The utilization of corncob for the manufacture of charcoal briquette as an alternative fuel

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Abstract. Biomass of sweet corncob and birdlime that is much found in society is the garbage that until now have not widely used as a product that have value added. This research aims to use biomass of sweet corncob and the birdlime as an alternative fuel to substitute fossil energy sources. One alternative to make sweet corncob and birdlime as an alternative fuel is process them into charcoal briquettes so it can produces high calorific value. The process to make charcoal briquettes from corncob and birdlime is very easy which includes charcoal raw material drying, preparation of the adhesive, printing and drying the Briquettes. Besides, the testing of briquettes quality of sweet corncob includes: density (0.54 – 0.78 gr/cm³), calorific value (4936.454 cal/gr), water level (6.39%), ash level (3.8%), vaporized substance level (16.72%) and bonded carbon level (79.48%). Whereas, birdlime corncob include: density (0.61 – 1.3 gr/cm³), calorific value (6033.650 cal/gr), water level (6.83%), ash level (4.8%), vaporized substance level (18.41%) and bonded carbon level (76.48%).

1. Introduction

Natural resources that are not renewable such as carbon fossil-fuel is the main energy source that used by humans. But the availability of carbon fossil-fuel is not comparable with the increasing human population rate and the industrial rate in many countries in the world, especially Indonesia. It raises concern the occurrence of fuel scarcity. Besides, the disadvantage of fossil fuel usage is, it will cause environmental damage. Because of that, came an idea to use an eco-environment alternative energy to replace fossil fuel usage. As an agricultural country, Indonesia has a lot of solid organic cesspool (biomass) that very abundant and underutilized. The biomass has the potential to become an alternative energy source with the relatively large energy content. Besides, a biomass energy source has some advantages of its usage, such as: This energy source can be use sustainably because of its characteristic (renewable resources), Not contain of sulphur element which causes air pollution of the fossil fuels usage, To increase efficiency of utilization agriculture cesspool [1].

The development of biomass as an alternative fuel is an eco-environment product and as an optimization of resource use to increase the added value. As an example of biomass which is found in
the country rimland is corn cob [2]. Corn is one of the agricultural products that much produced in Indonesia. The central statistics bureau of Indonesian republic reported that the land area of harvested corn in Indonesia at 2010 reached 4.184.091 Ha with the production 18.016.537 tons [3]. While for Central Sulawesi province, based on statistics data Food and Nutrition Security Bulletin Central Sulawesi Province 2009, the harvest area is 42.245 Ha with the production 164.282 tons [4].

One corn can produces corn cob cesspool about 30% [2]. If we convert with the amount of the corn production in Indonesia at 2010, so Indonesia has high potential to produces corn cob about 5.404.961 tons, while for Central Sulawesi province at 2009 has potential to produces corn cob about 49.285 tons.

Corncob cesspools can potentially cause a lot of trash everywhere, so if the use of corn cob as a biomass to become energy source is successful, then it will a new hope for citizens to get an alternative energy source from local raw material, moreover with the production of corn seed held by the government, especially for Central Sulawesi Provincial Government with GEMA PALAGUNG program that planned since 2015.

A way to decrease that cesspool is to make corn cob as an alternative fuel that is processed into solid fuel made called charcoal briquettes that can use to substitute kerosene fuel to fulfil the household’s fuel-needs everyday. Corn cob, firstly can made into charcoal then we process it to become charcoal briquettes because it can minimalize the pollution of sulphur emissions and also can give value added, these are the raw material of cesspool, high calorific value, high combustion efficiency, and high selling price [5]. Corn cob contains energies about 3.500-4.500 kcal/kg, and the combustion temperature can reach 205°C [6]. Corncobs contain a certain amount of energy which, if properly utilized, can reduce the problem of the global energy crisis [7] and research on the characterization of biomass briquettes from tannery solid waste (TSW). TSW, which consists of hair, feathers, chrome shavings, and fiber dust, is collected from tanneries in Kano, Nigeria. The developed briquettes have calorific values between 18,632 and 24,101 MJ / kg [8].

Based of the problem’s review about the corn cob cesspool, this research aims to use sweet corn cob and birdlime corn cob for the manufacture of charcoal briquettes as an alternative fuel to substitute the kerosene usage, and to determine the characteristics of the charcoal briquettes product.

2. Method

2.1. Tools and materials used

The materials used in this research are: sweet corn cob and sticky corn cob, sago powder with water as the binder mixture. As for, the tools that we use in this research are: Briquettes mold as a place to print samples of charcoal briquettes of sweet corn cob and birdlime corn cob; Chamfer pad as a place to drying the charcoal briquettes; Bomb Calorimeter is to measure the calorific value of charcoal briquettes produced.

2.2. Make the Charcoal

Sweet corn cob and birdlime corn cob are dried under the sunlight until the water level is decrease. Then, we insert each of sweet corn cob and birdlime corn cob to paint can, after that we burn them, in this case do not let the burning process of sweet corn cob and birdlime corn cob turn into ash, therefore when the burning process we need to turn of the fire quickly, and release the smoke until the sweet corn cob and birdlime corn cob turn into charcoal. The charcoal of sweet corn cob and birdlime corn cob need to weighed, then we make it into charcoal flour by pound it and accommodate it in basin before we process it into charcoal briquettes of sweet corn cob and birdlime corn cob.

2.3. Make the Charcoal Briquettes

The smooth charcoal of sweet corn cob and birdlime corn cob need to weighed, each is weigh for 500 gr. Then, weigh the mixed adhesive that is sago flour about 100gr. The concentrate ratio between sago and charcoal is 1 : 5. The sago flour is added about 500 ml, then we heat it on the stove (heater), stir it slowly to prevent the clumping until it produces gel. The sago adhesive is prepared to mix with charcoal flour of sweet corn cob and birdlime corn cob. The consecrate ratio of sago and water is 1 : 5. Insert the gel to basin which each filled with the charcoal flour of sweet corn cob and birdlime corn cob, stir them until mix perfectly. The mixture between charcoal flour of sweet corn cob and birdlime corn cob with the gel...
is inserted into the mold and press it until in solid form. The charcoal briquettes of sweet corncob and birdlime corncob product then dried it under the sunlight till it dry.

2.4. The Testing of Charcoal Briquettes Product

The main parameter of briquettes product quality testing that investigated in a research is the physical and the chemical properties. The physical properties include of: the calorific value and density, and the chemical properties include of: water level, ash level, evaporated substance level, and bonded carbon level.

2.4.1. Density

The principle to determine the density is expressed in the comparison between weight and volume of charcoal briquettes, which is express with formula: [9]

\[
\text{Density (gr/cm}^3\) = \frac{\text{mass (gram)}}{\text{Volume (cm}^3\)}
\]

2.4.2. Calorific value

Calorific value is calculated based on the amount of released heat is equal to the amount of absorbed heat, expressed in cal/g with the formula [9]:

\[
\text{Calorific Value (cal/gr)} = \frac{Cv \times (t_2 - t_1)}{A} - B
\]

\(Cv\) = Heat Capacity Calorimeter (cal/°C)

\(t_2\) = Temperature after combustion (°C)

\(t_1\) = Initial temperature (°C)

\(A\) = The mass of burned sample (gram)

\(B\) = Heat correction of iron wire (m)

How to test the calorific value sweet corncob and birdlime corncob charcoal briquettes are as follows: open the Bomb Calorimeter, Place the distant bomb Calorimeter, then each sample sweet corncob and birdlime corncob charcoal briquettes weighed as much as 1 gram, and then place it on the plate. We cut and pair nichrome wire 10 cm at the positive and negative poles in the cup and touch the nichrome wire at each sample of sweet corncob and birdlime corncob charcoal briquettes. But, don’t touch the capsule, insert it slowly into reactor and close tightly and correctly (do not get the nickel off from the sweet corncob and birdlime corncob charcoal briquettes).

Fill the reactor with oxygen with pressure about 30 Bars and then close gas crane opener correctly. Tube / laver heating filled with water 2000 mls accurately, entered into the reactor vessel reactor heater and connected with the positive and negative poles of the current. Before the ionized, note the initial temperature of the water first, then note again after 5 minutes, wait for 1 minute, the close correctly, pair the special thermometer for calorimeter bomb properly and turn on stirrer until the temperature in the heater vessel constant and homogeneous (stir for 5 minutes).

2.4.3. Water Level

In principle, that the level of water is boiling off parts water free contained in briquettes to achieve balance the water level with the surrounding air. The formula of water level [9]:

\[
\text{Water Level} = \frac{\text{Sample Weight ([initial weight] - (the weight after dried))}}{\text{Initial Sample Weight}} \times 100\%
\]

How to test the water level of sweet corncob and birdlime corncob charcoal briquettes are: Insert the cup into the oven until the weight of the cup with a constant temperature of 105°C for ± 10 minutes. The cup which has been constant cooled in a desiccator, weighed the mass of the cup that is heated in a digital balance. Insert each sample of sweet corncob and birdlime corncob charcoal briquettes into the cup and weighed it in a digital balance digital with weigh about 2 grams, and oven it with temperature constant of 105°C for 15 minutes. Each cup containing the sample of sweet corncob and birdlime
cornob charcoal briquettes which been heated, cooled them in the desiccator and weighed it until it has a constant mass every 5 minutes.

2.4.4. Ash Level
Ash in charcoal briquettes composed of minerals that can not disappear or evaporate in the incineration process. Ash level is calculated by the equation [9]:

\[
\text{Ash level} = \frac{\text{(cup weight+ash)} - \text{(empty cup weight)}}{\text{Initial Sample Weight}} \times 100\%
\]

How to test the ash level of sweet corncob and birdlime corncob charcoal briquettes are: Heat the cup in furnance with the temperature about 600°C until the weight of the cup is constant for ± 10 minutes. Cooled the constant cup in desiccators and weigh it. Enter each of 1-2 grs sweet corncob and birdlime corncob charcoal briquettes sample into the cup. Put the cup with sweet corncob and birdlime corncob charcoal briquettes sample in it to furnance at temperature 600°C for 3 hours. Next, cool it in the dessicator.

2.4.5. Evaporated Substance Level (ESL)
Evaporated substance level is obtained by evaporating all the volatile substance (Volatile matter) in charcoal briquettes pollen besides water. Evaporated substance level is expressed by formula: [9]

\[
\text{ESL} = \frac{\text{Dried sample weight} - \text{Dried sample weight of water level}}{\text{Initial sample weight of water level}} \times 100\%
\]

To test the evaporated substance level of sweet corncob and birdlime corncob charcoal briquettes, we can do things such as follows: weigh the cup and fill each sweet corncob and birdlime corncob charcoal briquettes sample based on water level calculation. Then, heat each of the sweet corncob and birdlime corncob charcoal briquettes sample in furnance at 800-900°C for 15 minutes, after that we make cool that in dessicator then weigh it.

2.4.6. Bonded Carbon Level
Bonded carbon is carbon fraction (c) in briquettes, besides fraction of water, evaporated substance and ash. Bonded carbon level is expressed in percent with the formula: [9].

Bonded carbon level (%) = (100 – evaporated substance level – ash level) %

3. Results

3.1. Charcoal flour making
Charcoal is the residue that has solid form which is a residual of carbonaceous material carbonation under controlled condition in the closed room like charcoal kitchen [10]. Sweet corn charcoal and birdlime corncob charcoal of dried corn that are then dried and then burned in large paint cans, allowed to burn until all corn cobs become charcoal which marked no more smoke.

![Charcoal](image1.jpg)

(a) Sweet Corn Cob (b) Birdlime Corn Cob

*Figure 1. Charcoal (a) Sweet Corn Cob (b) Birdlime Corn Cob*
The formed charcoal (Figure 1) was allowed to cool and then weighed. 500 grams of charcoal is then crushed and mashed to charcoal powder (Figure 2). This charcoal powder will be processed into charcoal briquettes. Subtlety of charcoal powder is very influential on the quality of briquettes produced.

3.2. Mixing charcoal powder with adhesives

Adhesive is a substance or material that has the ability to bind two objects through the bonding surface. With the adhesive, so the particle compositions are the better, more regular and dense so the process of compression firmness and charcoal briquette will be better [11]. The adhesives should have a good smell when burned, the ability to stick well, the price is cheap, and easily to get [6]. Starch adhesive, dextrin, and rice flour will produce a smokeless briquettes and durable but the calorific value is not as high as the charcoal [12]. The following Table 1 is a of adhesive materials analysis.

| Flour type        | Water (%) | Ash (%) | Fat (%) | Protein (%) | Crude Fiber (%) | Carbon (%) |
|-------------------|-----------|---------|---------|-------------|-----------------|------------|
| Rice Flour        | 7,58      | 0,68    | 4,53    | 9,89        | 0,82            | 76,90      |
| Wheat Flour       | 10,70     | 0,86    | 2,00    | 11,50       | 0,64            | 74,20      |
| Tapioca Flour     | 9,84      | 0,36    | 1,50    | 2,21        | 0,69            | 85,20      |
| Sago Flour/starch | 14,10     | 0,67    | 1,03    | 1,12        | 0,37            | 82,70      |

The use of adhesive materials is intended for bonding between particles will be stronger. The criterion for assessing the accuracy of the binder composition in briquettes is that the mixture is mixed, the mixture can be coagulated, the water does not leak out at the time of printing, and the briquette restretching is not too large after the drying process [13]. This stage is an important step and determine the quality of the resulting briquettes. The adhesive used should preferably have a good odor when burned, good adhesive ability, low cost, and easy to obtain [14].

3.3. Charcoal briquette printing and charcoal briquette drying

The charcoal powder that has been mixed with sago gel is inserted into the mold and pressed to solid. The higher the pressure given the better the briquette density. In this study, the mold used is a cylindrical mold so that the resulting charcoal briquettes become denser and regularly shaped. The printed briquettes are then dried back under sun for two days. Charcoal briquettes produced can be seen in Figure 3.

The advantage that we can get from charcoal briquettes usage is the cost is really cheap. The tools that we use for the manufacture of charcoal briquettes are quite simple and also the price of the raw materials is very cheap. Charcoal briquettes are environmentally friendly, as evidenced by the test results of the Agency for Assessment and Application of Technology (BPPT) which is shows that the burning of 1 kg briquettes for 2-3 hours just produce carbon monoxide (CO) emissions about 106 ppm in average. While the kerosene is about 250-390 ppm, or three times of it.
3.4. Briquettes quality testing

3.4.1. Density
Density affects the quality of charcoal briquettes, due to its high density that can increase the calorific value of charcoal briquettes. The value of density is influenced by the size and the homogeneity of charcoal briquettes composition. The density is influenced by the homogeneity of the mixed adhesive and charcoals with stir that is increasingly uneven. So the product of charcoal briquettes will get stronger, it caused the charcoal particle is quite char evenly. With high density level has advantages, these are the briquettes become denser and stronger also has high level of stability.

The data of sweet corncob and birdlime corncob charcoal briquettes density can be seen on Table 2 and Table 3.

| Table 2. Density value of sweet corncob charcoal briquettes. |
|-------------------------------------------------------------|
| Num | Characteristics of Sweet Corncob | Mass (gr) | Height (cm) | Diameter (cm) | Volume (cm$^3$) | Density (gr/ cm$^3$) |
|-----|---------------------------------|-----------|-------------|---------------|-----------------|--------------------|
| 1   |                                 | 43,6      | 3,5         | 4,5           | 55,6            | 0,78               |
| 2   |                                 | 31,5      | 3           | 4,5           | 47,7            | 0,66               |
| 3   |                                 | 23,9      | 2,8         | 4,5           | 44,5            | 0,54               |
| 4   |                                 | 28,9      | 2,5         | 4,5           | 39,7            | 0,73               |

According to the data from Table 2, the density value of sweet corncob charcoal briquettes is about **0.54-0.78 gr/cm$^3$**. The value isn’t fulfill the requirements that made by England (0.84 gr/cm$^3$), America (1 gr/cm$^3$) and Japan (1 – 1.2 gr/cm$^3$). And the data on Table 3, the density value of birdlime corncob charcoal briquettes is about **0.61 – 1.3 gr/cm$^3$**. This value is fulfill the requirements that made by England (0.84 gr/cm$^3$), America (1 gr/cm$^3$), and Japan (1–1.2 gr/cm$^3$).

| Table 3. Density value of birdlime corncob charcoal briquettes. |
|---------------------------------------------------------------|
| Num | Characteristics of Sweet Corncob | Mass (gr) | Height (cm) | Diameter (cm) | Volume (cm$^3$) | Density (gr/ cm$^3$) |
|-----|---------------------------------|-----------|-------------|---------------|-----------------|--------------------|
| 1   |                                 | 41        | 2.5         | 4             | 31,4            | 1,3                |
| 2   |                                 | 34,6      | 3           | 4             | 37,7            | 0,92               |
| 3   |                                 | 33,8      | 3,3         | 4             | 41,4            | 0,81               |
| 4   |                                 | 26,9      | 3,5         | 4             | 43,9            | 0,61               |

Table 4. The quality of charcoal briquettes made by England, Japan, America, Indonesia, and SNI [10,15].

| Analysis Type | Charcoal Briquettes |
|---------------|---------------------|
|               | England | Japan | America | SNI     |
| Water level   | 3,59 %  | 6 – 8 % | 6,2%    | 8%      |
3.4 Analysis Type

| Analysis Type       | Charcoal Briquettes |
|---------------------|---------------------|
|                     | England | Japan | America | SNI  |
| Ash level           | 8,26%   | 3 – 6 % | 19 – 28% | 8%   |
| Evaporated substance level | 16,41% | 15 – 30% | 8,3% | 15% |
| Bonded carbon level | 75,33% | 60-80% | 60% | 77% |
| Density (gr/cm³)    | 0,84    | 1-1,2 | 1 | -   |
| Calorific value (cal/gr) | 7289 | 6000-7000 | 6230 | 5000 |

The quality of briquettes product is depend on England, Japan, America, and Indonesia standard that can be seen on Table 4, as the comparison data so we can know the quality of briquettes product in this research. The size of the density is influenced by the size and the homogeneity of the charcoal of briquette constituents. The higher the density, the more the burning rate, and the better the quality of the briquettes.

3.4.2 Calorific value

Calorific value really determines the charcoal briquettes quality. The higher calorific value, make quality of charcoal briquettes product is better. The calorific value is influenced by water level and ash level of charcoal briquettes. The higher water level and ash level of charcoal briquettes, it will lower the calorific value of charcoal briquettes product [10]. Additionally, the calorific value is relate closely with bonded carbon level which is contained in briquettes, the higher bonded carbon level in charcoal briquettes, so as the higher calorific value of charcoal briquettes. This is due to the combustion process that needs carbon react with the oxygen to produce carbon as well [16]. The calorific value also affects the burning rate, the higher calorific value make the burning rate turn slower. High calorific value will make the burning process become more efficient and save the briquettes need [17]. The calorific value data of sweet corn cob and birdlime corn cob charcoal briquettes can be seen on Table 5.

Table 5. Calorific value data of sweet and birdlime corn cob charcoal briquettes.

| Charcoal Briquettes | Temperature | Calor capacity of Calorimeter (w=cal/°C) | Wire correction | Calorific Value (cal/gr) |
|---------------------|-------------|------------------------------------------|-----------------|--------------------------|
|                     | T2          | T1           | m (gr)         | T2 - T1                  |                            |
| Sweet Corn cob      | 32.32       | 30.58        | 1.74           | 0.6                      | 1707.46                    | 15.18 | 4936,454 |
| Birdlime Corn cob   | 30.5        | 28.62        | 1.88           | 0.53                     | 1707.46                    | 23    | 6033,650 |

Depend on the data above (Table5), the calorific value that is produced by sweet corn cob charcoal briquette is 4936,454 cal/gr. The value isn’t fulfill the requirement made by England (7289 cal/gr), America (6230 cal/gr), and Japan (6000-7000 cal/gr). But, the value is approaching the SNI requirement that is 5000 cal/gr. And for the calorific value of birdlime corn cob charcoal briquette is 6033,650 cal/gr. This value isn’t fulfill the calorific value requirement made by England (7289 cal/gr), America (6230 cal/gr). But, it’s fulfill the requirement made by (6000-7000 cal/gr) and SNI (5000 cal/gr).

The research result shows if the calorific value of birdlime corn cob briquettes is higher than sweet corn cob briquettes, that’s because birdlime corn cob briquettes has bigger density value compare than sweet corn cob briquettes. The higher density value of bio-briquettes so the burning process get slower. However, as the density value of briquettes gets bigger it caused the calorific value gets bigger too [18].

3.4.3 Water level

Water level affects the quality of charcoal briquettes, the lower the water level, the higher the calorific value. Charcoal briquettes is very easy to absorb water or high hygroscopic. That’s why, the determination of water level aims to determine the hygroscopic properties of charcoal briquettes. Water level value data of sweet corn cob and birdlime corn cob charcoal briquette can be seen on Table 6.
Table 6. Calorific value data of sweet and birdlime corncob charcoal briquettes.

| Charcoal Briquettes     | Temperature T2 | Temperature T1 | T2 - T1 m (gr) | Calor capacity of Calorimeter (w=cal/°C) | Wire correction | Water Level |
|-------------------------|----------------|----------------|----------------|-----------------------------------------|-----------------|-------------|
| Sweet Corncob           | 32.32          | 30.58          | 1.74           | 0.6                                     | 1707.46         | 15.18       |
| Birdlime Corncob        | 30.5           | 28.62          | 1.88           | 0.53                                    | 1707.46         | 23          |

According to the data (Table 6), the water level value that is produce by sweet corncob charcoal briquettes is 6.39%. This value fulfills the SNI requirement (8 %), Japan (6 – 8 %). But not fulfill the England requirement (3.59%), and America (6.2%). And for the water level value that is produced by birdlime corncob charcoal briquettes is 6.83%. The value fulfills the SNI (8 %) and Japan (6–8 %) requirements. But also not fulfill the England requirement (3.59%), and America (6.2%). High water content is due to the raw material of charcoal briquettes that have a low density so it can more easily absorb the moist air from the surrounding. This can lead to high water content of charcoal briquettes produced.

3.4.4. Ash level
The remaining ash is a combustion process parts that are no longer have the element carbon. Charcoal briquette ash level is affected by the ash content, silica, raw material powders and adhesive level that we use. One of the main elements that compose ash is silica and the impact isn’t good for calorific value of charcoal briquettes. If the ash level is higher, so the quality of the briquettes is getting lower, that’s because of the high ash level lowered the calorific value of charcoal briquettes. The data of ash level value of sweet corncob and birdlime corncob charcoal briquettes can be seen on Table 6.

Table 7. Ash level data of sweet and birdlime corncob charcoal briquettes.

| Charcoal Briquettes     | Weight of empty cup | Cup weight + first sample | Weight of first sample | Cup weight + ash | Ash weight | Ash level |
|-------------------------|---------------------|--------------------------|------------------------|-----------------|------------|-----------|
| Sweet Corncob           | 38.1725             | 40.1764                  | 2.0039                 | 38.2489         | 0.0764     | 3.86%     |
| Birdlime Corncob        | 35.6884             | 37.6894                  | 2.0010                 | 35.7854         | 0.0970     | 4.86%     |

According to the data above (Table 7), the ash level value which is produced by sweet corncob charcoal briquettes is 3.8 %. This value qualifies SNI (8%), America (19-28%), UK (8.26%) and Japan (3-6%) requirements. And for the value of the birdlime corncob charcoal briquettes ash level is 4.8 %. This value qualifies SNI (8%), America (19-28%), UK (8.26%) and Japan (3-6%) requirements. The higher the ash content, the lower the quality of the briquettes because the high ash content can decrease the calorific value of the charcoal briquettes [9].

3.4.5. Evaporated substance level
Evaporated substance is volatile substance (Volatile matter) that can evaporate as the product of compounds decomposition in charcoal briquettes besides water. The content of high evaporated substance level can create more smoke when we turn on the briquettes. This is caused by the reaction that happens between carbon monoxide (CO) and the derivate of alcohol [19]. Evaporated substance level data of sweet corncob and birdlime charcoal briquettes can be seen on Table 8.

Table 8. Evaporated substance level data of sweet and birdlime corncob briquette.

| Charcoal Briquettes     | Dry sample weight of water level | Weight first sample of water level | The weight after heated at 900°C | Volatile matter |
|-------------------------|---------------------------------|------------------------------------|---------------------------------|-----------------|
| Sweet Corncob           | 1.8730                          | 2.0001                             | 1.5385                          | 16.72 %         |
According to the data (Table 8), value of evaporated substance level that is produced by sweet corncob charcoal briquette is 16.72%. But the value isn’t fulfill the requirement of SNI (15%), America (8.3%), England (16.41%). However, the value fulfill the Japan requirement (15 - 30 %) and for the value of evaporated substance level of birdlime corncob charcoal briquette is 18.41%. This value isn’t fulfill the requirement of SNI (15%), America (8.3%), England (16.41%). But, the value fulfills the Japan requirement (15 - 30 %). The high levels of volatile substances in charcoal briquettes are thought to be due to the perfection of the carbonization process and are also affected by the time and temperature of the frying process [20]. The greater the temperature and the time of the refining the more vaporized matter is wasted, so that at the time of the test the content of the volatile substances will be obtained low levels of evaporate [9].

3.4.6. Bonded carbon level
Ash level value and evaporated substance level value is influence the bonded carbon. Bonded carbon level will have high value if the value of ash level and evaporated substance level are low. A good charcoal briquette has high bonded carbon level. Bonded carbon level affects the calorific value of charcoal briquette, the higher calorific value so the bonded carbon value is higher as well. Data about bonded carbon level of sweet corncob and birdlime corncob charcoal briquettes can be seen on Table 9.

| Ash Level | Evaporated Substance Level | Fixed Carbon |
|-----------|---------------------------|--------------|
| 3.8 %     | 16.72%                    | 79.48 %      |
| 4.8 %     | 18.4%                     | 76.80 %      |

According to the data above (Table 9), bonded carbon value that the sweet corncob charcoal briquette produce is 79.48%. The value isn’t qualify the requirements of England (75.33%), America (60%), SNI (77%), Japan (60-80%) and for bonded carbon value of birdlime corncob charcoal briquette is 76.80%. This value qualifies the England (75.33%), America (60%), and Japan (60-80%) requirements. But not qualify SNI requirement (77%) (Look at Table 4)

Data about quality result of sweet corncob and birdlime corncob charcoal briquettes

| Analysis Type       | Sweet Corncob | Birdlime Corncob |
|---------------------|---------------|------------------|
| Density             | 0.54 – 0.78 gr/cm³ | 0.61 – 1.3 gr/cm³ |
| Calorific Value     | 4936.454 cal/gr   | 6033.650 cal/gr   |
| Water Level         | 6.39%          | 6.83%            |
| Ash Level           | 3.8%           | 4.8%             |
| Evaporated Substance Level | 16.72%       | 18.41%          |
| Bonded Carbon Level | 79.48%         | 76.48%           |

A good charcoal briquette’s quality has low water level, low ash level, and high calorific value. The quality of charcoal briquette is also determined by its material manufacturer / constituent that affects the quality of calorific value, water level, ash level, evaporated substance level, and bonded carbon level of the briquette [12]. We can say that briquette has a good quality if the product of combustion process has characteristics such as follow: Not have black color and if we burn it on fire it will has bluish color, Briquette burns without smoke, no fire sparks and no smell, Combustible not too fast, Tinkled like metal when we hit/beat [19]

4. Conclusions
Corncob especially sweet corncob and birdlime corncob are one of the biomass that can we use to become charcoal briquettes as an alternative kerosene fuel substitution. The process to make sweet
corn cob and birdlime corncob charcoal briquettes is very easy and need a simple technology that include raw material gathering process, raw material drying, charcoal ing, charcoal flour making, adhesive preparation, charcoal flour and sago gel mixing, charcoal briquette printing, and charcoal briquette drying.

Test results of the sweet corncob charcoal briquettes quality include: density value (0.54 – 0.78 gr/cm³), calorific value (4936,454 cal/gr), water level value (6,39%), ash level value (3,8%), evaporated substance level value (16,72%) and bonded carbon level value (79,48%).

Test results of the birdlime corncob charcoal briquettes quality include: density value (0.61 – 1.3 gr/cm³), calorific value (6033,650 cal/gr), water level value (6,83%), ash level value (4,8%), evaporated substance level value (18,41%) and bonded carbon level value (76,48%).

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