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Article

Characteristics of Compost from Straw and Fisheries Waste: A Comparative Analysis of Different Decomposers

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Abstract: The objective of this research was to assess the efficacy of three different decomposers in producing compost of high quality that meets the compost maturity standards (SNI 19-7030-2004). The experimental study was conducted with three treatments, each replicated five times, resulting in a total of fifteen composting holes. The research was conducted in South Batu Kuta Village, Narmada District, West Lombok Regency, from October to December 2019. The treatments included D1 (EM4 decomposer), D2 (Promi decomposer), and D3 (Phosphate Solubilizing Bacteria (PSB) decomposer). Various parameters, such as color, smell, temperature, pH, C-Organic, Total N, and C:N ratio, were assessed. The findings demonstrated that all three decomposers effectively decomposed the compost, yielding a high-quality product suitable for various plant applications. The compost produced by EM4, Promi, and PSB decomposers exhibited characteristics such as a blackish color, soil-like smell, a temperature ranging from 29.2°C to 29.8°C, a pH ranging from 6.83 to 6.87, organic carbon content ranging from 12.87% to 14.73%, total nitrogen content ranging from 0.83% to 0.87%, and a C/N ratio ranging from 14.35% to 14.60%. These results align with the compost maturity standards specified in SNI 19-7030-2004.

Keywords: Compost Fertilizer, Decomposer, Fishery Waste, Straw

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1. Introduction

The demand for organic fertilizer has been consistently increasing each year. In 2011, the demand for organic fertilizer reached 12.394 million tons, while state-owned fertilizer factories were projected to produce only 2.601 million tons of organic fertilizer in the same year. By 2015, the demand for organic fertilizer had further risen to 13.4 million tons. However, the production capacity of state-owned fertilizer factories in 2015 was only 4.69 million tons [1]. The responsibility of fulfilling the shortage of organic fertilizer is entrusted to the community and private entrepreneurs.

This has prompted various parties, particularly agricultural industry advocates, to promote the utilization of organic fertilizers in farming practices. Among the organic fertilizers that are currently in high demand is compost fertilizer. Composting, which involves the biological breakdown and stabilization of organic materials at a thermophilic temperature (high temperature), yields a high-quality material suitable for soil use without causing harm to the environment [2]. Demposers comprising bacteria and enzymes played a crucial role in promoting the decomposition process [3]. When selecting decomposers, it is crucial to consider the composition of the compost's raw materials, such as rice straw that contains lignocellulose.

The presence of lignocelullose in the material provided an oppurtunity to employ lignocellulolytic microbes, thereby hastening the decomposition process [3]. The quality and stability of compost depend entirely on its characteristics. Sources of organic materials used in composting include compost, green manure, manure, harvest residues (such as straw, crop stubble, corn cobs, and coconut husks), livestock waste, fishery waste, industrial waste that utilizes agricultural materials, and municipal waste [4]. One potential source of organic material for composting is straw and fishery waste, specifically fish pond sediment. Organic waste derived from straw and fishery waste can be effectively utilized and processed into compost. Rice straw has a lot of potential as a local raw material that can be turned into organic fertilizer [5]. Despite its abundant availability during harvest, it has yet to be fully harnessed to its optimal potential. An estimated 1-1.5 kg of rice straw was produced per 1 kg of grain [6].

The decomposition rate significantly impacts the nutrient availability in organic material composting. To expedite the decomposition process, various types of decomposers have been developed and are available in the market under different commercial brands. The abundance of decomposer brands in the market inevitably influences the compost's quality. the quality of the compost composition and the type of microorganisms found in each decomposer affect the quality of the compost. The ideal compost quality is defined by meeting the criteria outlined in the SNI 19-7030-2004 standard. Utilizing multiple decomposers such as Effective Microorganisms 4 (EM4), Promoting Microbe bioactivator, and PSB (Phosphate Solubilizing Bacteria) is expected to have an impact on the resulting compost's quality.

Throughout the composting process, several factors including the C:N ratio, pH of the final product, composting temperature, and moisture content was considered to asses the quality and stability of the compost [7]. Therefore, this research is conducted to observe and assess the capabilities of different decomposers in terms of maturity time and compost quality, following the Indonesian National Standard 19-7030-2004 which outlines compost maturity standards.

2. Materials and Methods

2.1. Research site and materials

The research was conducted from October to November 2019 in rice field Batu Kuta Village, South Batu Kuta, Narmada District, West Lombok Regency. The materials used in this experiment are fish pond sludge, straw, dolomite, decomposers (EM4, bioactivator promi, and PSB). The tools used in this experiment are a 10 kg capacity scale, a bucket, a hoe, a shovel, a measuring tape, a crowbar, a knife, a sifter, a measuring cup, a thermometer, and a pH meter.

2.2. Design experiment

The research methodology employed was descriptive method that refers to the SNI 19-7030-2004 (compost maturity standards). This experiment consists of 3 treatment levels with 4 repetitions each, resulting in a total of 12 experimental units. The composting process commences with the preparation of compost materials, specifically straw and fish waste. Compost holes are created, each measuring 50 x 50 x 50 cm, resulting in a total of fifteen experimental holes. Each hole is then filled with a layered arrangement of compost materials, comprising of two layers. Each layer is treated with specific decomposers, and dolomite is added. After filling all the compost holes with compost material, a 3 x 4-meter tarp is used to cover them, providing protection from rainwater. Throughout the composting process, turning and watering are performed on a weekly basis until the compost reaches maturity.

2.3. Parameters Observed

The parameters observed include compost color, compost smell, compost temperature, pH, C-organic, Total N, and C/N ratio. Compost has been observed in both beginning and completion of the composting process. The compost temperature was measured every 3 days. pH levels were measured every 2 weeks using a pH meter. The organic carbon (C-Organic) value was obtained through calorimetric analysis in the laboratory every 2 weeks. The total-N value was determined using Kjeldahl analysis every 2 weeks. The calculation of the C/N ratio calculated on the values of C Organic and Total N every two weeks throughout the six week composting process.

3. Results and Discussion

3.1. Physical Characteristics of Compost

3.1.1. Compost Color

During the initial stages of decomposition, all treatments exhibit the same color as their raw materials, which is a yellowish-brown hue (a mixture of straw and fish waste) (Fig. 1).

Figure 1. Average edamame aroma in dairy milk and goat milk yogurt

1) The color of the compost at the initial of the composting process
2) The color change of compost D1 (EM4) at the end of the composting process
3) The color change of compost D2 (Promi) at the end of the composting process
4) The color change of compost D3 (PSB) at the end of the composting process

Overall, during the composting process, the color of the compost material underwent a gradual shift to a dark brown shade. This change was observed in the recent study, where the compost material indeed transformed into a dark brown color. This change occurred due to the oxidation reacting during the conversion of organic matter into inorganic compounds and the formation of humus [7].

From each treatment, the resulting colors adhere to the mature compost criteria outlined in the Indonesian National Standard 19-7030-2004, which specifies a dark color. Mature compost emits an earthy smell reminiscent of soil. The composition of mature compost closely resembles soil material, exhibiting a dark brown color that arises from the presence of stabilized organic matter [8].

3.1.2. Compost Smell

The aerobic composting process can be described as follows [10].

$$\text{Organic matter} + O_2 \xrightarrow[\text{aerobic}]{\text{microorganis}} CO_2 + H_2O + \text{humus}$$

The smell of the compost in this experiment was assessed both before and after the composting process. During the composting process, a panel of evaluators employed their sense of smell to determine the degree of humus smell, which was then compared to the scent of soil. Initially, the detected smell was a combination of straw and earthy notes. However, upon completion of composting for the three treatments, namely D1 (EM4), D2

(Promi), and D3 (PSB), the smell closely resembled that of soil. The resulting smell from the compost corresponds to the definition of mature compost as outlined in the SNI 19-7030-2004 standard, characterized by a soil-like scent. The results of the compost smell perception are presented in Table 1.

Table 1. Observation of compost smell using the sense of smell

Treatment	Smells	
	The Start of Composting	The End of Composting
D1 (EM4)	+++	+
D2 (Promi)	+++	+
D3 (PSB)	+++	+

Description: +++ = very characteristic smell of raw materials,
+ = similar soil

3.1.3. Compost Temperature

Every 3 days, the temperature of the compost was tested for a duration of 6 weeks during the composting process using a mercury thermometer. The data obtained from the temperature measurements of the compost are presented in Fig 2.

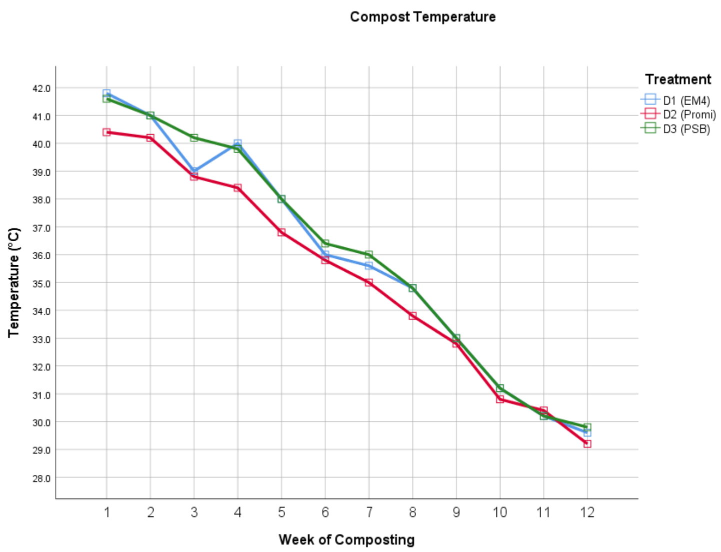

Figure 2. Average temperature of the compost every three days

In this study, it is shown that there is a continuous decrease in temperature from the first three days of observation until the last day of observation in each treatment (EM4, Promi, and PSB), resulting in a consistent decrease in compost temperature. The compost temperature in this study tends not to experience an increase during composting. This is based on the quality of the compost raw materials utilized in this study, a mixture of straw and fish waste, with the straw having a C/N ratio of 40.49% [10] and the fish waste having a C/N ratio of 3.63% [11].

Laboratory analysis results indicate that both mixtures of materials used in this composting process produce a C/N ratio below 25% at the beginning of composting. The decreasing temperature trend is consistent with the findings of [12], which generally indicate that all treatments experience a normal decrease in temperature from the first week of observation until the eighth week of observation. This achieved temperature reduction occurs in line with the increasing length of time for organic waste composting until the compost reaches normal maturity.

At the conclusion of the composting process, varying temperatures were produced in each treatment, measured every 3 days, thats 29.6°C, 29.2°C, and 29.8°C. These temperatures fall within the range of the criteria for mature compost as per the SNI 19-7030-2004.

3.2. Chemical characteristics of the compos

3.2.1. Compost pH

A pH meter was used to determine the pH of the compost at regular intervals of two weeks throughout the six-week composting period. The pH measurements of the compost are depicted in Fig 3.

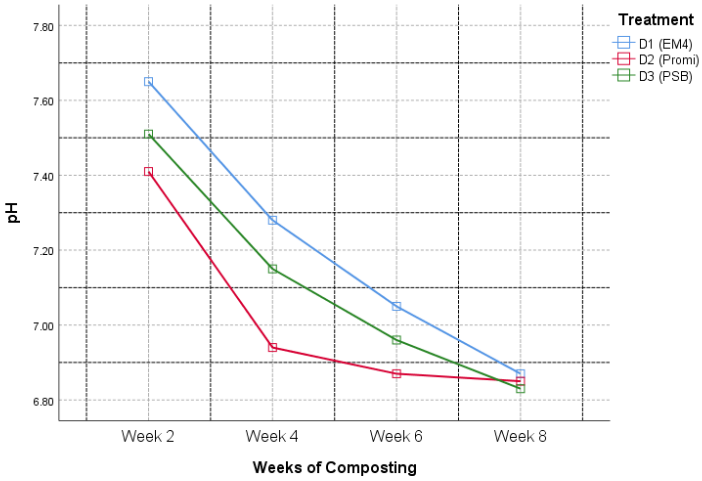

Figure 3. Average pH of the compost every two weeks

From the graph provided, it is evident that the pH of each treatment follows a consistent decreasing pattern. The pH continues to decline throughout the composting process, reaching its lowest point by the 6th week. The pH decrease can be attributed to the increased synthesis of organic acids throughout the composting process [13]. These acidic conditions promote the growth of fungi, which are essential in breaking down the cellulose and lignin found in compost [14]. Moreover, the decline in pH signifies the presence of microbial activity involved in the decomposition of organic matter. Overall, the pH values of each treatment indicate the maturity of the compost and fall within the range specified by the Indonesian National Standard, which is 6.87, 6.85, dan 6.83.

3.2.2. C-Organic

C-Organic observations were conducted at regular intervals of every two weeks throughout the six-week composting period. The measurement results of C-Organic for the different treatments (EM4, Promi, PSB) during the composting process are depicted in Fig 4.

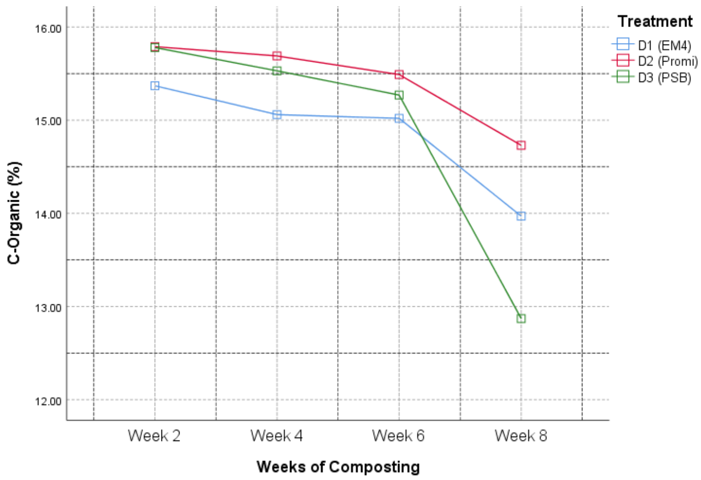

Figure 4. Average c-organic of the compost every two weeks

From the observations, it can be seen that the organic carbon content increases at the beginning of composting from the second week to the fourth week in treatment D1 (EM4). Essentially, organic matter grouping consists of several components, including particulate organic matter (leaf litter, macro-organic matter, and light fraction), humus (non-substance and humic substance), moist organic matter (inert), and soluble organic matter. The decomposition process begins with the easily soluble components of organic matter, such as glucose, amino acids, and organic acids, which will be mineralized and used as a source of fuel and energy by microbes to break down more complex organic material [15].

The increase in organic carbon content at the beginning of composting is caused by the death of microorganisms [16]. Furthermore, treatment D3 (PSB) experiences a drastic decrease in organic carbon content from 15.27% in the sixth week to 12.87% in the eighth week. This is thought to be due to an increase in the number of microbes, which will drive the decomposition of organic matter from more complex organic compounds, resulting in previous carbon loss in the form of CO2 [17]. By the completion of the composting process in week 8, all treatments had decreased their organic carbon levels by 13.97%, 14.73%, and 12.87%, respectively. These values have met the quality standards for compost with a minimum organic carbon content of 9.8% according to SNI 19-7030-2004.

3.2.3. Total N

Observations of the total N content were conducted at regular intervals of every two weeks throughout the six-week composting process. The results of the total N measurements during composting for the three decomposers (EM4, Promi, and PSB) are presented in Fig 5.

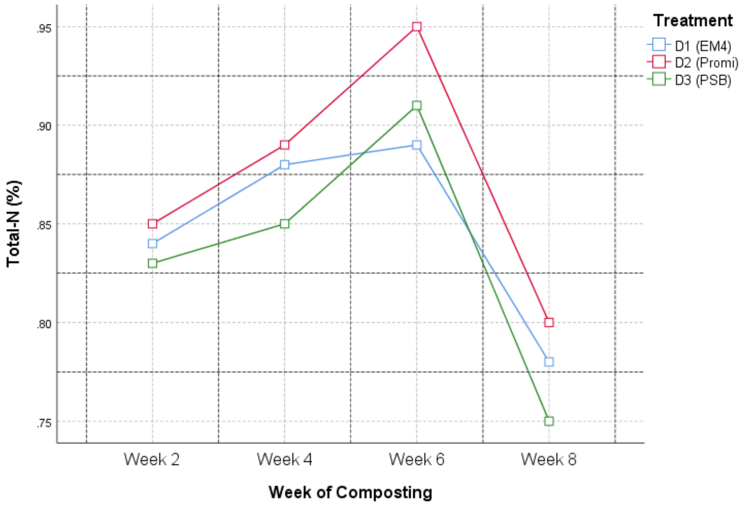

Figure 5. Average total-n of the compost every two weeks

In the graph above, the change iTotal N nitrogen (N-total) levels from week 2 to week 4 in treatments D1 (EM4), D2 (Promi), and D3 (PSB) shows a similar pattern, which is an increase in N-total levels. This increase in N-total levels is believed to be due to composting organic materials containing nitrogen compounds. During the decomposition process, organic matter will produce NH4+ through a process called ammonification [18]. Proteins present in organic materials are broken down by microorganisms into amino acids. These amino acids then undergo ammonification, resulting in ammonium compounds (NH4+). This study's findings were comparable to those of [19], which stated that an increase in nitrogen content occurs after two weeks of the composting process, attributed to the mineralization of protein compounds. Meanwhile, in the last week of composting, N levels had decreased.

This probably occurred because most of the proteins or compounds containing N had been decomposed so that no more NH4+ was disassembled. The results of this study are relatively the same as the findings of [19] who said that the mineralization of protein compounds resulted in an increase in nitrogen content after 2 weeks of composting. In the last week, the N levels in treatments D1 (EM4), D2 (Promi), and D3 (PSB) were 0.83%, 0.87%, and 0.82%, respectively. These total N levels fall within the acceptable range for nitrogen content (total N), which is a minimum of 0.40% according to SNI: 19-7030-2004.

3.2.4. C/N Ratio

The organic carbon and nitrogen levels are calculated to determine the C/N ratio every two weeks throughout a six-week composting period. The C/N ratio measurements for the treatments (EM4, Promi, PSB) are shown in Fig 6.

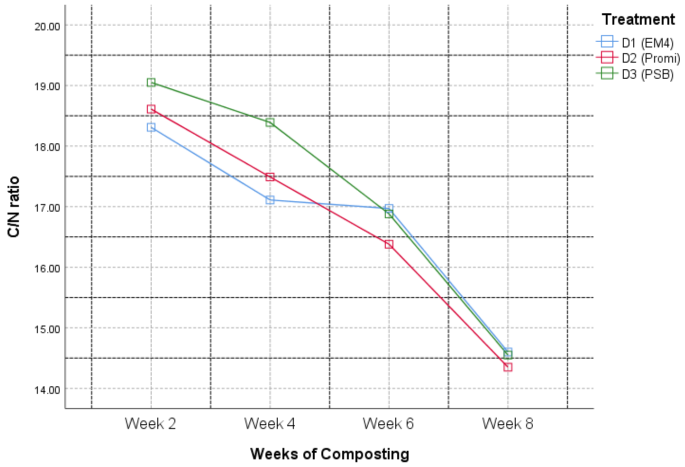

Figure 6. Average C/N Ratio of the compost every two weeks

All treatments demonstrated a decreasing C/N ratio pattern from the beginning to the end of the composting process. During the second to fourth weeks, treatment D2 (Promi) underwent a reduction in the C/N ratio. The occurrence of breakdown processes is indicated by the decrease in the C/N ratio. Furthermore, treatments D1 (EM4) and D3 (PSB) underwent a drastic decrease from the fourth week to the sixth week of the composting process. The rate at which the C/N ratio decreased depended on the level of microbial activity involved in decomposing organic matter throughout the composting process [20]. In intensive decomposition processes, there is a drastic change in the C/N ratio. It is suspected that during composting, there is the development of fungi and actinomycetes, as well as other microorganisms besides the decomposer microorganisms. These microorganisms become active, multiply rapidly, and produce a significant amount of CO2, resulting in a decrease in organic carbon [21].

The C/N ratios at the end of the composting process for each treatment, D1 (EM4), D2 (Promi), and D3 (PSB), were 14.60%, 14.35%, and 14.55%, respectively. These C/N ratios indicate that the produced compost has matured according to the requirements of the SNI (Indonesian National Standard) 19-7030-2004, which states that a good C/N ratio ranges from 10-20%.

3.2.5. Characteristics of Compost Based on SNI 19-7030-2004

During the composting process that lasted for 6 weeks, changes have occurred in the observed parameters. Composting using straw and fish waste (pond sediment) as raw materials, along with several decomposers (EM4, Promi, and PSB), exhibited compost characteristics as shown in Table 2.

Table 2. Standard quality criteria versus observational results

No	Parameters	Units	SNI	Result		
				D1 (EM4)	D2 (Promi)	D3 (PSB)
1	Temperatures	°C	maks. 30	29.60	29.20	29.80
2	pH	-	6.80 – 7.49	6.87	6.85	6.83
3	Color	-	blackish	blackish	blackish	blackish
4	Smell	-	like soil	like soil	like soil	like soil
6	C/N Ratio	%	10 - 20	14.60	14.35	14.55
7	C-Organic	%	9.8 - 32	13.97	14.73	12.87
8	N-Total	%	min. 0.40	0.83	0.87	0.84

Source: SNI 19-7030-2004 and Laboratory test result

4. Conclusions

The three decomposers (EM4, Promi, and PSB) have been able to decompose compost made from straw and fish waste for 6 weeks with good results, and they are ready to be applied to various types of plants. The compost produced by the decomposers EM4, Promi, and PSB has the following characteristics: it has a blackish color, soil-like smell, a temperature ranging from 29.2°C to 29.8°C, a pH ranging from 6.83 to 6.87, organic carbon content ranging from 12.87% to 14.73%, total nitrogen content ranging from 0.83% to 0.87%, and a C/N ratio ranging from 14.35% to 14.60%. These findings align with the compost maturity standards established by SNI 19-7030-2004..

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