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Biobriquette Manufacturing from Orange Peel and Sugarcane Bagasse using Pyrolysis Method

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Abstract. The availability of domestic raw materials is gradually decreasing, while the need for energy sources is increasing. Therefore, it is necessary to have renewable energy sources, one of which is biomass. In this study, researchers will discuss the waste of sugarcane bagasse and orange peel which can be used as bio briquettes. Usually, these wastes are only used as animal feed, and sometimes they are just thrown away. The goals and benefits expected by the author in this study are to provide information that the manufacture of bio briquettes from bagasse and Pacitan's orange peel can be used as an alternative fuel. So, it can be implemented to reduce fossil fuels, whose availability is getting less and less.

Keywords: orange peel, bagasse, bio briquette, pyrolysis

INTRODUCTION

Indonesia is a wealthy country in natural resources, especially in the plantation and agricultural sectors. In addition, Indonesia has a large land area, so it is suitable for plantation land. One of the plantation products that play an essential role in the export sector is sugar cane and citrus. Citrus plants are spread throughout Indonesia; some post-harvest results are directly sold in the market without being used for other products. So that the potential for post-harvest citrus yields cannot be adequately optimised, even though parts of oranges such as fresh orange flesh and rotten orange flesh and peel can be processed into products that have economic value. Orange peel waste can be used as new and renewable energy, namely bio briquettes.

Biobriquettes can be made from biomass raw materials. Biomass is one of the alternative energy sources produced from plants, either directly or indirectly, in large quantities. Biomass can be used directly without carrying out the carbonization process, but the benefits generated will be less efficient. An example is the use of wood which is used as fuel, the energy used is less than 10%. The energy produced from burning wood is only 2,300 kcal/g, while the energy produced from burning biochar can reach 5,000 kcal/g [1].

Charcoal is a solid that has pores made from the carbonization process. Therefore, most charcoal pores are still covered by hydrocarbons, tar, and other compounds containing components of tethered carbon (such as ash, water, nitrogen and sulfur). Meanwhile, biochar is alternative energy made from biomass raw materials such as rice husks, wood, twigs, leaves, grass, straw, or other agricultural wastes.

Biochar can be reprocessed through a processing process to be a biochar briquette product. Briquettes are solids in lumps made of soft raw material 2 then hardened. Meanwhile, biochar briquettes are lumps made of biochar. Several factors will affect the properties of charcoal briquettes, namely the specific gravity of the charcoal powder or the type of fuel, fineness of the powder, carbonization temperature, compression pressure, and mixing formula [2].

Making briquettes from orange peels makes an effort to convert biomass residues into renewable energy. Several things need to be considered to make quality bio briquettes, namely the selection of raw materials used, water content, temperature, addition of substrate, and particle size. Biobriquette compared to ordinary charcoal made from wood is very different. Biobriquettes are cleaner when used, produce perfect heat and require relatively narrow storage space. To compete in the briquette market, namely briquettes that have met quality standards, chemical and physical properties also significantly affect the quality of briquette fuel.

Table 1. Briquette Quality Standards in Several Countries

Properties of Charcoal Briquettes	Indonesia	Jepang	Inggris	Amerika
Water content (%)	8	6-9	3-6	6,2
Volatile content (%)	15	15-30	16,4	19-24
Ash content (%)	8	3-6	5,9	8,3
Carbon content (%)	77	60-80	75,3	60
Density (g/cm3)	-	1-1,2	0,46	1
Compressive strength (kg/cm3)	-	60-65	12,7	62
Calorific Value (cal/g)	5000	6000-7000	7289	6230

Quality briquettes to be used as fuel must also meet physical criteria, such as [2] :
- Easy to turn on
- Does not emit smoke
- Combustion gas emissions are non-toxic
- Water-resistant and combustion products do not get mouldy when stored for a long time
- Shows a reasonable combustion rate effort (time, combustion rate and combustion temperature)

The pyrolysis or devolatilization method is a process of chemical decomposition of materials, where the process takes place by heating in the absence of oxygen or a little oxygen. Pyrolysis technology is usually used to convert organic waste that is not used optimally to be turned into biomass. The pyrolysis process produces a product in a solid fuel called carbon, a liquid mixed with tar and other substances. Other products are formed in the form of carbon dioxide gas, methane, and other gases with minimal content. The pyrolysis results are three types of roducts, namely solid charcoal, gas, and bio-oil. Generally, the pyrolysis method occurs at temperatures above 300 °C within 4-7 hours [3].

Bagasse is a by-product produced from the sugarcane juice milking process, which ranges from 35-40% of the weight of the milled sugarcane [4]. Chemically, bagasse components contain cellulose, polyose, hemicellulose, lignocellulose and lignin groups [1].

Bagasse can also be said as a by-product of the sugarcane juice extraction process, which has a fibre length of about 1.7 – 2.2 mm with a diameter of 20 m. Bagasse fibre is insoluble in water because most of its content is cellulose, pentosan and lignin [5].

Table 2. Chemical composition of bagasse (Hajar, 2016)

Content	(%)
Ash	3
Lignin	0,79
Cellulose	44,7
Alcohol juice	27,9
Pentosan	12,7
Benzene essence	2
Solubility in hot water	3,7

Pacitan's oranges are one of the most abundant fruits in Indonesia. It has a sweet taste, has a lot of water content, contains vitamin C, ranging from 27-49 mg/100 grams of fruit flesh. Citrus juice in Pacitan oranges ranges from 40-70 mg of vitamin C per 100 mL. Depending on the type of orange, the older it is, the less the vitamin C content [6].

Commodity	Orange
Year	2002
Fruit shape	Round, the top of the tip is slightly flat, the base is flat
Leaf shape	Oval
Fruit skin thickness	3.1-3.5 mm
Flesh color	Pale yellow to yellow
Fruit size	Fruit height 6.6 – 6.9 cm
Leaf size	Diameter 6.8 – 7.1 cm
Plant shape	12 cm long, 7.6 cm wide

(Source: Ministry of Agriculture, Agricultural Research and Development Agency 2019)

The adhesive is a material that can be used to glue or bind two objects through a surface bond so that the addition of adhesive material can make the bond between particles stronger. So that the grains of charcoal briquettes will stick together and cause water to be bound in the pores of the charcoal. The function of the addition of adhesive can also affect the quality of the briquettes produced, namely at the time of ignition and combustion [4].

Based on the use and quality, the selection of adhesive materials can be classified as follows:

- ✓ Based on the nature/raw material of briquette glueing
  It has an excellent cohesive force when mixed with coal, is flammable and smokeless, is easily obtained in large quantities and is affordable, does not emit odour, is non-toxic and harmless
- ✓ By type
  The types of raw materials generally used are inorganic adhesives and organic adhesives. Examples of inorganic binders are cement, clay and sodium silicate. While examples of organic binders are starch, tar, asphalt, starch, molasses and paraffin. As for those using adhesive from tapioca, caustic soda, which has a concentration of 98% and clay. Of the several types of adhesives, the most frequently used is starch adhesive [1].

Making charcoal briquettes must go through a carbonization process, in which all materials are heated in a room without contact with air during the combustion process until charcoal is formed. In this process, incomplete combustion of organic materials with a very minimal amount of oxygen produces charcoal. It causes the decomposition of organic compounds that make up the material's structure to form water vapour, methanol, acetic acid vapours and hydrocarbons. The carbonization process can be divided into four stages, namely:

- ✓ Evaporation of water, there is a breakdown of cellulose into a distillate containing large amounts of acids and methanol in this process.
- ✓ Intensive decomposition of cellulose to produce less gas and water
- ✓ Decomposition of lignin compounds that can produce more tar which will increase in number over a long time and at high temperatures
- ✓ The formation of hydrogen gas is a process of purifying the formed charcoal

In the manufacture of charcoal, bio briquettes must undergo a briquetting technology process. This process is a processing process that goes through a refining process, mixing raw materials, printing and drying under predetermined conditions. So that it can be obtained briquettes that have specific shapes, physical sizes, and chemical properties, this process aims to improve fuel quality, facilitate handling and transportation, and reduce material loss in the form of dust in the transportation process. Several factors that influence the process of briquetting technology are particle size and distribution, material hardness, elasticity, and plasticity.

The quality parameters of briquettes need to be considered because they will affect the benefits and uses of briquettes; some of these parameters are:

- ✓ Calorific value
  The calorific value can be obtained by burning a sample of briquettes using the Bomb Calorimeter tool by returning the system to the ambient temperature. The Net Calorific Value is usually between 93-97% of the Gross Value and depends on the Inherent Moisture content and the hydrogen content in the briquettes [1].
  The calorific value is a quality parameter known for the maximum amount of heat energy released by fuel, and the amount is obtained due to the complete combustion reaction of the unit mass or volume of the fuel.

The purpose of the calorific value test is to obtain data on the heat energy that can be liberated by fuel by the occurrence of a reaction or combustion process.

- ✓ Proximate analysis

  It is an analytical test to determine the moored water, fixed, ash, and volatile matter. The higher the volatile matter content, the lower the calorific value. Meanwhile, the higher the fixed carbon value, the higher the calorific value [7].
- ✓ Water content

  There are two types of water vapour, namely free and bound water vapour. Free water vapour can be lost by evaporation, for example, by water dying. While the bound water vapour is determined by heating the briquettes between temperatures of 104-110 °C for one hour
- ✓ Ash content

  All briquettes contain inorganic substances that can be determined as the remaining weight if the briquettes are burned completely. The substance left behind is called ash. Ash produced by briquettes is produced from clay, sand, and other mineral substances. Briquettes with a high ash content are very unprofitable because they will form a crust
- ✓ The content of volatile substances

  The volatile matter produced from briquettes consists of flammable gases, such as hydrogen, carbon monoxide, and methane gas. Volatile matter is part of the briquette, which will turn into a product when heated without air at a temperature of approximately 950 °C [1].

Table 3. Biobriquette Quality Standards based on SNI 01-6235-2000 [7]

Test type	Unit	Requirements
Water content b/w	%	Max. 8
Missing part at 90 . fitting	%	Max. 15
Calorie ash content	%	Max. 8
ADBK	Kal/gr	Min. 5000

Table 4.. Biobriquette Quality Standards

Parameters	**SNI**
Moisture content (%)	<8
Ash content (%)	<8
Carbon content (%)	>77
Calorific value (cal/gr)	>5000

Source: Forestry Research and Development Agency (1994) Source: Forestry Research and Development Agency (1994) in [7]

METHOD

This study aims to determine the potential of sugarcane bagasse and orange peel waste that can be used as raw materials for making bio briquettes. This research was carried out at the Chemical Engineering Laboratory and Panggungrejo Village. This research was carried out using pyrolysis to produce bio briquettes from bagasse and orange peel raw materials.

The fixed variable used in this research is the pyrolysis method. With a carbonization time of 4 hours, the volume of water is 250 mL, the mass of raw materials (orange peel and bagasse) is 1 kg, and the drying time is three days. The control variables that we use are bagasse and orange peel raw materials. While the variables that changed in this study were the mass ratio of bagasse and orange peel, 1:1; 1:2; 1:3; 1:4; bagasse 100 grams; orange peel 100 grams and the total mass of the adhesive used is as much as 20% of the total mass of the mixture.

This study uses a press, a sieve, a 1.5 dim pipe mould with a height of 3 cm, drums, burlap sacks, winnowing, collisions, simple combustion furnaces and containers. Then the materials used are hot water, bagasse, orange peel, clay, tapioca flour and banana midrib.

The research procedure in the manufacture of bio briquettes includes four stages: the preparation of raw materials, the carbonization process, the moulding process, and the analysis test. The first stage is the preparation of raw materials. In this stage, the initial step is to cut the bagasse and orange peel into smaller sizes, then dry in the sun for three days.

The second stage is the carbonization process. In this stage, firstly, put 1 kg of bagasse and 1 kg of dried orange peel into the drum (the carbonization process is carried out separately, then cover the drum with banana stems, burlap sacks and add wet clay. Carry out the carbonization process for 4 hours. After the carbonization process is complete, remove the raw materials that have become carbonized. Then mash separately until entirely smooth.

The third stage is the printing process. First, weigh the bagasse and orange peel according to the specified variables. Then, weigh the tapioca flour as much as 20% of the total mass, then mix the tapioca flour with 50 mL of hot water. After that, mix the bagasse and orange peel weighed with tapioca flour and stir until evenly distributed. Put it into the mould, then forged with a press. After that, dry using the sun for three days.

The last stage is the analysis test. There is heat test, water content test, briquette flame duration test, ash content test, moisture content test, solid carbon content test, and volatile content test. The calorific value can be obtained and known by burning the prepared variable briquettes, then testing using a bomb calorimeter. Then the flame test was carried out by pouring a little kerosene into the briquette sample, then igniting. The initial time was observed until the briquettes completely turned to ash. The moisture content test was carried out by weighing the briquettes before being in the oven, then placing the briquette samples into a porcelain dish, then in the oven for 24 hours at a temperature of 105 °C. Then cool for 10 minutes, then weigh the briquettes.

$$\text{water content} = \frac{\text{mass of residual ash (g)}}{\text{dry mass of briquettes (g)}} \times 100\% \tag{1}$$

The ash content test in briquettes can be determined by placing a porcelain cup in an oven at 105 °C for 1 hour. Then weigh the briquettes before being put into the furnace. Then, put the briquettes along with the porcelain cup into the furnace for 3 hours at a temperature of 700 °C. Then cool for 15 minutes.

$$\text{ash content} \ \frac{\text{mass of residual ash (g)}}{\text{dry mass of briquettes (g)}} \times 100\% \tag{2}$$

Moisture content in briquettes can be known and obtained by calculating the weight loss of the sample heated under standard conditions. Using the following formula:

$$\text{water content (\%)} = \frac{(b\text{-}c)}{(b\text{-}a)} \times 100 \tag{3}$$

Description :
a = weight of the cup + sample (grams)
b = weight of empty cup (grams)
c = weight of the cup + sample after heating (grams)

Solid carbon content in briquettes can be known and calculated using the following calculation formula:

$$\text{Fixed carbon (\%)} = 100 - (\text{IM} + \text{Ash} + \text{VM}) \tag{4}$$

Description :
IM = Moisture content
Ash = ash content
VM = Content of volatile matter

The volatile matter content in briquettes can be determined and calculated by calculating the weight loss of the sample heated (without being oxidized) under standard conditions, and then it can be checked and re-corrected against its moisture content.

$$\text{volatile content (\%)} = \frac{(b\text{-}c)}{(b\text{-}a)} \times 100 \tag{5}$$

description :
a = weight of the cup + sample (grams)
b = weight of empty cup (gram
c = weight of the cup + sample after heating (grams)

RESULTS AND DISCUSSION

1. Heat test
The calorific value determines the quality of the briquettes; the higher the calorific value, the better the quality of the briquettes. The calorific value of briquettes is influenced by water content, ash content, and carbon content. According to SNI, the calorific value of briquettes must be below 5000 (cal/gram). after the briquettes have dried. Based on the tested samples, it was found that the highest calorific value of 5949.114 (cal/gram) in sample 2: 1 met SNI, while the lowest calorific value of 4252,755 (cal/gram) in sample 1: 1 did not meet SNI.

Table 5. Average Caloric Value

No.	Sample	Calorific Value (cal/gram)
1	1 : 1	4252.755
2	2 : 1	5949.114
3	3 : 1	5706.348
4	4 : 1	5026.064
5	Bagasse ash 100%	4832.612
6	Orange peel 100%	4833.912

2. Test the briquette flame time
The flame length test was carried out to determine the length of time the briquettes ran out to become ash. The flame duration of briquettes is influenced by the structure of the material and the carbon content. Based on the tested samples, it was found that the longest flame time was 54 minutes 22 seconds on the 3:1 sample, while the fastest flame time was 18 minutes 23 seconds on the 100% bagasse sample.

Table 6. Average length of the flame

No.	Sample	Flame duration (min)
1	1 : 1	00:30:22
2	2 : 1	00:35:33
3	3 : 1	00:54:22
4	4 : 1	00:70:00
5	Bagasse ash 100%	00:18:23
6	Orange peel 100%	00:23:04

3. Test ash content
The by-product of burning briquettes produces ash, where the ash contains silica which affects the calorific value of the briquettes produced. The smaller the value of the ash content, the higher the carbon content and calorific value. According to SNI, the ash content of the briquettes must be below 8% after the briquettes after the burn test. Based on the samples that have been tested, it was found that the lowest ash content value in sample 4: 1 was 88.919 grams, while the highest ash content value was in the 100% orange peel sample as much as 98.665 grams. So that in the analysis of the ash content test, there are no briquettes that meet SNI.

Table 7. Average ash content

No.	Sample	Ash Content (%)
1	1 : 1	93.496 %
2	2 : 1	90.252%
3	3 : 1	92%
4	4 : 1	88.919%
5	Bagasse ash 100%	89.218%
6	Orange peel 100%	98.665%

4. Moisture moisture test

The water content in briquettes is caused by the hygroscopic nature of briquettes, which is easy to give up water from the environment. According to SNI, the water content of briquettes must be below 8% after the briquettes have dried. Based on the tested samples, it was found that the lowest water content value in the 100% orange peel sample was 1.335%, while the largest water content value was in sample 4: 1 as much as 11.081%, where this sample did not meet SNI because the water content was more than 8%. The high and low water content in briquettes is influenced by the pores in the briquettes. The higher the water content in the briquettes, the fuel power of the briquettes will decrease, and the briquettes will produce smoke.

Table 8. Average water content

No.	Sample	Moisture (%)
1	1 : 1	6.504%
2	2 : 1	9.748%
3	3 : 1	8.000%
4	4 : 1	11.081%
5	Bagasse ash 100%	10.782%
6	Orange peel 100%	1.335%

5. Solid carbon content test

The carbon fraction (C) bound to the briquettes determines the fixed carbon content. The high carbon content is influenced by the ash content and the content of volatile substances in the low briquettes. The higher the carbon content in the briquettes, the higher the calorific value. According to SNI, the value of solid carbon content in briquettes must be more than 77%. Based on the tested samples, it was found that the highest carbon content value in sample 4: 1 was 10,859%, while the lowest carbon content value was in 100% orange peel sample as much as 1.308%. So that in the analysis of the solid carbon content test, there are no briquettes that meet SNI.

Table 9. Average solid carbon content

No.	Sample	Solid carbon content
1	1 ; 1	6.374%
2	2 ; 1	9.553%
3	3 ; 1	7.840%
4	4 ; 1	10.859%
5	Bagasse ash 100%	10.567%
6	Orange peel 100%	1.308%

6. Test for volatile matter

The level of volatile matter / volatile matter will affect the flame of the briquette. The higher the volatile matter content, the easier the briquettes will ignite. Based on the tested samples, the lowest volatile value was found in the 100% orange peel sample, as much as 1.335%, while the highest volatile matter value in the 4:1 sample was 11.081%.

Table 10. Average volatile matter

No.	Sample	Volatile matter content (%)
1	1 : 1	6.504%
2	2 : 1	9.748%
3	3 : 1	8.000%
4	4 : 1	11.081%
5	Bagasse ash 100%	10.782%
6	Orange peel 100%	1.335%

CONCLUSION

Comparison of the ratio of ingredients affects the calorific value of the resulting briquettes. With the appropriate ratio, a high calorific value will also be obtained; the results of the heat test show that with a material ratio of 2:1, 3:1, 4:1, the calorific value of briquettes reaches a value of more than 5000 (cal/gram).

The ratio of materials affects the length of the flame of the briquettes, the more addition of bagasse charcoal, it will tend to increase the burning time, the longest time for briquettes to burn is with a material ratio of 4:1.

The ash content test shows where the more ratios of bagasse, the less ash content of the briquettes, the smallest ash content in the 100% bagasse sample; this will also affect the sample with different ratios, in samples that have different ratios obtained that the higher the bagasse ratio, the lower the ash content.

The moisture content of briquettes is influenced by the use of materials; bagasse briquettes have a high water content test result because from bagasse itself, including materials that easily absorb water compared to orange peel, briquettes from 100% orange peel material have high water content. Very low, namely 1.335%, this will affect the sample with different ratios; the result is that the more the ratio of bagasse, the higher the water content of the briquettes.

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