

## The Effect of Charcoal Composition from Candlenut Shells (*Aleurites Moluccana*) and Rubber Fruit Shells (*Hevea Brasiliensis*) on the Quality of Charcoal Briquettes

Rindayatno<sup>1\*</sup>, Kurniawan Joan<sup>2</sup>, Irvin Dayadi<sup>3</sup>, Agus Nur Fahmi<sup>4</sup>, Muhammad Rosyid Ridho<sup>5</sup>

Universitas Mulawarman

**Coressponding Author:** Rindayatno [rindayatno@fahutan.unmul.co.id](mailto:rindayatno@fahutan.unmul.co.id)

---

### ARTICLE INFO

*Keywords:* Candlenut Shells, Rubber Fruit Shells, Quality of Charcoal Briquettes

*Received :* 2 February

*Revised :* 14 March

*Accepted:* 24 April

©2025 Rindayatno, Joan, Dayadi, Fahmi, Ridho: This is an open-access article distributed under the terms of the [Creative Commons Atribusi 4.0 Internasional](https://creativecommons.org/licenses/by/4.0/).



### ABSTRACT

Charcoal briquettes are a type of solid fuel that can be used as a complement to fossil fuels because they are made from biomass waste. The advantages of charcoal briquettes are that they have high calorific value, high density, uniform size and quality, easy to store and ship. The purpose of this study was to analyze the effect of charcoal composition from candlenut shells and rubber fruit shells. A simple completely randomized design was used with 5 treatments with 5 replications for testing density, moisture content, compressive strength, and 5 treatments with 3 replications for testing volatile matter, ash content, fixed carbon, and 5 treatments with 2 replications for testing calorific value. The test results showed the following values: average density 0.52-0.66 gr/cm<sup>3</sup>, moisture content 9.52-11.23%, compressive strength 0.78-2.03 kg/cm<sup>2</sup>, volatile matter content 31.50-43.31%, ash content 6.79-15.48%, fixed carbon 29.96-52.15%, and calorific value 4,986.73-6,057.89 cal/g. The best quality charcoal briquettes were obtained from treatment A (100% candlenut shells) and the best combination was found in treatment B (75% candlenut shells and 25% rubber seed shells). The calorific value of charcoal briquettes has met the SNI No. 01-6235-2000 standard (>5,000 cal/g), except for 100% rubber fruit shell charcoal briquettes

## INTRODUCTION

Charcoal briquettes appear as one of the alternatives to replace fossil fuels is one option to reduce carbon emissions into the atmosphere (Andasuryani & Putri, 2017). Utilization of candlenut shells and rubber fruit shells as charcoal briquettes that have high economic value is one way to overcome the increase in waste from candlenut and rubber plantations.

There hasn't been much research done on charcoal briquettes made from biomass, or plants and their waste, including rubber fruit and candlenut shells. Therefore, in order to make charcoal briquettes, study on the composition of charcoal from both biomass is required.

## LITERATURE REVIEW

Wood charcoal that has had its density, size, and shape altered by pressing a powder mixture with an adhesive is known as a charcoal briquette. Various techniques for producing briquettes of charcoal (Wijayanti, D.S. 2009).

1. After sawdust is pressed into charcoal briquettes, medium-pressure carbonization occurs.
2. Carbonization and pressing at the same time.
3. Making charcoal briquettes by pressing a combination of sawdust and charcoal, then carbonizing them.
4. Forming charcoal briquettes by pressing a mixture of adhesive and charcoal powder, then drying and occasionally re-carbonizing.

The chemical components of raw materials determine the quality of charcoal briquettes. The following are the chemical components in candlenut shells and rubber fruit shells.

Table 1. Chemical Compounds in Candlenut Shells

Chemical compounds	(%)
Holocellulose	49.22
Pentose	14.55
Lignin	54.46
Ash	8.73

(Susanto, et.al. 2021)

Table 2. Chemical Compounds in Rubber Fruit Shells

Chemical compounds	(%)
Cellulose	48.64
Lignin	33.54
Pentose	16.81
Ash	1.25
Silica	0.52

(Harahap, 2022)

Important markers for calculating the quantity of energy generated from biomass are the chemical components found in wood. According to Pasaribu et al. (2005), Indonesian wood kinds are categorized according to their chemical composition.

Table 3. Types of Indonesian Wood Based on Chemical Components

Chemical Components	Classification		
	High	Medium	Low
Cellulose (%)	>45	40-45	<40
Lignin (%)	>33	18-33	<18
Pentocene (%)	>24	21-24	<21
Extractive (%)	>4	2-4	<2
Ash (%)	>6	0,2-6	<0,2

SNI 01-6235-2000 (BSN, 2000) is a quality reference that is required to ascertain whether or not the charcoal briquettes are of good quality.

Table 4. Charcoal Briquettes Quality Reference

Charcoal Briquette Quality Parameters	SNI 01-6235-2000
Density (g/cm <sup>3</sup> )	-
Moisture content (%)	≤ 8
Compressive strength (kg/cm <sup>2</sup> )	-
Volatile matter content (%)	≤ 15
Ash content (%)	≤ 8
Fixed carbon content (%)	-
Calorific value (cal/gr)	> 5,000

## METHODOLOGY

The raw materials used are candlenut shells, rubber fruit shells, tapioca flour and water.

The equipment to be used is a charcoal furnace, a pounder, 40 mesh and 60 mesh sieves, a digital scale, an oven, a charcoal briquette mould, a press, a heat balancer (desiccator), a digital caliper, a Universal Testing Machine (UTM), ash tool (furnace), a calorific value measurement (peroxide bomb calorimeter), ash cup, and cup clamp.

The raw materials are prepared first, the carbonization process is separate for both materials, making charcoal powder, sieving charcoal powder, mixing charcoal powder with tapioca adhesive, moulding and pressing charcoal briquettes, conditioning and drying charcoal briquettes, and until testing the quality of charcoal briquettes which includes: testing its density, water content, compressive strength, volatile matter content, ash content, fixed carbon content, and calorific value at the end of the production process.

The composition of making charcoal briquettes from a mixture of candlenut shell charcoal powder and rubber fruit shell charcoal powder is presented in Table 5, where tapioca adhesive will be added to the composition with a ratio of 1:15 to water, while the composition of tapioca adhesive used is 10% of the weight of the dry furnace charcoal powder.

Table 5. Composition Charcoal of Candlenut shell and Rubber Fruit Shell

Treatment	Candlenut shell	Rubber fruit shell
A	100%	0%
B	75%	25%
C	50%	50%
D	25%	75%
E	0%	100%

The charcoal briquettes process flow is as following figure:

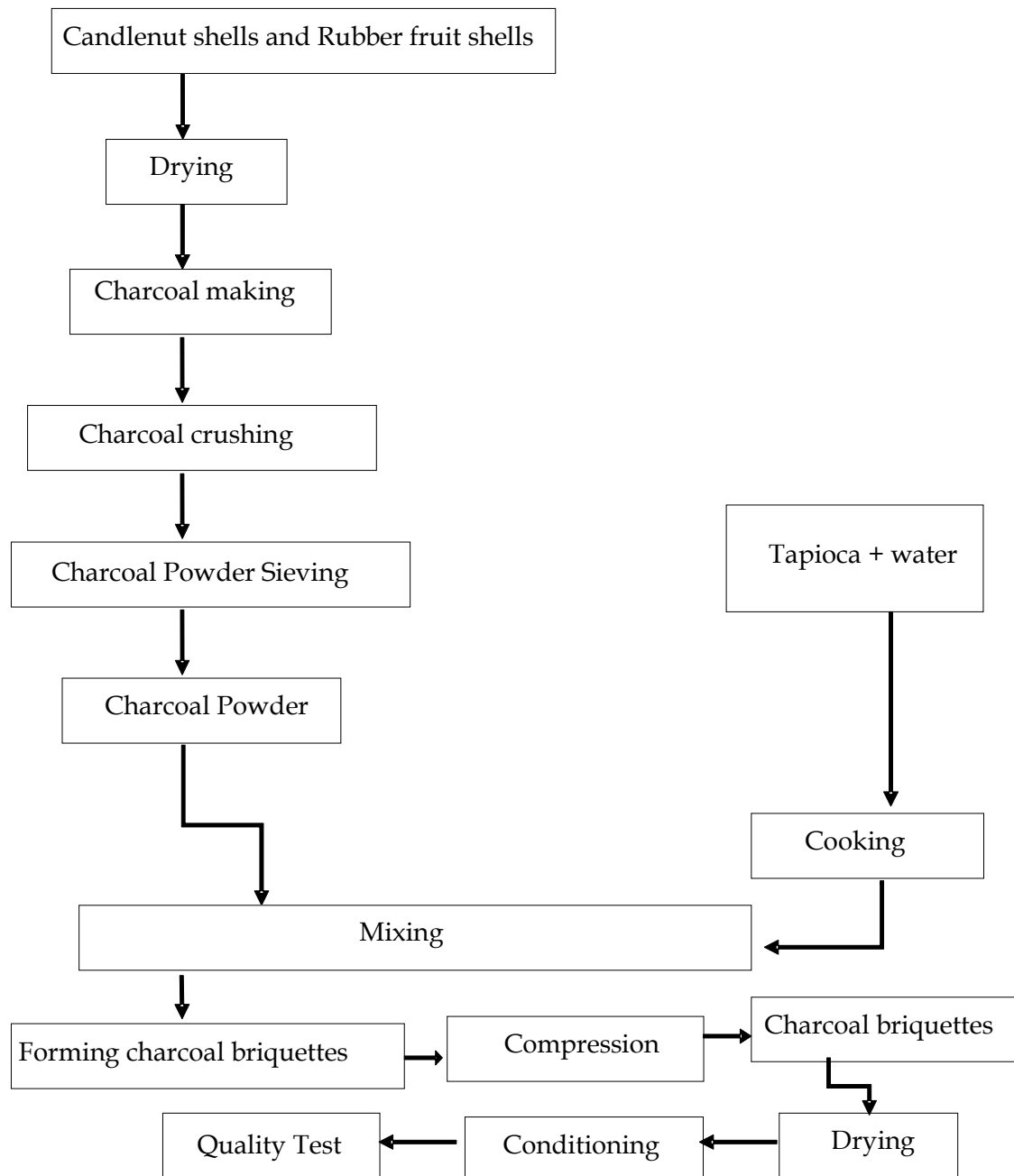


Figure 1. Charcoal Briquettes Making Process

Using a press tool with 40 bar of pressure for 50 minutes to create charcoal briquettes.

Analysis of the effect of raw material composition on the quality of charcoal briquettes, the test result data was further processed using a Completely Randomized Design (CRD) with five treatments and five replications, namely testing specific gravity, water content and compressive strength. Five treatments with three replications in testing volatile matter content, ash content, and fixed carbon content. Meanwhile, five treatments with two replications were carried out on the calorific value. If there is a significant or very significant treatment effect, a Least Significant Difference (LSD) test is carried out.

## RESULTS

These are the results of quality tests on charcoal briquettes.

Table 6. Charcoal Briquette Quality Test Results

Charcoal Briquettes Quality Parameters	Treatments				
	A	B	C	D	E
Density (g/cm <sup>3</sup> )	0.66	0.65	0.61	0.59	0.52
Moisture content (%)	9.52	9.79	10.26	10.79	11.23
Compressive strength (kg/cm <sup>2</sup> )	2.03	1.46	1.32	0.96	0.78
Volatile matter content (%)	30.13	31.53	37.23	43.22	43.31
Ash content (%)	6.79	10.71	13.38	13.27	15.48
Fixed carbon content (%)	52.15	49.35	39.12	32.72	29.96
Calorific value (cal/gr)	6,057.8	5,568.1	5,333.7	5,142.4	4,986.73

Each charcoal briquette quality parameter test result was compared with the value in the SNI 01-6235-2000 standard, whether it met the standard or not.

Table 7. Compliance with Charcoal Briquette Quality Standard References

Quality Parameters	SNI 01-6235-2000	Samples	Remark
Density (g/cm <sup>3</sup> )	-	0.52-0.66	-
Moisture content (%)	≤ 8	9.52-11.23	x
Compressive strength (kg/cm <sup>2</sup> )	-	0.78-2.03	-
Volatile matter content (%)	≤ 15	30.13-43.31	x
Ash content (%)	≤ 8	6.79-15.48	x
Fixed carbon (%)	-	29.96-52.15	-
Calorific value (cal/gr)	> 5.000	4,986.73-6,057.8	√

Only the calorific value meets the SNI 01-6235-2000 standard. This will be a serious concern in the following research by further improving the procedure for making and testing charcoal briquettes and calculating the amount of raw materials needed to produce better charcoal briquettes.

## DISCUSSION

The test results of each charcoal briquette quality parameter were analyzed using analysis of variance (ANOVA) to determine the effect of material composition on the quality of charcoal briquettes. The effect is at the level of not significant, significant, very significant. Significant and very significant effects were retested using the Least Significant Difference (LSD) test to determine in more detail the effect of each treatment on the quality of charcoal briquettes.

The effect of treatment on the quality properties of charcoal briquettes can be seen in the following analysis of variance (ANOVA) table:

Table 8. Analysis of Variance on the Effect of Treatment on the Quality of Charcoal Briquettes

Charcoal Briquettes Quality Parameters	Error	Treatments	
	Mean Square	Mean Square	F-Count
Density <sup>(a)</sup>	0.0003	0.0165	55.255**
Moisture content <sup>(a)</sup>	0.002	2.483	1,284.913**
Compressive strength <sup>(a)</sup>	0.092	1.187	12.942**
Volatile matter content <sup>(b)</sup>	10.317	116.692	11.311**
Ash content <sup>(b)</sup>	0.764	33.311	43.615**
Fixed carbon content <sup>(b)</sup>	5.768	290.580	50.380**
Calorific value <sup>(c)</sup>	243.98	35,0495.7	1,436.578**

Notes : (a) = 5 replications = F-table 5% = 2.866 ; 1% = 4.431

(b) = 3 replications = F-table 5% = 3.478 ; 1% = 5.994

(c) = 2 replications = F-table 5% = 5.192; 1% = 11.392

\*\* = very significant

### 1. Density (g/cm<sup>3</sup>)

Based on the analysis of variance, it is known that the composition treatment of candlenut shell and rubber fruit shells has a very significant effect on the density of charcoal briquettes. Then the LSD test was carried out as follows:

Table 9. LSD Test on the Effect of Each Treatment on the Density of Charcoal Briquettes

Treatments	Average	A	B	C	D	E
A	0.66	-	0.002 <sup>ns</sup>	0.046**	0.066**	0.140**
B	0.65	-	-	0.044**	0.044**	0.138**
C	0.61	-	-	-	0.020*	0.094**
D	0.59	-	-	-	-	0.074**
E	0.52	-	-	-	-	-

Notes : LSD 5% = 0.023 ; 1% = 0.031

ns = not significant ; \* = significant ; \*\* = very significant

Charcoal briquettes with a high composition of candlenut shells have a higher density. The density of the raw materials used has an influence on the high and low density of charcoal briquettes (Rindayatno, et.al. 2017).

## 2. Moisture Content (%)

The moisture content of charcoal briquettes is known to be significantly impacted by the composition treatment of rubber fruit shells and candlenut shell, according to the analysis of variance. The LSD test was then conducted as follows:

Table 10. LSD Test on the Effect of Each Treatment on the Moisture Content of Charcoal Briquettes

Treatments	Average	A	B	C	D	E
A	9.517	-	0.27**	0.75**	1.27**	1.72**
B	9.791	-	-	0.47**	1.00**	1.44**
C	10.262	-	-	-	0.53**	0.97**
D	10.791	-	-	-	-	0.44**
E	11.234	-	-	-	-	-

Notes : LSD 5% = 0.058 ; 1% = 0.079

\*\* = very significant

The density of charcoal briquettes affects the moisture content of charcoal briquettes. Charcoal briquettes that have low density will have a higher water content compared to briquettes that have high density (Rindayatno, et.al. 2017).

## 3. Compressive Strength (kg/cm<sup>2</sup>)

Based on the analysis of variance, it is known that the treatment of rubber fruit shells and candlenut shells composition has a very significant effect on the compressive strength of charcoal briquettes. Furthermore, the LSD test was carried out as follows:

Table 11. LSD Test on the Effect of Each Treatment on the Compressive Strength of Charcoal Briquettes

Treatments	Average	A	B	C	D	E
A	2.03	-	0.576*	0.710**	1.071**	1.256**
B	1.46	-	-	0.134 <sup>ns</sup>	0.495*	0.680**
C	1.32	-	-	-	0.361 <sup>ns</sup>	0.547*
D	0.96	-	-	-	-	0.185 <sup>ns</sup>
E	0.78	-	-	-	-	-

Notes : LSD 5% = 0.400 ; 1% = 0.545

ns = not significant ; \* = significant ; \*\* = very significant

The density of the briquettes tends to affect the compressive strength of the charcoal briquettes, the higher the density value, the higher the compressive strength value (Setiowati & Tirono, 2014)

## 4. Volatile Matter Content (%)

The composition of rubber fruit shells and candlenut shells has a very significant effect on the volatile matter content of charcoal briquettes, according to the results of the analysis of variance. Then, the LSD test was carried out as follows:

Table 12. LSD Test on the Effect of Each Treatment on the Volatile Matter Content of Charcoal Briquettes

Treatments	Average	A	B	C	D	E
A	30.13	-	1.40 <sup>ns</sup>	1.40 <sup>ns</sup>	13.09 <sup>**</sup>	13.18 <sup>**</sup>
B	31.53	-	-	5.70 <sup>*</sup>	11.68 <sup>**</sup>	11.78 <sup>**</sup>
C	37.23	-	-	-	5.99 <sup>*</sup>	5.99 <sup>*</sup>
D	43.22	-	-	-	-	0.09 <sup>ns</sup>
E	43.31	-	-	-	-	-

Notes : LSD 5% = 5.840 ; 1% = 8.310

ns = not significant ; \* = significant ; \*\* = very significant

The high and low levels of volatile substances are determined by the temperature and time of charring and the levels of extractives in the raw materials (Supriyati, et al., 2023). Extractive substances such as lignin in candlenut shell raw materials are mostly decomposed in the charring time range with an average temperature of 310°C, Kuriama (1961) in (Rindayatno, et.al. 2017) said that at a temperature of 310-500°C most lignin decomposes and more tar. The tar produced is mostly from the decomposition of lignin with increasing temperature and charring time.

#### 5. Ash Content (%)

The findings of the analysis of variance indicate that the ash content of charcoal briquettes is significantly impacted by the composition of rubber fruit shells and candlenut shells. The LSD test was then conducted as follows:

Table 13. LSD Test on the Effect of Each Treatment on the Ash Content of Charcoal Briquettes

Treatments	Average	A	B	C	D	E
A	6.79	-	3.93 <sup>**</sup>	6.59 <sup>**</sup>	6.48 <sup>**</sup>	8.69 <sup>**</sup>
B	10.71	-	-	2.66 <sup>*</sup>	2.55 <sup>*</sup>	4.77 <sup>**</sup>
C	13.38	-	-	-	0.11 <sup>ns</sup>	2.10 <sup>*</sup>
D	13.27	-	-	-	-	2.21 <sup>*</sup>
E	15.48	-	-	-	-	-

Notes : LSD 5% = 1.590 ; 1% = 2.260

ns = not significant ; \* = significant ; \*\* = very significant

Low density biomass has more mineral content in its cell walls compared to raw materials with high density. The lower the ash content of a briquette, the better the quality of the briquette. The mineral content in candlenut shell pentose is 49.22% and in rubber seed shell cellulose is around 48.64%. Adhesives also affect the ash content of charcoal briquettes, the higher the adhesive content, the higher the ash content produced (Maryono, et al., 2013)

#### 6. Fixed Carbon Content (%)

The analysis of variance's findings indicate that the fixed carbon content of charcoal briquettes is significantly impacted by the composition of rubber fruit shells and candlenut shells. Following that, the LSD test was conducted as follows:

Table 14. LSD Test on the Effect of Each Treatment on the Fixed Carbon Content of Charcoal Briquettes

Treatments	Average	A	B	C	D	E
A	52.15	-	2.81 <sup>ns</sup>	13.03 <sup>**</sup>	19.43 <sup>**</sup>	22.20 <sup>**</sup>
B	49.35	-	-	10.23 <sup>**</sup>	16.62 <sup>**</sup>	19.39 <sup>**</sup>
C	39.12	-	-	-	6.39 <sup>*</sup>	9.16 <sup>**</sup>
D	32.72	-	-	-	-	2.77 <sup>ns</sup>
E	29.96	-	-	-	-	-

Notes : LSD 5% = 4.370 ; 1% = 6.210

ns = not significant ; \* = significant ; \*\* = very significant

The content of fixed carbon in briquettes is influenced by the carbonization process and the content of volatile substances, the lower the content of volatile substances, the higher the content of fixed carbon (Rindayatno and Lewar, 2017). A good carbonization process will increase the content of fixed carbon and reduce the content of hydrogen and oxygen in charcoal Sudrajad (1982) in (Rindayatno and Lewar, 2017).

The cellulose content in raw materials affects the fixed carbon of charcoal briquettes, the amount of cellulose in candlenut shells is 49.22% and rubber fruit shells are 48.64%. (Hutagaol, 2015) states that cellulose affects the content of fixed carbon in raw materials for making briquettes, this is because the composition of cellulose is mostly carbon elements.

The fixed carbon content is greatly influenced by the density level of charcoal briquettes. High density represents the amount of charcoal powder which is a representation of the carbon contained in charcoal briquettes. The fixed carbon content will follow the density value of the raw material (Cao. Z.. et.al. 2019). Other factors are the volatile matter content and ash content, if both are at a low level will increase the fixed carbon content in charcoal briquettes.

#### 7. Calorific Value (cal/g)

The analysis of variance results show that the calorific value of charcoal briquettes is significantly impacted by the composition of rubber fruit shells and candlenut shells. The LSD test was then conducted in the manner described.

Table 15. LSD Test on the Effect of Each Treatment on the Calorific Value of Charcoal Briquettes

Treatments	Average	A	B	C	D	E
A	6,057.89	-	489.78 <sup>**</sup>	724.15 <sup>**</sup>	915.40 <sup>**</sup>	1,071.16 <sup>**</sup>
B	5,568.11	-	-	234.37 <sup>**</sup>	425.62 <sup>**</sup>	581.38 <sup>**</sup>
C	5,333.74	-	-	-	191.25 <sup>**</sup>	347.01 <sup>**</sup>
D	5,142.49	-	-	-	-	155.76 <sup>**</sup>
E	4,986.73	-	-	-	-	-

Notes : LSD 5% = 40.152 ; 1% = 62.981

\*\* = very significant

The calorific value is influenced by the fixed carbon content in the briquette, if the fixed carbon content is high then the calorific value of the briquette will also be high (Setyawan, 2006 in Hutagaol, 2015).

Biomass in the form of shells has a fairly high calorific value, approaching the calorific value of wood, namely 4,000 cal/g, and will increase if it has been carbonized (Tajalli. A. 2015). The calorific value of the charcoal briquettes tested met the SNI 01-6235-2000 standards.

## **CONCLUSIONS AND RECOMMENDATIONS**

Increasing the amount of charcoal from candlenut shells in the composition of charcoal briquette materials can improve the quality of charcoal briquettes, although only the calorific value of charcoal briquettes meets the requirements of the SNI 01-6235-2000 standard.

## **FURTHER STUDY**

The use of additional biomass wastes that are plentiful and have not yet been fully utilized, such as waste from plantation and agricultural crops, to create charcoal briquettes requires more further research.

## **ACKNOWLEDGMENT**

The collaboration of the study team and additional contributors is sincerely appreciated by the author.

## **REFERENCES**

- Andasuryani & Putri, R, E. 2017. Study of Charcoal Briquette Quality Using Biomass Waste Raw Material. *Teknologi Pertanian Andalas*, p 21.
- Badan Standardisasi Nasional (BSN). 2000. SNI 01-6235-2000 Charcoal Briquettes. National Standardization Agency. Jakarta.
- Cao. Z., Zhang. S., Wang. C., Jiang. F., Huang. X., Li. H., Zhang. Y., & Lyu. J. 2019. Investigation on the physical properties of the charcoal briquettes prepared from wood sawdust and cotton stalk. *Energy Sources. Part A: Recovery. Utilization and Environmental Effects*. 41(4). <https://doi.org/10.1080/15567036.2018.1520332>
- Harahap, N. 2022. The effect of rubber seed shell ash on the characteristics of bricks. Doctoral dissertation, Universitas Islam Negeri Sumatra Utara.
- Hutagaol W.M., Tunggal T., & Hayati A. 2015. The Effect of Pressure and Size of Charcoal Particles Composing Briquettes on the Characteristics of Oil Palm Frond Briquettes. *Jurnal Teknik Pertanian Sriwijaya*.
- Maryono, Sudding, & Rahmawati. 2013. Pembuatan dan Analisis Mutu Briket Arang Tempurung Kelapa Ditinjau dari Kadar Kanji. *Jurnal Cemica*, vol 14, 74-83.
- Pasaribu. G., et al. 2005. Analysis of Chemical Components of Four Types of Wood from North Sumatra. West Sumatra

- Rindayatno dan Lewar D. O. 2017. Charcoal Briquette Quality Based on the Composition of Ironwood Charcoal Mixture (*Eusideroxylon zwageri* Teijsm & Binn) and Sengon Wood (*Paraserianthes falcataria*). *Jurnal Ulin Hutan Tropis*, 39-48.
- Rindayatno, Sari. MK, & Wagiman, S. 2017. The Quality of Charcoal Briquettes is Based On the Composition of the Charcoal Mixture from Red Meranti Wood (*Shorea* sp.) and Coconut Shells. (*Cocos nucifera* l.). *Proceedings of the 1st National Seminar on Baristand East Kalimantan*. p. 98-111.
- Setiowati R., & Tirono. 2014. The Effect of Variations in Pressing Pressure and Material Composition on the Physical Properties of Charcoal Briquettes. *Jurnal Neutrino Jurusan Fisika Fakultas Sains dan Teknologi Universitas Islam Negeri Maliki Malang*.
- Supriyati. W., Silalahi. E. R., Nuwa., & Alpian. 2023. Characteristics of Charcoal Briquettes with Composition of Sungkai Wood Powder (*Peronema canescens*) and Ulin Wood (*Eusideroxylon zwageri* Teijsm & Binn). *Jurnal Hutan Tropika*, 99-108.
- Susanto, H., Addi, F. N., & Kesuma, R. A. 2021. Utilization of Aleurites Moluccana (Candlenut) Candlenut Shells as Coarse Aggregate for the Compressive Strength of Lightweight Concrete. *Teknologi Sipil: Jurnal Ilmu Pengetahuan dan Teknologi*, 44-54.
- Tajalli. A. 2015. Guide to assessing the potential of biomass as an alternative energy source in Indonesia. Penabulu Alliance.
- Wijayanti. D.S. 2009. Characteristics of Charcoal Briquettes from Sawdust with the Addition of Palm Kernel Shell Charcoal. Bachelor of Agriculture Thesis. University of North Sumatra. Medan.