Original Research Article

Palapa Briquettes: A Potential Renewable Energy Source from Nutmeg-Coconut Shell Waste in North Maluku, Indonesia

ABSTRACT

In 2019, North Maluku exported 54,470,489 kg of copra and 2,712,999 kg of nutmeg. The large export value of these two commodities shows that not a small amount of organic hard waste is produced per year. The high market demand for these two superior commodities will have an impact on the high production of waste generated. Waste that is not handled properly will have a worse impact in the future. On the other hand, these wastes have excellent potential if utilized as a renewable energy source. In this study, Palapa briquettes (PB) were made from nutmeg shell charcoal (NSC) and coconut shell charcoal (CSC) as basic materials, while the adhesive used a 4% starch solution. The ratio of AP:AK in the briquettes is as follows: Formula PB1 (3:1); Formula PB2 (1:1); and Formula PB3 (1:3). The briquettes were evaluated with reference to SNI 01-6235-2000. The results of the briquette evaluation are as follows: Formula PB1 (water content 7.21 %; volatile matter 36.28 %; ash content 7.50 %; calories 6219.07 Cal/g); Formula PB2 (water content 7.18 %; volatile matter 32.39 %; ash content 6.52 %; calories 6485.14 Cal/g); and Formula PB3 (water content 6.93 %; volatile matter 29.41 %; ash content 7.06 %; calories 6813.80 Cal/g). Based on the briquette evaluation results, Formula PB3 is the best quality briquette.

Keywords: nutmeg shells, coconut shells, charcoal briquettes

1. INTRODUCTION

Coal and fossil fuels are still used in large quantities in developing countries as the main fuel in industry and power generation. The utilization of agricultural and forest waste has not been used efficiently. The use of coal and fossil fuels can emit harmful pollutants such as Sulphur dioxide (SO_2) and Nitrogen oxides (NOX). The resulting pollutants can cause environmental pollution such as acid rain, global warming and climate change. In addition, these pollutants can have harmful effects on health such as respiratory and lung diseases. On the other hand, the exploitation of firewood can also cause serious natural disasters such as deforestation, soil erosion, flooding, landslides, and others [1]. The people of every country need alternative energy sources to reduce the use of fossil fuels that are environmentally friendly and ready for long-term use. Renewable energy sources such as solar, biomass, wind and geothermal are abundant in nature. On the other hand, non-renewable resources such as coal, petroleum, fossil fuels, and natural gas, have been depleted. Biomass is one of the important renewable energy sources. Biomass is considered a renewable energy source with high potential to contribute to the energy needs of people in both developed and developing countries. It can reduce the occurrence of environmental damage. Biomass energy sources include wood and wood waste, agricultural crops and their waste by-products, municipal solid waste, animal waste, fruit waste, waste from food processing, aquatic plants, and algae [2,3].

North Maluku has many promising export commodities, including copra and nutmeg. Nutmeg is in the top five export commodities and copra is the largest export commodity in North Maluku. In 2019, North Maluku exported 54,470,489 kg of copra and 2,712,999 kg of nutmeg [4,5]. On the other hand, the large export value of these two commodities shows that a lot of organic hard waste is produced per year. If not handled properly, the waste will cause environmental pollution problems that will trigger other problems, including health problems.

The widespread distribution of coconut plants in Indonesia and the high use of coconut-based ingredients in industries and households lead to abundant coconut shell waste. This waste has not been optimally utilized in the community. The common utilization in the community is to burn coconut shells into charcoal and then sell it as fuel.

However, direct burning can trigger respiratory problems due to the presence of carbon monoxide (CO), sulphur dioxide (SO2), and particulate matter [6,7].

Similar to nutmeg, not all parts of nutmeg are utilized by the community. Nutmeg consists of pulp (77.8 %), mace (4 %), shell (5.1 %), and seeds (13.1 %). The pulp, mace, and seeds are the parts that have economic value while the shell has not been utilized properly. Nutmeg is native to Indonesia, originating from the Maluku Islands. Indonesia is the largest producer of nutmeg in the world (70 %), where most of the nutmeg plantations in Indonesia are cultivated by smallholder plantations (98 %) and the rest (2 %) by large plantations [8,9].

Lack of information regarding the utilization of coconut shell and nutmeg shell waste makes both wastes of low economic value or even worthless. Briquettes provide a solution made mostly from plant waste and other organic materials, commonly used for power generation, heating, and cooking fuel. The advantages of using briquettes as fuel are the high calorific value, longer burning time, and less smoke [10,11]. Briquettes can also provide social and economic benefits for farmers such as the creation of more jobs, strong support for local and regional businesses, and can reduce dependence on energy imports [12].

This study reports the evaluation results of Palapa Briquettes in the form of water content, volatile matter, ash content, and calories. This refers to SNI 01-6235-2000 on Wood Charcoal Briquettes.

2. MATERIAL AND METHODS

2.1 Materials

This study used materials including coconut shells, nutmeg shells, tapioca flour, and water.

2.2 Tools

This study used tools including bomb calorimeter (IKA, C2000, China), briquette mould, moisture analyzer (AnD, MX-50, USA), analytical balance (Fujitsu, FS-AR, Japan), oven (Memmert, Germany), stirring hotplates (Thermo Scientific, Cimarec+, USA), and furnace (Faithful, SX3, China).

2.3 Preparation of Starch Solution 4 %

A total of 4 g of tapioca flour is dissolved into 100 ml of water. Once homogeneous, heat the solution until a clear and thick paste is formed. The starch solution is ready to use.

2.4 Briquette Formulation

Palapa briquettes (PB) were prepared in three different formulas by varying the concentration of nutmeg shell charcoal (NSC) and coconut shell charcoal (CSC) (see Table 1).

Table 1. Palapa briquette formulation

Formulas	Ingredients (%)		
	NSC	**CSC**	**SS**
PB1	44.5	14.8	40.7
PB2	29.65	29.65	40.7
PB3	14.8	44.5	40.7

PB1 Palapa briquette with NSC: CSC ratio 3:1
PB2 Palapa briquette with NSC: CSC ratio 1:1
PB3 Palapa briquette with NSC: CSC ratio 1:3

2.5 Briquette Evaluation

2.5.1 Water Content

A total of 5 g of mashed PB was put into the moisture analyzer sample container. Heat the PB at 115 ℃. Wait until the device stops automatically and the percentage of water content will appear on the device screen.

2.5.2 Volatile Matter

A total of 2 g of pulverized PB was put into a porcelain cup of known weight. Heat the cup containing PB in a furnace at 800-900 ℃ for 2 hours. The cup and its contents were placed in a desiccator until cool and then weighed. The percentage of ash content was calculated using the following formula:

$$\text{Ash content } (\%) = \frac{\text{w1} - \text{w2}}{\text{w1}} \text{ x } 100\ \%$$

w1 : initial PB weight (gram)
w2 : weight PB after heating (gram)

<u>2.5.3 Ash Content</u>

A total of 2 g of mashed PB was put into a porcelain cup of known weight. Another cup is placed on top of the known weight. Heat the cup containing PB in a furnace until it reaches a temperature of 950 ℃. The cup and its contents were put into a desiccator until cool and then weighed. The percentage of volatile matter is calculated using the following formula:

$$\text{Ash content } (\%) = \frac{\text{w1}}{\text{w2}} \text{ x } 100\ \%$$

w1 : residual (gram)
w2 : PB weight (gram)

<u>2.5.4 Calories</u>

Put 1 g of crushed PB into the sample crucible and keep it in the crucible holder. Set the oxygen pressure at 30 bar. Switch on the device and wait for 15 minutes until the calorific value of the sample appears. Rinse the crucible and vessel using distilled water as much as 25 ml. Titrate with 0.0709 N Na_2CO_3 and record the titration results. Calorific value is calculated using the following formula:

$$\text{Calories (Cal/g)} = \left(\text{cal x } \frac{1 \text{ calorie}}{4.1868 \text{ J}}\right) - \left(\text{Vt x } 1 \frac{\text{calorie}}{\text{g ml}}\right)$$

cal : calories measured (J/g)
w2 : volume of titrant (ml)

3. RESULTS AND DISCUSSION

The nutmeg shell and coconut shell wastes were nested first. Palala briquettes (PB) were made by mixing nutmeg shell charcoal (NSC) and coconut shell charcoal (CSC) until homogeneous. A starch solution 4 % (SS) was added to the charcoal mixture and then stirred until homogeneous. printed briquettes were then dried using an oven at 115 ℃ for 24 hours. After drying, the briquettes were stored in an airtight container.

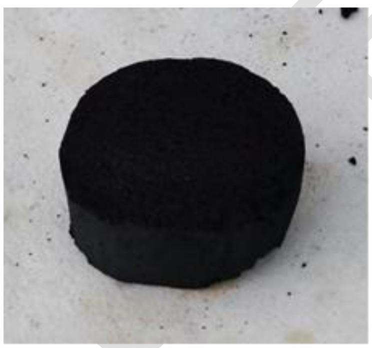

Fig. 1. Appearance of briquettes after drying

PB was prepared in three formulations by varying the concentration of NSC and CSC. The quality requirements of PB were evaluated by measuring the water content, volatile matter, ash content, and calorific value to see the differences of each briquette (see Table 2) [13][14].

Table 2. Briquette quality requirements according to Indonesian National Standards

Parameters	Unit	Requirements
Water content	%	Maximum 8
Volatile matter	%	Maximum 15
Ash content	%	Maximum 8
Calories	Cal/g	Minimum 5000

3.1 Water Content

Table 3 shows the results of the water content evaluation of the three PBs. PBs fulfil the quality requirements of briquette water content with a percentage below 8 %. PB3 shows the smallest percentage of water content. The smaller the water content of a briquette, the better the quality of the briquette.

Table 3. Evaluation of PBs water content

Formula	Water Content (%)
PB1	7.21
PB2	7.18
PB3	6.93

The water content is affected by the amount of starch solution used because it contains water. If the adhesive concentration is lowered, it can reduce the water content of the briquettes. In addition, the drying time of the briquettes also affects the water content of the briquettes. The longer the drying time, the lower the water content of the briquettes [15].

3.2 Volatile Matter

Table 4 shows the volatile matter evaluation results of the PBs. All three PBs did not meet the volatile matter quality requirements of briquettes with percentages above 15 %. PB3 showed the smallest percentage of volatile matter. The smaller the volatile matter of a briquette, the better the briquette quality.

Table 4. Evaluation of PBs volatile matter

Formula	Volatile Matter (%)
PB1	36.28
PB2	32.39
PB3	29.41

The high volatile matter content in the briquettes is influenced by the large amount of silica content in the briquettes as a result of the decomposition of compounds that are still present in the briquettes besides water and ash. This can be caused by imperfections in the carbonization process and is influenced by the time and temperature when charring nutmeg shells and coconut shells. The greater the temperature and the longer the charring time can result in a lot of volatile matter being wasted so that when testing volatile matter, low results will be obtained [16].

3.3 Ash Content

Table 5 shows the results of the ash content evaluation of the three PBs. All three PBs fulfil the quality requirements for briquette ash content with percentages below 8 %. PB2 shows the smallest percentage of ash content. The smaller the ash content of a briquette, the better the quality of the briquette.

Table 5. Evaluation of PBs ash content

Formula	Ash Content (%)
PB1	7.50
PB2	6.52
PB3	7.06

The main element in ash is the silica mineral contained in the briquettes and will affect the calorific value produced. This is because silica minerals cannot burn during the briquette combustion process. High ash content can also be caused by impurities such as SiO_2 (silicon dioxide), Al_2O_3 (aluminium oxide), Fe_2O_3 (iron (III) oxide), CaO (calcium oxide), and alkali [17].

3.4 Calories

Table 6 shows the calorific evaluation results of the three PBs. All three PBs fulfil the calorific quality requirements of briquettes with calorific values above 5000 Cal/g. PB3 shows the largest calorific value. The greater the calorific value of a briquette, the better the briquette quality. The calorific value of a briquette will be high if the water, volatile matter, and ash content of the briquette are low. In addition, high lignin content can result in greater calorific value [18].

Table 6. Evaluation of PBs calories

Formula	Calories (Cal/g)
PB1	6219.07
PB2	6485.14
PB3	6813.80

4. CONCLUSION

The best quality briquettes were found in PB3 with a ratio of nutmeg shell charcoal and coconut shell charcoal of 1:3. PB3 has a water content of 6.93 %; volatile matter of 29.41 %; ash content of 7.06 %; and calories of 6813.80 Cal/g. These briquet es will be very promising if developed and researched further.

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