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Study on the Use and Composition of Bio-Charcoal Briquettes Made of Organic Waste

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ABSTRACT

The purpose of this research is to identify the ideal composition of bio-charcoal briquette made of organic waste on heat production. The employed method involved an experiment with a sample briquette with the weight of 120 g obtained using a simple random sampling technique, consisting of 4 treatments with 5 repetitions, i.e. treatment 1 (50% leaf: 40% twig: 10% paper), treatment 2 (60% leaf: 30% twig: 10% paper), treatment 3 (70% leaf: 20% twig: 10% paper), treatment 4 (80% leaf: 10% twig: 10% paper). The results showed that there was different composition variety of organic waste forming the briquette on the heat value (p value = 0.001 ≤ 0.05). Organic waste composition that was most effective in making bio-charcoal briquettes was in the treatment 1 with briquette's heat value was 4.632 cal/g – 5101 cal/g, with initial temperature of 28°C and final temperature of 85°C and time length needed to become ash was 67 minutes.

Keywords: bio-charcoal briquettes, heat value, temperature, time length, composition, organic waste.

INTRODUCTION

Many industries have not maximized their waste sector potency (Fikri et al., 2016), especially organic waste. PT. Asia Pacific Fibers (PT. APF) located in Karawang Indonesia has an area of 50 ha with an open area of ± 25 Ha (APF, 2017).

On the basis of the data from PT.APF, the waste generated from PT. APF was derived from industrial production activities, office activities, and nature (falling leaves, twigs in industrial areas). Data observed for 8 days, the waste generation at PT. APF was as high as 4.9 m^3/day, weighing 193.33 kg/day (APF, 2017). The concept of waste processing that is still used by PT APF is the old paradigm with the end-of-pipe approach that is to manage waste with the collecting – transporting – casting off (Fikri et al., 2015).

Briquette is a solid produced through the process of forging and pressurizing and if burned, it will produce a small amount of smoke. Charcoal briquette or bio-charcoal is charcoal processed with a pressing system using adhesive, so that a briquette –shape can be obtained for use. Briquettes have an economical advantage because they can be produced in a simple process, have high heat value, and the raw materials are readily-available in the industry, enabling to compete with other fuels (Rafsanjani et al., 2012).

An important factor in briquette production is to pay attention to the material composition, since it will affect the absorption of water content, ash content, and the quality of resulting heat value (Thoha et al., 2010). Heat value is a fuel property that expresses the energy content of the fuel. Heat value of a fuel can be determined by testing and estimating, based on the composition. Determination of the heat value also enables to identify the burning heat value of a material. The heat value of a material is influenced by water and ash contents and closely related to fixed carbon content. Low levels of water and ash contents will increase the heat value of a material. On the other hand, high levels of fixed carbon in the material will increase the heat value.

MATERIAL AND METHODS

The design used in this study was an experiment with Post-test Without Control research design (Sugiyono, 2009). The utilized sample involved making variation of organic waste composition (leaves, twigs, papers) and then testing the heat value on the briquette. Some of the controlled variables in this study were:

Sample design

The sample design was randomized sampling, which is part of the organic waste generated by PT APF. The sample size was adjusted to the number of treatments, i.e. 4 treatments with 5 repetitions (Gomez, 2007). Therefore, the total mass of organic charcoal waste used was 2000 grams and total starch used was 20% of the total volume of organic charcoal waste (400 grams). The following table compares the sample number from each composition of organic waste:

Data collecting tools and research procedures

The tools used in collecting the research data are:

a) Scales to measure the weight of organic waste, starch, and briquettes.
b) Calorimeter bomb to measure the heat value of briquettes.
c) Firing temperature thermometer to measure the temperature of the briquettes and the banding process.
d) Mercury thermometer to measure the temperature of the cooking water using briquettes.

The research procedure began with process of carbonization of organic waste materials (leaves, twigs, papers) which were turned into charcoal and then poured and sieved using 40 mesh size. The next step was to make briquette dough based on the briquette composition in which the heat value had been determined and tested by ASTM D 5856 method (BSN, 2000).

RESULTS AND DISCUSSION

Briquette heat value

The data in Table 3 shows that the heat value of briquettes has fluctuated. The lowest heat value was found on the organic waste composition of 80% Leaves: 10% Twigs: 10% Paper, which equals to 4632 cal/g, while the highest heat value of briquettes was found in the organic waste composition of 50% Leaves: 40% Twig: 10% 5101 cal/g and with an average heat value of 4881.40 cal/g.

Thermal process temperature

On the basis of the results from burning the organic waste into charcoal and carbonization

Table 1. Confounding variables of and the control

No	Confounding variables	Control of the confounding variables
1	Various types of leaves, twigs, papers	Dry when sorting of various types of organic waste materials
2	Carbonization process	During the carbonization, it should be kept in the absence of air with temperatures above 150 °C
3	Briquette shape	Cylindrical briquettes and adjusted with press tools
4	Various types of starch	Use type starch made of flour
5	Type of briquatte	Use a fine briquette type with 40 mesh sieving

Table 2. Comparison of organic waste samples composing briquette

Treatment	Daun, %	Leaf, g	Twig, %	Twig, g	Paper, %	Paper, g	Charcoal weight, g	Total of starch flour, g	Total of treatment, g
LTP 1	50	50	40	40	10	10	100	20	600
LTP 2	60	60	30	30	10	10	100	20	600
LTP 3	70	70	20	20	10	10	100	20	600
LTP 4	80	80	10	10	10	10	100	20	600
Total									2400

Notes: LTP – leaves, twigs, papers.

Figure 1. Organic waste carbonization process

Figure 2. Pressing briquettes with pressing tool

carried outfor 8 hours, it was fund that the minimum temperature value was 143°C for burning leaves, and the maximum temperature was 220°C in the case of burning twigs, with the average temperature ranging from 162.22 °C to 199.67 °C (Table 4). This shows the difference in the temperature of carbonization process in the drum due to the difference in the type of material used in the carbonization process. Another research conducted by Pari et al. (2013) in the experimental

Figure 3. Charcoal sieving with 40 mesh size

Figure 4. Bio-charcoal briquettes

Table 3. Briquette heat value

Variable (%)	N	Mean, cal/g	Std. Deviation	Minimum, cal/g	Maximum, cal/g
50L; 40T; 10P	5	5055.4	±31.801	5022	5101
60L; 30T; 10P	5	4975.2	±32.538	4953	5032
70L; 20T; 10P	5	4804.6	±62.280	4724	4890
80L; 10T; 10P	5	4690.4	±53.910	4632	4774
Total	20	4881.4	±152.641	4632	5101

Table 4. Temperature measurement in organic waste carbonization process

Organic waste	Measurement, °C			Temperature mean, °C	Temperature max, °C	Min temperature, °C
	I	II	III			
Leaf	144	199	143	162	199	143
Paper	156	212	154	174	212	154
Twig	185	220	194	200	220	185

study on the Combination Test of Combined Coconut Milk and Coconut Shredded Fuel As an Alternative Fuel, indicates that the carbonization (pyrolysis) process is the decomposition of biomass (lysis) into heat (pyro) at the temperature over 150°C using different types of materials.

On the basis of the result of weighing organic waste experiment before and after becoming charcoal, it was observed that the burning shrinkage was 82.78% to 88% with percentage of becoming charcoal of 11.35% to 14.08% (Table 5). The results of research conducted by Supriyatno (2010) indicate that during the process of carbonization, the higher the heating temperature, the more time isrequired and the more non-carbon substances are reduced, resulting in smaller charcoal weight. The results of this study are strengthened by the results of the research conducted by Tirono et l.. (2012) on the Effect of Temperature on the Carbonization Process on Coconut Shell Charcoal Heat Value, which explains that the decrease of material mass caused by heating results in material decomposition or the release of easily evaporated compounds.

According to Toha et l.. (2010), carbonization of biomass is a process to increase the heat value of biomass and produce clean combustion with a bit smoke. Carbonization results in the formation of charcoal which is black and composed of carbon. This indicates that the lagging mass and the amount of charcoal obtained decrease as the carbonization temperature increases.

According to Supriyatno et l.. (2010), heating leaves with high temperature will produce a low weight of charcoal because many green leaf substances are burned. During the heating of leaves using pyrolysis, the higher the temperature, the faster the combustion process. Carbonization on twigs produces less charcoal, and at the temperature of 300°C, it requires a relatively short period of time. The resulting charcoal color is black and the charcoal becomes very soft after being smoothed.

According to Borowski et al. (2017) two types of binders were repeatedly used to produce briquettes of native wheat starch and modified wheat starch, at 8% of the whole. The combustion test showed quite different burning properties. Briquettes should be characterized by short firing up time and lower smokiness, as well as high maximum temperature and long burning time. In this research it was concluded that briquettes with native wheat starch used as a binder are more appropriate for burning in the grill.

On the basis of the results described in Figure 5 and reference to Indonesian National Standard (SNI) no. 01–6235–2000 regarding minimum qualified heat value (5,000 cal/g), treatment 1 with

Table 5. Measurement of organic burned waste

Type of waste	Initial weight, kg	Charcoal weight, kg	Burned weight, kg	Burned percentage, %	Percentage of becoming charcoal, %
Leaf	9.74	1.10	8.64	85.91	14.08
Paper	10.60	1.82	8.77	82.78	17.21
Twig	30.83	3.50	27.33	88.64	11.35

5 repetitions indicates that the briquette quality with heat value meets SNI requirement in 100%.

The results of various differences between organic waste composition of leaves, twigs, and papers and heat values are influenced by each composition. The composition with the highest heat value is obtained from treatment 1 that comprises 50% Leaves: 40% Twigs: 10% Papers, the heat value at the treatment 1 is at least 5,022 cal/g and the maximum heat value is 5,101 cal/g (which meets SNI requirements). This is due to a greater share of twigs in the composition , which is in accordance with research conducted by Damanhuri et al. (2016) who explain that the heat value of twigs is 4716 cal/g, heat value of leaves is 3998 cal/g, and heat value of paper is 3024 cal/g. On the other hand, the research conducted by Gandhi (2010) states that the heat value of wood is greatly affected by carbon, lignin, and resin substances, while the cellulose content of wood is not so influential. Therefore, the higher the share of twig (wood) in the composition, great er the value of the resulting heat .

Bivariate test results

On the basis of the analysis results using one way Anova, the obtained F value is 61.323 and P value is 0.001 (α = 0,05) (Table 6). This shows that there is a difference between various composition of organic waste composing briquette and the heat value briquettes produced.

The comparisons of Post Hoc test results indicate that p-value was <0.05 in all treatments, so it can be assumed there are differences in all treatments (Table 7). The largest mean difference value is in the treatment 1 compared to the other treatments, meaning that the treatment 1 gives the greatest effect.

Briquette usage try outs

On the basis of the briquette usage for boiling water in the pan, it was fund that the briquette 1 indicates a temperature of 450°C, briquette 2 indicates a temperature of 419°C, briquette 3 a temperature of 407°C, and the fourth briquette showed a temperature of 401°C (Figure 6). Hence, the organic waste briquette that was characterized by the highest temperature was briquette 1 with heat value of 5101 cal/g. The results also showed that the briquettes used in treatment 1 during water boiling had the initial temperature of 28°C and the final temperature was 88°C, the briquette 2 had the initial temperature of 28°C and the final temperature was 82° C, briquette 3 had initial temperature of 28°C and the final temperature was 85°C, whereas the briquette 4 had initial temperature of 28°C and the final temperature was 79°C. Therefore, the organic waste bri-

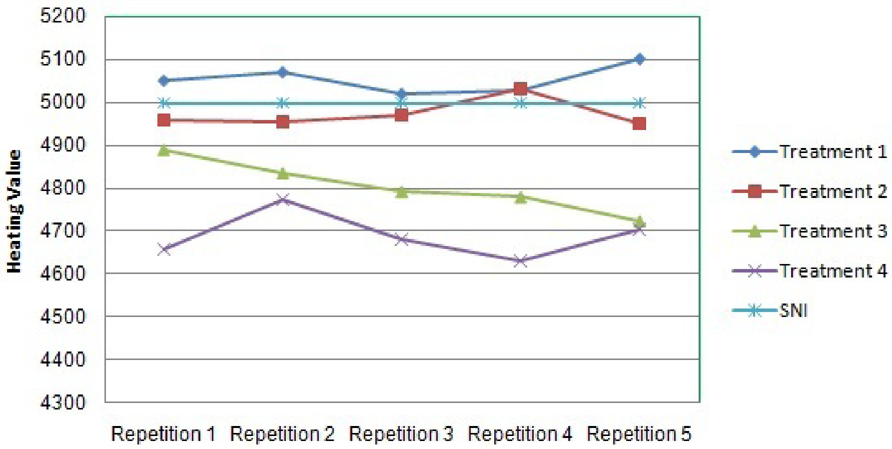

Figure 5. Briquettes with heat value meets Indonesia National Standard (SNI)

Table 6. Results of one way Anova data analysis

Variable	SD	95% CI	Min – Max	p-value	F
Treatment 1	31.801	5015.91 – 5094.89	5022–5101	0.001	61.323
Treatment 2	32.538	4934.80 – 5015.60	4953–5032		
Treatment 3	62.280	4727.27 – 4881.93	4724–4890		
Treatment 4	53.910	4623.46 – 4757.34	4632–4774		

Table 7. Results of multiple comparisons Post Hoc data analysis

Variable		Mean difference	P value
Treatment 1	Treatment 2	80.200*	0.016
	Treatment 3	250.800*	0.001
	Treatment 4	365.000*	0.001
Treatment 2	Treatment 1	-80.200*	0.016
	Treatment 3	170.600*	0.001
	Treatment 4	284.800*	0.001
Treatment 3	Treatment 1	-250.800*	0.001
	Treatment 2	-170.600*	0.001
	Treatment 4	114.200*	0.001
Treatment 4	Treatment 1	-365.000*	0.001
	Treatment 2	-284.800*	0.001
	Treatment 3	-114.200*	0.001

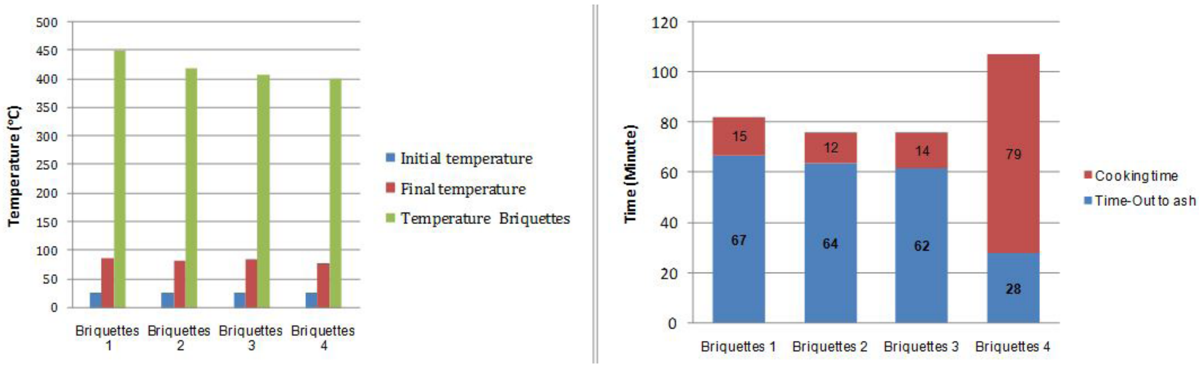

Figure 6. Temperature observation result (°C), time (minute) during the briquette usage try outs using water boiling method

quette that had the highest temperature was briquette 1 because the composition of twig (wood) is more dominant.

The results also explain that during the boiling of water, using briquettes with a volume of 500 ml for each aluminum pot, in the case of treatment 1, briquette 1 could boil the water for 15 minutes while the length of time needed for the briquette turn to ashes was 67 minutes, treatment 2 for 12 minutes and was reduced to ashes after 64 minutes, treatment 3 for 14 minutes and turned to ashes after 62 minutes, and treatment 4 for 23 minutes and reduced to ashes after 93 minutes. The briquette with treatment 1 showed the best quality because of the maximum temperature that can be reached and the ideal time length needed to turn to ashes. The results of the research conducted by Arni et al. (2014) on the Study of Physical Characteristics of Bio-Charcoal Briquettes as Alternative Energy Sources – investigating the physical comparison tested from the combustion of bio-charcoal briquette – indicated that the cylindrical shape enables to achieve maximum temperature, and the time required to turn into ideal ash, which is reviewed based on the combustion test.

CONCLUSIONS

1. The utilization of organic waste produced in PT.APF is used as bio-charcoal briquettes.
2. There is a significant difference from various composition of briquette organic waste to the heat value (p value = 0.001 ≤ 0.05).
3. Composition of organic waste that is most effective in the production of charcoal briquettes is the treatment 1 with variations of 50% leaves: 40% twigs: 10% paper, with heat value of 4632 cal/g – 5101 cal/g (corresponding to the standard value of briquette in Indonesian National Standard).
4. The results of try outs using briquettes with the boiling water show that composition 1 is characterized by the initial temperature of 28° C and the final temperature of 85°C with the time required to turn to ash amounting to 67 minutes.

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