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# Production of oil palm empty fruit bunch compost for ornamental plant cultivation

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**Abstract**. The aim of this research was to produce the oil palm empty fruit bunch (EFB) compost for ornamental plant cultivation. EFB compost was produced by chopping fresh EFB into 1-3 cm pieces, inserting the pieces into basket composter (33 cm W × 28 cm L × 40 cm H), and adding activated liquid organic fertilizer (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 compost processed was then mixed with sand and rice husk with a ratio of 1:1:1; 1:3:1; 1:0:1 and was used as a potting medium for planting some valuable ornamental plants i.e. cactus (*cactaceae*), sansevieria, and anthurium. Composting was carried out for 40 days and the 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%. The compost-sand-husk rice mixture can be used as a growing medium where the best ratio for cactus, sansevieria, and anthurium was 1:3:1; 1:1:1; and 1:0:1, respectively.

## 1. Introduction
The palm oil industry is the industry that makes the most important contribution to the Indonesian economy. However, in the processing of fresh fruit bunches (FFB) in palm oil mill (POM), besides producing palm oil and palm kernel oil also produce by-products that are 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 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].

Several studies have been converted EFB into compost by mixing it with additional materials such as manure [9] or palm oil mill effluent (POME) [10]. While in this study, active liquid organic fertilizer (ALOF) is used as an alternative additional materials such as that 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 produce the oil palm empty fruit bunch (EFB) compost for ornamental plant cultivation. These include to obtain of the EFB composting degradation data, the quality of the compost produced, and the best of sand-rice husk-compost ratios for planting media of ornamental plants.

## 2. Materials and Methods

### *2.1. Materials*

Main materials for the composting were EFB and ALOF. EFBs were obtained from Rambutan POM, Sumatera Utara, Indonesia. Before being used, the EFB was shredded and cut to size of 1-3 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 have been presented by Trisakti et al [6]. Meanwhile for planting media, the materials were sand, rice husk, and the EFB compost. The sand is black sand that forms from the lava or magma of the volcano that cools rapidly. Usually referred to as Malang sands because it is produced from highland area or volcano around Malang. Rice husks used are derived from local rice mills which are fried without oil before use.

### *2.2. Composting 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. Detailed sketch of the composter has been presented in Trisakti et al [6].

### *2.3. Composting Process*

Composting process was conducted by shredding and cutting EFB to size of 1-3 cm, measuring the weight of EFB total, and putting into the composter. Next, ALOF was poured and mixed until moisture content of compost reach 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. Preparing The Planting Media*

The planting media was mixture of EFB compost, sand, and rice husk. The ratios of the mixture were 1:1:1, 3:1:1, and 1:0:1. EFB compost is the result of this research, the sand is black sand, and the rice husk is fried without oil before use.

*2.5. 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 size of 1-3 cm and then mixing with ALOF. Composting process was conducted in the basket composter with turning frequency three days. The compost produced then mixed with sand and rice and was used as a potting medium for planting of cactus (*cactaceae*), sansevieria, and anthurium. 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. Profiles of Temperature and Moisture Content*
Temperature and moisture content is the most important parameter to be measured in the composting process [11]. Profiles of temperature and moisture content during the composting process which evaluated every three days is presented in Figure 1.

Previously, temperature of composting material was 27$^{o}$C, and after being mixed with ALOF, the composting process started, then the temperature of the composting material increased to 35$^{o}$C after 3 days. This is in accordance with research reported by Hock et al. [12], if material containing cellulose, such as EFB, mixed with highly organic matter material, heat would be generated in the piles due to the metabolic heat generation from biodegradation process. The high error bars on the temperature curve showed a relatively large temperature differences both in the morning and evening as well as on each compost pile height in the composter.

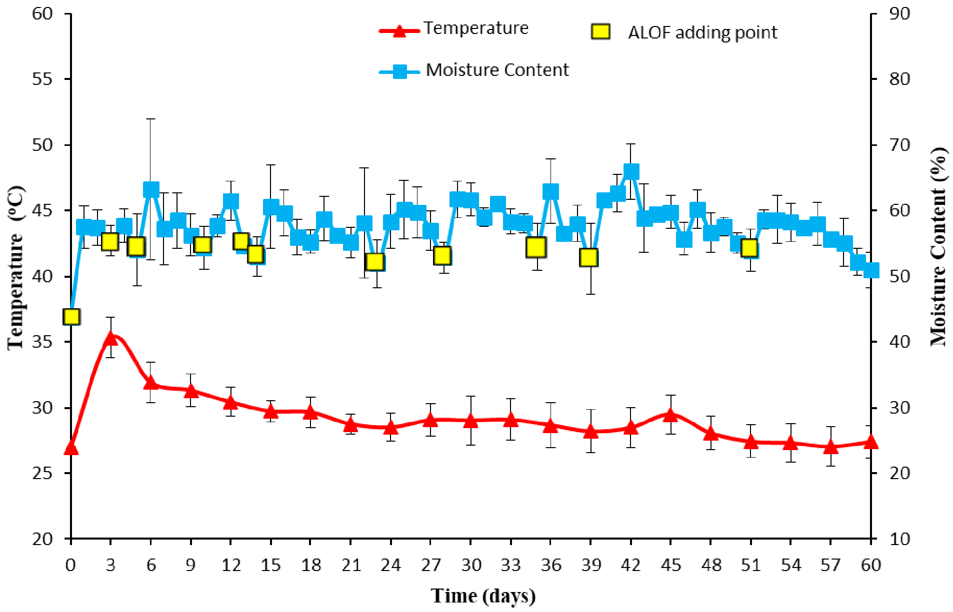


**Figure 1.** Profiles of temperature and moisture content during the composting

Temperature profile tends to decline during the composting process. The average maximum temperature of 35°C was reached on the 3rd day. Then, the temperature slowly began to decline until the 50th day and the next day until the 60th day became constant at 27°C. This indicates that the degradation process has completed which is similar case as reported by Shen et al. [13] and Hock et al. [12]. They reported in their researches that after a rapid increase in temperature, it will decrease slowly which indicates that the composting process slows down as the depletion of nutrient availability.

Moisture content is an important parameter to optimize the composting process. According to Hock et al. [12], the dependence on water to support microbial growth can affect its ability to biodegrade of organic materials. In this research, the addition of ALOF to EFB has two purposes, first as a source of microbes and nutrients; and second to maintain the moisture content in the range of 55-65%. Initial moisture content of EFB was 43.83% and then after being added 2.97 liters of ALOF, it changed the value of its moisture content to 57%.

Turning of the compost pile during the process decreased the value of moisture content, except on the 3rd, 18th, 21st, 24th, 39th, 48th, and 51st days. The disadvantage of turning process due to the moisture content of the composting material was reported by Tiquia et al. [14], the turning process of compost pile can cause continuous loss of water due to the evaporation. High error bar on moisture content curve (Figure 2) shows the difference of moisture content in each section of compost pile; at the top, middle, or bottom of the composter. This is because the data of moisture content was collected before the turning process carried out, so that the value of moisture content in each section of compost pile was different.

Final moisture content of compost after 60 days was 50.99%. This moisture content value is similar to the value obtained by the previous studies that also performing the turning process frequency once in three days. As reported by Hock et al [12] in their research, they obtained final moisture content about 50% after 39 days, while Baharuddin et al [5] obtained final moisture content was 52%. Meanwhile, Tiquia et al [15] stated that in order for the microbes to survive, moisture content of composting materials should be around 40-60%, if they exceed to 80%, the aerobic microbes will die because of lack of oxygen.

### *3.2. pH Profile During The Composting*

The pH profile during the composting process is presented in Figure 3. In Figure 2 shows the pH range during sixty days of composting process which is in the range of 8.7 to 9.5. This indicates that the operational condition tend to be alkaline. The pH increased at the beginning of 10 days of composting, then dropped at the 35th day, and then tends to be constant until the 60th day.

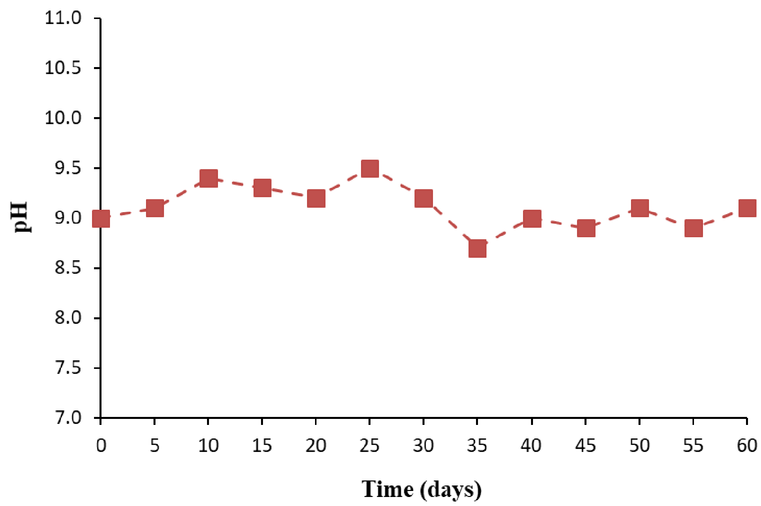


**Figure 2.** The pH profile during the composting

The changes of pH during the composting process were caused by microbial activity [16,17]. In the first ten days, the pH increased from 9.0 to 9.4. It occurred because the N transformed into $NH_3$ or $NH_4^+$ via ammonification process [16]. However, from the next day until the 35th day, pH tends to decrease to 8.7, although at the 25th day it increased to 9.5. The decrease of pH is caused by the process of volatilization of ammonium and the release of hydrogen ions as a result of nitrification process [5]. Finally, pH of mature compost was 9.1.

Overall condition that occurred during the composting process tends to base condition which pH ranges from 8.7 to 9.5. This happens because of the turning process was performed once in 3 days. By performing the turning process, it can emit $CO_2$ gas which is trapped in the empty space among particles of the composting material, thus preventing the acidic conditions in the compost pile or significant decrease in pH [18,19]. Increasing the pH to alkaline conditions is good for the composting process as this may inhibit the growth of pathogens such as fungi that can survive in acidic conditions [20].

### *3.3. C-N Ratio and Compost Quality Analysis*

Maturity of the compost produced is determined by analyzing the compost based on the CN ratio. The CN ratio of the compost material at $0^{th}$, $40^{th}$, and $60^{th}$ day is presented in Figure 3. Meanwhile, the quality of the compost was analysis and the results of complete analysis of compost quality are presented in Table 1.

The decreasing value of CN ratio is due to the decreasing of C content during composting process, otherwise N content is increasing during composting. This occurs because of the decomposition of organic materials from the microbial activity [12,21]. CN ratio is one of the important indicators that express the maturity of compost [10,22]. The value of CN ratio of the EFB initially was 33.48, then on the 40th day was 12.15, and finally on the 60th was 11.74. This means that the EFB have been composted less than 40 days because compost mature standard on CN ratio has a value between 10-20 [10,23].

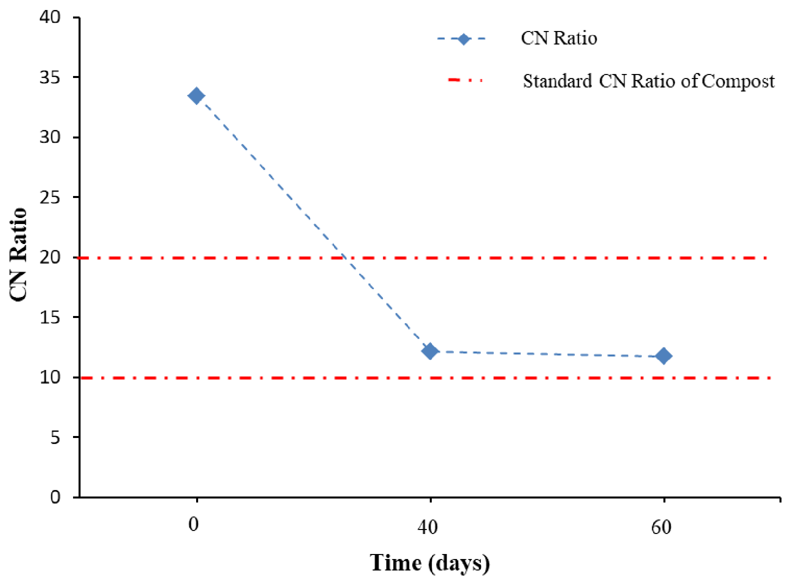


**Figure 3.** CN ratio changes during the composting

**Table 1.** The EFB compost quality and standard of compost

| Parameters | Composting material | | | Standard of compost* | |
|---|---|---|---|---|---|
| | Start up | 40th days | 60th days | Minimum | Maximum |
| MC (%) | 43.83 | 61.57 | 50.99 | - | 50.00 |
| pH | 9.10 | 9.00 | 9.10 | 6.80 | 7.49 |
| WHC (%) | 62.00 | 76.00 | 80.00 | 58.00 | - |
| C (%) | 33.15 | 23.81 | 28.41 | 9.80 | 32.00 |
| N (%) | 0.99 | 1.96 | 2.42 | 0.40 | - |
| C/N | 33.48 | 12.15 | 11.74 | 10.00 | 20.00 |
| P (%) | - | - | 0.58 | 0.10 | - |
| K (%) | - | - | 0.95 | 0.20 | - |
| Na (ppm) | - | - | 0.51 | | |
| Ca (ppm) | - | - | 1.65 | - | 25.50 |
| Mg (ppm) | - | - | 0.53 | - | 0.60 |
| Cd (ppm) | - | - | 1.52 | - | 3.00 |
| Cu (ppm) | - | - | 2.09 | - | 100.00 |
| Fe (ppm) | - | - | 0.98 | - | 2.00 |
| Pb (ppm) | - | - | 2.34 | - | 150.00 |
| Zn (ppm) | - | - | 3.19 | - | 500.00 |

* Standards of compost according to the Indonesian National Standard

### *3.4. The EFB Compost as Potting Media*

The EFB compost produced by this research is further mixed with sand and rice husk. The mixture is further used as a growing medium of some high value ornamental plants such as cactus, sansieviera, and anthurium. The growth of the three ornamental plants on a variety of mixed ratio of growing medium is presented in Table 2.

**Table 2.** Growth of plants on several of mixed ratio of growing media

| Plants | Ratio of Compost – Sand – Rice husk | Plant growth |
|---|---|---|
| Cactus | 1 : 3 : 1 | good |
| Cactus | 1 : 1 : 1 | medium |
| Cactus | 1 : 0 : 1 | bad |
| Sansevieria | 1 : 3 : 1 | good |
| Sansevieria | 1 : 1 : 1 | good |
| Sansevieria | 1 : 0 : 1 | bad |
| Anthurium | 1 : 3 : 1 | bad |
| Anthurium | 1 : 1 : 1 | medium |
| Anthurium | 1 : 0 : 1 | good |

Cactus and sansevieria like the planting medium is porous, rough-textured, and containing little organic material. Porous planting medium will ensure the availability of oxygen for plant roots so that plant growth becomes good. In addition, high porosity of planting media causes good drainage so that planting medium does not store too much water. Cactus and sanseviera dislikes the overly moist planting media conditions that can cause root rot. While anthurium, although also like porous medium but fine textured and contains high organic material. This is so that the roots of this plant is easy to grow and spread.

## Conclusions

Composting of oil palm empty fruit bunches (EFB) mixed with activated liquid organic fertilizer (ALOF) was carried out for 40 days and the 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%. The compost-sand-husk rice mixture can be used as a growing medium where the best ratio for cactus, sansevieria, and anthurium was 1:3:1; 1:1:1; and 1:0:1, respectively.

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