Characteristics of Charcoal Briquettes Corn Cobs Charcoal with the Addition of Areca Peel Charcoal

Muhammad Satria, Noviar Harun, Faizah Hamzah*, Angga Pramana

Agricultural Technology Industry- Agriculture Faculty, Riau University
Kampus Bina Widya KM 12.5 Pekanbaru Riau
Faizahhamzah12@gmail.com

Abstract. Corn cobs and areca peel are biomass waste that can be used in the form of charcoal briquettes as an alternative source of energy because they contain lignin and cellulose. The purpose of this research was the best obtain character briquettes from a combination corn cobs charcoal and areca peel charcoal. This research used complete randomized design with 5 treatment and 3 replications. Data were statically analyzed by analysis of variance (ANOVA). The treatments in this research include ratio of corn cobs charcoal and areca peel charcoal 90:10, 80:20, 70:30, 60:40, and 50:50. The result of analysis showed that the ratio of corn cobs charcoal and areca peel affect on density, water content, fix carbon content, ash content but did not significantly affected calorific value. The best treatment briquettes was (90:10) with density content 0.66 g/cm³, water content 4.23%, volatile matter content 15.01%, ash content 3.68%, fixed carbon content 77.07% and calorific value of 6528.73 cal/g.

1. Introduction
The need for energy derived from fuel increases along with the increasing human population and increasing industrial activity. Fossil fuels such as petroleum take a long time to be renewed, which affects prices. Society and industry players increasingly spend more to carry out their activities. Technological innovation is needed to play a role in alternative fuels to reduce costs. Alternative fuels are expected to meet the fuel needs of the community and industry players by paying attention to raw materials to follow the criteria for fuels that have been frequently used.

Riau Province has the potential for agricultural waste because agricultural activities are quite high. Corn is one of the food commodities of Riau Province. According to data from [1], it shows that in 2018 Riau Province had a corn plantation area of 9,352 hectares and 25,723 tons. Corn collectors only take corn kernels to be used as food, thus leaving corn cobs that are rarely used. According to [2], corn cobs have lignin of 19.74% and cellulose 41.45% as a fuel source. Corn cobs can be charcoal for briquette raw materials and have met the SNI criteria> 5000 cal / g at calorific value. Corn cobs charcoal briquettes have a calorific value of 7,507 cal / g, so they have the potential to improve the calorific value of charcoal briquettes from other raw materials that have not met the SNI criteria [3].

Areca nut is a plantation crop with many uses, among others, for consumption, the cosmetic industry, health, and colouring in the textile industry. According to data from [4], it shows that in 2018 Riau Province had an areca nut plantation area of 19,521 hectares and 10,536 tons. The skin of the betel nut is currently not used optimally, so far, the areca nut skin is only thrown away by the betel nut collectors. According to [5], betel nut skin has 31.6% lignin and 34.8% cellulose, which can be used as an alternative fuel source. Using of fruit peels as an alternative fuel to better utilize waste ensures that
it becomes a product with economic value. Areca fruit skin charcoal has not reached the SNI criteria> 5000 cal / g at calorific value. The calorific value of areca nut skin charcoal is 4.853 cal / g. Other raw materials are needed, which are expected to improve areca nut skin charcoal briquettes [6].

Previous research on briquettes has been carried out[7], the use of corn cobs and rubber seed shells in the manufacture of briquettes with the best treatment of 50:50 obtained the results of the analysis of water content of 7.12%, ash content of 3.11%, volatile matter content of 18.57%. bound carbon content 71.18%, density 0.42% g/cm³ and a calorific value of 6444.7 cal / g. Furthermore, [8], the preparation and biomass characteristics of areca nut and coconut shell into briquettes with tapioca adhesive as the best treatment was 50:50. The analysis results were 6.9% moisture content, 5.8% ash content, and 60% bound carbon content. This study aims to obtain the characteristics of the best combination charcoal briquettes, the ratio of high-quality corncob and areca nutshell charcoal according to SNI No. 01-6235-2000.

2. Method
This research has been carried out in the Agricultural Products Processing Laboratory and Agricultural Product Analysis Laboratory, Faculty of Agriculture, Energy Conversion Laboratory, Faculty of Engineering, Riau University. This research has been going on for six months, from October to March 2021. The materials used in this research are corn cobs and areca nut skin as raw materials obtained from community gardens in Maharatu Village, Marpoyan Damai District, Pekanbaru City. Tapioca flour as an adhesive for the brand (Rose Brand) purchased at Simpang Baru Market, Pekanbaru City. The tools used in this study were a 60 mesh spoon sieve, tray, stirrer, pestle, cylindrical mould, manual press, carbonization drum, stove, porcelain dish, desiccator, analytical scale, oven, furnace, oxygen bomb calorimeter, micro mire, cotton thread, stationery, and camera.

The research was conducted with an experimental method [Experimental Method] using a completely randomized design (CRD) consisting of 5 treatments and three replications to obtain 15 experimental units. The treatment in this study refers to [7]. The treatment used was the difference in the ratio of corn cobs and areca nut charcoal. The ratio of charcoal to treatment in the study is as follows:
P1 = corn cobs and areca nuts (90:10)
P2 = corn cobs and areca nuts (80:20)
P3 = corn cobs and areca nuts (70:30)
P4 = corn cobs and areca nutshell charcoal (60:40)
P5 = corn cobs and areca nut skin charcoal (50:50)

Parameters to be observed in briquettes with corn cobs and areca nutshell charcoal concentrations are density, moisture content, substance content evaporates, ash content, bonded carbon content, and heating value to SNI 01-6235-2000 [9].

2.1. Density
The briquette density refers to [3] the density test step, namely preparing the equipment used, including the sample, weighing the sample, measuring the sample volume, and then calculating the briquette density. The density of briquettes can be calculated using the following formula:

\[ \rho = \frac{m}{V} \]

Description:
\( \rho \) = density [g/cm³]
\( m \) = weight of briquettes [g]
\( V \) = volume [cm³]

2.2 Water content
Determination of water content refers to [10], clean porcelain dishes are carried out drying in the oven at 100°C for 10 minutes. The porcelain plate was then put into a desiccator for 30 minutes and then weighed. Samples were weighed as much as 2 g, then put in a porcelain dish and dried in an oven at 105°C for 2 hours. The sample is then put into a desiccator for 30 minutes and then weighed. This
drying was repeated until the final material's weight was obtained, a constant weight was obtained [the difference between the weights before and after ± 0.02 g]. The water content can be calculated by the formula:

$$\text{water content} = \frac{W_1 - W_2}{W_1} \times 100\%$$

Description:
W1 = Weight of initial sample
W2 = Weight of final sample

2.3 The concentration of the volatile substance
The determination of the evaporating substance's concentration refers to America Standard Test Methode D 5142 [2004], the plate containing the sample from the determination of the moisture content, is entered into the furnace at 950°C for 6 minutes. After the evaporation is complete, the plate is put into a desiccator for 30 minutes, then it is weighed to get the sample weight after heating. The content of the volatile substance can be calculated by the formula:

$$\text{volatile substance} = \frac{X_1 - X_2}{W} \times 100\%$$

Description:
W = Weight of the initial sample in the analysis of water content
X1 = Weight of the sample after determination of water content
X2 = Weight of the sample after heating at 950°C

2.4 Ash content
Observation of ash content refers to [10], the clean porcelain dishes are dried in an oven at a temperature of 100°C for 10 minutes. The porcelain plate was then put into a desiccator for 30 minutes and then weighed. Samples were weighed as much as 2 g and then put into a porcelain dish, then burned in the furnace at a temperature of ashing 600°C for 3 hours until ash was obtained. The sample was then put into a desiccator for 30 minutes, then weighed to get the ash weight. The ash content can be calculated by the formula:

$$\text{ash content} = \frac{X_2}{X_1} \times 100\%$$

Description:
X1 = Weight of sample
X2 = Weight of ash

2.5 Bound carbon content
Observation of bonded carbon content refers to SNI 01-6235-2000 [9], namely by calculating the carbon fraction by calculating the moisture content results, volatile matter content, and ash content obtained from each sample to the formula for bound carbon content. The content of bonded carbon can be calculated using the formula:

$$\text{Content of bonded carbon} = 100\% - (\text{moisture content} + \text{ash content} + \text{volatile matter content})\%$$

2.6 Calorific value
The calorific value level observation refers to America Standard Test Methode D 5865 [2010], namely using a bomb calorimeter PARR 1261. The test is carried out by weighing 1 g and putting it in a cup crucible. A water jacket vessel was prepared and filled with 2 litres of distilled water. A micro mire is 6 cm long placed on both arms of the bomb vessel, and in the middle of the Micro mire is tied with 10 cm of cotton thread. The sample is then placed into the bomb vessel until the cotton thread touches the sample. The vessel bomb is filled with pure oxygen with a pressure of 25 bar, then inserted into the vessel calorimeter. The temperature gauge and stirrer were inserted into the calorimeter vessel. The bomb calorimeter is ready for use by pressing the switch on. The bomb calorimeter is calibrated with set 0, then fire is pressed. The temperature display screen is observed to reach the highest rate of increase. The calorific value can be calculated using the formula:
The observational data obtained were analyzed statistically, using variance fingerprint [ANOVA] with software SPSS version 2.5. If the data shows the F count ≥ F table, then a further test with the Duncan New Multiple Range (DNMR) test at the 5% level to determine each treatment's differences.

3. Result and Discussion

3.1. Density

Density can be seen in Table 1. P1 data is significantly different from P2, P3, P4 and P5, while P2 is different from P3. The average density value of charcoal briquettes in this study ranged from 0.66 to 0.72 g / cm³.

| Treatment                                      | Density (g/cm³) |
|------------------------------------------------|-----------------|
| P1 = corn cobs and areca peel charcoal(90:10) | 0.66ᵃ           |
| P2 = corn cobs and areca peel charcoal(80:20) | 0.68ᵇ           |
| P3 = corn cobs and areca peel charcoal(70:30) | 0.69ᵇ           |
| P4 = corn cobs and areca peel charcoal(60:40) | 0.71ᵇ           |
| P5 = corn cobs and areca peel charcoal(50:50) | 0.72ᶜ           |

The density value of charcoal briquettes increases with the fewer corn cobs charcoal and the greater the areca nut charcoal. This is because the density of corn cobs briquettes is low compared to areca nut skin charcoal briquettes. Based on the analysis, the density of corn cobs charcoal briquettes is 0.65 g / cm³. In comparison, the density of areca peel charcoal briquettes is 0.78 g / cm³, so adding of areca nut skin charcoal can increase the briquette density. According to[11] different types of raw materials affect the size of the density value of charcoal briquettes produced. Raw materials that have high specific gravity will produce high-density briquettes. The density is also affected by the lignin content in the raw material. This is because the raw material used in this study is corn cobs which has a lignin content of 19.74% [7] while the areca nut skin which has a higher lignin is 31.6% [5] so that the increase in density is influenced by the amount of lignin. Areca nut skin charcoal. Lignin functions as a binding material for cellulose fibre components so that they become stiff. The more lignin contained in raw material, the higher the density of the briquettes produced.

This study's density is higher when compared to the density value [12] regarding the manufacture of briquettes from corn cobs and tea leaves with the resulting density values of 0.36 - 0.15 g / cm³. This is because the lignin of the areca nut skin is higher than the tea dregs lignin which has a lignin content of 12.03%.
3.2. Water Content

in Table 2. Water content data of P1 is significantly different from P2, P3, P4, and P5, while P4 is not significantly different from P5. The average moisture content of briquettes obtained in the study ranged from 3.88 to 4.23%.

Table 2. Average moisture content

| Treatment                                      | Water content (%) |
|------------------------------------------------|-------------------|
| P1 = corn cobs and areca peel charcoal(90:10) | 4.23^a            |
| P2 = corn cobs and areca peel charcoal(80:20) | 4.22^b            |
| P3 = corn cobs and areca peel charcoal(70:30) | 4.16^c            |
| P4 = corn cobs and areca peel charcoal(60:40) | 3.95^d            |
| P5 = corn cobs and areca peel charcoal(50:50) | 3.88^d            |

The water content of charcoal briquettes decreased along with the fewer corn cobs charcoal and the greater the amount of areca nut skin charcoal. The high and low water content of charcoal briquettes is caused because it is influenced by the raw material for making charcoal briquettes to affect the amount of water content produced. The moisture content of corn cobs charcoal briquettes is higher than areca nut skin charcoal briquettes. Based on the analysis, the moisture content of corn cobs charcoal briquettes was 4.26%, while the water content of areca nut skin charcoal briquettes was 3.33%, so the addition of areca nut skin charcoal could reduce the water content of the briquettes. This is consistent with the research [8] regarding the manufacture of briquettes from areca nut skin charcoal and coconut shell charcoal, showing that the less areca shell charcoal composition will increase the water content of the briquettes due to the dominant influence of coconut shell water content. The research charcoal briquettes made from areca nut skin and coconut shell charcoal ranged from 4.1-6.9%, the moisture content of corn cobs charcoal and areca nut skin charcoal in this study was low.

This study's moisture content results were SNI 01-6235-2000, with a maximum water content value of 8%. The initial stage of carbonization is to evaporate the water first to form charcoal so that the resulting charcoal moisture content is lower [13]. The water content is also influenced by the cellulose content in the raw material. This is because the raw material used in this study was corn cobs with a cellulose content of 41.45%, [7] while the areca nut skins had lower cellulose, namely 34.1% , so that the water content decreased was affected. The less cellulose content According to [14], the water content is related to the hygroscopic properties of charcoal, so that the amount of cellulose in the raw material affects the high and low water content produced. Water will make hydrogen bonds in each of the -OH groups in cellulose to absorb water.

3.3. Content of the Volatile Substance

The content of the volatile substance can be seen in Table 3. Vaporizing substance levels P1 is significantly different from P2, P3, P4, and P5. The average levels of volatile substances in this study ranged from 15.01 to 17.57%.

Table 3. Volatile substance content

| Treatment                                      | Volatile substance content(%) |
|------------------------------------------------|------------------------------|
| P1 = corn cobs and areca peel charcoal(90:10) | 15.01^a                      |
| P2 = corn cobs and areca peel charcoal(80:20) | 15.81^b                      |
| P3 = corn cobs and areca peel charcoal(70:30) | 16.36^c                      |
| P4 = corn cobs and areca peel charcoal(60:40) | 17.19^b                      |
| P5 = corn cobs and areca peel charcoal(50:50) | 17.57^c                      |

Levels of charcoal briquettes evaporating substance increases with fewer corn cobs and more areca nut skin charcoal. According to [11], the high and low levels of charcoal briquette vaporizing
substances are caused because it is influenced by the raw material for making charcoal briquettes, affecting the number of volatile substances produced. Based on the analysis, the flammable substance content of the corncob charcoal briquettes was 14.06%. In comparison, the areca nut skin charcoal briquettes were 20.64%, so adding areca nut skin charcoal could increase the briquettes' moisture content.

This study's volatile substance content did not meet the quality requirements and the quality of SNI 01-6235-2000 briquettes with a maximum range of 15% evaporating substance. This study's volatile substance was lower than in research [15], which used corn cobs and rubber seed shell charcoal to manufacture briquettes with a volatile substance content of 18.51-18.57%. The high content of volatile substances causes more smoke when the briquette is ignited. The higher the vaporized substance's content, the less residue is produced, meaning that the carbon content is lower so that the resulting calorific value is lower.

### 3.4. Ash Content

Content can be seen in Table 4. Data for P1 is significantly different from P2, P3, P4, and P5, while P3 is not significantly different from P4. The average ash content in this study ranged from 3.68 to 4.65%.

| Perlakuan | Kadar abu (%) |
|-----------|--------------|
| P1 = corn cobs and areca peel charcoal(90:10) | 3.68<sup>a</sup> |
| P2 = corn cobs and areca peel charcoal(80:20) | 4.06<sup>b</sup> |
| P3 = corn cobs and areca peel charcoal(70:30) | 4.35<sup>c</sup> |
| P4 = corn cobs and areca peel charcoal(60:40) | 4.46<sup>c</sup> |
| P5 = corn cobs and areca peel charcoal(50:50) | 4.65<sup>d</sup> |

The ash content of charcoal briquettes increased with fewer corn cobs and more areca nut skin charcoal. This is because of the raw material used in making charcoal briquettes. Areca nut skin charcoal has a higher ash content than corn cobs. Based on the analysis of the ash content of corncob charcoal, it has an ash content of 3.48%, in comparison areca nutshell charcoal has an ash content of 5.36%, so the addition of areca nutshell charcoal can increase the ash content of the briquettes. The ash content is influenced by the cellulose content in the raw material. This is because the raw material used in this study is corn cobs with a cellulose content of 41.45 [7]. At the same time, the areca nut skin has higher cellulose, namely 34.1% [5], indicating less cellulose in the content. Material, the higher the remaining extractive substance and has no energy.

In this study, the ash content was higher than in research [15], which used corn cobs and rubber seed shell charcoal to manufacture briquettes with an ash content ranging from 3.11% to 3.14%. The ash content of the rubber seed shell charcoal was lower than the ash content of the areca nutshell. The ash content of rubber seed shells was 2.09%, so areca nut shells to corn cobs could increase the ash content.

This study's ash content has met the quality requirements and the quality of SNI 01-6235-2000 briquettes with a maximum ash content of 8%. Organic materials in the combustion process will burn, but the inorganic components do not burn and have no energy.

### 3.5. Confined Carbon Content

Confined carbon content can be seen in Table 5. P1 data is significantly different from P2, P3, P4, P5, while P4 is not significantly different from P5. The average bound carbon content in this study ranged from 73.90 to 77.08%.
Table 5. Bonded Carbon

| Treatment                                      | Bonded carbon content (%) |
|------------------------------------------------|----------------------------|
| P1 = corn cobs and areca peel charcoal(90:10)  | 77.08^a                    |
| P2 = corn cobs and areca peel charcoal(80:20)  | 75.91^ab                   |
| P3 = corn cobs and areca peel charcoal(70:30)  | 75.12^bc                   |
| P4 = corn cobs and areca peel charcoal(60:40)  | 74.40^c                    |
| P5 = corn cobs and areca peel charcoal(50:50)  | 73.90^c                    |

The carbon content bound to charcoal briquettes decreased along with less and more areca nut skin charcoal. This is because of the raw material used in making charcoal briquettes. Based on the analysis of the bound carbon content of corn cob charcoal briquettes, it has a determined carbon content of 78.21%, while areca nut skin charcoal briquettes have a bound carbon content of 70.66%, so the addition of areca nut skin charcoal can reduce the briquette carbon content. This study's bound carbon content was higher than the study [15], which used corn cobs and rubber seed shell charcoal to manufacture of briquettes with a bonded carbon content of 70.15% - 71.18%.

The carbon content bound to P1 has met the quality and quality requirements of SNI 01-6235-2000 briquettes with a minimum bonded carbon content of 77%. This is because the water content is higher, but the volatile matter content and the ash content in this study are lower, with fewer corn cobs and more areca nut skin charcoal. This is because the raw material is corn cobs with a cellulose content of 41.45% (America Standard Test Method D 5142, 2004). At the same time, the areca nut skin has lower cellulose, namely 34.1% [5], so that the decrease inbound carbon content is affected with less cellulose content with the amount of areca nut skin used. According to [11], bonded carbon has something to do with chemical content, such as high cellulose, which results in high connected carbon content. According to [16], the value of bound carbon content depends on the importance of water content, ash content, and volatile matter content. The lower the result of the sum of water content, ash content, and vaporized substance content, the greater the bound carbon content's value and vice versa. The high content of bonded carbon indicates high carbon in the material. Carbon as fuel, air, and a heat source will react to form fire.

3.6. Calorific Value

The calorific value can be seen in Table 6. The data shows that this study's average calorific value ranges from 5,578.31-6,528.73 cal / g.

Table 6. Average heating value calorific

| Treatment                                      | Calorific value (Kal/g) |
|------------------------------------------------|-------------------------|
| P1 = corn cobs and areca peel charcoal(90:10)  | 6,528.73                |
| P2 = corn cobs and areca peel charcoal(80:20)  | 6,202.91                |
| P3 = corn cobs and areca peel charcoal(70:30)  | 6,060.63                |
| P4 = corn cobs and areca peel charcoal(60:40)  | 5,887.66                |
| P5 = corn cobs and areca peel charcoal(50:50)  | 5,578.31                |

The calorific value of corn cobs charcoal briquettes with the addition of areca nut skin charcoal was not significantly different for each treatment. The calorific value of charcoal briquettes decreased along with less and more areca nut skin charcoal. This is because of the raw material used in making charcoal briquettes. Areca nut skin charcoal has a lower calorific value than corn cobs. This is because corn cobs have a cellulose content of 41.4% [7], in contrast betel nut rind has lower cellulose, namely 34.1% [5], so that the decrease inbound carbon content is influenced by the less cellulose content with the number of fruit peels areca used.
According to [11], corn cobs charcoal briquettes have a calorific value of 7,507.83 cal / g. In contrast, according to [17], areca nut skin briquettes have a calorific value of 4853 cal / g, so that there is less corn cob charcoal and more areca nut skin charcoal. Can reduce the calorific value.

This study's calorific value has met the quality and quality requirements of SNI 01-6235-2000 briquettes with a minimum calorific value of 5,000 cal / g. This study's calorific value is higher than in research [18], which used corn cobs and rice husk charcoal to manufacture of briquettes with heating values ranging from 3,979.40-6,078 cal / g. The calorific value of rice husk is lower than that of areca nut skin. The calorific value of rice husk charcoal briquettes is 3979.40 cal / g. The corn cob charcoal briquettes with the addition of areca nut skin charcoal do not experience a decrease in calorific value.

According to [19], the increase in heating value is influenced by moisture content, ash content, and volatile matter content. The lower the water content, the ash content, and the evaporating substance content, the better the calorific value. The water content in this study decreased with fewer corn cobs charcoal and more areca nut skin charcoal. The lower the water content, the higher the resulting calorific value, so that the water content in this study affects the calorific value. Low water content can result in a calorific value that tends to be high. The low water content causes the combustion to take place completely so that the water is appropriately evaporated and the resulting charcoal has a high heating value [6].

This study's volatile substance content was high in line with the less corn cob charcoal and the more areca nut skin charcoal. The lower the vaporized substance's level, the higher the resulting calorific value, increasing the calorific value. The vaporized substance's content affects the perfection of combustion and the resulting flame, thus affecting the heating value [10].

This study's ash content was high, along with fewer corn cobs and more areca nutshell charcoal. The lower the ash content, the higher the calorific value. According to [20], the ash content plays a vital role in the heating value because the higher the briquettes' ash content, the less good the quality of the briquettes produced because they can form a crust. High ash content will reduce the rate of briquettes because ash reduces the calorific value [19].

The content of bonded carbon can also affect heating value. According to [21], the content of bound carbon affects the briquette burn's heating value. The higher the carbon content bound to charcoal, the higher the calorific value is good charcoal. The combustion process requires carbon that reacts with oxygen and a heat source to produce heat. This study's bound carbon content was also lower, with fewer corn cobs and more areca nut skin charcoal.

4. Conclusion
Based on the results of research on the characteristics of corn cob briquettes and areca nut shell charcoal, it can be concluded that corn cob briquettes and areca nutshell charcoal have a significant effect on density, moisture content, volatile substance content, ash content, and the resulting bound carbon content while the calorific value does not. have a real impact. The treatment selected in this study was at P1, namely briquettes with a ratio of corn cobs and areca nutshell charcoal (90:10). The average density value is 0.66 g / cm³, water content is 4.23%, volatile substance content is 15.01%, ash content is 3.68%, bound carbon content is 77.07% and a calorific value is 6528.73 cal / g. P1 observation results that moisture content, ash content, bound carbon content, and heating value are by the quality standards of wood charcoal briquettes, while the volatile substance content has not met the SNI No. 01-6235-2000.

References
[1] Dinas Ketahanan Pangan Riau. Buku Statistik Pangan Tahun 2019 69
[2] Purwaningrum CR 2010 Biodelignifikasi tongkol jagung menggunakan fungi pelapuk putih (white rot fungi) Institut Pertanian Bogor
[3] Fitri N 2017 Pembuatan briket dari campuran kulit kopi (Coffea arabica) dan serbuk gergaji dengan menggunakan getah pinus (pinus merkusii) sebagai perekat UIN Alauddin Makassar
[4] Dinas Perkebunan. Rencana Strategis 2020-2024. Pekanbaru: Dinas Perkebunan;
[5] Chandra JCS, George N, Narayankutty SK 2016 Isolation and characterization of cellulose nanofibrils from arecanut husk fibre Carbohydr Polym. 142 158–66
[6] Gandhi Aquino 2010 Pengaruh varian jumlah campuran perekat terhadap karakteristik briket arang tongkol jagung J Prof 8(1) 1–12
[7] Pakpahan HS, Hamzah FH, Ayu DF 2019 Pemanfaatan tongkol jagung dan cangkang biji karet pada pembuatan briket. JOM Faperta 6(1) 1–10
[8] Frida E, Darnianti D, Pandia J 2019 Preparasi dan karakterisasi biomassa kulit pinang dan tempurung kelapa menjadi briket dengan menggunakan tepung tapioka sebagai perekat. JUITech Jurnal Ilm Fak Tek Univ Qual 3(2).
[9] SNI. Briket Arang Kayu 2009 1(11) 639–57
[10] Simorangkir A 2014 Analisa Proximate, Analisa Ultimate dan Analisa Miscellaneous pada Batubara. Institut Teknologi Medan
[11] Hendra D. 2007 Pemanfaatan Enceng Gondok untuk Bahan Baku Briket sebagai Energi Alternatif. J Penelit Has Hutan 29(2) 189–210
[12] Faiz TA, Harahap LA, Daulay SB 2015 Pemanfaatan tongkol jagung dan limbah teh sebagai bahan briket. J Rekayasa Pangan dan Pertan. 4(3) 427–32
[13] Widarti BN, Sihotang P, Sarwono E 2016 Penggunaan tongkol jagung akan meningkatkan nilai kalor pada briket. J Integr Proses 6(1) 16–21
[14] Irandar R 2020 Karakteristik Briket Arang Tongkol dan Kelobot Jagung dengan Perekat Tapioka 21
[15] Maharani S, Loka I 2010 Pembuatan Biobriket Sabut Pinang dengan Proses Karbonisasi Institut Teknologi Sepuluh November
[16] Faizal M, Andynaprativi I, Purti PD 2014 Pengaruh komposisi arang dan perekat terhadap kualitas biobriket dari kayu karet J Tek Kim 20 36–44
[17] Kurniawan O, Marsono 2008 Superkarbon, Bahan Bakar Alternatif Pengganti Minyak Tanah dan Gas. Jakarta: Penebar Swadaya
[18] Sudarmadji S, Haryono, Suhardi B 1996 Analisa Bahan Makanan dan Pertanian. Yogyakarta: Liberty Yogyakarta
[19] Maryono, Suding, Rahmawati 2013 Pembuatan dan analisis mutu briket arang tempurung kelapa ditinjau dari kadar kanji. J Chem 14(1) 74–83
[20] Artati, Wahyu Kusuma S, Noriyanti RD 2012 Kajian eksperimental terhadap karakteristik pembakaran briket limbah ampas kopi instan dan kulit kopi J Tek POMITS 1–6
[21] Bahri S 2008 Pemanfaatan limbah Industri pengolahan kayu untuk pembuatan briket arang dalam mengurangi pencemaran lingkungan di Nangroe Aceh Darussalam Universitas Sumatera Utara