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ANALYSIS OF MOISTURE CONTENT, CALORIFIC VALUE AND BURNING RATE OF CORNCOB AND KAPOK RANDU (*Ceiba pentranda*) SKIN BRIQUETTE

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Abstrak. Penelitian ini telah dikaji nilai kadar air, nilai kalor, dan laju pembakaran briket kulit tongkol jagung dan kapuk randu (Ceiba pentranda). Pembuatan briket dilakukan dalam 5 tahap: Pertama, bahan utama tongkol dan kulit kapuk randu (Ceiba Pentranda) dijemur agar beratnya berkurang 20%. Kedua, karbonisasi bahan utama dengan suhu 400˚C selama 60 menit dengan furnace dan diayak. Ketiga, briket dipadatkan dengan komposisi kulit tongkol jagung dan kapuk randu (Ceiba Pentranda sebagai berikut A (100%: 0%), B (75%: 25%), C (50%: 50%), D (25 %: 75 %), E (0%: 100%) dengan 10% w/w tepung tapioka sebagai bahan pengikat. Keempat, jemur sampel briket dan oven pada suhu 100 ˚C selama 60 menit. Kelima, sampel diuji dengan bomb calorimeter. Hasil penelitian menunjukkan bahwa nilai kadar air tertinggi pada sampel E 3,33%, Nilai kalor tertinggi terdapat pada sampel E yaitu sebesar 6195,05 Cal/gram dan laju pembakaran tertinggi terdapat pada sampel D dengan nilai 0,0622 gram/menit.

Abstract. This research has studied the value of moisture content, calorific value, and the rate of burning of corncob skin briquettes and kapok kapok (Ceiba pentranda). The briquettes were produced in 5 steps: First, the main material for cobs and kapok randu (Ceiba Pentranda) skin is dried so that the weight is reduced by 20%. Second, the carbonization of the main materials with a temperature of 400˚C for 60 minutes with a furnace and sieved. Third, compressed briquettes with corncob and kapok randu (Ceiba Pentranda) skin composition in the following ratios of A (100%: 0%), B (75%: 25%), C (50%: 50%), D (25%: 75 %), E (0%: 100%) with 10% w/w tapioca starch as binder. Fourth, dried the briquette sample and roasted at a temperature of 100˚C for 60 minutes. Fifth, the samples were then characterized by bomb calorimeter. The results show that the highest moisture content value was in sample E 3,33%, the highest calorific value was in sample E which was 6195.05 Cal/grams, and the highest burning rate was found in sample D with the value was 0.0622 grams/minute.

Keywords: *Briquettes, Corncob, Kapok randu (Ceiba pentranda) skin, moisture content, calorific value, burning rate.*

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INTRODUCTION

Energy is a basic need for humans. The use of energy is increasing every year, but the existence of energy sources is decreasing, so there is a need for new solutions to obtain renewable energy, such as implementing new energy conservation. Energy needs in Indonesia are generally obtained from mining products, where the supply is running low until one day it will run out. Data from the Ministry of Energy and Mineral Resources in 2018 states that the Indonesian state has 3.2 - 3.3 per barrel or 0.2% of world oil and gas reserves are only 15% of world gas reserves [1]. Based on these data, it shows that the availability of fuel oil in Indonesia is decreasing so that it has an impact on fuel price increases, therefore it is necessary to use other energy sources as alternative energy, one of which is the use of biomass.

Biomass is used as alternative energy, one of which is briquettes. Briquettes can be defined as a fuel that is solid and comes from the remaining organic material which has undergone a compression process with a certain compressive power. Briquettes can replace the use of firewood which is starting to increase in consumption and has the potential to destroy forest ecology. Briquettes are quite economical, have high, flavorless, durable, and can be made with easily available materials, for example, corn cobs and kapok randu (Ceiba Pentranda) skin [2]. Corn cobs as raw material are quite abundant, cheap, and renewable. Corn cobs contain 33% crude fiber, 44.9% cellulose and 33.3% lignin. From some of these ingredients, corn cobs can be used as raw material for charcoal briquettes [3]. While the kapok randu (*Ceiba pentranda*) skin has a supportive content for briquette raw materials including 50-69% Holocellulose, 23-36% cellulose, and 10-26% lignin [4].

The use of corn cobs for briquettes can increase the high calorific value [3]. According to Laily (2017) and Andi, et al. (2011) corn cob briquettes produce low ash content, high ash content causes low briquette quality. Corn cobs briquettes can produce a low water content of 6.01%. The low water content will result in the combustion rate, the higher the water content, the faster the briquettes will run out when burned [5][6]. Also, kapok randu (*Ceiba pentranda*) skin can be used as an ingredient for briquettes. According to Faizal, et al (2018) the raw material for kapok randu (*Ceiba pentranda*) skin can produce a calorific value that exceeds the Indonesian briquette standard, with a predetermined carbonization temperature of 400° -600° C [4]. In previous studies, making briquettes from a mixture of kapok randu (*Ceiba pentranda*) seeds and kapok randu (*Ceiba pentranda*) skin with a ratio of 50%: 50% with 30% starch adhesive resulted in a calorific value of 4981 Cal/g [7]. The production of biomass from kapok randu (*Ceiba pentranda*) skin with 10% starch adhesive also has a high calorific value of 6782 Cal/g and produces a fairly low water content [8].

Making briquettes cannot be done without adhesive, the use of adhesive is to increase the calorific value and burning time [9]. There are several kinds of adhesive, including starch adhesive, flour adhesive, sugar cane adhesive, adhesive, sodium silicate, and others. According to previous research, the starch adhesive will produce high-value briquettes in terms of density and ash content. In the research of Nasruddin and Risman (2011) 4% starch adhesive will produce a calorific value of 4552 Cal / g higher than sugar cane adhesive which produces 4485 Cal / g with the main ingredient of corn cobs and adhesive composition of 4% each. The use of a higher composition will result in a higher density and longer combustion process [6]. A study conducted by Unokoly, et al. (2016)

with the main ingredients of corn cobs and bamboo showed that variations in the composition of the adhesive produced a burning time value that was not too much different, including 10% adhesive burned in 123,10 minutes, 20% with 123,147 minutes and 30% with 123,363 minutes [2]. The use of the type and composition of the adhesive is an important factor in making briquettes.

This research was conducted by analyzing the calorific value and the rate of burning in the manufacture of briquettes from two materials, namely, corn cobs and kapok randu (Ceiba Pentranda) skin with starch adhesive. Of the two main ingredients, variations in the composition will be tested with 5 samples, namely Briquette A (100% pure corn cobs), Briquette B (corn cobs and kapok randu (Ceiba Pentranda) skin = 75%: 25%), Briquette C (corn cobs and kapok randu (Ceiba Pentranda) skin = 50%: 50%), Briquette D corncob and kapok randu (Ceiba Pentranda) skin = 25%: 75%), and Briquette E (100% pure kapok randu (Ceiba Pentranda) skin). This study aims to obtain the results of moisture content, heating value, and combustion rate following Indonesian briquette standards.

METHODOLOGY

The method used in this research is experimental. The making of briquettes through several steps including First, the main material for cobs and kapok randu (*Ceiba pentranda*) skin is dried in the sun for 3 days so that the weight of the ingredients is reduced by 20%. Second, the carbonization of the main material with a temperature of 400˚C for 60 minutes with a furnace and then sieved with a 50 mesh size. Third, compressed 6 grams of briquettes sample with the composition of corn cobs and kapok randu (*Ceiba pentranda*) skin with ratio A (100%: 0%), B (75%: 25%), C (50%: 50%), D (25%: 75%), E (0%: 100%) with 10% w/w of tapioca starch as a binder, and then pressed with a strength of 1,32 tons. Fourth, drying the briquette sample under the sun for 3 days (20 hours) and oven at 100˚C for 60 minutes. Fifth, characterized the sample for moisture content, calorific value, and burning rate.

Moisture Content

Determination of water content can be obtained using the Eq. (1).

$$MC(\%) = \frac{w_1 - w_2}{w_1} \times 100\%. \quad (1)$$

MC = Moisture Content
w_1 = Initial weight
w_2 = Weight after drying

Calorific Value

Calorific value was determined with bomb calorimeter. The equation of calorific value using Eq. (2).

$$CV\left({}^{Cal}/_{g}\right) = \frac{(\Delta T.W) - e_1 - e_2}{m}. \quad (2)$$

CV = Calorific Value
ΔT = $T_1 - T_2$

W = Benzoate acid value (2465,57 ˚C)
e_1 = Burnt wire x 2,3 Cal
e_2 = Ml titration x 1 Cal
m = Mass

Burning Rate

The burning rate is the ratio between the mass of the briquette burned with the duration of time. Materials with low density have a larger air cavity so that the amount of material burned is greater. The Eq. (3) and (4) used to determine the rate of combustion.

$$M_a = M_1 - M_{2.} \quad (3)$$

$$BR = \frac{M_a}{t}. \quad (4)$$

BR = Burning rate
M_a = Mass of the briquette burned
M_1 = Mass of Initial Briquette
M_2 = Mass of residual briquette
t = Duration of burning time

RESULT AND DISCUSSION

Moisture Content

Table 1 is the percentage of moisture content the briquette, showing that the briquettes with composition E have the highest moisture content of 3,33% and briquettes with composition B has the lowest moisture content of 2,45%. The moisture content that is still contained in the briquette is due to the water trapped in the particles of the main materials when drying cannot come out completely. Besides, the water trapped in the adhesive material used causes the water content in the briquettes to remain high. The water trapped in the briquette is due to the difficulty of evaporating some waters during the drying process because the outside has dried first and forms a strong bond [6]. The moisture content in the briquette is related to the initial ignition of the fuel. If the moisture content higher, so it will be more difficult to ignition the briquettes. Because it takes energy to evaporate the moisture in the briquette [10].

Table 1. Moisture Content of the Briquette

Sample	Moisture Content (%)
Sample A	3,11
Sample B	2,46
Sample C	2,52
Sample D	2,57
Sample E	3,33

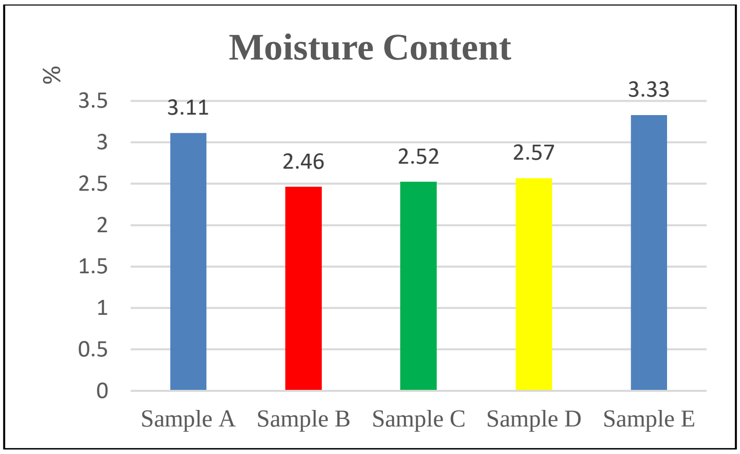

Figure 1. Moisture Content

Based on Figure 1, the water content value of sample B to sample E has increased based on the ratio of increasing the composition of kapok randu (*Ceiba pentranda*) skin. The difference in composition of each briquette sample will result in a different surface area of the briquette, so this has an effect on the absorption of moisture in the briquette. The adhesive composition and the type of adhesive also affect the moisture content value.

Table 2. Bio Briquette Quality (SNI 01-6235 2000)

No	Parameters (Units)	Value
1.	Inherent Moisture (%)	Max. 8
2.	Ash Content (%)	Max. 8
3.	Volatile Matter (%)	Max. 15
4.	Fixed Carbon (%)	Min. 77
5.	Calorific Value (Cal/gr)	Min. 5000

All samples made have met the national briquette standards that have been determined by Badan Standar Nasional (BSN) according to table 2 (Indonesian Briquette Standards) [11]. The results of this study with a moisture content of 2,45 -3,3%, were lower than previous studies. The value of the moisture content of this study is better than the previous research conducted by Faiz et al. (2015) regarding the combination of corn cobs and tea waste resulted in the lowest moisture content of 2,89% and the highest was 3,90% [12]. Research conducted by Lilih and Budi (2017) briquettes of corn cobs with variations and percentages of tapioca starch showed an average moisture content value of 4,58% [9].

Calorific Value

Figure 2 shows that the calorific value has decreased from sample A to sample D along with the decreasing composition of the corn cobs. The lowest calorific value was found in sample D, which is 3803,96 Cal/gram. The low calorific value can be caused by several factors, among others. First, the low temperature and time of carbonization resulted in a low heating value [3]. Second, the more adhesive is added, the more water and ash content that comes from the adhesive will result in high moisture content and ash content [9]. The calorific value determines the quality of the briquette. The higher the calorific value, the better the briquette quality. This is inversely proportional to the moisture content and ash content, the higher the water content and the ash content, the less good the briquette quality.

Table 3. Calorific Value of the Briquette

Sample	Calorific Value (Cal/gram)
Sample A	4960,45
Sample B	4725,9
Sample C	4644,06
Sample D	3803,96
Sample E	6195,05

Figure 2 shows that the more corn cobs composition in the briquette making, the higher the calorific value is obtained. The results of this study are in line with the research conducted by Budi et al. (2016) with variations in the composition resulting in the highest calorific value at the composition of 100% corn cobs, namely 6078 Cal/gram. [3]. The highest calorific value is found in sample E which is 6195,05 Cal/gram. Research by Faizal, et al. (2018) obtained the highest calorific value results from the carbonization temperature. This is because the higher the carbonization temperature, the higher the carbon content in the briquette charcoal, while the water content will be lower so that it will produce a high calorific value in the briquette. [4]. The calorific value obtained from 5 samples according to the briquette standard according to SNI is only 1 sample that meets the standards, namely sample E (6195,05 Cal/gram).

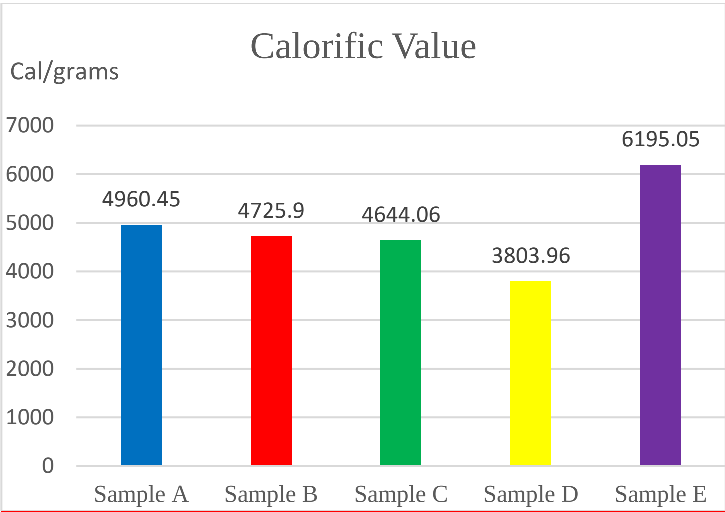

Figure 2. Calorific Value

Burning Rate

Based on Table 4 shows that the highest burning rate is in sample D. While the lowest burning rate of briquettes was found in sample E with a value of 0.0448 gram/minute. The less the composition of the corn cobs in making briquettes, the higher the value of the burning rate obtained. The high and low burning rate is influenced by the calorific value contained in the briquette [13]. It can be seen in Figure 3 that sample E has the lowest combustion rate but has the highest calorific value.

Table 4. Burning Rate of the Briquette

Sample	Burning Rate (gram/minute)
Sample A	0,0596
Sample B	0,0557
Sample C	0,0597
Sample D	0,0622
Sample E	0,0448

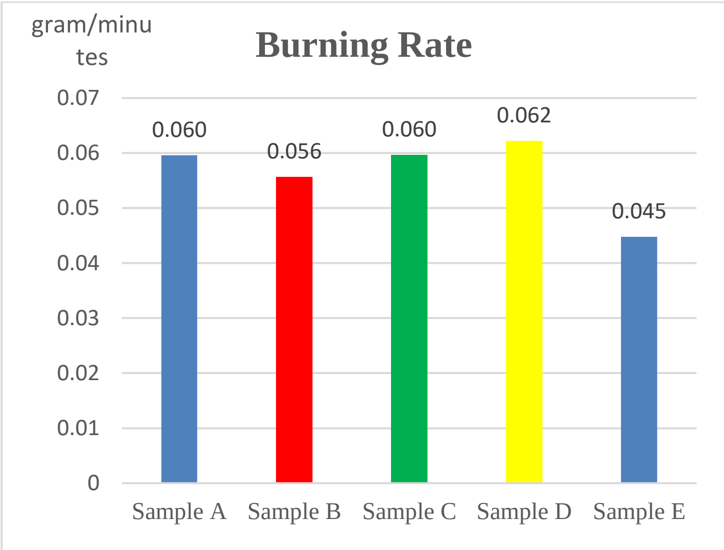

Figure 3. Burning Rate

Besides being influenced by the composition of the briquette material, the burning rate is also influenced by the presence of adhesive. The use of high adhesive concentrations results in high density, compressive strength and slows down the burning rate. The use of the type and composition of the adhesive in the manufacture of briquettes is an important factor in making briquettes [2].

CONCLUSIONS

Corn cobs and kapok randu (Ceiba Pentranda) skin can be used as ingredients for briquettes with a mixture of tapioca starch adhesive. The results show that the highest moisture content value in sample E is 3.3303% and the lowest moisture content in sample B (2.4587%). The highest calorific values are sample E which is 6195.05 Cal/gram. While the lowest calorific value was found in sample D which was 3803.96 Cal/gram. The lowest burning rate was found in sample E with a value was 0.0448 gram/minute. While the highest burning rate was found in sample D with the value was 0.0622 gram/minute.

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