Biomass Briquette as a Renewable Energy Alternative

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Abstract. Biomass waste can be found in many areas, this research used briquettes from tofu dregs and from spent coffee grounds. Spent coffee grounds are produced after someone drinks their coffee, and until now become waste. Several types of waste are produced in tofu production, one of which is tofu dregs. This research aims to determine whether the spent coffee grounds briquette and the tofu dreg briquette comply with the national energy source standard. The measurement parameters are density, water content, ash content, volatile matter, fixed carbon, and calorific value of spent coffee ground briquettes and tofu dreg briquettes. Briquette making is done by combining the biomass with additive material with several combinations. The results showed that spent coffee briquettes comply with the standard in parameter density, water content, ash content, and fixed carbon, while tofu dreg briquettes just comply with water content parameters.

Keywords: Tofu dregs, water content, ash content, volatile matter, calorific value

1 Introduction

Energy is a basic human need, but currently, the energy sources that are widely used are non-renewable sources, such as petroleum and coal. In 2018, around 114 million tonnes of oil equivalent (MTOE) was used, divided into the transportation sector at 40%, industrial sector at 36%, household use at 16%, commercial sector at 6%, and others at 2% [1]. The high use of energy from non-renewable energy sources gives strong consideration to obtaining the latest energy alternatives, especially from biomass.

In 2021, Indonesia was the fourth-largest coffee producer but had a very big increase in coffee consumption (74.000 kg in 1998 become 288.360 kg in 2019). Coffee cultivation is very promising since Indonesia is the second-largest coffee plantation in the world at a total of 1,192,000 Ha in the year 2018 spread over 34 provinces [2].

Biomass waste is often found on agricultural land or in industries that use agricultural product raw materials. One of the biomass wastes is often found in the tofu industry, considering that tofu uses soybeans as its raw material. Apart from that, tofu is a food that people like, so production is quite high and will continue to increase. According to the Central Bureau of Statistics, the average per capita consumption of tofu is 0.158 kg every week in 2021, and this amount is up 3.27% compared to 2020 which was 0.153 kg every week [3].

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There are tofu industrial centers in various places in Indonesia, one of which is in Bumiayu village, Brebes, Central Java. According to [4], the average weight of tofu dregs is 1.12 times the weight of dry soybeans, and the volume is between 1.5 to 2 times the volume of dry soybeans. Soybean production in 2009 was 972.95 thousand tons of dry beans, meaning that that year 1,089,704 tons of tofu dregs were produced, which is quite a high amount if utilized.

In this research, briquettes were made from spent coffee ground with tapioca and tofu dregs mixed with rice husks and tapioca, The objectives to be achieved were to determine the parameters of water content, ash content, volatile matter, and calorific value of spent coffee ground and tofu dregs briquettes that met the national standard of Indonesia.

2 Literature review

2.1 Spent coffee ground and tofu dregs

From 2014 to 2018, the average coffee production in West Java was 9,736 tons for Arabica and 8,1 tons for Robusta [5]. The Coffee residue is a byproduct of brewing ground coffee beans, whether through an espresso machine or a brewing process. The residue can be recycled in a variety of ways, such as bio-briquettes, bio-pellets, fertilizer, odor repellent, and beauty products [6].

Tofu dregs are solid waste obtained from the tofu-making process. The protein, carbohydrate, and mineral content in tofu dregs is significant enough to be reused. One reuse of tofu dregs is as animal feed [4]. Another material used in making briquettes in this research was rice husks. Rice husks are a waste that is often used as a material for making briquettes. Availability is also quite large, according to BPS, in 2021 rice production will be 54.42 million tons, and rice husks constitute 30% of rice production [7].

Biomass consists of various kinds of material from living organisms, both alive and dead. Biomass is the result of the photosynthesis process, where solar energy is used to convert carbon dioxide or CO_2 and water into compounds such as hydrogen, carbon and oxygen. One of the main advantages of biomass is its easy availability and positive impact on the environment, as well as its ability to be renewed [8]. The energy potential that can be taken from biomass generally comes from residues produced by the forestry, plantation and agricultural sectors. This waste material includes residues from plants such as rice, corn, cassava, forest wood waste, and waste materials from plants. coconut, sugar cane and palm oil. The total potential energy that can be produced from biomass waste in Indonesia is approximately 49,807.43 megawatts (MW). However, to date, the capacity for utilizing energy from newly installed biomass waste is around 178 MW, representing only around 0.36% of the actual potential [9].

2.2 Briquette making

Making briquettes begins with a carbonization process, namely turning the starting material into black carbon. The characteristic smoke at the carbonization stage is blue as an indication of the completion of the carbonization process [10]. The next stage is burning which will produce white ash, and before all the energy is released, the burning is stopped so that there is still energy left that can be used [11].

The resulting charcoal product is uniform in size with other materials, so that it can be mixed with other materials. After mixing, it is then molded into briquettes of uniform size. After the briquettes are molded, they are dried to reduce the water content, making the briquettes harder, more resistant to mold growth, and more physically stable [12].

The quality of the briquettes is expected to meet the briquette standards. Previously, the standard used was from the Indonesia Forestry Research and Development Agency year 1994, but changed in 2020 to use SNI-01-6235-2000. In the previous standard, there were 7 parameters (density, water content, ash content, volatile matter, fixed carbon, heat value, and compressive strength), but in the new standard just 4 parameters. The SNI-01-6235-2000 and the standard from Forestry Research and Development are shown in Table 1. In this research, SNI-01-6235-2000 was used to see the quality of the briquette.

Table 1. National Standard SNI-01-6235-2000 and Indonesia Forestry Research and Development Agency, 1994

SNI-01-6235-2000				Indonesia Forestry Research and Development Agency, 1994			
No	Parameter	Unit	Standard	No	Parameter	Unit	Standard
1	Water Content	%	Max 8	1	Water Content	%	Max 8
2	Ash Content	%	Max 8	2	Ash Content	%	Max 8
3	Volatile Matter	%	Max 15	3	Volatile Matter	%	Max 30
4	Calorific Value	Cal/g	Min 5000	4	Calorific Value	Cal/g	6000
				5	Density	gr/cm^3	Min 0.7
				6	Fixed Carbon	%	Min 60
				7	Compressive Strength	Kg/cm^3	12.0

3 Research method

This research uses a quantitative approach. The research objects are spent coffee grounds from cafes in Jakarta and tofu dregs produced from the home-based tofu industry in Bumiayu sub-district, Brebes Regency, Central Java. Sampling was carried out randomly, and data was collected through observation. In spent coffee ground experiment and tofu dreg experiment using 3 treatments with 2 replications. The treatment for the spent coffee ground experiment is the ratio of the use of spent coffee ground, tapioca, and water, namely 50:25:25, 50:17:33, and 34:22:44 respectively. The treatment for the tofu dreg experiment is a ratio of the use of tofu dregs, rice husks, tapioca, and water, namely 30:20:17:33, 25:25:17:33, and 20:30:17:33 respectively. Each briquette was made weighing 18 grams, and for each parameter measurement, a different briquette was used. The statistical analysis method was used to see the significant difference between the measurement and with standard and used ANOVA to see the difference among the treatments.

4 Result and discussion

4.1 Research Data

Parameter measurements used based on the previous standard, in the spent coffee ground experiment, measured 6 parameters, and in the tofu dreg experiment measured 7 parameters. The results of measurement from the spent coffee ground experiment are shown in Table 2 and from the tofu dreg experiment in Table 3.

Table 2. Data from spent coffee ground experiment

Sample	Density (gram)	Water content (%)	Ash content (%)	Volatile matter (%)	Fixed carbon (%)
A1	0.6625	5.2153	1.6688	93.7274	0.6116
A2	0.6441	4.6008	1.6995	94.2504	0.5506
B1	0.5819	3.8365	1.7798	95.0739	0.6903
B2	0.5776	3.8723	1.7886	94.9489	0.6097
C1	0.6105	7.5978	1.4089	91.4025	0.4092
C2	0.6186	6.9444	1.2995	92.1265	0.3704

Table 3. Data from tofu dreg experiment

Sample	Density (gram)	Water content (%)	Ash content (%)	Volatile matter (%)	Fixed carbon (%)	Calorific value (Cal/g)
A1	0.5952	5.1574	24.7839	50.0150	25.2011	4384
A2	0.5991	4.9725	24.9950	50.0849	24.9201	4301
B1	0.5502	4.3474	29.6108	41.2598	24.7820	4083
B2	0.5490	4.4578	29.4979	42.5072	23.5371	4075
C1	0.5839	3.6756	32.7669	37.9053	25.6522	3683
C2	0.5887	4.3478	32.6339	38.0667	24.9516	3884

From Tables 2 and 3, it can be seen that the water content value is still below 8%, the ash content value is lower than the standard for spent coffee ground briquette but greater than the standard for tofu dreg briquette, the volatile matter value is far above the standard, and the calorific value is below 5000 cal/g (just from Tofu dreg experiment). From these data, different tests can be continued using the t-test, for water content and ash content, while volatile matter and calorific value are too different from standard values.

From the t-test carried out on the water content parameters for spent coffee grounds and tofu dreg briquette, it was found that all treatments met the standards, it can be said that the water content was significantly less than 8%. For the ash content parameter for spent coffee ground briquette, the test has shown that the ash content from spent coffee ground briquette complies with the standard.

Making the briquette from biomass is still a challenge. Tables 4 and 5 show the t-test for water content and ash content from spent coffee grounds and tofu dreg briquettes. The briquettes did not comply with others' standards yet. Many improvements need to be made to get a good and comply to standard.

Table 4. T-test of water content

	Spent coffee ground		Tofu dreg	
	Variable 1	Variable 2	Variable 1	Variable 2
Mean	5.3445167	8	4.4930833	8
Variance	2.529652	0	0.2766024	0
Observations	6	6	6	6
Pooled variance	1.264826		0.1383012	
Hypothesized mean difference	0		0	
df	10		10	
t stat	-4.0896752		-16.33327	
P(T<=t) one-tail	0.0010902		7.693E-09	
t critical one-tail	1.8124611		1.8124611	
P(T<=t) two-tail	0.0021803		1.539E-08	
t critical two-tail	2.2281389		2.2281389	

Table 5. T-test for ash content from spent coffee grounds briquette

	Variable 1	Variable 2
Mean	1.6075167	8
Variance	0.0418024	0
Observations	6	6
Pooled variance	0.0209012	
Hypothesized mean difference	0	
df	10	
t stat	-76.585132	
P(T<=t) one-tail	1.759E-15	
t critical one-tail	1.8124611	
P(T<=t) two-tail	3.518E-15	
t critical two-tail	2.2281389	

5 Conclusion

The conclusion of this research shows that the spent coffee ground briquettes comply with the water content and ash content standard, while tofu dreg briquettes only comply with water content.

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