Effect of pieces size of Empty Fruit Bunches (EFB) on composting of EFB mixed with activated liquid organic fertilizer

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Abstract. This research was to determine the effect of pieces sizes of oil palm empty fruit bunch (EFB) on the composting of EFB mixed with activated liquid organic fertilizer (ALOF) in a basket composter in order to obtain high quality compost. The composting process was started by cutting the EFB into pieces with varies sizes, inserting the EFB pieces into basket composter (33 cm W × 28 cm L × 40 cm H), and adding ALOF until moisture content (MC) in the range of 55-65%. During composting, the compost pile was turned every 3 days and the MC was maintained at 55-65% range by adding the ALOF. The sizes of the EFB pieces were varied into <1, 1-3, 4-7, 8-11, and 12-15 cm. The parameters analysed during the composting were temperature, pH, MC, compost weight, water holding capacity (WHC), CN ratio, and the quality of the final compost. Composting was carried out for 40 days and the best result obtained at EFB pieces size was 1-3 cm with compost characteristic were pH 9.0; MC 52.59%; WHC 76%; CN ratio 12.15; N 1.96%; P 0.58%; and K 0. 95%.

1. Introduction

Oil palm plantations have become the most important economic contributor in Indonesia. However, in the processing of fresh fruit bunches (FFB) at palm oil mill (POM), besides producing palm oil and palm kernel, also produced by-product of liquid and solid waste. For every ton of treated FFB will be produced about 0.6 to 0.87 m^3 of liquid waste (or 2.4 to 3.7 tons of liquid waste per tonne of palm oil produced) [1] with biological oxygen demand (BOD) 20,000-25,000 mg/L, chemical oxygen demand (COD) of 40,000-50,000 mg/L, and pH 3.8 to 4.5 [2,3]. In addition, for every ton of TBS processed, POM also generates large amounts of solids wastes such as empty fruit bunch (EFB) (23%), shell (5%), and mesocarp fiber (12%) [4,5].

Before 1996, EFB was burned in an incinerator to ashes. The ash of EFB can be used as fertilizer, because its potassium content is relatively high ± 30%. However, to prevent air pollution, the EFB combustion process is prohibited through Minister of Environment Decree number 15 of 1996 on the blue-sky program [6].

Today, most EFB is used as mulch on oil palm lands by placing EFB around the oil palm tree. Although the existence of mulch is useful to control weeds, maintain moisture and prevent soil erosion but its utilization is costly for labor and transportation [7]. Moreover, the processes of composting of mulch take a long time depending on environmental factors. Therefore, EFB should be composted before being spread to the field, or distributed to the farmers. Compost will also become potential products when used for the cultivation of ornamental plants [6].

Composting is a means to change various organic wastes into products that can be used safely and profitably as a biological fertilizer. The main function of the compost is to help improve the physical, chemical and biological of soil. Physically, compost can loosen the soil, compost application into the soil increase the number of cavities so that the soil becomes loose. While chemical properties capable addressed by the application of compost is increasing the cation exchange capacity (CEC) of the soil and can increase the ability of soil to water retain (water holding capacity). As for the improvement of biological characteristics, the compost can improve soil microorganism populations [8]. The composting process are influenced by number of factors such as nutrients, CN ratio, size of the compost material, temperature, pH, water content, and turning frequency [6,9].

Several studies have been conducted to process EFB into compost by mixing it with additional materials such as manure [10] or palm oil mill effluent (POME) [11]. This research used activated liquid organic fertilizer (ALOF) as alternative additional materials as it is also used by Trisakti et al [6]. ALOF is product of advance fermentation of treated biogas effluent from methanogenic anaerobic digester, which still has high nutritional and microbial sources. Hence, mixing EFB with ALOF in the basket composter might enrich the compost material with high nutrient and microbial sources [6]. Therefore, the aim of this research is to determine the effect of EFB pieces sizes on the rate of composting of EFB mixed with ALOF in a basket composter.

2. Materials and Methods

2.1. Materials

Main materials in this research were EFB and ALOF. EFBs were obtained from Rambutan POM, Sumatera Utara, Indonesia. The EFB was shredded and cut to varied size of <1, 1-3, 4-7, 8-11, and 12-15 cm. While, ALOF were liquid product from methanogenic anaerobic digestion obtained from USU - Biogas Pilot Plant, Pusdiklat LPPM, USU, Medan, Indonesia. Characteristics of EFB and ALOF are presented in Table 1.

Table 1. Characteristic of EFB and ALOF

Parameters	Unit	EFB	ALOF
Moisture	(%)	43.83	-
pH	-	9.00	8.09
C	(%)	33.15	0.58
N	(%)	0.99	0.10
C/N	-	33.48	5.80
WHC	(%)	62.00	-
P_2O_5	(%)	-	0.016
K_2O	(%)	-	0.167
COD	mg/l	-	1,580

2.2. Equipment

Main equipment of this research was basket composter same as used by Trisakti et al [6]. Composter is a holes plastic basket that is usually used as a laundry basket. Inside of the basket is covered with perforated carpet in order to control the influx of oxygen and to release the gases as composting product. The front side of composter is equipped with three holes, which are used for sampling and temperature measurements. The detailed sketch of the composter has been presented in Trisakti et al [6].

2.3. Composting Process

Composting process was started by shredding and cutting EFB to size of The EFB was shredded and cut to varied size of <1, 1-3, 4-7, 8-11 and 12-15 cm, measuring the weight of total EFB, and putting into the composter. Next, ALOF was poured and mixed until the moisture content of compost reached 55-65% and maintained at that value range during the composting proceed. During the process, compost pile was turned every three days in order to reduce and equalize the moisture content.

2.4. Sampling and Data Collection

Sampling was carried out by collecting approximately 20 g of composting materials through sampling holes. Meanwhile, temperature measurement was performed by inserting digital thermometer through thermometer holes. Data collected during the experiment were temperature, moisture content (MC), pH, CN ratio, and compost quality. Temperature measurement was performed twice a day, in the morning and afternoon. Moisture content was determined everyday by drying oven method. pH was measured every two days. Content of C and N were determined on days 0th, 40th, and 60th, by Walkley & Black and Kjeldahl methods.

3. Results and Discussions

The composting process of EFB from palm oil mill was carried out by shredding and cutting EFB to varied size of <1, 1-3, 4-7, 8-11, and 12-15 cm and then mixing with ALOF. Composting process was conducted in the basket composter with turning frequency three days. Composting process was evaluated for 60 days by measuring and determining the temperature, moisture content (MC), pH, CN ratio, and others compost quality. The results of the research are described in this following section.

3.1. Effect of EFB Pieces Size on Temperature and Moisture Content

Temperature and moisture content are the most important parameter to be measured in the composting process [12]. The average of temperature and moisture content during the composting process that EFB pieces sizes of <1, 1-3, 4-7, 8-11, and 12-15 cm was presented in Figure 1.

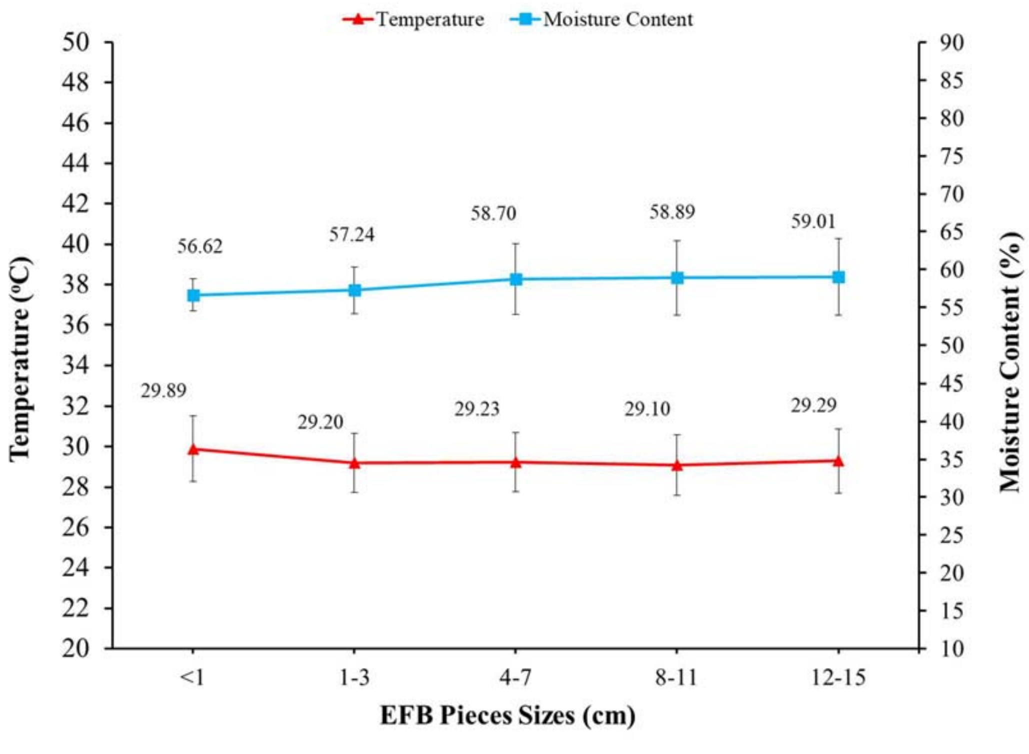

Figure 1. Effect of EFB pieces size on temperature and moisture content

Figure 1 shows that the average temperature in composting of EFB pieces sizes of <1, 1-3, 4-7, 8-11, and 12-15 cm were 29.89 ± 1.63, 29.20 ± 1.46, 29.23 ± 1.47, 29.10 ± 1.49, and 29.29 ± 1.59°C, respectively. This means, an increase in the size of EFB pieces (compost material) cause to lower composting temperatures and the highest average temperature achieved at composting EFB with size <1 cm. This is consistent with the statement of Bueno et al., that the highest temperature is achieved at the smallest compost size [13]. This is due to the small particle size making porosity between small materials and not providing air space between particles [14], so heat will increase in the stack [15]. The error bar at temperature curve shows the temperature difference at each part of compost material pile, because the activity of microorganisms in each section height of compost material pile is different [16].

Figure 1 also shows that the average MC in composting of EFB pieces sizes of <1, 1-3, 4-7, 8-11, and 12-15 cm were 56.62 ± 3.05, 57.24 ± 3.05, 58.70 ± 4.68, 58.89 ± 4.91, and 59.01 ± 5.10%, respectively. The value of average MC increased with the increasing of EFB pieces size but the values are in the range of 56.62 - 59.01% or still in the range of best MC value for composting [4,17]. Baharuddin et al. [4] reported that the best of MC value for composting is in the range of 55-65%. If the MC value is too high, it can inhibit the growth of microorganisms because water molecules are going to fill the air cavity resulting in anaerobic conditions, which will cause odor and can kill aerobic microorganisms due to oxygen deficiency [16,18].

3.2. Effect of EFB Pieces Size on ALOF Addition

ALOF addition in each composter depends on the MC value of compost pile. It is maintained in the range of 55-65%. Therefore, at the end of composting, the total number of ALOF added to each composter is different. The number of ALOF added to each composter containing the sized EFB pieces <1, 1-3, 4-7, 8-11, and 12-15 cm is presented in Figure 2.

Figure 2 shows that the total addition of ALOF in composting of EFB pieces sizes of <1, 1-3, 4-7, 8-11, and 12-15 cm were 12.66, 11.91, 11.3, 11.65 and 10.14 liters, respectively. The biggest ALOF addition is compost with EFB pieces size <1 cm and the smallest is compost with EFB pieces size 12-15 cm. However, the difference is relatively small due to the average of ALOF addition was 11.53 ± 0.92 liters.

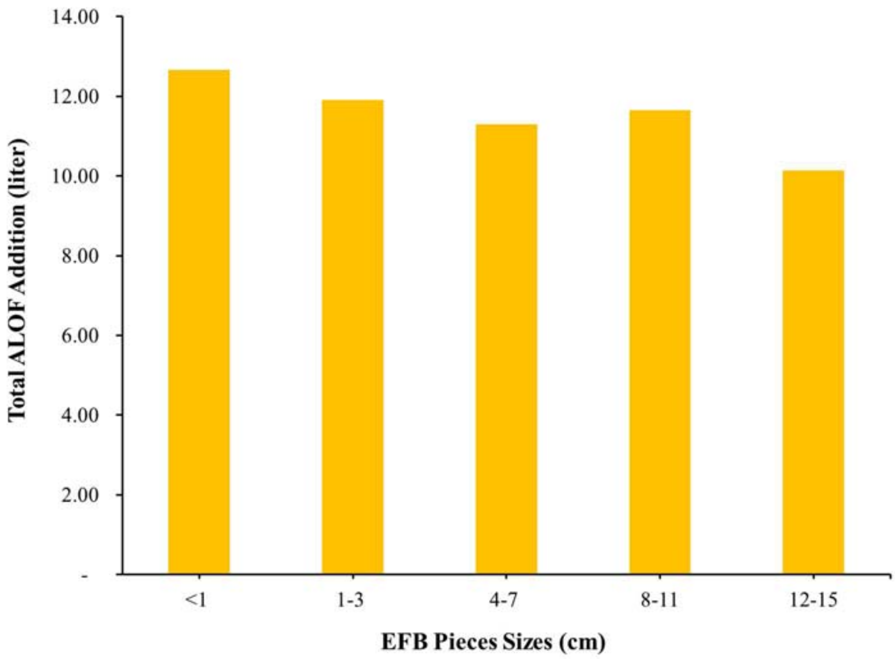

Figure 2. Effect of EFB pieces size on ALOF addition

3.3. Effect of EFB Pieces Size on Compost pH

The average value of compost pH during the composting process of EFB pieces sizes of <1, 1-3, 4-7, 8-11, and 12-15 cm is presented in Figure 3.

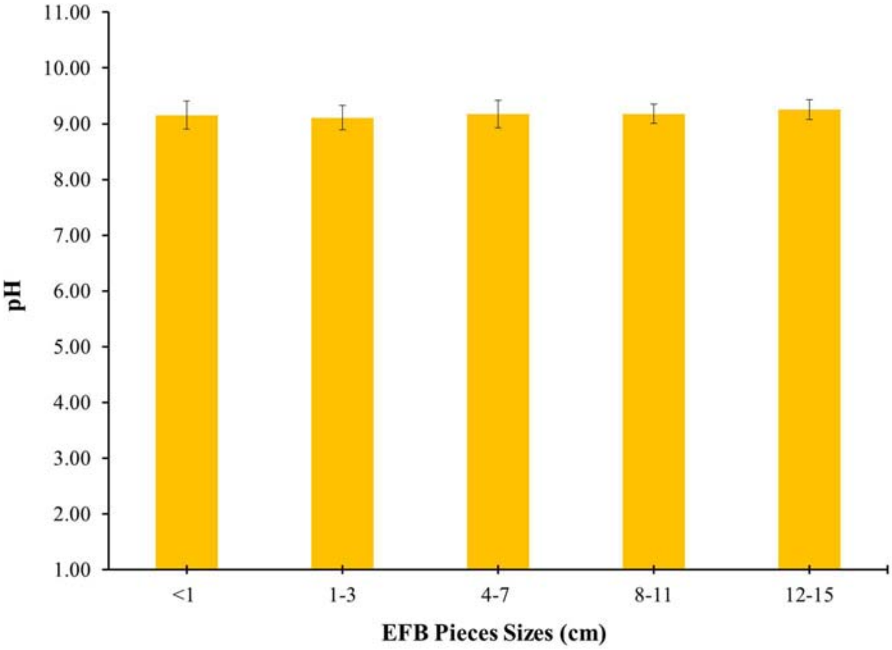

Figure 3. Effect of EFB pieces size on compost pH

Figure 3 shows that the average value of compost pH in composting of EFB pieces sizes of <1, 1-3, 4-7, 8-11, and 12-15 cm were 9.15 ± 0.25, 9.11 ± 0.22, 9.17 ± 0.25, 9.18 ± 0.17, and 9.25 ± 0.18%, respectively. The highest average value of compost pH is compost with EFB pieces size 12-15 cm and tends to fall with decreasing of EFB pieces size, but the lowest pH value is compost with EFB pieces size 1-3 cm.

The pH value of the compost tend to base condition and this is good because it can inhibit the growth of pathogens such as fungi that can survive in acidic conditions [19]. The base condition occur because, if the size of the compost material increases than more N elements will decrease [17]. Reducing N in composting occurs because N turn to NH_3 or NH_4^+ by the ammonification process, so the pH increases [20].

3.4. Effect of EFB Pieces Size on CN Ratio

Maturity and quality of the compost produced is determined by analyzing the compost based on the CN ratio. The CN ratio of the compost material at 0th, 40th, and 60th day of compost with EFB pieces sizes of <1, 1-3, 4-7, 8-11, and 12-15 cm is presented in Figure 4.

Figure 4 shows that the initial CN ratio of composting material at each EFB pieces sizes variation is the same, i.e. 33.48. On the 40th day, the CN ratio of the compost drastically decreased, where the CN ratio of compost with EFB pieces sizes of <1, 1-3, 4-7, 8-11, and 12-15 cm were 18.79, 12.15, 26.50, 24.65, and 17.46, respectively. Finally, on the 60th day, the CN ratio of compost with EFB pieces sizes of <1, 1-3, 4-7, 8-11, and 12-15 cm were 10.00, 11.74, 13.48, 16.07, and 12.11, respectively. The CN ratio decreases is occurs because of the organic matter decomposition as the results of microbial activity [17,21]. On 60^{th} day, C-N ratio for each EFB pieces size variation is below 20, it means the compost is already mature and appropriate with the quality of the standard of CN ratio of compost mature i.e. in the range of 10-20 [11,22]. While on the 40th day, only compost with pieces size <1, 1-3, and 12-15 cm the value of the CN ratio in the range of 10-20, while compost with pieces size 4-7 and 8-11 cm the CN ratio is still above 20. Results of complete analysis of compost quality and standard of compost are presented in Table 2.

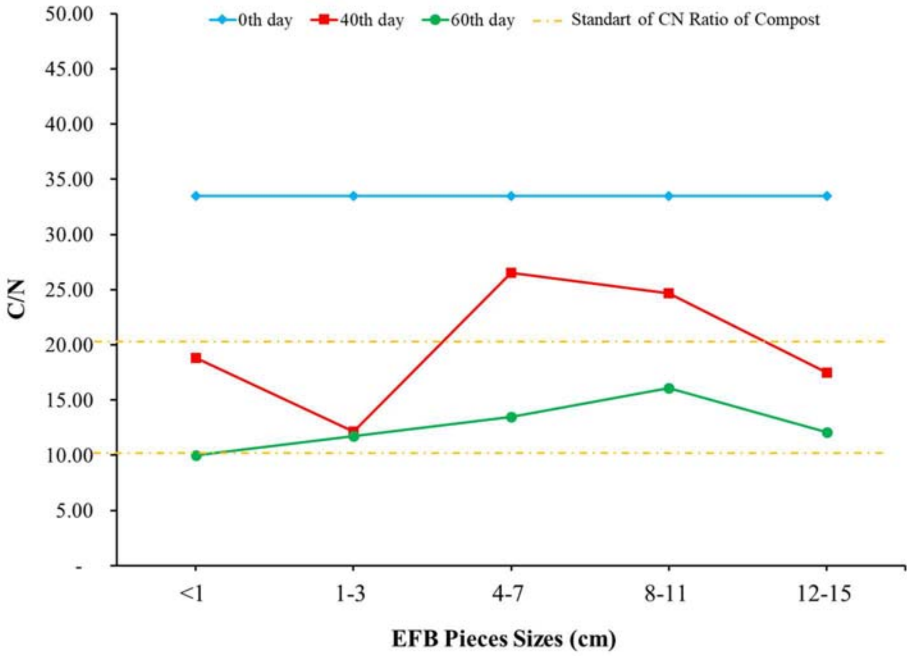

Figure 4. Effect of EFB pieces size on CN ratio

Table 2. Results of complete analysis of compost quality and standard of compost

Parameter	EFB Pieces Size (cm)					Standard of compost*	
	<1	1-3	4-7	8-11	12-15	Minimum	Maximum
MC (%)	55.61	52.69	61.27	58.89	58.26	-	50.00
pH	9.40	9.00	9.30	9.10	9.20	6.80	7.49
WHC (%)	74.00	76.00	68.00	74.00	80.00	58.00	-
C (%)	21,05	23.82	29.68	27.61	29.34	9.80	32.00
N (%)	1.12	1.96	1.12	1.12	1.68	0.40	-
C/N	18.79	12.15	26.50	24.65	17.46	10.00	20.00
P (%)	0.68	0.58	1.30	1.35	1.48	0.10	-
K (%)	0.74	0.95	0.56	0.83	0.62	0.20	-
Na (ppm)	0.51	0.51	0.51	0.51	0.51		
Ca (ppm)	1.65	1.65	1.65	1.65	1.65	-	25.50
Mg (ppm)	0.53	0.53	0.53	0.53	0.53	-	0.60
Cd (ppm)	1.52	1.52	1.52	1.52	1.52	-	3.00
Cu (ppm)	2.09	2.09	2.09	2.09	2.09	-	100.00
Fe (ppm)	0.98	0.98	0.98	0.98	0.98	-	2.00
Pb (ppm)	2.34	2.34	2.34	2.34	2.34	-	150.00
Zn (ppm)	3.19	3.19	3.19	3.19	3.19	-	500.00

* Standards of compost according to the Indonesian National Standard

It can be said that the value of the CN ratio decreases with the smallness of the EFB pieces size. This is because the smaller particle size will cause the surface area of the particle to be large, so the decomposition process becomes faster [14]. However, there is an aberration that the smallest CN ratio value is generated by the EFB pieces size of a 1-3 cm. This is because the EFB pieces size of a 1-3 cm is in accordance with the basket composter used.

Conclusions

Composting of oil palm empty fruit bunches (EFB) mixed with activated liquid organic fertilizer (ALOF) was carried out for 40 days and the best result obtained at EFB pieces size was 1-3 cm with compost characteristic were pH 9.0; MC 52.59%; WHC 76%; CN ratio 12.15; N 1.96%; P 0.58%; and K 0. 95%.

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