The Effect of Tapioca Flour Adhesives to the Biopellet Characteristics of Rice Husk Waste as Renewable Energy

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IOP Conference Series: Earth and Environmental Science

PAPER · **OPEN ACCESS**

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To cite this article: A Damayanti *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **700** 012028

The Effect of Tapioca Flour Adhesives to the Biopellet Characteristics of Rice Husk Waste as Renewable Energy

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Abstract. The abundance of rice husk waste in Indonesia and more than 50% of its cellulose content have the potential to become environmentally friendly and renewable energy, including biopellet. The purpose of this research aims to evaluate the addition of adhesives to the biopellet production. Tapioca flour used as adhesives which a concentration were 10%, 15%, and 20% (w/w) of rice husk waste. Densification process of biopellet production was used by pellet mill machine with a capacity of 120 kg/h. The quality of biopellet product can fulfill the Indonesian biopellet national standard namely SNI 8021:2014. The characterization of biopellet product was to determined the quality of the fuel, which including test of density, water content, fixed carbon content, volatile matter content, and caloric value. The results shows that the characteristics of biopellet of rice husk waste contained tapioca flour concentration (% w/w) 10, 15, and 20 were 8.18, 8.88, 9.18% for water content; 0.81, 0.9, 0.9 g/cm3 of density; 12, 11.17, 11.95% of fly ash content; and 4068, 4013, 4004 cal/g of caloric value. Rice husk waste has the potential as a biopellet solid fuel.

1. INTRODUCTION

Global demand for energy is increasing along with population growth and depletion of fossil energy sources caused energy consumption [1]. Global warming caused largely by emission of greenhouse gas (GHG) such as CO_2, SO_x, and NO_X [2]. Therefore, alternative clean energy is needed to reduce the use of fossil fuels, one of which is biomass energy due to the availability [3]. The main sources of biomass energy in Indonesia can be obtained from palm oil byproducts [4], rice residues [5], *plywood*, sugar residues, and cacao residues [6]. Biomass energy can also be converted to produce electricity and mechanical energy such as biohydrogen fuels gas from citrus fruit waste [7], bioethanol liquid fuels from passion fruit peel [8], and also in the form of solid fuels [9]. However, the main constrain of biomass energy in the form of solid fuels is low energy convertion [10], including biopellets or pellets biopellet or pellet [11].

The biopellet was made by densification process using pellet mill machine to increase the caloric value[12], and densities [13]. It is made based on cellulose material [14] where most of it comes from agricultural waste such as wood, oil palm empty fruit bunches [4], corn waste [15], and other [16]. Rice husk waste consists of 50% cellulose so that it can be used as raw material for biopellet [17]. The abundance of rice husk waste in Indonesia is more than 28 million tons or 51 % of the total rice production in 2018 [18].

A binder is an important material in the manufacture of pellets because biomass waste is glued together with it.[19]. In addition of adhesives also aims to increase the bond between particles, provide a uniform colour and also provide fragrant smell [20].One adhesive that is often used is tapioca becauseits availability is easily and the price is cheap [21], able to absorb water from the air and reduce the quality of biopellets due to smoke [20]. However, the use of tapioca flour greatly affects to the quality of the pellets [22]. The best research of biopellet production from pod husk which was obtained 20 % (w/w) concentration of tapioca flour [7].

The research aims to study the different concentration of tapioca flour on biopellet that can fulfil the Indonesian National Standard (SNI 8021:2014) (Table 1).

Table 1. The biopellet parameters of SNI 8021:2014 [23]

Characteristics	Units	SNI 8021:2014
Density	g/cm^3	>0.8
Water Content	%	<12
Fly Ash Content	%	<1.5
Fixed Carbon Content	%	>14
Volatile Matter Content	%	<80
Caloric Value	Cal/g	>4000

2. METHODS AND MATERIALS

2.1 Material
The rice husk waste was obtained from magelang, Indonesia and tapioca flour ("rose brand", Semarang, Indonesia).

2.2 Preparation of Adhesive Concentration
Ten % from 1000 g of rice husk that was one hundred g of tapioca flour was dissolved into 500 g of tap water, then were homogenized. The adhesives concentration 15% and 30% (w/w) were made by under the same experimental conditions as 10% (w/w).

2.3 Biopellet Production
Thousand g of rice husk was mixed with a concentration of 10% (w/w) and then stirred until homogeneous and put into a pellet mill for printed. The result of pellet is dried using an oven for 30 minutes. The manufacture of biopelet with adhesive concentrations of 15 and 20% (w/w) was carried out the same as the adhesive concentration of 10% (w/w).

2.4 Characterization of Biopellet
Characterization of biopellet refers to SNI 8021:2014 [23] test method will be held at the Tekmira Testing Laboratory, Bandung (Table 2).

Table 2. Characterization of biopellet method according to SNI 8021-2014

No	Parameter	Methods
1	Caloric Value	Bomb Calorimeter (SNI 8021:2014)
2	Density	Mass divided by volume (SNI 8021:2014)
3	Water Content	Dried in a oven with temperature 105 °C for 3 hours (SNI 8021:2014)
4	Fly Ash Content	Burned in the furnace at 650 °C for 5 hours (SNI 8021:2014)
5	Volatile Matter Content	Burned in the furnace at 950 ° C for 10 minutes (SNI 8021:2014)
6	Fixed Carbon Content	100% - (water content + fly ash content + fixed carbon content) (SNI 8021:2014)

While the standard geometry of the product was cylindrical and have shape in a diameter of 0.4-0.7 cm and a length between 2.5-3.6 cm [24].

3. RESULTS AND DISCUSSION

3.1 Product Geometry
Biopellet geometry of variaty of the adhesive concentration was detected and illustrated in Table 3.

Table 3. Biopellet geometry of variaty of the adhesive composition

Composition	Adhesive Concentration (% w/w)	Product Geometry
1000 g rice husk + 500 g water	10	D : 0.4 cm, L : 3.1 cm
	15	D : 0.4 cm, L : 2.8 cm
	20	D : 0.4 cm, L : 2.6 cm

Table 3 shows that all adhesive consentrations of biopellets have the same diameter, i.e 0.4 cm. While, the length of biopellet for adhesive concentration (% w/w) 10, 15, and 20 were 3.1 cm, 2.8 cm and 2.6 cm, respectively. Its means that the biopellet produced were in accordance with geometry standards [24].

3.2 Characterization
Characterization of pellets is the nature of rice husks results that are in accordance with the product geometry that had been determined, then tested with parameters based on regulations from BSN [25]. Characteristics of rice husk biopellet was listed in Table 4.

Table 4. Characteristics of rice husk biopellet

Adhesive Concentration (% w/w)	Characteristic					
	Density (g/cm^3)	Water Content (%)	Fly Ash Content (%)	Volatile Matter Content (%)	Fixed Carbon Content (%)	Caloric Value (cal/g)
10	0.8	8.18	14	65.82	12	4068
15	0.9	8.88	12.98	66.42	11.72	4013
20	0.9	9.18	12	66.73	11.95	4004

Table 4 shows that density, water content, volatile matter content, and caloric value of the pellet have been in accordance SNI 8021: 2014 (Table 1). While fly ash content to pellets was bigger 8 times and fixed carbon content to pellets was smaller 0,85 times from multiplied SNI 8021: 2014. This is allegedly due to the high silica content in rice husks [26].

3.2.1 Density
Pellet with high density values can easier the storage, handling, and transportation of pellets [27]. High or low density in pellets can affected by the pressure during compaction [19]. Density also can affected by the particle size of the material, where more larger particle size of pellet, more smaller the density will be [11]. The value of density in pellets was presented in Figure 1.

It can be seen from Figure 1. that the pellet density values for adhesive concentration (% w/w) 10, 15, and 20 were 0.8, 0.9, and 0.9 g/cm^3. It had fulfilled the Indonesian biopellet national standard SNI 8021:2014 (Table 1). This is presumably because rice husks have small particles so that the binder was easily bonded with it [28].

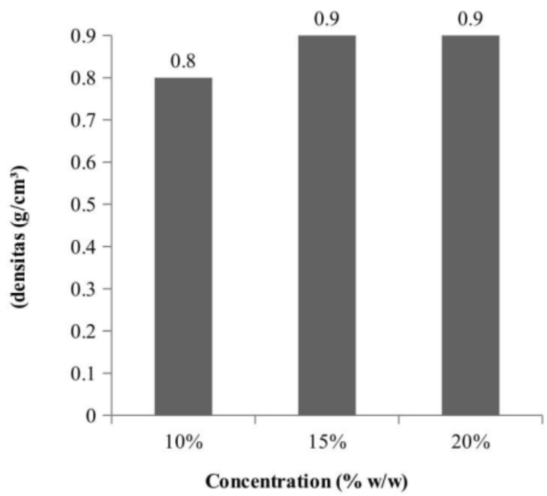

Figure 1. Density chart for biopellet product

3.2.2 Water Content

The greater water content in the fuel, the smaller calorific value, and vice versa [29]. Water content is one of the parameters determining the quality of pellets that affected the caloric value of combustion, ease of ignition, combustion power, and the amount of smoke produced during combustion [3]. The value of water content in pellets was presented in Figure 2.

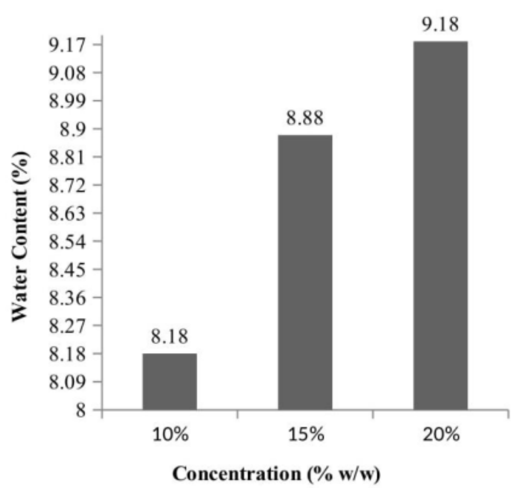

Figure 2. Water content chart for biopellet products

It can be seen from Figure 2. that the value of pellet water content for adhesive concentration (% w/w) 10, 15, and 20 is in the range of 8-10%. The value of water content in the pellets produced was in accordance with Indonesian biopelet standards SNI 8021: 2014 (Table 1). The amount of water content in pellets affects the calorific value [30].

3.2.3 Fly Ash Content

Ash in solid fuels is a mineral that can not be combusted after combustion process and contributes to the decline in the quality of biopelet [29] and contains elements of calcium, potassium, magnesium, and silica which affect the calorific value of combustion [31]. The value of ash content in pellets was presented in Figure 3.

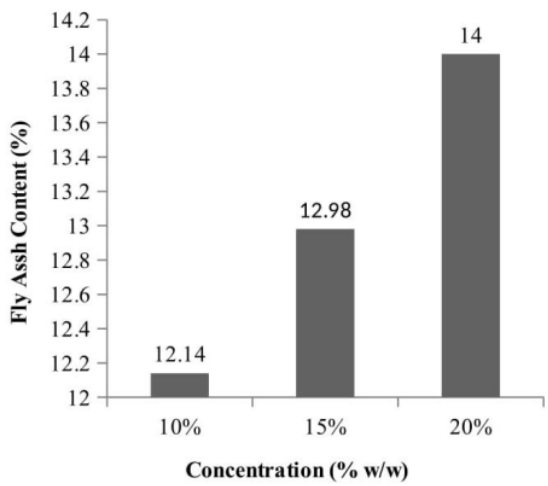

Figure 3. Fly ash content chart for biopellet content

It can be seen from Figure 3. that the fly ash content of pellets for adhesive concentration (% w/w) 10, 15, and 20 respectively were 14%, 12.98% and 12.14%. It's means that fly ash was bigger 8 times from multiplied SNI 8021:2014 (Table 1). This is presumably because rice husks contain high silica [26]. The higher the silica in the biomass, the higher the fly ash content, thereby reducing the quality of combustion [19].

3.2.4 Volatile Matter Content

Volatile matter content is an indicator amount of smoke produced when burning in pellets [5]. The value of volatile matter substance in pellets was presented in Figure 4.

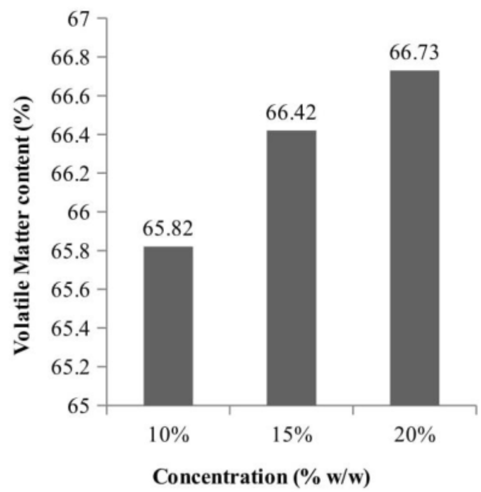

Figure 4. Volatile matter content chart for biopellet products

It can be seen from Figure 4 that the value of volatile matter content was directly proportional to the addition of flour adhesives in the range of 65-67%. The highest and the lowest of volatile matter content were 66.73% (20% w/w) and 65.82% (10% w/w). The volatile matter content in this study were already good, because had fulfilled the SNI 8021:2014 biopelet standards which is less than 80%. The higher the amount of volatile matter in the pellet, the more smoke is produced during the combustion process [21]and the fuel efficiency decreases [32].

3.2.5 Fixed Carbon Content

Fixed carbon content is a component of carbon fraction contained in materials other than water, ash, and volatile matter, so that the presence of fixed carbon to the pellet can be affected by the value of fly ash content and volatile matter content in the pellets [21]. The value of fixed carbon content to the pellet was presented in Figure 5.

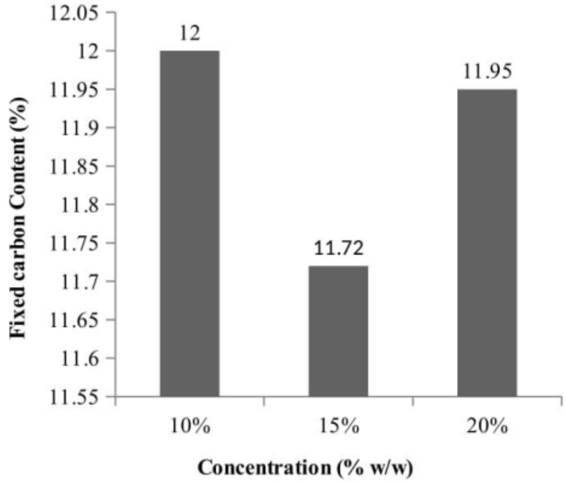

Figure 5. Fixed carbon concent chart for biopellet products

It can be seen from Figure 5. that fixed carbon content to pellets is relatively low in the range of 11.7-12%, with the highest value in 10% (w/w) at 12% and the lowest in 15% (w/w) at 11.72%. These results did not fulfilled the requirements of SNI 8021:2014 (Table 1) allegedly due to the high fly ash content and high volatile matter content [21]. Fixed carbon content also greatly affected the amount of caloric value. The higher fixed carbon content, the higher caloric value, so the fuel quality will be better [33].

3.2.6 Caloric Value

The caloric value is the most important parameter for determining the quality of biopelet [19]. The higher caloric value, the quality of biopelet will be better [5]. The caloric value in the pellet was presented in Figure 6.

It can be seen from Figure 6. that the caloric value produced is in the range of 4000-4100 cal/g with the highest caloric value in 10% (w/w) at 4068 cal/g and the lowest value in 20% (w/w) at 4004 cal/g. It shows that the produced rice husk pellets has fulfilled the Indonesian SNI 8021: 2014 standard (Table 1). The decrease in caloric value is thought to be due to the increased concentration of tapioca flour adhesive. The caloric value is better than the caloric value of acacia wood biopellet 3731.41-3810.4 cal/g [34], sengon wood biopellet 3556.03-3726.08 cal/g [34], and rice crop biopelet 3100-3400 cal/g [5]. The high caloric value in the pellet is influenced by the energy content in rice husks, water content, and fly ash content in the pellets [3].

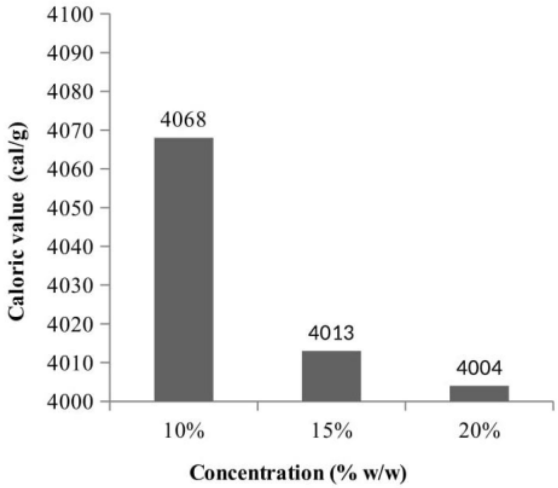

Figure 6. Caloric value chart for biopellet products

4 CONCLUSION

The best and suitable biopelet SNI 8021:2014 produced from variations in adhesive concentration of tapioca flour 10% with characteristics of a density of 0.8 g/cm^3, water content 8.18%, volatile matter content 65.82%, and caloric value 4068 cal/g except fixed carbon content 12% and fly ash content 14%.

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