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Briquettes Made with Mixtures of Salak Seed (*Salacca zalacca)* Charcoal and Coconut Shell Charcoal and the Potential as an Alternative Energy Source

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Abstract

Fuel briquttes made with mixtures of salak seed (*Salacca zalacca*) charcoal and coconut shell charcoal have been studied. This research was conducted in order to produce briquettes from mixtures of salak seed (*Salacca zalacca*) charcoal and coconut shell charcoal blended with tapioca as its adhesive agent. The method used in this study is: dehydration of salak seed and coconut shell, charcoal making by pyrolysis, charcoal blending with tapioca, printing and compressing, briquette drying and proximate analysis. The briquette was made by blending the charcoal mixture with tapioca. Proximate analysis showed that the moisture content of briquettes made from mixtures of salak seed charcoal and coconut shell charcoal ranged from 7.06% to 14.45%; ash content 5.27– 13.24%; volatile matter 52.77 – 67.33%, and the calorific value of its combustion is 5,729-6,062 calories/gram.

Keywords: Briquettes, salacca zalacca seed, coconut shell, fuel oil

INTRODUCTION

A problem that is common in society is the expensiveness of fuel oil which has been considered as primary need these days. Besides, fuel oil is a non-renewable energy, yet it is consumed as the main fuel by people, which eventually leads to the scarcity of petroleum or fossil fuel. The increase in consumption of fuel oil caused by the explosive population growth, declining amount of petroleum and the emission of fossil fuel combustion has become a big urgency to search for new sources of energy as alternative renewable fuel. Maryono explained that by the decreasing amount of fuel oil, a solution to overcome this problem is needed, and it is by utilising eco-friendly, wasted materials[1].

Some studies have been done by scientists to minimize dependence on non-renewable fuel oil, some of them are the utilization of renewable energy from biomass. Biomass is a type of material obtained from wastes of forest, horticultural, agricultural and animal husbandry products. Those biomasses could be used as an alternative fuel by turning it into briquettes. Briquettes are solid fuel made from organic materials. The manufacture of charcoal briquettes are mainly made of biomass wastes such as straw, wood sawdust, organic wastes, coconut shell, rice husk and corncobs.

People of Pangu village is one of many salak (*Salacca zalacca*) producers in Southeast Minahasa. Mostly, salak farmers in Pangu only sell salak to collectors or consumer, but there are also people who utilize salak to be products such as candied salak and salak coffee. The existence of salak industry increases the salak seed waste. Salak seed is hard in texture and is difficult to be processed as economically useful product. Researches regarding salak seed waste are still in need nowadays and the publication of salak seed processing is still confined.

The main chemical component of salak seed is carbohydrate which consists of 28.98% cellulose and 59.37% hemicellulose as glucomannan; in each gram of salak seed, there are 0.1637 grams of mannosa and 0.0089 grams of glucose[2]. Salak seed has higher percentage of mass as a waste compared to salak skin. Salak seed has 25-30% mass of a whole salak fruit, while the skin only made up the 10-14% of its total mass[3]. Salak seed has also been produced as coffee by people from North Sumatera and Java. By consuming salak coffee, people testified that their blood pressure have decreased[4].

Coconut shells are wastes produced from coconut processing; it is mainly produced as ingredient for activated charcoals and briquettes. Other than that, coconut shells are also used to make unique, nature-based handicrafts[5].The calorific value of coconut shell biomass is 20,890 kJ/kg, and this value is still in the range of low calorific value[6].

By doing literature investigation, we found that briquettes from salak seed charcoal and coconut shell charcoal, along with the determination of its calorific value have not been reported. Therefore, we tried to conduct a study to find out the utilization of salak seed as renewable energy source by making briquettes made with mixtures of it and coconut shell charcoal. The process of briquette making is preceded by pyrolysis under high temperature. We expect that the pyrolysis product could produce high quality charcoal, thereby could be a usable briquette with high calorific value and also could satisfy the standard established by Standar Nasional Indonesia (SNI).

RESEARCH METHOD

Materials

Materials needed for this research were salak seed and coconut shell, 10 kg each, collected from Pangu village, Kecamatan Ratahan, Kabupaten Minahasa Tenggara (Southeast Minahasa). As binding material, 5 kg of Amylum (branded Gunung Agung) was used.

Equipments

Equipments used in this research were briquette pressing machine with height 4 cm and width 4 cm, 40-mesh sieve, oven, digital balance, thermometer, stopwatch, desiccator, Bomb Calorimeter, porcelain cup, clamp, a set of pressing maching or briquette printing machine and a set of pyrolysis apparatus.

Method

1. Drying the main materials

In this process the salak seed and coconut shell were washed and cleaned from dirt like soil and other impurities. For coconut shell, it was crushed into smaller size to make the charring easier. Salak seed and coconut shell were dried under sunlight for seven days to dehydrate the sample.

2. Pyrolysis of salak seed charcoal and coconut shell charcoal

The dried salak seed was weighed as much as 10 kg. The weighed material was put into the pyrolysis apparatus. The apparatus was then closed tightly to prevent leak, and was heated using liquid petroleum gas (LPG). The pyrolysis lasted 6 hours. The gas produced from pyrolysis was condensed and the liquid smoke was accomodated. The pyrolysis was stopped as the smoke thinned out and there was no more liquid dripping. The salak seed charcoal was then cooled for 24 hours, and was taken out from the fireplace subsequently. The coconut shell charcoal was also made by pyrolysis, following the same procedure as the salak seed charcoal.

3. Grinding and sifting

The formed charcoal of salak seed and coconut shell was ground into fine particles. The ground charcoal powder was sifted using 40-mesh sieve, in accordance with SNI 01-6235-2000.

4. Mixing of charcoal with the binding material

The adhesive was made by heating 200 g of amylum with 750 mL of water under temperature of 70°C until it turned into gel. The formed adhesive was then blended thoroughly with the charcoal powder. The mixing composition and its ratio can be seen in Table 1.

Table 1. Mixtures of salak seed (SS) and coconut shell (CS) with binding material

Charcoal mixture (SS:CS)	Ratio			
	SS Charcoal (g)	CS Charcoal (g)	Amylum (g)	Water (mL)
Control (SS)	900	0	200	750
A (1 : 1)	450	450	200	750
B (2 : 1)	600	300	200	750
C (3 : 1)	675	225	200	750

5. Printing, compression and drying

The mixture of charcoal and amylum was put inside the cubic-shaped briquette printer with height 4 cm and width 4 cm, it was then compressed by hands. The briquette produced was dried for seven days under the sunlight. The dried briquette was then packed into plastic bag and was closed tightly to prevent moisture.

6. Proximate analysis

The briquette proximate analysis was done according to Elfiano[7] and Sutoyo and Rosyidi[8] which determines moisture content, volatile matter content, ash content and calorific value.

RESULT AND DISCUSSION

Pyrolysis of salak seed and coconut shell

The pyrolysis of 10 kg of salak seed produced 1 kg of liquid smoke (10%), 0.4 kg of tar (4%) and 7.8 kg charcoal (76%); the remaining is gas that cannot be isolated or condensed, those gases was approximately 0.8 kg (8%). Pyrolysis of 10 kg of coconut shell produced 2.2 kg of liquid smoke (22%), 0.9 kg of tar (9%) and 5.4 kg of charcoal (54%); also the remaining gas which cannot be collected was approximated about 1.5 kg (15%). The pyrolysis was done for 6 hours and the highest temperature recorded was 450°C.

The pyrolysis apparatus used in this research can be seen in Fig. 1.

Figure 1. Model of pyrolysis apparatus used for carbonizing the salak seed and coconut shell

Briquette making

Each charcoal was ground into fine particles and was sifted using 40-mesh sieve. Amylum binder was heated with water in 70°C until it turned into gel, the gel was then mixed with the charcoal thoroughly. The mixing composition of salak seed (SS), coconut shell (CS) charcoal and the amylum adhesive along with its ratio can be seen in Table 1 in the preceding research method part.

The mixture was put into the cubic-shaped printer with height 4 cm and width 4 cm and then was pressed using the hydrolic-powered press. The briquette was dried under the sun for seven days. Salak seed briquette (SS), coconut shell briqette (CS) and briquette made from mixture of both charcoal is shown by Fig. 2

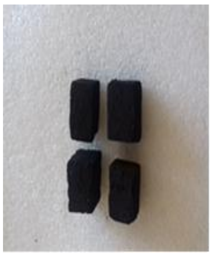		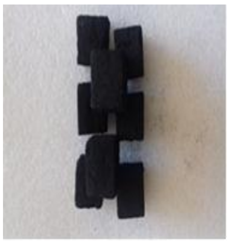	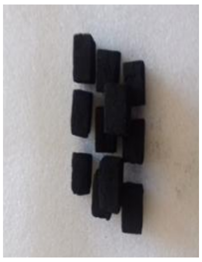	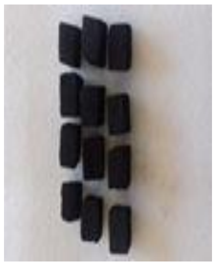
Control (SS)	**Control (CS)**	**A = SS : CS (1 : 1)**	**B = SS : CS (2 : 1)**	**C = SS : CS (3 : 1)**

Figure 2. Dried briquettes after seven days of sunbathe

A. Determination of briquette quality

1. Moisture content

Moisture content influences the quality of briquette produced. According to the analysis and calculations performed, the moisture content of salak seed briquette, coconut shell briquette and the mixture briquettes can be seen in Table 2.

Table 2. Moisture content of salak seed briquette, coconut shell briquette and the mixture briquettes

Briquettes	**Moisture content (%)**
Contol (SS)	4.89
Control (CS)	6.86
A = SS : CS (1 : 1)	7.06
B = SS : CS (2 : 1)	13.91
C = SS : CS (3 : 1)	14.45

Table 2 shows that the moisture content of salak seed briquette is 4.89%, while the moisture content of coconut shell briquette is 6.86%. Moisture content of A, B and C briquettes are in range between 7.06-14.45%. The lowest moisture content is the A briquette with composition of salak seed and coconut shell 1:1 (7.06%); briquette with the highest moisture content is the C briquette with composition of salak seed and coconut shell 3:1 (14.45%). The difference of moisture content in A, B and C briquettes could be caused by the difference in composition between salak seed and coconut shell charcoal. As the ratio of salak seed increases in a constant number of coconut shell, the moisture content went up. Moisture content of salak seed, coconut shell and the A briquettes met the standard established by SNI No.1/6235/2000 which is $\leq$ 8%, while the B and C briquette met the standard regulated by Indonesian Ministry of Energy and Mineral Resources No.47/2006 which is $\leq$ 15%. As explained by Riseanggara, the low moisture content in briquettes will facilitate the flaming and will not produce smoke when burned[9]. The moisture content of briquettes influence the heat produced. The higher the moisture content, the lower the calorific value[10, 11]. Another factor that influences the moisture content is the time needed to dry the briquette, moisture content reduces when the briquete drying time is elongated, to allow more evaporation[12]. Generally, a high moisture content could reduce the calorific value and burning rate because the need of extra heat to evaporize the water inside a briquette[1]. From this study, it is concluded that briquettes made with mixture of salak seed charcoal and coconut shell charcoal could be utilized as an alternative fuel because the moisture content met the permitted standard of usable briquettes.

2. Ash content

Determination of ash content was done in order to find out how much the unburned part of briquette (that no longer has carbon) remained after combustion. The ash content is comparable to the inorganic content in a briquette[1]. Ash content of salak seed briquette, coconut shell briquette and the mixture briquette can be seen in Table 3.

Table 3. Ash content of salak seed briquette, coconut shell briquette and the mixture briquettes

Briquettes	**Ash content (%)**
Contol (SS)	5.12
Control (CS)	11.51
A = SS : CS (1 : 1)	5.27
B = SS : CS (2 : 1)	6.83
C = SS : CS (3 : 1)	13.24

Based on Table 3, the lowest ash content was found in the A briquette, which is a mixture of 1:1 of salak seed and coconut shell, with value as much as 5.27%, while the highest ash content was found in the C briquette as much as 13.24% (salak seed:coconut shell, 3:1).

The increase in ash content of A, B and C briquettes could be caused by the difference in salak seed charcoal composition. Ash content rises as the amount of salak seed charcoal in the mixture get higher. Besides, high ash content could also be caused by a high amount of inorganic matter such as silica inside the charcoal. The ash content of salak seed, A and B briquettes met the SNI No.1/6235/2000 standard which is $\leq$ 8%, while coconut shell and C briquettes agree with USA standard which is 16%. Wahyu[11] and Maryono[1] explained that briquette with high ash content has one disadvantage: it produces crust. The higher the ash content, the more difficult to burn the briquette, and the calorific value will be low.

3. Volatile matter content

The content of volatile matter which evaporates under high temperature is produced by decomposition of compounds in a briquette. Volatile matter content of briquettes in this research can be seen in Table 4.

Table 4. Volatile matter content of salak seed briquette, coconut shell briquette and the mixture briquettes

Briquettes	Volatile matter content (%)
Contol (SS)	67.35
Control (CS)	80.32
A = SS : CS (1 : 1)	67.33
B = SS : CS (2 : 1)	52.88
C = SS : CS (3 : 1)	52.77

Table 4 shows that the volatile matter content of salak seed, coconut shell, A, B and C briquettes range between 52.77-80.32%. Briquette with the lowest volatile matter is the C briquette = 52.77%, and riquette with the highest volatile matter is the coconut shell briquette = 80.32%. As mentioned by Sunyata, the volatile matter will decrease whenever the pyrolysis temperature increase[12]. High content of volatile matter will reduce the quality of briquettes, because that means the amount of carbon will be smaller, thus the calorific value will drop and the combustion will produce more smoke[10]. The volatile matter content of salak seed, coconut shell, A, B and C briquettes met the standard regulated by Indonesian Ministry of Energy and Mineral Resources No.47/2006. The higher the volatile matter content in a briquette, the easier it is to be flamed and the faster its combustion rate.

4. Calorific value

Calorific value obtained from Bomb Calorimeter in each briquette can be seen in Table 5.

Table 5. Calorific value of salak seed briquette, coconut shell briquette and the mixture briquettes

Briquettes	Calorific value (cal/g)
Contol (SS)	6,102
Control (CS)	6,079
A = SS : CS (1 : 1)	6,062
B = SS : CS (2 : 1)	5,881
C = SS : CS (3 : 1)	5,729

From Table 5, the calorific value of the salak seed, coconut shell, A, B and C briquettes range between 5,729 cal/g and 6,102 cal/g. Briquette with the highest calorific value is the salak seed control briquette with calorific value as much as 6,102 cal/g, while briquette C has the lowest calorific value, 5,729 cal/g. The difference of A, B and C briquettes are due to the difference in ratio of salak seed and coconut shell charcoal.

The calorific value needs to be known in making briquettes, because by that we can understand how much heat a briquette could produce to be used as a fuel. The higher the calorific value, the better the quality. If a biomass has a range of calorific value from 3,000-4,500 cal/g, the energy it contains is potential to be used as heat[13]. Biomass from agricultural and forestry wastes are utilizable as alternative energy sources, by turning it into biocharcoal which has higher calorific value[14]. According to the calorific value obtained from this research, the salak seed, coconut shell and A briquettes have values that agree with the Japanese standard for briquettes, 5,000-6,000 cal/g, while the B and C briquettes satisfy the standard established by SNI No.1/6235/2000.

CONCLUSION

From the study of briquette manufacture using mixtures of salak seed charcoal and coconut shell charcoal, we conclude that:

1. The waste of salak seed and coconut shell can be used as a briquette fuel or as an alternative energy due to its high calorific value.
2. Mixture with the best composition is the A briqutte, which has calorific value as much as 6,062 cal/g.
3. Results obtained from the proximate analysis showed that the A (SS:CS, 1:1), B (2:1) and C (3:1) briquettes are high in quality based on the standard recommended by Standar Nasional Indonesia (SNI).

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