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The Effect of Raw Material Mixture Composition and Adhesive Concentration on Candlenut Shell (*Aleurites molucanna*) and Empty Palm Fruit Bunches (*Elaeis guineensis* jack) Biobriquette Quality

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Abstract

Biobriquettes serve as a renewable energy alternative with the potential to replace conventional charcoal while producing lower emissions. This study aimed to evaluate the effects of varying the ratio of raw material mixtures and the concentration of binder made from cassava starch on the quality of biobriquettes produced from candlenut shells (*Aleurites moluccana*) and empty palm oil fruit bunches (*Elaeis guineensis* jack). The selection of these raw materials was based on their abundant availability in Indonesia and their high lignocellulosic content. The biobriquettes were produced through a carbonization process, in which the candlenut shells were heated at 350°C for 30 minutes, while the palm oil empty fruit bunches were carbonized at 300°C for the same duration. The study applied variations in the composition ratios of candlenut shells to empty fruit bunches (100:0, 80:20, 60:40, 40:60, 20:80, and 0:100), as well as binder concentrations of 10%, 20%, and 30% (w/w) using cassava starch. The resulting biobriquettes were tested according to the Indonesian National Standard SNI 01-6235-2000 through proximate and physical analyses. The findings indicated that the variation.

Keywords: *Biobriquettes, candlenut shell, empty fruit bunches, adhesive concentration, carbonization*

1 Introduction

Biobriket itself is a form of solid fuel produced from biomass waste by compacting it at a pressure of 45 kg/cm² to 150 kg/cm². This pressure greatly affects the physical characteristics and combustion of the biobriquette. The greater the pressure applied, the denser the biomass particles will become. These particles fill the empty spaces, thereby increasing the density of the biobriquettes and decreasing their porosity [10]. Biobriquettes can serve as an alternative to conventional charcoal and are used for various purposes such as cooking, room heating, and fuel for small-scale industries [11].

The advantage of using biobriquettes is that they produce low emissions. Additionally, the production of biobriquettes is also one way to utilize biomass waste, which is often underutilized. Thus, the production of biobriquettes can help reduce the accumulation of organic waste [2].

Biomass with high energy content is considered suitable as a basic material in the production of biobriquettes. This feasibility can be assessed from the composition of lignin and cellulose it contains. The higher the lignin and cellulose content, the greater the potential of the biomass to produce dense, sturdy briquettes with high calorific value. The high lignin content in biomass plays a significant role because lignin is a type of compound with aromatic rings that contain a large amount of carbon. The higher the lignin content in the raw material, the more carbon is stored in the resulting biobriquettes.

When undergoing the process of pyrolysis or combustion, these bonds will break down and produce thermal energy, thereby contributing to the calorific value of the biobriquettes. Although the calorific value produced by cellulose is generally lower than that of lignin, its presence remains important because it helps stabilize the combustion process and accelerates the ignition of the biobriquettes. The high lignin content in

biomass not only contributes to the increase in calorific value but also acts as a natural binder that helps strengthen the structure of the biobriquettes [5].

The research conducted by [3] discusses the production of biobriquettes based on candlenut shells. The carbonization process in the study used a furnace at a temperature of 400°C for one hour. The results obtained show that the biobriquettes produced have met all quality requirements based on SNI 01-6235-2000.

Meanwhile, [9] also studied briquettes made from TKKS waste. The carbonization process was carried out at a temperature of 550°C for 2.5 hours. Although most quality parameters have been met, the ash content in the briquettes does not meet the standards. Therefore, the selection of a combination of raw materials between candlenut shells and empty fruit bunches (EFB) becomes relevant. It is hoped that the mixing of these two types of biomasses can improve the quality of the biobriquettes to meet the quality standards of SNI 01-6235-2000, compared to using only TKKS as the main raw material.

The quality of biobriquettes is not only determined by the type of raw materials used but is also greatly influenced by the type and concentration of adhesives used during the manufacturing process. The concentration of the binder plays an important role in enhancing the physical strength or mechanical durability of the biobriquette. In addition, the concentration of the binder can also affect the results of the proximate analysis. Some of the affected parameters include moisture content, ash content, and volatile matter content.

This research was conducted to evaluate the effect of variations in the composition of the raw material mixture between candlenut shells and TKKS, as well as the effect of adhesive concentration on the quality of biobriquettes. This research is expected to make a significant contribution to the development of efficient and environmentally friendly alternative energy, as well as to encourage the more effective and sustainable utilization of biomass waste.

2 Method

This research was conducted at the Final Project Laboratory, Faculty of Biotecnology, Del Institute of Technology Meanwhile, the calorific value testing phase was carried out at the Mineral and Coal Analysis Laboratory, Bandung Institute of Technology (ITB). The stages of the research include drying the raw materials, the carbonization process, briquette molding, and the drying of biobriquettes. Next, proximate testing of the biobriquettes is conducted in accordance with SNI 01-6235-2000, as well as physical tests such as the shatter index and burn rate. The calorific value test was conducted separately at ITB using the ASTM D5865 testing standard.

2.1 Preparation Materials

The candlenut shells and TKKS are first washed to remove any dirt or contaminants that may be present. The cleaned candlenut shells are dried in an oven at 100°C for 1 hour. The same goes for the TKKS, which, after the cleaning process, is dried at 100°C for 2 hours.

2.2 Preparation Adhesive

The cassava that will be used as an adhesive is first washed with water to remove dirt adhering to its surface. Next, the cleaned cassava will be peeled and cut into pieces. These pieces of cassava are grated, and the grated mixture is then soaked in water for 30 minutes to facilitate the separation of starch.

After soaking, the mixture is filtered and pressed to separate the suspension components, pulp, and water. The obtained suspension is allowed to stand for 48 hours until a starch precipitate is formed. The sedimentation process plays a role in separating soluble compounds such as tannins, soluble proteins, and mucilage, which can interfere with the performance of starch as an adhesive.

2.3 Carbonization

The purpose of the carbonization process is to break down the organic structure of the raw material under limited oxygen conditions, resulting in charcoal with a higher carbon content. After undergoing the pretreatment stage, the raw material is carbonized using a furnace at a temperature of 350°C for 30 minutes [3]. Similarly, the TKKS that has undergone the pretreatment stage will be further processed through carbonization using a furnace at a temperature of 300°C for 30 minutes [8].

2.4 Refinement

Charcoal obtained from the carbonization process will undergo a refinement stage using a siever to obtain smaller-sized particles. The charcoal powder is then sifted using a 60-mesh sieve according to the SNI 01-6235-2000 standard.

2.5 Mixing With Adhesive Materials

Charcoal powder will be mixed with a binder aimed at binding the charcoal particles and strengthening the biobriquette.

2.6 Printing and Drying

After the biobriquette mixture is evenly blended, the next stage is molding to shape the biobriquettes according to the desired size and form. This mixture is then placed into a cylindrical mold with a hole in the center. The mold used is cylindrical with a hole in the center, where the outer diameter is 3.5 cm and the inner hole diameter is 1.5 cm. The height of the mold is 7 cm. The molding was carried out using a hot press machine with a pressure of 50 kg/cm² [4]. After the printing process, the biobriquettes are dried using an oven. The drying process is carried out at a temperature of 50°C for 1 hour [17].

2.7 Quality Testing

The biobriquettes that have been completed are then subjected to quality testing through proximate and physical tests. The proximate test includes the analysis of moisture content, ash, volatile matter, fixed carbon, and calorific value in accordance with the SNI 01-6235-2000 standard. On the other hand, physical tests are conducted to assess the burning rate and the durability index.

2.7.1 Water Content

To determine the moisture content, the first step is to weigh the previously dried porcelain cup. After that, the biobriquette sample is placed into the cup, and the total weight of the cup and sample is recorded as the initial weight. The sample is then dried in an oven at 115°C for 3 hours. The sample is then removed from the oven and cooled in a desiccator at room temperature for 30 minutes. After reaching room temperature, the sample is weighed again to obtain the final weight. The difference between the initial weight and the final weight is used as the basis for calculating the moisture content in the biobriquettes.

2.7.2 Ash Content

The measurement of ash content begins with cleaning the porcelain crucible. Next, the porcelain crucible is heated in an oven at 105°C for one hour. After this process is complete, the crucible is cooled in a desiccator for 15 minutes, then weighed to obtain the initial weight. The biobriquette samples from each variation were weighed first, then placed into porcelain dishes. The combustion process is carried out in a furnace at a temperature of 800°C for two hours. After combustion, the dish containing the sample is placed in a desiccator for 30 minutes. Once the sample temperature decreases, reweighing is performed. The difference in weight before and after the combustion process serves as the basis for determining the ash content in the biobriquettes.

2.7.3 Calorific Value

The sample is weighed to about 1 gram and placed in a special sample container inside the bomb calorimeter. The bomb is then filled with high-pressure oxygen and sealed airtight. After that, the bomb is placed into a calorimeter bucket that contains water of a predetermined volume, and the initial water temperature is recorded. The sample is ignited electrically so that complete combustion occurs inside the bomb at a constant volume. During the combustion process, the heat generated will cause the temperature of the water surrounding the bomb to rise. After the combustion is complete, the final temperature of the water is recorded [9].

2.7.4 Volatile Matter Content

The porcelain crucible used must be cleaned first. Next, the porcelain crucible is heated using an oven at a temperature of 105°C for 2 hours to ensure the crucible is completely free of moisture. After the heating process, the porcelain crucible is placed in a desiccator for 30 minutes and weighed. Then, the sample is placed into the porcelain crucible and heated at 950°C for 7 minutes to remove the volatile compounds contained within. After the heating process is complete, the crucible containing the sample is cooled in a desiccator for 30 minutes to prevent weight changes due to air humidity. Next, the porcelain dish and sample are reweighed [15].

2.7.5 Fixed Carbon Content

The fixed carbon content is calculated by subtracting the percentages of moisture content, ash content, and volatile matter content from the total 100% composition of the biobriquette [15].

2.7.6 Destruction Index

The biobriket is weighed to obtain the initial weight data. After that, the biobriket is dropped from a height of 1.8 meters onto a prepared surface that is flat and smooth to ensure consistent testing results. After the dropping process, the biobriket is weighed again to obtain the weight after the drop test. The difference between the initial weight and

the weight after being dropped is used to calculate the biobricket's destruction rate [19].

2.7.7 Combustion Rate

The combustion rate test was conducted by burning briquettes to determine the duration of the fuel's flame, then measuring the mass of the burned briquettes. The burning time was recorded using a stopwatch, while the mass of the briquettes was determined with a digital scale [1].

3 Result and Discussion

The results obtained from this study include the proximate quality and physical quality of the biobriquettes. The proximate quality parameters include moisture content, ash content, fixed carbon content, and volatile matter content, which are evaluated based on the SNI 01-6235-2000 standard, as well as the calorific value analyzed according to ASTM D5865. Meanwhile, the physical quality of the biobriquettes is determined through testing the durability index and burning rate, also referring to the SNI 01-6235-2000 standard.

3.1 Proximity Test

3.1.1 Water Content

Based on **Fig. 1**, the higher the adhesive concentration, the lower the moisture content of the resulting biobriquettes. From the image, the lowest moisture content is found in the adhesive concentration variation of 30%, which is 5.4%. Meanwhile, the highest moisture content is found in the adhesive concentration variation of 10%, which is 20.24%.

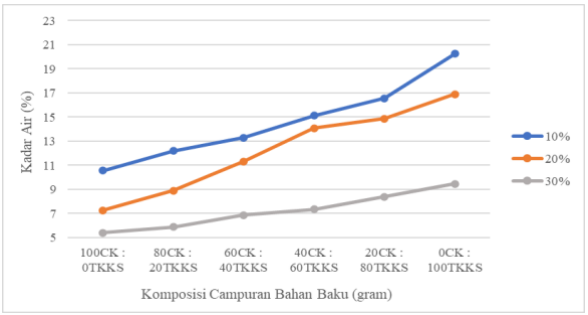


Figure 1. Results of the biobriquette moisture content test

Referring to the graph in **Fig. 1**, briquettes with a higher proportion of candlenut shells show relatively lower moisture content. Conversely, an increase in the composition of empty fruit bunches (EFB) in the mixture results in higher moisture content. This difference is due to the characteristics of candlenut shells, which have a lower initial moisture content and a denser structure [13].

3.1.2 Ash Content

Based on **Fig. 2**, the increase in adhesive concentration is directly proportional to the increase in ash content in the biobriquettes. The lowest ash content is found in the variation with 10% adhesive concentration, which is 4.21%. Meanwhile, the highest ash content is found in the variation with 30% adhesive concentration, which is 12.05%.

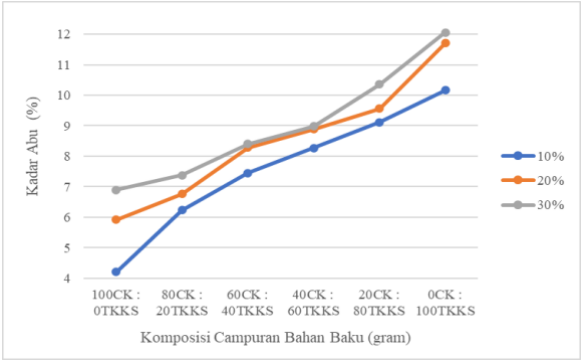


Figure 2. Results of the ash content test of biobriquettes

It is evident that increasing the proportion of candlenut shell in the raw material mixture results in a lower ash content in the biobriquettes. This phenomenon is caused by the difference in chemical composition between candlenut shell and TKKS. Candlenut shell produces less ash residue after combustion because it has a lower silica content, which is 4.89% [16].

3.1.3 Volatile Matter Content

Fig. 3 shows that the concentration of the adhesive contributes to the increase in volatile matter content in the biobriquettes. The lowest volatile matter content is found in the 10% adhesive concentration variation, which is 2.46%. Meanwhile, the highest volatile matter content is found in the 30% adhesive concentration variation, which is 3.24%.

Based on **Fig. 3**, it is known that the increase in the proportion of candlenut shell in the raw material mixture tends to decrease the volatile matter content in the biobriquettes. The higher the composition of candlenut shell, the lower the volatile matter content produced. Conversely, the increase in the proportion of empty fruit bunches (TKKS) causes the volatile matter content to increase. This phenomenon can be explained from the aspect of the chemical composition of each

raw material, particularly its lignocellulosic content. The concentration of the adhesive will affect the calorific value of the biobriquette; the higher the concentration, the lower the calorific value [12].

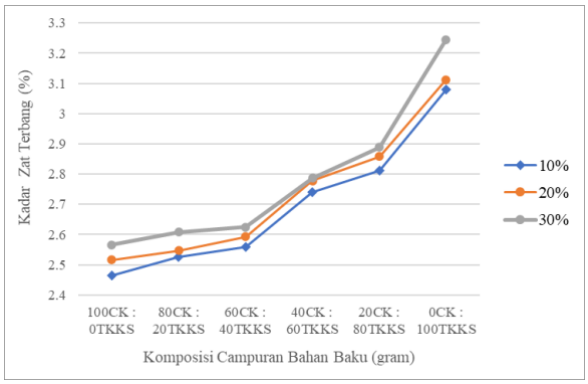


Figure 3. Results of the volatile matter content test of the biobriquette

3.1.4 Fixed Carbon Content

From **Fig. 4**, the increase in adhesive concentration affects the increase in fixed carbon content in the biobriquettes. The lowest fixed carbon content is found in the 10% adhesive concentration variation, which is 69.59%. Meanwhile, the highest fixed carbon content is found in the 30% adhesive concentration variation, reaching 87.70%.

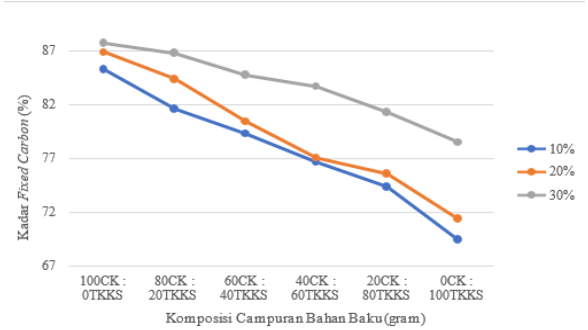


Figure 4. Results of the fixed carbon content test of biobriquettes

It can also be seen in Figure 4 that the increase in adhesive concentration positively correlates with the fixed carbon content. This is because the presence of the adhesive helps strengthen the briquette structure and enhances the bonding between carbon particles, thereby minimizing particle loss during carbonization and combustion [14].

3.1.5 Calorific Value

Based on **Fig. 5**, mixtures with a higher proportion of candlenut shell tend to produce higher calorific values. This is indicated by the composition of 100 CK: 0 TKKS, which has the highest calorific value at each variation of adhesive concentration.

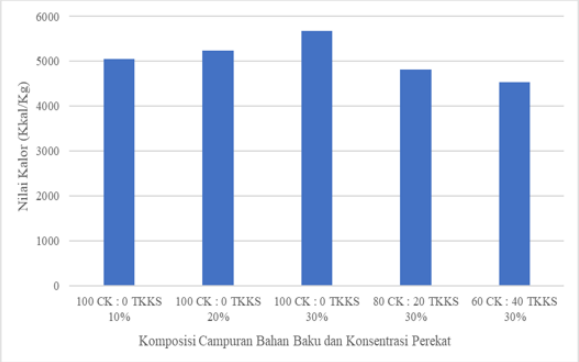


Figure 5. Results of the calorific value test of the biobriquette

The increase in the proportion of candlenut shell in the mixture results in a higher calorific value. The calorific value of a solid fuel such as briquettes is greatly influenced by its main chemical composition, particularly the lignin and cellulose content. Candlenut shells contain 54.46% lignin [18]. Meanwhile, the lignin content in oil palm empty fruit bunches (OPEFB) is 31.68% [7].

3.2 Physical Test

3.2.1 Destruction Index

Based on **Fig. 6**, the increase in adhesive concentration is inversely proportional to the briquette destruction index, where higher adhesive concentrations result in lower destruction indices. The highest destruction index was recorded at an adhesive concentration of 10% at 0.85%, while the lowest value was found at a concentration of 30%, at 0.21%.

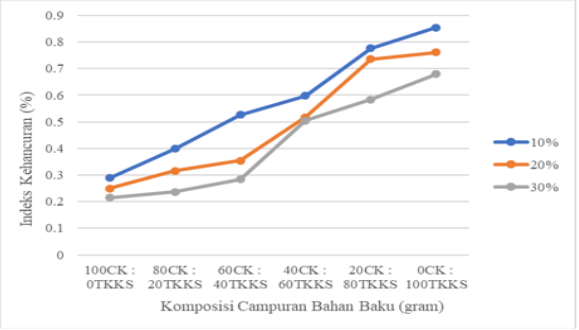


Figure 6. Results of the biobriquette destruction index test

The effect of increasing adhesive concentration also influences the destruction index of the

biobriquettes. It can be seen in Figure 4.6 that the higher the adhesive concentration, the lower the destruction index. Adhesives like cassava starch fill the spaces between particles and form a sticky matrix that strengthens the adhesion between particles [6].

3.2.2 Combustion Rate

Fig. 7 shows that the increase in adhesive concentration correlates with the increased combustion rate of the biobriquettes. The lowest combustion rate is found in the variation with 10% adhesive concentration. Meanwhile, the highest combustion rate is found in the variation with 30% adhesive concentration. Additionally, the increase in the proportion of candlenut shells in the mixture results in a higher combustion rate, whereas the increase in the proportion of empty palm fruit bunches decreases the combustion rate.

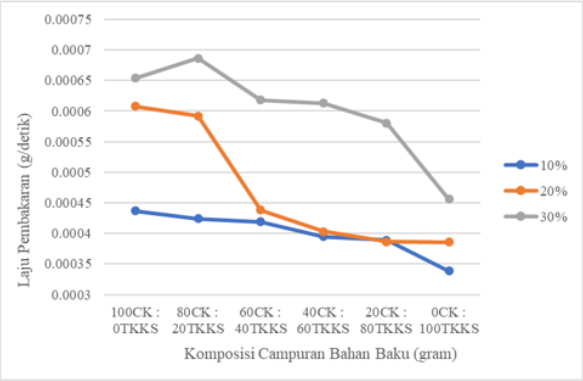


Figure 7. Results of the biobriquette combustion rate test

The increase in the proportion of candlenut shells in the raw material mixture results in a higher combustion rate. Biobriquettes with a composition of 100% candlenut shells exhibit the highest combustion rate across all variations of adhesive concentration. This is due to the high lignin content in the candlenut shells, which provides a more stable and long-lasting combustion.

4 Conclusion

Variations in the composition of the raw material mixture and the concentration of the adhesive have been proven to significantly affect the quality of the produced biobriquettes. The quality of the biobriquettes was assessed based on several parameters, namely moisture content, ash content, volatile matter content, fixed carbon content, durability index, and burning rate. Among all the variations tested, the variation with a composition of 100% candlenut shell: 0% TKKS and adhesive concentrations of 30% and 20% showed the best results because they met the quality parameters of moisture content, ash content, volatile matter content, fixed carbon content, durability index, and burning rate according to the SNI 01-6235-2000 standard.

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References

[1] Aljarwi, M. A., Pangga, D., & Ahzan, S. (2020). Test of Combustion Rate and Calorific Value of Rice Husk Wafer Briquettes with Pressure Variations. ORBITA: Journal of Studies, Innovations, and Applications in Physics Education, 6(2), 200. https://doi.org/10.31764/orbita.v6i2.2645

[2] Amri, A., Lindawati, L., & Fitriani, F. (2021). Contenido de cenizas del carbón de cáscara de nuez de la india producido por una herramienta de carbonización de cáscara de nuez de la india utilizando un sistema de cámaras múltiples vertical. IOP Conference Series: Earth and EnvironmentalScience,644(1). https://doi.org/10.1088/17551315/644/1/012074xiv

[3] Aqiilah, F. A., Saifullah, H. A., & Siswati, N. D. (2024). The production of biochar from industrial spice seed shell waste using the carbonizationmethod.19(1),1–6. https://doi.org/https://doi.org/10.33005/jurnal_tekkim.v16i2.4810

[4] Firmansyah A. (2024). The influence of composition variations in peanut shell and candlenut shell briquettes with tapioca flour binder on the quality of biomass briquettes. National Institute of Technology,15(1),64. https://eprints.itn.ac.id/15052/

[5] Handayani, H., Ningsih, Y., & Permana, B. (2019). Analysis of the Influence of Composition in the Production of Biocoal Briquettes from a Mixture of Coal and Purun Tikus Biomass (Eleocharis Dulcis). 23–24. https://repository.unsri.ac.id/17502/

[6] Handra, N., Indra, A., & Purnama, I. (2020). Biomass Briquettes Based on TKKS Fiber with the Addition of Pine Powder and Starch in a Screw Extruder System on Strength. Proceedings of the National Industrial Technology Engineering and Information XV Year2020,2020,122–128.

https://journal.itny.ac.id/index.php/ReTII/article/view/2068

[7] Hertantri Y. R., Yuni K., M. H. (2024). Proceedings of the seminar on research and community service results: isolation of cellulose from empty palm oil fruit bunches using deep eutectic solvent (DES) based on choline chloride and lactic acid. Proceedings of the Seminar on Research and Community Service Results. E-ISSN: 2963-2110 P-ISSN: 2615-0255,7(1),57–64. https://ojs.poltesa.ac.id/index.php/SEHATI_ABDIMAS/article/view/912

[8] Ihsanudin, M. (2022). Test of the calorific value, moisture content, and ash content characteristics of charcoal briquettes made from a mixture of palm kernel shells and corn cobs. Final Project, University of Tidar (Vol. 33, Issue 1).

[9] Indah, M., Hasan, A., & Junaidi, R. (2024). The production of palm kernel shell and empty fruit bunch biobriquettes using a Muffer Furnace. IX(4),11164–11174. https://jse.serambimekkah.id/index.php/jse/article/view/534

[10] Khairun. (2024). Characterization of Biobriquettes from Candlenut Shells. https://doi.org/10.29103/cejs.v4i3.15088

[11] Mahendry, S., Anggara, M., & Hidayat, A. (2023). Analysis of the Characteristics of Briquettes from Candlenut Shells and Corn Cobs as Alternative Fuels. Flywheel Journal,14(2),50–58. https://doi.org/10.36040/flywheel.v14i2.6964

[12] Mega Silalahi. 2022. Mega Silalahi. 2022. The Effect of Concentration and Type of Adhesive Material on the Quality of Biobriquettes from candlenut shells (Aleurites Moluccana). Final Project of the Del Institute of Technology

[13] Nanda, R. A., & Fona, Z. (2018). Análisis de Calidad de Briquetas de Carbón de Cáscara de Café, Cáscara de Nuez de Candlenut y Cáscara de Coco Basado en el Contenido de Adhesivo de Almidón. Actas del Seminario Nacional del Politécnico Estatal de Lhokseumawe, 2(1), 19–22. https://ejurnal.pnl.ac.id/semnaspnl/article/view/739

[14] Rahardja, I. B., Hasibuan, C. E., & Dermawan, Y. (2022). Analisis briket fiber mesocarp kelapa sawit metode karbonisasi dengan perekat tepung tapioka. SINTEK JURNAL: Jurnal Ilmiah Teknik Mesin, 16(2), 82. https://doi.org/10.24853/sintek.16.2.82-91

[15] Ridjayanti, S. M., Hidayat, W., Bazenet, R. A., Banuwa, I. S., & Riniarti, M. (2022). Pengaruh variasi kadar perekat tapioka terhadap karakteristik briket arang limbah kayu sengon (Falcataria mollucana). ULIN: Jurnal Hutan Tropis,6(1),38. https://doi.org/10.32522/ujht.v6i1.5597

[16] Riska, Y., Sinta, D., Cahyono, L., & Dermawan, D. (2023). The Effect of Calcium Oxide (CaO) Candlenut Shell Ash with the Addition of Silica (SiO2) as a Cement Substitute on the Compressive Strength of Hollow Bricks. 261(2623), 261–265

[17] Silaen, T. (2023). Analysis of the quality of candlenut shell biobriquettes with variations in carbonization temperature and adhesive concentration. Final Project of the Del Institute of Technology

[18] Sutanto, H., Abdi, F. N., & Kesuma, R. A. (2021). Pemanfaatan Cangkang Kemiri Aleurites Moluccana (Candlenut) Sebagai Agregat Kasar Terhadap Kuat Tekan Beton Ringan. Jurnal Teknologi Sipil, 5(1), 44–54. https://doi.org/https://doi.org/10.30872/ts.v5i1.6299

[19] Wahyudi, W., & Tanggasari, D. (2023). Characterization test of teak sawdust briquettes mixed with sugarcane bagasse based on varying amounts of binder (glutinous rice flour). Sultra Journal of Mechanical Engineering (SJME), 2(1),1728.https://doi.org/10.54297/sjme.v2i1.426