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Evaluating the Quality and Added Value of Durian Peel Briquettes Using Tar Waste as Adhesive

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A B S T R A C T

Durian peel has a cellulose content that reaches 64.51%. The high cellulose value in durian peel has the potential to be an energy source for making bio-briquettes. Charcoal bio briquettes require adhesive to hold the charcoal powder together, affecting the calorific value. In this research, the adhesive used was tapioca flour and tar. To measure the quality of durian peel briquettes, water content, ash content, calorific value, and added value of the product were tested. The research showed that durian peel briquettes treated with variations in tapioca flour and tar adhesive (3:1) had good quality. This can be seen from the water content of 9.41% and the ash content of 13.6%; these values are still by the Minister of Energy and Mineral Resources Regulation No. 47 of 2006. The calorific value of the briquette product is 9694.53 cal/g and entered into SNI standards. Calculation or analysis of product-added value is calculated using the Hayami method. IDR is the added value from the one-time processing of durian peel bio briquette production with 30 kg of raw materials. IDR. 7000/kg. Based on the added value ratio when connected to Hubeis theory, the added value of this biobriquette product is in the high category (>40%).

1. INTRODUCTION

1.1. Research Background

Durian peel is the part of durian with the highest percentage among the parts of the durian fruit (flesh and seeds), namely 69.16%. This shows that 1 durian fruit produces more skin than the fruit (22%) and seeds (8.84%); in other words, the waste produced from durian in the form of skin is quite high. From the data above, the potential availability of durian peel is 124,494.22 tons/year [1]. Durian peel has a cellulose content that reaches 64.51% [2]. The high cellulose value in durian peel has the potential to be a source of energy to be used as biobriquettes.

Briquettes are solid fuels used as an alternative energy source to replace fuel oil, which goes through a carbonation process and is then molded under a certain pressure, either with or without a binder or other additional materials. Briquette-making materials generally have a small particle size and are in powder form, such as sawdust, rice husks, dregs or, charcoal, etc. Briquettes are charcoal powder made from biomass or waste raw materials from agro-industrial production/processing processes, which are added with adhesive material and then molded into a certain shape of charcoal. Agricultural biomass, especially agro-industrial waste, is a material often considered to have little or no economic value, so it is cheap and, to some extent, a source of pollution for the environment [3].

Biobriquettes or charcoal briquettes require adhesive to hold the charcoal powder together and affect the calorific value. The raw material that can be used as an adhesive for bio-briquettes is generally sago flour/starch. Apart from sago flour/starch, the liquid tar produced from the pyrolysis/burning coconut shell process can also be used as an adhesive for bio briquettes. Tar is a waste product from distillation that melts when passed through a cooler so it has a heavier fraction. The tar produced in the detailing process is tar that already has the form of a thickened and sticky liquid. To the naked eye, the physical characteristics of tar include a dark black liquid with a pungent odor [4].

Charcoal briquettes or bio briquettes have several advantages compared to other solid fuels, including being able to produce heat or a high amount of heat, not having a lot of smoke, and burning coals longer, so they have the potential to be used as a substitute for coal. With the advantages that charcoal briquettes have, they are quite popular with the public. To keep public and market interest from declining, charcoal briquettes have quality requirements to maintain the quality of the product produced. The quality of briquettes is based on SNI standards, which include water content (%), ash content (%), amount of heat (g/h), and so on.

Durian peel charcoal briquette products (using waste tar as adhesive) that are of good quality will add value or economic value to the product. Added value is the difference between the value of sacrifices made/made in processes and commodities handled at certain steps with elements such as capital, human resources, labor and management, which are sources of added value [5]. Using durian peel as raw material for briquettes can reduce the amount of durian peel waste. Utilizing fruit peels in biobriquettes can increase the density and added value of the products produced [6]. This research aims to determine the quality and added value of charcoal briquettes derived from durian peel with the addition of tar as an adhesive.

1.2. Literature Review

Durian peel contains quite a high amount of crude fiber at 33.87% and has a lignin content of 12.11%, cellulose of 24.76%, and hemicellulose of 16.96% [1]. These contents indicate that durian peel can be used as fuel or as raw material for making briquettes as an alternative fuel.

Biobriquettes are alternative fuels that come from biomass, a renewable energy source that is very abundant on this earth [7]. Biobriquettes are also solid fuels derived from raw materials that can be continuously renewed. They are made from a mixture of biomass such as wood, twigs, leaves, grass, straw, and other agricultural waste [8]. The adhesive material commonly used in making briquettes is tapioca. In this study, tapioca and tar were used as the adhesive. The addition of these two types of adhesive will influence the characteristics and quality of the durian peel briquette products that will be produced. Analysis/quality test of the bio briquettes produced is done by testing the water content, ash content, and heating value, which refers to the SNI 01-6325-2000 bio briquette standard [9]. Good quality briquette products will have added value and economic value.

Added value is a commodity's value increase due to the functional input applied to the commodity in question. The functional input is in the process of changing the form/form utility, moving the place/place utility, and the storage process/time utility. Added value describes rewards for labor, capital, and management [10].

1.3. Research Objective

This study aims to determine the quality of durian peel bio briquettes and analyze the added value of durian peel bio briquettes with the addition of the ratio of tar and tapioca flour as an adhesive (1:3; 1:1; 3:1)

2. MATERIALS AND METHODS

2.1 Materials

The materials used in this research were durian peel, coconut shell tar, and tapioca flour. This research uses equipment for testing the characteristics of bio briquettes (testing water content, volatile matter content, ash content, and heat content) as well as tools used in composing, such as pyrolysis tools.

2.2 Method For Making Tar

The initial step in acquiring tar is to perform pyrolysis, which entails burning coconut shells in the absence of air to produce liquid smoke. One method of producing tar involves the distillation of liquid smoke resulting from the incomplete combustion of coconut shells. During the process of combustion, the primary constituents of the coconut shell, namely cellulose, hemicellulose, and lignin, will undergo pyrolysis. Tar is the dense component that remains after distillation and solidifies when it is cooled. The tar generated during the coconut shell carbonization process is a viscous and adhesive substance with a liquid-like consistency.

Fig. 1. Coconut shell tar as adhesive

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2.3 Method For Making Durian Peel Briquettes

Durian peels raw materials are cut into 5-7 cm sizes and then dried/dried in the sun. Next is the carbonization process using a pyrolysis device, which has a capacity of 30 kg with a temperature ranging from 400ºC – 450ºC for 3 to 4 hours. Briquettes processed at a carbonation temperature of around 450 ºC produce the most optimum quality [11]. After pyrolysis, the durian peel charcoal was ground using a 60-mesh disk mill. Durian peel charcoal is mixed with adhesive and water. The raw material (durian peel charcoal powder) used in each treatment was 1000 gr. For the adhesive (10% of the raw material), the ratio of coconut shell tar and tapioca flour was used with the following composition:

P1: 25 g Tar and 75 g tapioca flour (1:3)
P2: 50 g Tar and 50 g tapioca flour (1:1)
P3: 75 g Tar and 25 g tapioca flour (3:1)

Durian peel charcoal, which has been mixed with adhesive (coconut shell tar and tapioca), is then pressed/molded and then tested for quality of durian peel charcoal briquettes referring to SNI standard No.1/6235/2000, which includes tests for water content, ash content, and value: Heat and added value calculations.

The assessment criteria for products that have added value are:

a) If the added value is > 0, then the durian peel briquette product with tar adhesive provides added value (positive);

b) If the added value is <0, the durian peel briquette product with tar adhesive provides an added (negative) value. The results of

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the added value calculation can also determine whether the agro-industry category has low, medium, and high added value. The added value of agroindustry is said to be low if the ratio value is <40% [12]

Fig. 2. Durian peel charcoal pyrolysis equipment.

2.4 Observation (Test Quality and Added Value)

2.4.1 *Water Content*

A 2-gram bio briquette sample was weighed in a cup of known weight. The samples were then dried in an oven at 105°C for 3 hours. Samples that have been oven-cooled in a desiccator for 15 minutes and then weighed. Water content is calculated using the equation:

$$(\%) = \left(\frac{W1}{W2}\right) \times 100\ \%$$

W1 is the weight loss after heating and W2 is the sample weight.

Based on SNI No.1/6235/2000, good-quality briquettes have a water content of ≤ 8% (BSN, 2020). According to the Minister of Energy and Mineral Resources (Energy and Mineral Resources) Regulation No. 47 of 2006, the water content in briquettes is ≤—10%.

2.4.2 Ash Content

A sample of 2 grams was weighed and placed in a porcelain cup of known weight. The sample was heated in a furnace at 750°C for 6 hours. The heated sample is cooled in a desiccator and weighed. Drying and weighing were repeated until a constant weight was obtained. Ash content is calculated based on the equation:

$$\text{Ash Content } (\%) = \left(\frac{C}{A}\right) \times 100\ \%$$

Where *C* is the weighed of remaining residue on the dish after ashing, and *A* is the initial sample weight. Based on SNI No.1/6235/2000, good quality briquettes have a ash content of ≤ 8% (BSN, 2020). According to the Minister of Energy and Mineral Resources (Energy and Mineral Resources) Regulation No. 47 of 2006, the ash content in briquettes is 14-18 %.

2.4.3 Calorific Value

Calorific value is the amount of heat or heat produced from an object by a complete combustion reaction per unit mass/volume of the fuel. In this research, the calorific value was tested using a bomb calorimeter

Briquettes that have good quality according to SNI No.1/6235/2000 have a heating value above 5000 cal/g (BSN, 2020). According to the Minister of Energy and Mineral Resources (Energy and Mineral Resources) Regulation No. 47 of 2006, the ash content is ≤. 14-18%.

2.5 Added Value Analysis

The added value of durian peel briquette products is used to compare the amount of added value and profits obtained and to find out the amount of value that will be sacrificed when producing durian peel briquette products. Analysis of the added value of this product uses the Hayami (1987) method.

Table 1. Hayami Method of Added Value Analysis

No	Variabl2	Value
I. Output, Input and Price		
1	Output (Kg)	1
2	Raw material input (kg)	2
3	Labor (HOK)	3
4	Conversion Factor	1:2
5	Labor Coefficient	3:2
6	Output Price	6
7	Direct Labor Wages (IDR/ HOK)	7
II. Revenue and Profits		
8	Price of Raw Materials (IDR/kg)	8
9	Other Input Contributions (IDR/Kg)	9
10	Output value (IDR/kg)	4x6
11.a.	Added Value (IDR/Kg)	10-8-9
11.b.	Value Added Ratio (%)	11 a : 10
12.a.	Direct Labor Income (IDR/kg)	5 x7
12.b.	Ratio (%)	12a : 11a
13.a.	Profit (IDR/kg)	11a-12a
13.b.	Profit Rate (%)	13a : 11a
III. Remuneration for Owners of Production Factors		
14	Margin (IDR/kg)	10-8
14a	Direct Labor Income (%)	12a :14
14b	Contribution of Other Inputs (%)	9 : 14
14c	Processor profit (%)	13a : 14

3 RESULT AND DISCUSSION

3.1 Durian peel Charcoal Yield

Durian peel charcoal is processed using a pyrolysis device at a temperature of 400 °C – 450 °C for 3 hours, then the charcoal is ground to obtain charcoal flour. The results of calculating the yield of durian peel charcoal flour can be seen in Table 2.

Table 2. Durian peel charcoal yield

Raw Material (kg)	Charcoal Weight (kg)	Weight of charcoal powder (kg)	Charcoal yield (%)	Charcoal flour yield (%)
30	11.23	10.3	37.44	34.33

The yield of durian peel charcoal was 37.44%, obtained from the weight ratio of charcoal and pyrolyzed raw materials multiplied by 100%. The charcoal flour yield of 34.33% was obtained from the weight ratio of charcoal flour and pyrolyzed raw materials multiplied by 100%. The yield value in the combustion/pyrolysis process is influenced by temperature and length of carbonization time. Water vapor will increase with the length of carbonization time and increasing temperature which causes the amount of CO and H to increase while the amount of C (carbon) will decrease [13].

3.2 Water Content

Testing the water content in durian peel briquette products aims to determine the amount of water content in the briquettes because the greater the water content will affect the calorific value/heat produced from the briquette product. Based on SNI standard No.1/6235/2000, the water content value in briquettes is ≤ 8% [14], while according to the Minister of Energy and Mineral Resources (Energy and Mineral Resources) regulation No. 47 of 2006 the water content in briquettes is ≤. 10 %. The calculation of the water content value in durian peel briquettes with the ratio of tar adhesive and tapioca flour can be seen in table 3.

Table 3. Water content of durian peel briquettes with various adhesives

Briquette Treatment	Tar (g)	Tapioca (g)	Water Content (%)
P1	25	75	9.32 ±0.13
P2	50	50	9.32 ±0.23
P3	75	25	9.41 ±0.13

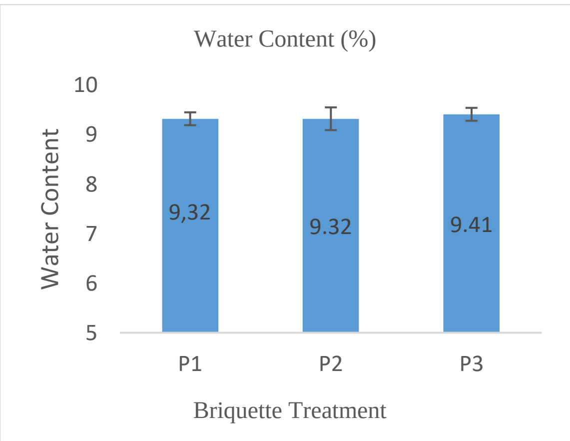

Fig. 3. Water content in each briquette treatment with variations in tar adhesive and tapioca flour

The water content of durian peel briquettes with different treatments (P1, P2, and P3) in table 3 and graphic picture 3 complies with the Minister of Energy and Mineral Resources Regulation No. 47 of 2006, which specifies a maximum water content of 10%. The water content in briquettes is affected by the use of water and tapioca flour during the adhesive mixing procedure. The initial step in obtaining tar is the process of pyrolysis, which includes burning coconut shells in the absence of air to produce liquid smoke. One method of producing tar involves the distillation of liquid smoke resulting from the incomplete combustion of coconut shells. During the process of combustion, the primary constituents of the coconut shell, namely cellulose, hemicellulose, and lignin, will undergo pyrolysis. Tar is the dense component that remains after distillation, and it undergoes melting when it is cooled. The tar derived from the process of coconut shell detailing is a viscous and adhesive substance resembling a thick liquid. [14].

Water content can affect the quality of charcoal briquette products, briquettes that have a high-water content make it more difficult to ignite/burn the briquettes. Charcoal has the ability to absorb large amounts of water from the surrounding air so that the ability of charcoal to absorb water is also influenced by the pores and surface area of the charcoal and is influenced by the large content of bound carbon contained in the briquette. Briquettes absorb water from the air.

3.3 Ash Content

Testing the ash content of durian peel briquettes aims to determine the burned parts that do not have carbon content when the briquettes are burned. The ashing method uses a temperature of 750 °C for 6 hours. Briquettes that have a low ash content will increase the quality of the briquettes. The ash content will also affect the calorific value of the briquettes because the smaller the ash content, the greater the calorific value of the briquettes. Based on SNI standard No.1/6235/2000, the ash content value in briquettes is ≤ 8%, while according to the Minister of Energy and Mineral Resources (Energy and Mineral Resources) regulation No.47 of 2006 the ash content in briquettes is 14-18% . The calculation of the water content value in durian peel briquettes with the ratio of tar adhesive and tapioca flour can be seen in table 4.

Table 4. Ash content of durian peel briquettes with various adhesives

Briquette Treatment	Tar (g)	Tapioca (g)	Ash Content (%)
P1	25	75	14.27 ±0.88
P2	50	50	14.29 ±0.55
P3	75	25	13.60 ±0.24

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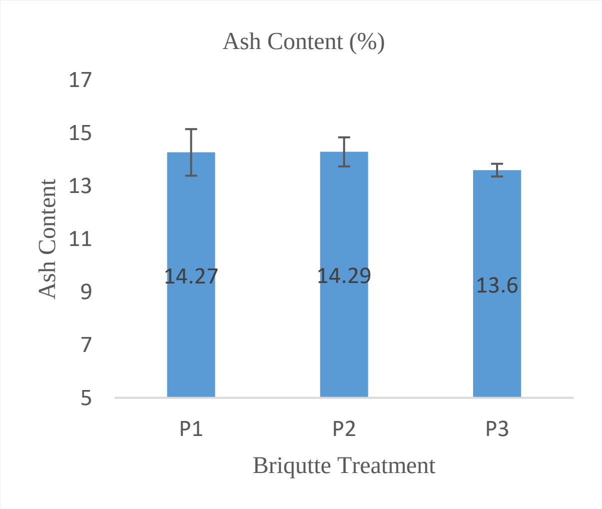

Fig. 4. Ash content in each briquette treatment with variations in tar adhesive and tapioca flour

The ash level of durian peel briquettes treated with different methods (P1, P2, and P3) in Table 3 and Figure 3 complies with the ash content limit set by Minister of Energy and Mineral Resources Regulation No. 47 of 2006, which is below 14-18%. The P3 briquette treatment, which has a tar adhesive to tapioca flour ratio of 3:1, exhibits the lowest ash concentration. Consequently, the calorific value of this treatment is impacted. The presence of ash in a substance will impact its calorific value during combustion. A higher ash content in the fuel will result in a lower calorific value. [15]. The main constituent of ash is silica, the higher the silica content in the briquettes, the greater the amount of ash produced. Briquette products that have good quality are briquettes that have a low silica content so they produce little ash [16].

Based on the total ash content in each treatment, durian peel briquettes with a tar adhesive to tapioca flour ratio of 3:1 (P3) will have the highest calorific value compared to other treatments.

3.4 Calorific Vallue

The heating value is tested to determine the amount of heating value of a burning material and is the amount of heat obtained or produced in the material under perfect combustion conditions. Calculation of the calorific value of durian peel briquettes with the ratio of tar adhesive and tapioca flour can be seen in table 5.

Table 5. Calorific value of durian peel briquettes

Briquettes Treatment	Calorific Vallue (cal/g)
P1	5106.35
P2	9267.56
P3	9694.53

Based on the data in Table 5, it can be observed that the briquette treatment labeled as P3, which consists of 75 grams of Tar adhesive and 25 grams of tapioca flour, has the highest calorific value of 9694.53 cal/g compared to the other treatments. The three treatments of durian peel briquettes with various adhesives have a calorific value above 5000 cal/g and are included in SNI standard No.1/6235/2000. Briquettes that have good quality based on SNI have a calorific value above 5000 cal/gram [17].

The calorific value of briquetted products is also influenced by the water content and ash content of the briquettes. If the briquettes have low water content and ash content, the briquette product will have a high calorific value [18]

3.5 Added Value Analysis

Durian peel briquettes treated with variations in tar adhesive and tapioca flour (3:1) have good quality. This can be seen from the water content and ash content which are still in accordance with the Minister of Energy and Mineral Resources Regulation No. 47 of 2006 and the durian peel briquette products have a calorific value above 5000 cal/g which is included in the SNI standard.

Durian peel charcoal briquette products (using waste tar as adhesive) that have good quality will have added economic value or added value to the product. To calculate the added value of a product, the amount of output produced during the process/production must be known.

From table 2 it is known that by burning 30 kg of raw materials, around 10.3 kg of durian peel briquettes was produced. Analysis of the added value of durian peel biobriquette products needs to be carried out to determine the appropriate selling value, margin value and level of profit obtained from the production of durian peel biobriquettes.

Calculation or analysis of product added value is calculated using the Hayami method. The amount of added value in durian peel briquette products can be seen in table 6.

Table 6. Added value to durian peel briquette products

No	Variabel	Value
I. Output, Input and Price		
1	Output (Kg)	10.3
2	Raw material input (kg)	30
3	Labor (HOK)	2
4	Conversion Factor	0.34
5	Labor Coefficient	0.06
6	Output Price	103000
7	Direct Labor Wages (IDR/ HOK)	40000
II. Revenue and Profits		
8	Price of Raw Materials (IDR/kg)	2500
9	Other Input Contributions (IDR/Kg)	500
10	Output value (IDR/kg)	10000
11.a.	Added Value (IDR/Kg)	7000
11.b.	Value Added Ratio (%)	70
12.a.	Direct Labor Income (IDR/kg)	2666.66
12.b.	Labor Share (%)	38.09
13.a.	Profit (IDR/kg)	4333.33
13.b.	Profit Rate (%)	61.90
III. Remuneration for Owners of Production Factors		
14	Margin (IDR/kg)	7500
14a	Direct Labor Income (%)	35.56
14b	Contribution of Other Inputs (%)	6.67
14c	Company Owner Profit (%)	57.78

The added value from one-time processing of durian peel biobriquette production with 30 kg of raw materials is IDR. 7000/kg. Product added value results from reducing the product value by the price of raw materials and the prices of other inputs. This added value is not net added value because it does not include costs for labor and others.

The added value ratio of this durian peel briquette product is 70%. The added value ratio of biobriquette products is obtained from the comparison between the amount of added value and the output price of coconut shell briquettes (added value divided by the output price x100%). Based on the added value ratio when connected to Hubeis theory, the added value of this biobriquette product is in the high category (>40%). According to Sulaksana (2015) an agricultural commodity can be categorized as high, medium and low added value agroindustry [19]. The criteria for determining it are that if the added value of the product is below 15% then it is included in the criteria for low added value, if it is at 15-40% it is included in medium added value, and if it is more than 40% it is included in the criteria for products that have high added value.

The compensation/wages for direct labor for each processing of durian peel briquette production is IDR 40,000. The profit/level of profit obtained from one production of durian peel charcoal into briquettes is IDR 4333.33 with a profit level of 61.9%. The level of profit in agro-industry plays a role in increasing economic growth. If the level of profit (%) obtained is high, then the agro-industry plays a greater role in increasing economic growth and if the ratio of labor rewards to percent added value is high, then the agro-industry plays a greater role in providing income for its workers [20].

The potential for durian peel waste to be used as briquettes within one hectare (Ha) of durian plants, namely:

a. The average number of durian plants per hectare is around 100 trees

b. One durian tree produces ±70 durian fruit, so the potential for durian fruit in 1 ha is = 100 trees x 70 fruit = 7000 durian fruit

c. The weight of 1 durian fruit is approximately 4 kg, and the percentage of durian peel from the durian fruit parts (flesh and seeds) is 69.16%.

d. One durian fruit has a skin weight = 4 x 69.16 = ±2.76 kg

e. Added value of briquettes = IDR. 7000

The potential for durian peel waste that can be utilized in 1 ha is: 7000 x 2.76 kg = 19,320 kg so that 1 ha of durian peel has a potential added value of IDR. 135,240,000,- (added value x potential durian peel waste in 1 ha) and has a potential profit/ha of IDR. 83,713,560,-

4 CONCLUSION

The durian peel briquettes treated with variations in tapioca flour and tar adhesive (3:1) had good quality. This can be seen from the water content of 9.41%, the ash content of 13.6%, these values are still in accordance with the Minister of Energy and Mineral Resources Regulation No. 47 of 2006. The calorific value of the briquette product is 9694.53 cal/g and entered into SNI standards. Calculation or analysis of product added value is calculated using the Hayami method. The added value from one-time processing of durian peel biobriquette production with 30 kg of raw materials is IDR. 7000/kg. The added value ratio of this durian peel briquette product is 70%. The added value ratio of biobriquette products is obtained from the comparison between the amount of added value and the output price of coconut shell briquettes (added value divided by the output price x100%). Based on the added value ratio if connected to the Hubeis theory, the added value of this biobriquette product is in the high category (>40%)

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