growth of the human population, which is inversely proportional to the existence of fossil energy (Setyono & Purnomo, 2022). The use of organic wastes as bioenergy becomes one of the solutions both to provide eco-friendly energy as well as to reduce environmental pollution (Akam et al., 2024).

The choice of cassava as a renewable energy source becomes increasingly popular worldwide, be it in form of substrate for ethanol fermentation (Akaracharanya et al., 2011) or biogas, bioethanol (Ridwan et al., 2023), and biohydrogen (Andrade et al., 2022). Cassava skin wastes that are appropriately managed will become a commodity with high economic value (Rohimah & Kurnia, 2021; Azzahra et al., 2023). Organic waste from tape production could even be used as a biomass for efficient and economically profitable alternative fuel (Utami et al., 2021), which is also environmentally friendly (Obi et al., 2022).

Briquettes are alternative fuels made from organic wastes, which may have different calorific values depending on the biomass used (Sulmiyati & Said, 2017). Besides that, the addition of a suitable binder will increase the briquette's hardiness against outer pressure and add its calorific potential (Yuliati et al., 2021). The choice of adhesive agent or binder also plays an important role in holding ash particles together (Jannah et al., 2022; Obi et al., 2022).

For the first time, this study will generate cassava skin-based briquettes by using the epidermis layer starch of the cassava tuber as binder. Previous studies elaborated the benefits of cassava skin for bio-briquettes; however, tapioca powder was used as binder for both cases (Puri et al., 2022; Berlian et al., 2023). Hence, this study aims to analyse the feasibility of cassava skin-epidermis starch combination for making bio-briquette from the economical point of view and the quality assessment. These assessments will help to determine the bio-briquette quality and potential as a substitute for fossil energy, as well as solving the environmental problem caused by cassava waste in Pomahan Village, Bojonegoro Regency.

Method

This study utilized experimental methods with descriptive quantitative data analysis based on briquette quality assays and economic analysis. Raw material collection was done in Pomahan Village, Baureno District, Bojonegoro Regency. Laboratory experiments were done in the Laboratory of Entrepreneurship, Faculty of Agricultural Technology, and the Laboratory of Combustion Engine, Faculty of Engineering, both in Universitas Brawijaya Malang.

Data Collection

The main ingredients used in this study were cassava skin and epidermis layer starch. The types of equipment used were drum, sitting scales, machetes, 40-mesh sieves, pounders, buckets, stainless steel blades, measuring cups, stoves, and ovens. The equipment for product analysis included platinum or porcelain plates, digital balance, desiccators, and weigh bottles. The research flow chart is presented in Figure 1.

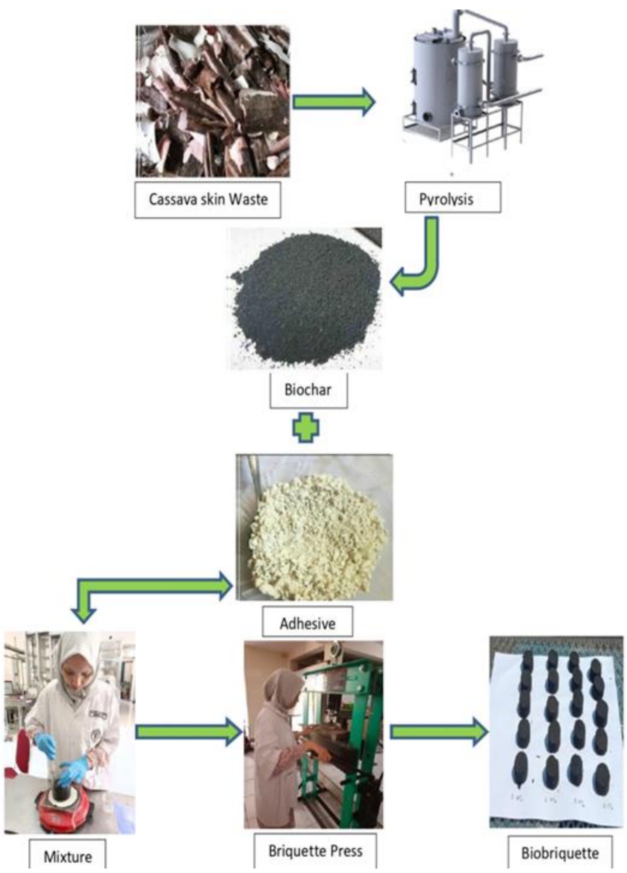

Figure 1. Research flowchart

The Production of Bio-Briquette

Bio-briquette production generally initiated by waste collection from home industries and moulding (Masyruroh & Rahmawati, 2021). For this study, firstly, cassava skin waste collected from Pomahan Village was weighed. After that, the collected waste was dried under direct sunlight for three days. The dried skin waste is shown in the upper part of the flowchart of Figure 1. The collected waste was then processed in a pyrolysis machine for 2 h. Lastly, the output product was ground and sifted with a 40-mesh sieve.

The epidermis layer of cassava root was collected by scratching the peeled cassava root with a knife until as many as 25-30 grams of epidermis starch was collected. The starch was dried with direct sunlight for three days before being ground and sifted. The pyrolyzed cassava skin waste in form of biochar (Figure 1) was mixed with the epidermis starch binder. The percentages of the starch used were 5, 10, 15, and 20% (g/g) of the total mass of 50 g. The mixtures were moulded with a briquette press machine at 20-30 MPa. The produced bio-briquette has a diameter of 2.2 cm with a thickness of 4 cm. Lastly, the bio-briquettes were dried under direct sunlight for three days, as illustrated at the end of flowchart in Figure 1.

Measurement of Water Content

The calculation of water content was conducted according to the formula and procedure described previously (Meiliyadi, 2017). The formula used is as follows.

$$\text{Water content (\%)} = \frac{m_2 - m_3}{m_2 - m_1} \times 100\% \quad (1)$$

Whereby:
m_1 = the weight of empty container
m_2 = the weight of container with sample
m_3 = the weight of container with sample after drying

Measurement of Ash Content

The ash content of the produced bio-briquette was estimated with the protocol and formula described in a previous study by Triantoro et al. (2019).

$$\text{Ash content (\%)} = \frac{m_2 - m_3}{m_2} \times 100\% \quad (2)$$

Whereby:
m_1 = the weight of empty container
m_2 = the weight of container with sample
m_3 = the weight of container with sample after drying

Measurement of Calorific Value

Calorific values were counted using the formula stated in a current research (Setiawan & Nurhidayah, 2021) as following.

$$\text{Calorific value} = \frac{(\text{EE} \times \Delta\text{T}) - (\text{Acid}) - (\text{Fulse})}{\text{Mass}} \quad (3)$$

Whereby:
EE = Benoit standard
Acid = Leftover ash
Fulse = Length of burned wire, 1 cm = 1 cal
ΔT = Temperature change

Economic Analysis

This analysis is aimed to assess the economic feasibility of a business form to be done (Rusdianto et al., 2020). The practical aspects considered in this study are the estimation of profit and loss and the business feasibility analysis. The latter consists of the Break Event Point (BEP), B/C Ratio, the rate of Return on Investment (ROI), and Pay Back Period (PBP) (Yusniati et al., 2021; Kasmi et al., 2023). The last parameter calculates the expected period for the business investment to be returned.

Result and Discussion

As many as four bio-briquettes were successfully produced in this study. These types were categorized based on the percentages of cassava's epidermis layer starch used in the mixture, namely 5, 10, 15, and 20%. The resulting bio-briquettes are presented in Figure 2. The visibly highest consistency and firmness were reported for the binder percentage of 5%.

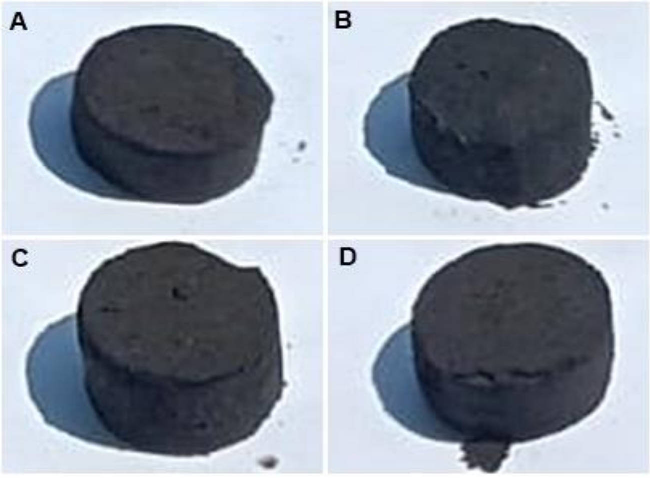

Figure 2. Four bio-briquettes with different binder percentages: (A) 5%, (B) 10%, (C) 15%, and (D) 20%

Further, the quality of the four bio-briquette types was examined by water content, ash content, and calorific value tests. The lower the water content of a bio-briquette, the easier it is to ignite (Akbari et al., 2022). In contrast, higher water content means that the bio-briquette will not be easily used for combustion (Akbari et al., 2022), increasing risk for decay, and unwanted chemical reactions (Fauzana et al., 2023). The determination of the water content is meant to measure the ability of the bio-briquette to absorb moisture in each composition. The water content will significantly affect the calorific value (Tira et al., 2023). The result of the bio-briquette water content calculated with formula (1) can be seen in Table 1.

Table 1. The Water Content of Each Bio-briquette

Sample	Cassava biochar (grams)	Starch (%)	Water content (%)
A	50	5	2.75
B	50	10	3.20
C	50	15	2.95
D	50	20	3.31

The numbers indicated that each briquette with 5, 10, 15, and 20% binder had water contents of 2.75, 3.20, 2.95, and 3.31%, respectively. All water content percentages are deemed satisfactory because it is less than the Indonesian national standard (SNI) value of 8% (Aziz et al., 2019). However, as can be seen in the data, the increasing amount of adhesive may cause the moisture content of the adhesive to bind with the ash. The water moisture becomes difficult to evaporate due to the higher density of the bio-briquette (Aziz et al., 2019). The next quality parameter is the ash content, as calculated with formula (2). Ash is an easily combustible material, although the inorganic content is not (Cholilie & Zuari, 2021). The result of the ash content test can be seen in Table 2.

Table 2. The Ash Content of Each Bio-briquette

Sample	Cassava biochar (grams)	Starch (%)	Ash content (%)
A	50	5	8
B	50	10	12
C	50	15	10
D	50	20	12

Table 2 showed that the highest ash content of 12% is in sample B and D, which used the binder mixture of 10% and 20%. Meanwhile, the lowest ash content of 8% can be found in sample A which had 5% of adhesive. Similar with water content, the ash content will crucially determine the calorific value. Lastly, calorific value is an indicator to measure the heat produced by a bio-briquette as a fuel. The higher calorific value of a briquette, the higher the quality of the briquette (Haliza & Saroso, 2023). The test results as calculated with formula (3) can be seen in Table 3.

Table 3. The Calorific Value of Each Bio-briquette

Sample	Cassava biochar (grams)	Starch (%)	Calorific value (cal/g)
A	50	5	5337.83
B	50	10	4453.78
C	50	15	4800.64
D	50	20	4162.26

Based on the results in Table 3, it is known that the highest calorific value is produced by the bio-briquette with 5% binder, which is 5337.83 cal/g. In contrast, the lowest value is that of the bio-briquette with 20% binder, which is 4162.26 cal/g; since the higher amount of binder is used, the higher the density of the bio-briquette (Nasrul et al., 2021). Therefore, the calorific value gets reduced, which explains why the lowest percentage of adhesive, which results in lesser density, exhibits the highest calorific value.

In comparison with calorific value of the previous studies, the value obtained for the mixture with 5% cassava starch adhesive in this study (5337.83 cal/g) is higher than that of cassava peel briquette with 5% tapioca binder at 2680 cal/g (Berlian et al., 2023), with lower water and ash contents. It is also higher than the calorific value of 90 : 10 mixture of corn husk and cassava peel at roughly 3186 cal/g (Waheed et al., 2019). The calorific value in this study is about the same as 5771 cal/g value obtained by durian peel briquette with 10% tapioca binder (Jannah et al., 2022). It is suspected that the use of cassava starch binder promotes higher calorific value, as pointed out by another study using durian peel mixture with 10% cassava starch binder, which gained 5880 cal/g (Suppalakpanya et al., 2020). However, this hypothesis needs further testing.

Other than the quality parameters of the bio-briquettes, this study also reviewed the economic feasibility of the bio-briquette production. The first component to be counted is the production cost, where the amount of the cassava skin waste was calculated based on the cost being paid. There are two categories: production cost (Table 4) and fixed cost (Table 5).

Table 4. The Bio-briquette Production

Items	Vol	Unit	Price (Rp)	Total (Rp)
Worker fee	2	Person	1,500,000	3,000,000
Electricity cost	1	Month	300,000	300,000

The next observation is the estimation of profit and loss which is based on: (1) the main ingredient, namely the cassava skin waste; (2) the binder, namely the epidermis layer starch; (3) the cassava skin waste used daily in form of 100 bio-briquettes; and (4) effective production period which was 26 days in a month.

With the assumption that the price of the bio-briquette is Rp. 7,800/kg, therefore:

Income = 100 kg x 26 days x Rp. 7,800
= Rp. 20,280,000 /month
Profit = total income–total production cost (Table 4)
= Rp. 20,280,000 – Rp. 3,300,000
= 16,980,000 /month

Table 5. The Fixed Cost of Bio-briquette Production

Item name	Vol	Unit	Price/ unit (Rp.)	Price (Rp.)
Pyrolysis equipment	1	Set	30,000,000	30,000,000
Briquette press machine	2	Set	1,500,000	3,000,000
Storage	1	Unit	15,000,000	15,000,000
Land	10	m^2	60,000	6,000,000
Briquette container	2	Unit	50,000	100,000
Mixing and sifting container	1	Unit	100,000	100,000
Briquette crusher	1	Unit	775,000	775,000
Total				54,975,000

The last component is the analysis of business feasibility, with the calculations as follows.

Break Event Point (BEP)
BEP = Total production cost/price per kg
=Rp. 3,300,000 /Rp. 7,800
= 423 kg/month

Thus, it can be said that the business will reach an impasse if as many as 423 kg of biobriquette can be sold per month.

B/C Ratio
B/C Ratio = Total income/Total production cost
= Rp. 20,280.000/Rp. 3,300,000
= 6.14

From the above estimation, it is understood that in each modal unit being used, the obtained income will be 6.14-fold of the modal unit.

Rate of the Return on Investment (ROI)
ROI = (Profit/Total of investment cost) x100%
= (Rp. 16,980,000/Rp. 54,975,000) x 100%
= 30 %

Pay Back Period (PBP)
PBP = Investment value (Table 4)/Profit in a year
= Rp. 54,975,000/(Rp.16,980,000 x 12 months)
= 0.2 year

The summary of all economic calculations can be found in Table 6 below.

Table 6. Results of Economic Feasibility Calculations

Feasibility aspects	Value
BEP	423 Kg/month
B/C *Ratio*	6.14
ROI	30%
PBP	0.20 year

Based on the results, the production of bio-briquettes from cassava skin waste with epidermis layer starch as adhesive has a potential for mass-production and can be deemed profitable in terms of economically valuable waste management (Septianingrum et al., 2023). The payback period is also especially faster compared to other study (Kasmi et al., 2023). As this study represents the first attempt to assess the quality of cassava-based bio-briquettes with cassava epidermis layer, it adds the economical values of cassava wastes itself as potential renewable energy.

Conclusion

The best mixture of bio-briquette in this study is 50 g cassava skin waste with 5% epidermis starch binder. This type of biobriquette had the highest calorific value of 5337.83 cal/g and the lowest water and ash content. If the adhesive amount exceeds 5%, the calorific value will get lower. It is thought that the starch binder may play a role in increasing the calorific value, which warrants further study. Based on the analysis of production economic feasibility, the capital will be returned if 423 kg of bio-briquettes are made and sold per month, with an expected profit of 30%. Thus, the income generated will be 6.14 times the production cost of Rp. 54,975,000. This capital return is estimated to happen within 0.2 years, or about 2-3 months. Therefore, the production of this cassava-based bio-briquette is profitable as an alternative, renewable energy source. From the environmental point of view, the production of cassava-based bio-briquettes does not emit high levels of pollutants. Using cassava skin as main ingredient for bio-briquette will help to reduce organic waste especially in Pomahan Village of Bojonegoro Regency, thus keeping the sustainability and hygiene of the environment.

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Author Contributions

Conceptualization: N. P. K., D. P., D. S., W. L. A.; methodology: N. P. K., D. P., D. S.; validation: D. P. and D. S.; formal analysis: N. P. K. and W.L.A.; investigation: N. P. K.; resources: D. P. and D. S.; data curation: N. P. K and W. L. A.; writing – original draft preparation: N. P. K; writing – review and editing: D. P., D. S., W. L. A; data visualization: N. P. K. and W. L. A. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The author declares that there is no conflict of interest in the research and publication of this research.

References

Akam, N. G., Diboma, B. S., Mtomo, J. Z., Ndiwe, B., Bot, B. V., & Biwole, A. B. (2024). Physicochemical Characterization of Briquette Fuel Produced from Cocoa Pod Husk Case of Cameroon. *Energy Reports*, *11*, 1580-1589. https://doi.org/10.1016/j.egyr.2024.01.029

Akaracharanya, A., Kesornsit, J., Leepipatpiboon, N., Srinorakutara, T., Kitpreechavanich, V., & Tolieng, V. (2011). Evaluation of the Waste from Cassava Starch Production as a Substrate for Ethanol Fermentation by Saccharomyces cerevisiae. *Annals of Microbiology*, *61*, 431–436. https://doi.org/10.1007/s13213-010-0155-8

Akbari, T., Panjaitan, F., & Dwirani, F. (2022). Analisis Kelayakan Teknis dan Ekonomi Pengolahan Limbah Cangkang Melinjo (Gnetum Gnemon) sebagai Briket. *Jurnal Lingkungan dan Sumberdaya Alam*, *5*(2), 132–146. https://doi.org/10.47080/jls.v5i2.2044

Andrade, L. R. S., Felisardo, R. J. A., Cruz, I. A., Bilal, M., Iqbal, H. M. N., Mulla, S. I., Bharagava, R. N., Souza, R. L., Azevedo, L. C. B., & Ferreira, L. F. R. (2022). Integrated Biorefinery and Life Cycle Assessment of Cassava Processing Residue from Production to Sustainable Evaluation. *Plants (Basel)*, *11*(24), 3577. https://doi.org/10.3390/plants11243577

Anggayasti, W. L., Herminingrum, S., & Kurniawan, A. (2022). Revisiting How the Javanese Traditional Food Safety Practice Significantly Reduces Cyanide Concentration of Marketed Cassava Roots. *Canrea Journal: Food Technology, Nutritions, and Culinary Journal*, *5*(1), 90-99. https://doi.org/10.20956/canrea.v5i1.578

Aziz, M. R., Siregar, A. L. Rantawi, A. B., & Rahardja, I. B. (2019). Pengaruh Jenis Perekat pada Briket Cangkang Kelapa Sawit terhadap Waktu Bakar. In *Prosiding Seminar Nasional Sains dan Teknologi*. Retrieved from https://jurnal.umj.ac.id/index.php/semnastek/article/view/5256

Azzahra, S., Safrida, S., Iswadi, I., Khairil, K., & Supriatno, S. (2023). Influence Utilization Leaf Cassava (Manihot utilissima) Fermented to Rate Growth Weight, Water Quality and Efficiency Freshwater Pomfret Fish Feed (Colossoma macropomum). *Jurnal Penelitian Pendidikan IPA*, *9*(1), 284–291. https://doi.org/10.29303/jppipa.v9i1.2865

Berlian, R. I., Meiliyadi, L. A. D., & Bahtiar, B. (2023). Pemanfaatan Limbah Kulit Singkong dan Sekam Padi dalam Pembuatan Biobriket dengan Perekat Tapioka sebagai Bahan Alternatif Biomassa. *Komunikasi Fisika Indonesia*, *20*(1), 1-8. http://dx.doi.org/10.31258/jkfi.20.1.1-8

Cholilie, I. A., & Zuari, L. (2021). Pengaruh Variasi Jenis Perekat terhadap Kualitas Biobriket Berbahan Serabut dan Tandan Buah Lontar (Borassus Flabellifer L.). *Agro Bali: Agricultural Journal*, *4*(3), 391–402. https://doi.org/10.37637/ab.v4i3.774

Fauzana, N. A., Redha, E., & Aminah, A. (2023). Hematological Response Studies of Climbing Perch (Anabas testudineus) Fed with Fermented Feed on the Fermentation of Kelakai Leaves (Stenochlaena palustris). *Jurnal Penelitian Pendidikan IPA*, *9*(10), 7879–7887. https://doi.org/10.29303/jppipa.v9i10.3568

Gerda, N., Riani, E., & Adji, S. S. (2023). Strategies to Reduce Food Waste at Household Level. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 919–923. https://doi.org/10.29303/jppipa.v9iSpecialIssue.4875

Haliza, H. N., & Saroso, H. (2023). Pembuatan Bio-Briket dari Sabut Kelapa dan Serbuk Kayu Jati dengan Menggunakan Perekat Tepung Tapioka. *DISTILAT: Jurnal Teknologi Separasi*, *8*(1), 238–244. Retrieved from https://search.app.goo.gl/4xDHMYE

Herminingrum, S. (2019). The Genealogy of Traditional Javanese cassava-Based Foods. *Journal of Ethnic Foods*, *6*(1), 1–16. https://doi.org/10.1186/s42779-019-0015-5

Jannah, B. L., Pangga, D., & Ahzan, S. (2022). Pengaruh Jenis dan Persentase Bahan Perekat Biobriket Berbahan Dasar Kulit Durian terhadap Nilai Kalor dan Laju Pembakaran. *Lensa: Jurnal Kependidikan Fisika*, *10*(1), 16-23. https://doi.org/10.33394/j-lkf.v10i1.5293

Kasmi, M., Aman, A., Makkulawu, A. R., Amir, S. M., Abdullah, A., & Usman, A. F. (2023). Feasibility Analysis and Production Increase Strategy for Marine Ornamental Fish Agribusiness. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 5689–5698. https://doi.org/10.29303/jppipa.v9i7.4697

Linggi, R. A., & Pawarangan, I. (2018). Pengaruh Sampah Rumah Tangga Organik dan Non Organik terhadap Lingkungan. In *Prosiding Seminar Nasional Kepariwisataan Berbasis Riset dan Teknologi*. Retrieved from https://journals.ukitoraja.ac.id/index.php/semkaristek/article/view/1301

Masyruroh, A., & Rahmawati, I. (2021). Pembuatan Recycle Plastik HDPE Sederhana Menjadi Asbak. *ABDIKARYA: Jurnal Pengabdian dan Pemberdayaan Masyarakat*, *3*(1), 53-63. https://doi.org/10.47080/abdikarya.v3i1.1278

Meiliyadi, L. A. D. (2017). Pengukuran Kalor Jenis Material Menggunakan Modifikasi Persamaan Teorema Stefann Boltzman. *Fisika dan Pendidikan Fisika*, *2*(2), 47-50. Retrieved from https://www.researchgate.net/publication/339302041

Nasrul, Z. A., Maulinda, L., Darma, F., & Meriatna, M. (2021). Pengaruh Komposisi Briket Biomassa Kulit Jagung terhadap Karakteristik Briket. *Jurnal Teknologi Kimia Unimal*, *9*(2), 35. https://doi.org/10.29103/jtku.v9i2.3668

Nugrahani, M. B., & Listyarini, R. V. (2023). Development of Universal Indicator from Organic Waste Material. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 1765–1771. https://doi.org/10.29303/jppipa.v9i4.1567

Obi, O. F., Pecenka, R., & Clifford, M. J. (2022). A Review of Biomass Briquette Binders and Quality Parameters. *Energies*, *15*(7), 2426. https://doi.org/10.3390/en15072426

Oghenejoboh, K. M., Orugba, H. O., Oghenejoboh, U. M., & Agarry, S. E. (2021). Value Added Cassava Waste Management and Environmental Sustainability in Nigeria: A Review. *Environmental Challenges*, *4*, 100127. https://doi.org/10.1016/j.envc.2021.100127

Prarikeslan, W., Nora, D., Mariya, S., Lovani, D., & Pratama, V.A. (2023). Community Empowerment through Organic Waste Processing. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9447–9453. https://doi.org/10.29303/jppipa.v9i11.5448

Puri, F. E., Mawardi, R. H., Darmawan, M. F., & Kurniawan, M. F. (2022). Biobriket Limbah Kulit Singkong (Manihot esculenta), Inovasi Sumber Energi Alternatif di Wonogiri. *Jurnal Jaringan Penelitian Pengembangan Penerapan Inovasi Pendidikan*, *8*(2), 113–122. https://doi.org/10.59344/jarlitbang.v8i2.20

Rohimah, S., & Kurnia, T. (2021). Peningkatan Ekonomi Masyarakat Melalui Inovasi Produk Olahan Keripik Kulit Singkong. *ALMUJTAMAE: Jurnal Pengabdian Masyarakat*, *1*(1), 11–18. https://doi.org/10.30997/almujtamae.v1i1.2914

Ridwan, R., Hermawati, H., Hamsina, H., Paredatu, T. A., Tang, M., Akrim, D., & Hasani, R. (2023). Making Bioethanol from Cassava as an Environmentally Friendly Fuel Mixing Material. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 6985–6991. https://doi.org/10.29303/jppipa.v9i9.4716

Rusdianto, A. S., Amilia, W., & Nugroho, D. A. (2020). Analisis Kelayakan Ekonomi pada Industri Virgin Coconut Oil (VCO) di Sukorejo Kecamatan Sumbersari Kabupaten Jember. *Jurnal Agroteknologi*, *14*(02), 137. https://doi.org/10.19184/j-agt.v14i02.16614

Septianingrum, D., Mizuno, K., & Herdiansyah, H. (2023). Extended Producer Responsibility for Waste Management Policy. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 2686–2692. https://doi.org/10.29303/jppipa.v9i5.3469

Setiawan, E. A., & Nurhidayah, D. A. (2021). Analisis Kesalahan Siswa dalam Mengerjakan Soal Teorema Pythagoras Berdasarkan Teori Kastolan di Masa Pademi Covid–19. *Edupedia Jurmas: Jurnal Mahasiswa Universitas Muhammadiyah Ponorogo*, *5*(2), 145–54. https://doi.org/10.24269/ed.v5i2.776

Setyono, M. Y. P., & Purnomo, Y. S. (2022). Analisis Kadar Air dan Kadar Abu Briket Lumpur IPAL dan Fly Ash dengan Penambahan Serbuk Gergaji Kayu. *INSOLOGI: Jurnal Sains dan Teknologi*, *1*(6), 696–703. https://doi.org/10.55123/insologi.v1i6.1047

Sulmiyati, S., & Said, N. S. (2017). Pengolahan Briket Bio-Arang Berbahan Dasar Kotoran Kambing dan Cangkang Kemiri di Desa Galung Lombok Kecamatan Tinambung, Polewali Mandar. *Jurnal Pengabdian kepada Masyarakat*, *3*(1), 108. https://doi.org/10.22146/jpkm.25529

Suppalakpanya, K., Nikhom, R., & Nikhom, S. (2020). Preparation of Biomass Briquettes Using Durian Peel Char and Spent Mushroom Compost Char. *International Energy Journal*, *20*(4), 621-628. Retrieved from http://www.rericjournal.ait.ac.th/index.php/reric/article/view/2412

Taqiyyah, A. M., Risjani, Y., Prihanto, A. A., Maulana, G. D., & Karimah, K. (2023). Utilization of Rice Waste Water on Biomass and Carotenoid Pigment Arthrospira platensis. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 832–837. https://doi.org/10.29303/jppipa.v9i2.2795

Tira, H. S., Mirmanto, M., Iwanuddin, I., Salman, S., & Sudirman, S. (2023). Analysis of the Calorific Value and Specific Gravity of Breadfruit Peel Bioalcohol (Artocarpus altilis) as an Alternative Fuel at Various Distillation Temperatures. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 5163–5169. https://doi.org/10.29303/jppipa.v9i7.2878

Triantoro, A., Mustofa, A., Kartini, K., & Hanafi, A. (2019). Studi Analisa Kualitas Biobriket Campuran

Bottom Ash Batubara dan Onggok Tepung Tapioka Menggunakan Karbonisasi. *Jurnal Fisika FLUX*, *1*(1), 54. http://dx.doi.org/10.20527/flux.v1i1.6147

Utami, L. G. G. G. M., Yulianti, N. L., & Wirawan, I. P. S. (2021). Karakteristik Briket Berbahan Baku Kulit Kopi dengan Variasi Suhu dan Lama Waktu Pengarangan yang Berbeda. *Jurnal BETA (Biosistem dan Teknik Pertanian)*, *10*(2), 364-374. https://doi.org/10.24843/JBETA.2022.v10.i02.p19

Veiga, J. P. S., Valle, T. L., Feltran, J. C., & Bizzo, W. A. (2016). Characterization and Productivity of Cassava Waste and Its Use as an Energy Source. *Renewable Energy*, *93*, 691-699. https://doi.org/10.1016/j.renene.2016.02.078

Waheed, M. A., Akogun, O. A., & Enweremadu, C. C. (2023). Dataset on the Performance Characteristics of Briquettes from Selected Agricultural Wastes Using a Piston-Type Briquetting Machine. *Data in Brief*, *50*, 109476. https://doi.org/10.1016/j.dib.2023.109476

White, O. I., Nurrahmania, V., & Wibowo, T. (2022). Pengolahan Limbah Kulit Singkong sebagai Upaya Mengurangi Pencemaran Lingkungan. *Jurnal Pengolahan Pangan*, *7*(1), 33–37. https://doi.org/10.31970/pangan.v7i1.64

Yuliati, Y., Santosa, H., Setiyadi, S., & Lourentius, S. (2021). Prospek Bisnis Briket Daun Kering dalam Kegiatan Pendampingan dan Pemberdayaan Masyarakat Surabaya Menuju Ekonomi Sirkular. *Jurnal Ilmiah Pangabdhi*, *7*(2), 99–104. https://doi.org/10.21107/pangabdhi.v7i2.11604

Yusniati, Y., Parinduri, L., & Sitanggang, S. A. (2021). Studi Kelayakan Produksi Briket Arang Koperasi Alumni Fakultas Teknik UISU. *Prosiding Seminar Nasional Teknik UISU*, 131–137. Retrieved from https://jurnal.uisu.ac.id/index.php/semnastek/article/view/4155