Effect of Cutting Size in the Composting Process of Oil Palm Empty Fruit Branches (EFB) Using Active Organic Liquid Fertilizer (AOLF) as Co-Composting

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Abstract. The size of organic waste materials plays a pivotal role in the composting process, influencing parameters such as decomposition rate, microbial activity, aeration, and nutrient availability. Currently, the study of compost has focused on the degradation of organic matter. The study began by varying the sizes of oil palm EFB to 1-3, 3-5, and 5-7 cm. Subsequently, the EFB were placed into a basket composter (33 cm length x 23 cm width x 40 cm height), and active organic liquid fertilizer was added to achieve a moisture content of around 55-65%. The observation period lasted for 60 days. Throughout the composting process, the moisture content was maintained at 55-65% by adding active organic liquid fertilizer, and the composter was turned every 3 days. Analyzed parameters during the composting process included temperature, pH, volatile suspended solids, electrical conductivity, and water holding capacity. The best results were obtained with a cutting size of 3-5 cm, yielding the following values: temperature 26.75 °C, pH 7.5, volatile suspended solids 211,640 mg/L, electrical conductivity 4.05 dS/m, and water holding capacity 65%.

1 Introduction

Indonesia is one of the world's largest producers of palm oil [1]. The palm oil plantations in Indonesia significantly contribute to the economy [2]. In the 2023/2024 period, the estimated palm oil production reached 46 million metric tons, an increase of 3 percent from the previous year. [3]. The processing of fresh fruit bunches (FFB) into palm oil in palm oil mills generates liquid waste ranging from 0.6 to 0.87 m3/ton of palm oil produced, with Biological Oxygen Demand (BOD) levels of 20,000-25,000 mg/L, Chemical Oxygen Demand (COD) levels of 40,000-50,000 mg/L, and pH levels of 3.8-4.5 [2]. Besides liquid waste, the processing of palm oil also produces solid waste such as EFB, accounting for 23%, palm kernel shell 5%, and mesocarp 12% per ton of processed FFB [4]. EFB can be used as raw material in the composting process [5].

Composting is a biological process involving the aerobic decomposition of organic waste with the assistance of microorganisms, ultimately transforming it into humus [6]. The primary function of compost is to enhance the physical, chemical, and biological properties of the soil. The composting process can be influenced by various parameters such as nutrients, C/N ratio, compost material size, temperature, pH, moisture content, and turning frequency [4]. Compost is the result of the decomposition of organic matter through a biological process with the assistance of decomposer organisms. The decomposition process can occur aerobically (with air) or anaerobically (without air) [7]. Compost from solid organic waste is becoming increasingly important worldwide, within the context of integrated solid waste management and particularly diverting biodegradables from landfills [10].

The primary function of compost is to enhance the physical, chemical, and biological properties of the soil [4]. Physically, compost can loosen the soil, increasing pore space and making it more friable. Chemically, compost can improve the cation exchange capacity of the soil and enhance its water retention ability. Biologically, compost can increase the population of microorganisms in the soil [9]. Macro-nutrients present in compost include K, Ca, Mg, Cu, Zn, Mn, Fe, and Na [10].

Oil palm EFB are lignocellulosic materials consisting of carbohydrates, lignin, extractives, and inorganic ash [11]. EFB contains cellulose 33%, lignin 34%, hemicellulose 30%, nitrogen 0.55%, potassium 1.28%, phosphorus 0.02%, and carbon 45.1% [12]. EFB is generally in fibrous form, with fibers resembling sticks that collectively form vascular bundles [13].

The composting process is an aerobic process where microorganisms convert organic substrates into carbon dioxide, water, minerals, and organic matter. The primary goal of the composting process is to produce high-quality humus [14]. In the composting process, organic substrates are broken down by aerobic thermophilic microorganisms present in the waste to produce nutrient-rich materials like humus. The
composting process consists of three stages: high-rate composting, stabilization and maturation in the degradation of organic substrates, and the destruction of pathogenic microorganisms to form stable materials. The benefits of the composting process include economic advantages, reduction of greenhouse gas emissions, and aiding in the restoration of materials by returning processed organic waste through natural cycles [15].

Organic fertilizers are a primary source of organic matter for the soil. The application of liquid waste as active organic fertilizer serves to supply more nutrients than chemical fertilizers, potentially causing adverse effects on groundwater quality [16].

2 Methodology

The raw materials used in this research are Oil Palm EFB from the Palm Oil Mill (POM) of PT. XYZ, Dolok Masihul District, Serdang Bedagai Regency, North Sumatra Province, and the AOLF is the result of anaerobic digestion of Palm Oil Mill Effluent (POME) from the Biogas Power Plant Pilot Plant, Research and Development Center for Human Resource and Research (Pusdiklat LPPM), Universitas Sumatera Utara, Medan. Their functions include co-composting, serving as a source of nutrients, and maintaining moisture content.

The process begins with weighing the basket and net containing rice husks. Subsequently, the Oil Palm EFB are cut according to size variations, namely 1-3, 3-5, and 5-7 cm. The prepared EFB is then placed into the composter, totaling 5 kg (to full capacity), and Active Organic Liquid Fertilizer (AOLF) is added until the moisture content reaches 55-65%. The moisture content is maintained constant by periodically adding AOLF, which is obtained from the byproduct of anaerobic digestion of palm oil mill effluent (POME). Parameters analyzed during the composting process include temperature, pH, volatile suspended solids, electrical conductivity, and water holding capacity.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
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<td>C</td>
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<td>Walkley &amp; Black Method</td>
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<tr>
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<td>Kjeldahl Method</td>
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<td>SNI 03-6787-2002</td>
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<tr>
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</tr>
<tr>
<td>K₂O</td>
<td>(%)</td>
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<td>AAS</td>
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3 Results and Discussion

3.1 Analysis of Composting Results Based on Temperature

Sustainability of the composting process in the composter can be observed through temperature changes during the composting process. Temperature measurements of the compost are conducted every day in the morning and evening. Temperature measurements are taken at three sampling points: top, middle, and bottom. The temperature change profile in the morning and evening is presented in Figure 1.
Figure 1 shows the morning temperature on day 0 in each composter was 30 °C. After adding AOLF, the temperature increased when measured in the evening, reaching 35.18, 35.25, and 33.33°C in each composter. During the morning temperature observations in each composter, there was an increase until the third day, with a temperature range of 34.33-41.00°C, indicating the presence of active decomposer microbes in the composter. Meanwhile, during the evening temperature observations in each composter, there was an increase in the first 3 days, reaching around 35.33-43.33 °C. This is due to the addition of AOLF after the morning sampling, resulting in an increase in decomposer microbes in the composter.

This aligns with findings reported by Hock et al. (2009), stating that when materials with high organic content are added to cellulose-containing substances (such as EFB), the generated heat in the pile comes from the biodegradation process [17]. The presence of high temperatures during composting is crucial for the hygienization process, aiming to eliminate pathogenic bacteria.

Composting processes typically occur in a combination of thermophilic and mesophilic temperatures [18]. The morning and evening temperature profiles tend to gradually decrease after the 8th day and slowly stabilize from day 45 to day 60. This indicates that the degradation process has been completed. This observation is consistent with reports from Hock et al. (2009) and Shen et al. (2011), stating that after a rapid temperature increase, a gradual decline in temperature suggests a slowing degradation process due to diminishing nutrient availability [18, 19].

3.2 Analysis of Composting Results Based on pH

To monitor the sustainability of the composting process, the pH of the compost in each composter needs to be measured daily. The profile of the pH analysis results in each composter can be observed in Figure 2. In Figure 2, the pH range during the 60-day composting period for each cut size varies between 6.6 and 9.6, indicating an overall alkaline condition. The pH shows an increase during the first 19 days and then tends to stabilize until day 60. Changes in pH during the composting process are influenced by microbial activity [20].

An increase in pH up to day 19, reaching the scale of 9.6, occurs because nitrogen (N) transforms into NH₃ or NH₄⁺ through the ammonification process, leading to an increase in pH [20]. However, on day 20, the pH tends to decrease to the scale of 9.0. This change in pH is attributed to the evaporation of ammonia and the release of hydrogen ions as a result of the nitrification process [5].

Overall, the conditions during composting tend to be alkaline, with a range of 6.6-9.6. This occurs due to the influence of pile turning, preventing CO₂ from being trapped in the empty spaces between compost particles, thereby preventing acidic conditions or significant pH decreases in the pile [21]. The increase in pH to alkaline conditions is beneficial for the composting process. Alkaline conditions can inhibit the growth of pathogens, such as fungi, which thrive in acidic conditions [22].

pH values at the end of composting for each cut size are 7.2, 7.5, and 7.6, respectively. Compared to the SNI 19-7030-2004 standard, which specifies a maximum pH of 7.5 for compost [23], the compost pH meets the standard.

3.3 Analysis of Composting Results Based on Volatile Suspended Solids (VSS)

Volatile Suspended Solids (VSS) is a measurement of the amount of solids that evaporate in a solution and is used to evaluate the level of organic matter content in a sample [24]. The concentration of VSS is typically used as an indicator of microbial growth and biomass production [25]. The profile of VSS analysis results in each composter can be observed in Figure 3. In Figure 3, changes in the microbial population over the composting period are apparent. The microbial count after the addition of AOLF for each cut size is 203,660; 205,080; and 199,180 mg/L, respectively. The microbial count then tends to stabilize until day 40 and gradually decreases until day 60. The stable profile observed from day 0 to day 40 is attributed to the bacterial activity in
decomposing the organic matter in Oil Palm EFB, allowing them to rapidly proliferate, along with the periodic addition of AOLF. Subsequently, after day 40, the bacterial count tends to decrease. This is due to the diminishing organic matter, leading to a lack of nutrients for the bacteria and causing them to die off. This aligns with findings reported by Yulianto et al. (2009), stating that during the initial stages of composting, thermophilic bacteria break down organic matter as they are active at high temperatures [26]. After the majority of the material has decomposed, the temperature gradually decreases to normal levels, causing thermophilic bacteria to die off.

**3.4 Analysis of Composting Results Based on Electrical Conductivity**

To determine the number of soluble salts in determining the quality of compost, it is necessary to conduct electrical conductivity analysis every 10 days. Electrical Conductivity reflects the level of salinity in a compost product, indicating the possibility of phytotoxic or phyto-inhibitory effects [27]. Changes in electrical conductivity values in each composter can be seen in Figure 4. In Figure 4, the changes in electrical conductivity values during the composting period can be observed. The electrical conductivity values of the compost on day 0 for each composter are 3.50; 3.50; and 3.42 dS/m (deciSiemens per meter). The electrical conductivity values of the compost fluctuate until day 60.

**Fig. 3.** Profile of volatile suspended solids (vss) during oil palm trunk composting

**Fig. 4.** Profile of electrical conductivity during oil palm trunk composting

**Fig. 5.** Profile of water holding capacity during oil palm trunk composting
The decrease in electrical conductivity values during the composting process is a direct result of the increase in nutrient concentrations such as nitrate and nitrite [28]. Meanwhile, an increase in electrical conductivity values can be caused by the release of cations and anions through the decomposition of organic substances [27]. The electrical conductivity values at the end of composting for each composter are 3.21; 4.05; and 3.54 dS/cm. Compared to the standard electrical conductivity of compost, which is ≥ 2 dS/m [29], the electrical conductivity of the compost meets the standard.

### 3.5 Analysis of Composting Results Based on Water Holding Capacity

To determine the amount of water retained by compost, it is necessary to conduct water holding capacity analysis every 10 days. Water holding capacity is the excess amount of water retained by soil/compost [30]. Changes in the water holding capacity values in each composter can be seen in Figure 5.

In Figure 5, the changes in water holding capacity values during the composting period can be observed. The water holding capacity values of the compost on day 0 for each composter are 39, 21, and 29%. The water holding capacity values of the compost then increase until day 60.

The increase in water holding capacity values during the composting process occurs due to the uniform physical structure of organic materials [31]. As a result of this increase in water holding capacity, compost can easily absorb nutrients carried by water [32]. In this study, water was replaced with AOLF as a nutrient source. The water holding capacity values at the end of composting for each composter are 67, 65, and 77%. Compared to the standard water holding capacity of compost, which is >58% [23], the water holding capacity of the compost meets the standard.

### 4 Conclusion

The optimal composting result achieved in this study was observed in the compost with a variation of EFB particle size ranging from 3 to 5 cm, exhibiting the following values: temperature 26.75 °C; pH 7.5; volatile suspended solids 211,640 mg/L; electrical conductivity 4.05 dS/m; and water holding capacity 65%. Additionally, conducting variations without reversing the composter is essential to observe the impact of turning frequency on these parameters. The incorporation of AOLF is vital for sustaining biological activity and serving as a nitrogen source. Consequently, it can be inferred that the resulting compost is suitable for application as a growing medium for plants.

### References