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Production and Characterization of Briquette from Low–Density Polyethylene waste, Empty Fruits Bunches and Used Cooking oil

Dhani Erlinda Novera[1], Ismiyati[2*], Mohammad Kosasih[3]

[1,2,3]**Master's Program of Chemical Engineering, Engineering Faculty, Universitas Muhammadiyah Jakarta Indonesia**

Abstract : Briquette is one of alternative energy source which made from biomass and is potential to sustitute the fossil fuels. Both empty fruit bunches (EFB) and low density polyethylene waste (LDPE) have high calorific value which is potential to be used as the source of briquette raw material. The objective of this study is to determine the optimal pressure and composition of briquette from the mixture of EFB and LDPE. Briquette production was done by variating the composition of EFB and LDPE as follows: 95/5, 90/10, 85/15, 80/20, 75/25 % (weight/weight). EFB was first carbonated under 300°C and the charcoal was pounded and mixed with small pieces of LDPE. The mixture was homogenized with starch adhesive in 10% concentration. The briquetting pressure was variated as follows: 2000, 3000, 4000, 5000 and 6000 Psia. After pressing the mixture, the briquette was soaked in used cooking oil for 30 mintues. Each stamped briquette was examined physically and tested for its calorific value. The result of statistical analysis using ANOVA shows that the best quality of briquette was obtained from 75/25% composition of EFB/LDPE with briquetting pressure of 3000 Psia. The characteristics of briquette was having 1,2% water content, 7000 calorie/gram calorific value, 5-7% ash content and 40-70% fixed carbon besides the effect of carbonization process under 300°C, starch content as the adhesiveand used cooking oil as the immersed liquid.

Key words : briquette, calorific value, EFB,LDPE, used cooking oil.

1. Introduction

As the number of population increases, the usage of fossil fuels as main energy source to support human activity is also increasing. Whereas, the number of fuel reserve is predicted to last for only a few decades. Briquette is potential to become one of the alternative source of energy, especially as household source of energy.

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Low density polyethylene (LDPE) is one of a thermoplastic which made from crude oil as the main composite. LDPE plastic is one of the easiest plastic to stamped when exposed to heat and pressure. LDPE plastic is one of the plastic which has low hazard level. LDPE is potential to be stamped as briquette, because it has high calorific value which is 11.758 cal/gram [1]. Oil palm empty bunches (EFB) is the bunches that already separated from oil palm flesh. EFB is one of biomass waste which is abundant in nature. EFB is also potential to be stamped as briquette with heat energy value of 18.795 Joule/gram or 4.489 cal/gram [2]. Briquette production was done by carbonizing EFB and then mixing the EFB charcoal with LDPE plastic waste and 10% starch to glue the particles in the mixture [3]. After that, the mixture was stamped with determined pressure. Used cooking oil is a household waste, which is often thrown away and not be recycled. Used cooking oil can be utilized for immersing the briquette after it is stamped. Immersion process was done to prevent the briquette from absorbing the water in nature [4].

To obtained high quality briquette, there is a need to determine optimal pressure and EFB to LDPE composition (%w/w). To determine the briquette quality, each briquette was undergo a characterization assay by examining main quality parameter such as briquette's water content, calorific value and fixed carbon. Whereas, another quality parameter was volatile matter content adn ash content. The result of characterization assay was then compared with briquette characteristics standard from goverment statue regarding national standard of briquette characteristicsSNI No. 1/6235/2000.

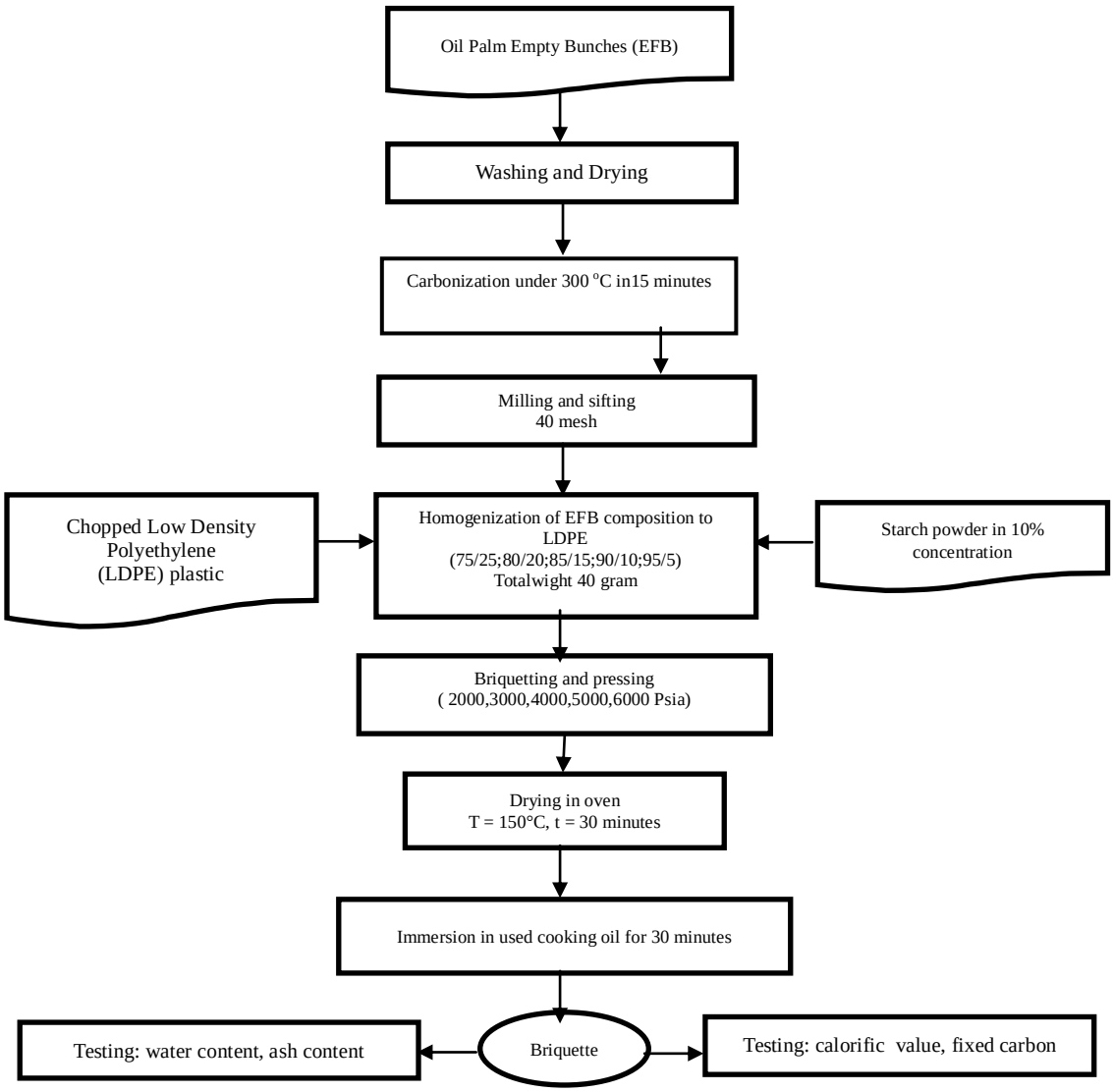
Previous studies show that the more LDPE plastic was added to the briquette, the higher calorific value and fixed carbon will be obtained. In contrast, the more LDPE plastics was added to the briquette, the lower water content and ash content will be obtained [5].

2. Methods

2.1. Procedure

Briquette production was done by carbonization process of EFB and LDPE plastic waste. There is a need to add adhesive during briquette production to glue particles of raw materials [3]. The briquetting process was done by specific pressure. Stamped briquette was then immersed in used cooking oil.

This research was done by variating the composition of EFB to LDPE. The composition of EFB to LDPE was variated as follows: 95/5, 90/10, 85/15, 80/20, and 75/25 (% w/w). The briquetting pressure of briquette was variated to 2000, 3000, 4000, 5000 and 6000 Psia. The adhesive in briquette production was starch powder diluted in water with 10% concentration. Stamped briquette was then immersed into used cooking oil for 30 minutes. After that, the characterization assay was done with briquette's water content, calorific value, ash content and fixed carbon as the parameters. Figure 1 shows the flow chart of briquette production.



Picture 1.Flow chart of briquette production and characterization

2.2. Data analysis

In this study, the two-way analysis of variance (ANOVA) was used to analyzed the assay result. Independent variable of this study was the composition of EFB to LDPE and the briquetting pressure. Dependent variable of this study was water content, calorific value, ash content and fixed carbon content. The data and graphs was processed using GraphPad Prism 9.0.0 software. Significance level (α) in this study was set in 5%.

Table 1. Two-way ANOVA calculation

Variance source	df	SS	MS	Calculated F
Between block	r-1	SS_B	$MS_P = \frac{SS_B}{r-1}$	$\frac{MS_B}{MS_E}$
Between treatment	t-1	SS_P	$MS_P = \frac{SS_P}{t-1}$	$\frac{MS_P}{MS_E}$
Within treatment (error)	(n-1)-(k-1)-(t-1)	$SS_E = SS_T - SS_B - SS_P$	$\frac{SS_E}{(r-1)-(t-1)}$	
Total	n-1	SS_T		

If the calculated F value is smaller than the F statistic value then the Ho is accepted which means the

average number of two treatment were not different significantly. Whereas if the calculated F value is higher than the F statistic value, the Ho is rejected and H1 is accepted. This means the average of both treatment were different significantly.

3. Result and Discussion

Table 2. Two-way ANOVA result is presented as below

Dependent Variable	Independent Variable	P-value	Significance
Calorific value	Pressure	<0.0001	Yes ****)
	Composition	<0.0001	Yes ****)
Water content	Pressure	<0.0001	Yes ****)
	Composition	<0.0001	Yes ****)
Ash content	Pressure	0.0195	Yes *)
	Composition	<0.0001	Yes ****)
Fixed carbon	Pressure	0.5710	No
	Composition	0.1285	No

Note: ****) = P-value < 0.0001
*) = P-value < 0.05

From the results showed in Table 2, it can be concluded that composition and pressure variance have significant effect to calorific value, water content and ash content. Whereas, variance in composition and pressure were not giving significant effect to fixed carbon content.

3.1. Water Content Analysis

Water content is one of the important parameter to determine the quality of briquette. Briquette will have higher quality if the water content is low. Figure2 shows the effect of EFB composition to LDPE and the effect of briquetting pressure to briquette water content.

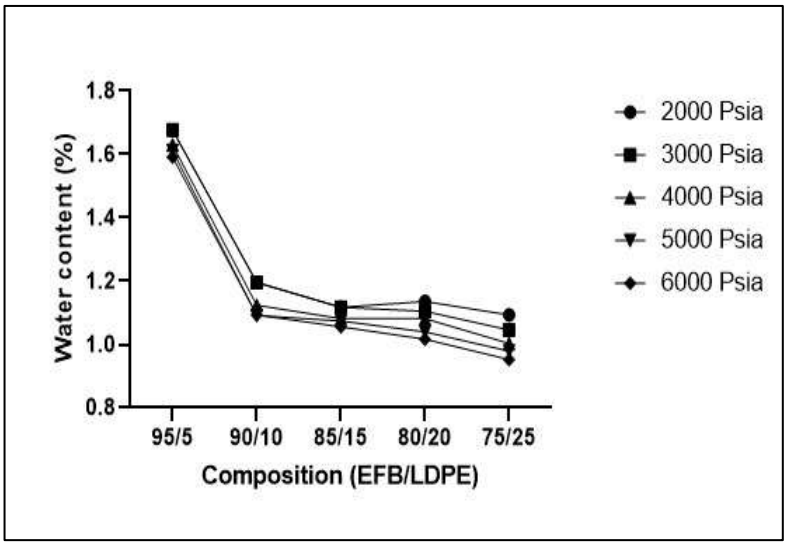


Figure 2.The correlation betweenEFB to LDPE composition and briquetting pressure to briquette water content

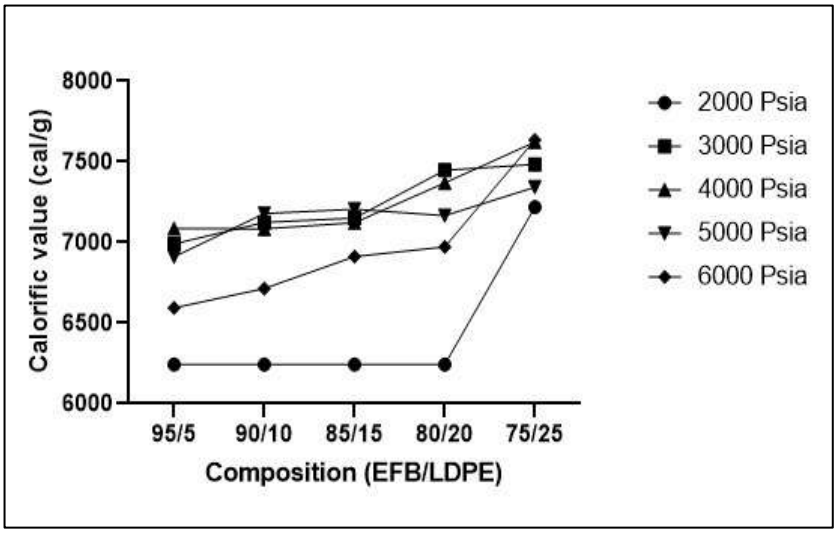
Table 2 and Figure 2 shows that composition variation of EFB to LDPE and briquetting pressure variation have significant effect to water content with <0.0001 p-value for each variable in 5% significance level. Water content in briquette has a tendency to decrease as the EFB and LDPE composition in briquette decrease. Water content also has a tendency to decrease as the briquetting pressure increases. The reason behind

those tendency were the big particles of LDPE plastic, which reduce the water content level. Pressure that was given in briquetting process, is also decreasingbriquette's water content significantly (p-value <0.0001) because it increases the briquette density.

The lowest briquette water content was obtained from 75/25 EFB to LDPE composition, with 3000 to 6000 Psia briquetting pressure. The water content with those characteristics was under 1,2%. The assay result of briquette water content was qualified compared to SNI 01-6235-2000 regarding quality standard of burning briquette coal, with $\leq$ 8% of water content as the standard.

3.2. Calorific ValueAnalysis

Calorific value is one of the quality parameter for briquette quality. The higher the heat produced, the higher the quality of the briquettes.



Picture 3. The correlation between EFB to LDPE composition and briquetting pressure tobriquette calorific value

Table 2 and Figure 3 shows the variation of briquetting pressure and EFB/LDPE composition which significantly affect briquette calorific value, with p-value <0.0001 for both under 5% significance level. Increasing number of calorific value was affected by the decreasing number in water content. Calorific value of briquette will become higher when the water content is low. The other factor that affect calorific value of briquette is its ash content. The lower the number of ash content in the briquette, the higher number of carbon is in the briquette. Calorific value also tend to be higher by the addition of LDPE plastic and used cooking oil.

The highest calorific value obtained in 75/25 composition of EFB to LDPE with pressure range between 3000 to 6000 Psia which was 7000 cal/gram. The resukt of this calorific value assay had meet the quality requirement of SNI 01-6235-2000 regarding quality standard of burning briquette coal, with $\geq$ 5000 cal/gram of calorific value as the standard.

3.3. Ash Content Analysis

Ash content is the combustion residue which does not have any carbon content. Anorganic substances content which can not be burned will remain as the ash. Ash content can be determined by calculating the ratio of remaining material with burned material. Ash content is one of the briquette quality parameter

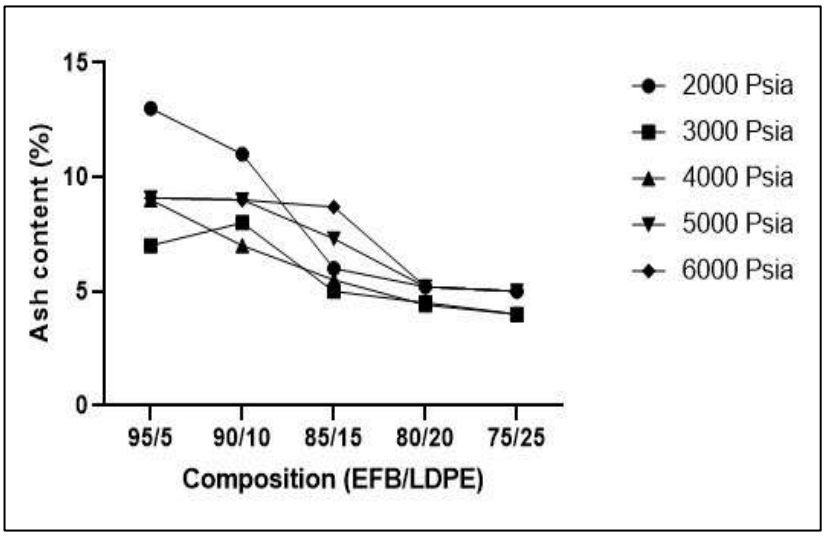


Figure4.The correlation between EFB to LDPE composition and briquetting pressure to briquette ash content

Table 2 and Figure 4 shows that the variance of EFB to LDPE composition gives significant effect to briquette as content with <0.0001 p-value under 5% significance level. In the other hand, briquetting pressure variable gives less significant effect to briquette ash content, with 0.0195 p-value. As the ratio of EFB to LDPE increases, the anorganic substances is decreasing until complete combustion happen. Ash content is also affected by the adhesive in briquette production process.

The most suitable ash content was determined in 75/25 EFB to LDPE composition and 1000 to 6000 Psia briquetting pressure, which was 5-7%. The result of ash content assay had meet the quality requirement of SNI 01-6235-2000 regarding quality standard of burning briquette coal, with $\leq$ 8 % of ash content as the standard.

3.4. FixedCarbon Analysis

Fixed carbon is the bonded carbon fraction in briquette coal beside the water fraction, volatile matter and ash.

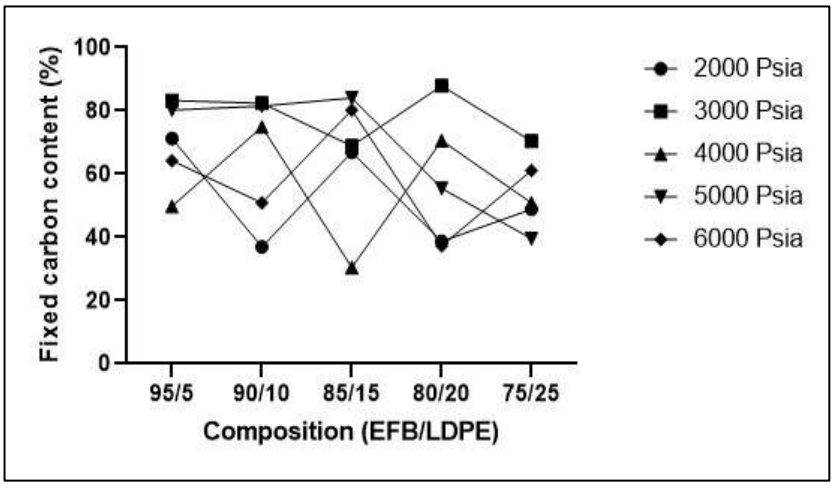


Figure5.The correlation between EFB to LDPE rasio and briquetting pressure to fixed carbon content

Table 2 and Figure 5 shows that both the variance of EFB to LDPE composition and briquetting pressure did not give significant effect to fixed carbon content of the briquette. The p-value of both variable was >0.05, which was 0,5710 for FEB to LDPE composition variable and 0,1285 for briquetting pressure variable. The result is coherent with ash content assay result where the carbon content in briquette coal is affected by ash

content and volatile matter content. Carbon coal content will have a high value if the ash content and the volatile matter content in the briquette are low.

High fixed carbon content will affect the calorific value of the briquette. As the carbon content increases, the calorific value of the briquette will also increase. Fixed carbon content is also affected by carbonization process. The factor that affect it was the temperature during the carbonization process. However, the result of fixed carbon content in both composition and briquetting pressure variable is still in the range between 40-70%. The result of briquette ash content had not meet the quality requirement of SNI 01-6235-2000 regarding quality standard of burning briquette coal, with ≥ 77 %of fixed carbon content as the standard.

From several characteristics assay of briquette production, it can be concluded that the variance of composition has an effect to the briquette product quality. The lower the EFB component or the higher the content of LDPE, the higher the quality of produced briquette. Whereas, optimum briquetting pressure was observed in 3000 Psia. The most qualified briquette was observed in 75/25 EFB to LDPE composition with 3000 Psia briquetting pressure, beside the effect of carbonization process under 300 ^{o}C, starch content as the briquette adhesive and used cooking oil as the immersion liquid. The produced briquette had meet the requirement ofSNI No.1/5235/2000 regarding quality standard of briquette and government statue of ESDM (PERMEN ESDM) No. 47 Year 2006 regarding production procedure and utilization of coal and coal based solid fuel. The quality standard parameter from both statue is presented in Table 3.

Table 3. Briquette quality standards

Briquette characteristics	**PERMEN ESDM No.47 Year 2006**	**SNI No.1/6235/2000**
Moisture (%)	≤ 15	≤ 8
Ash (%)	≤ 10	≤ 8
Volatile Matter (%)	As the raw material	≤ 15
Fixed Carbon (%)	As the raw material	≥ 77
Calorific value(cal/g)	4400	≥ 5000

4. Conclusion

Based on the briquette characteristics assay, it could be concluded that the composition which mostly affect the briquette quality was the composition with 75/25 EFB to LDPE. The lower the number of EFB composition, or the higher the number of LDPE in the briquette, the higher the quality of the produced briquette. The optimum condition for other parameter was 3000 Psia for the briquetting pressure, 1,2% for the briquette water content, 7000 cal/gram for the calorific value, 5-7% for the ash content and 40-70% for the fixed carbon content. The other parameter that also affecting the quality in briquette production were the temperature which was 300 ^{o}C, the usage of starch as adhesive and used cooking oil in the immersion process. Produced briquette had meet the requirement of SNI No.1/5235/2000 regarding quality standard of briquette and government statue of ESDM No. 47 year 2006 regarding production procedure and utilization of coal and coal based solid fuel.

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