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UTILIZATION OF TOFU LIQUID WASTE GENERATED FROM ANAEROBIC PROCESSING IN COMPOST PREPARATION

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ABSTRACT: This study aims to identify the ability of tofu liquid waste generated from anaerobic processing to act as a microorganism source to help expedite compost decomposition. In this research, composting was performed on 2 kg of rice husks to which tofu liquid waste was added in various volumes (500–2000 mL) and 1 kg of cow manure. This research used a nonfactorial completely randomized design with five treatments and four repetitions, which made a total of 20 unit trials. Changes in pH, humidity (rH), C composition, N, C/N ratio, and number of colonies were analyzed to observe the compost quality. The data collected were then analyzed using SPSS 16. The research findings showed that increasing the volume of tofu liquid waste has a significant impact on composting temperature, and all compost outputs were within proper compost criteria. Increasing tofu waste volume can improve the population of microorganisms, which accelerated the decomposition process of organic matter. The highest number of bacterial colonies, 73 colony forming units, was found on 1500-mL treatment. At this condition the values obtained were 17.94%, 0.9%, and 20.1 for C, N, and C/N ratio, respectively.

Keywords: Compost, Tofu Waste, C/N Ratio, Bacteria Colonies

1. INTRODUCTION

Tofu is a traditional oriental food and is typically processed by grinding and boiling of soybeans. The tofu industry is one of the industries that use a large amount of water in its processes. The water used in the process produces a large amount of tofu waste. Without a good handling process, tofu waste containing a high proportion of organic compounds may cause various adverse impacts, such as water pollution, various diseases, bad smell, increased mosquito population, and degrading the aesthetics of the environment. Liquid waste disposed to a water body without prior processing may also kill the biotic community in the water, including microorganisms, which have important roles in managing biological balance in the water. Small tofu processing industries usually dispose of their waste into the sewage system and do not go through appropriate processing [1],[2]. Some researchers have utilized liquid waste from the tofu industry as sources of methane and hydrogen gas [3],[4] by biological degradation (anaerobic process). After going through an anaerobic process, tofu liquid waste still contains mixed cultures of bacteria and organic matter. In previous research, Faisal et al. [4] used a thermophilic stirred anaerobic (TSA) reactor to process tofu liquid waste. The chemical oxygen demand value of the waste generated by the TSA process was in the order of 1900–2000 mg/L. This high organic matter could not be discharged to the environment, Thus, further processing was required (for example, aerobic, membrane) for proper waste quality that meets effluent regulations. One of the methods to utilize the waste is making it into a microorganisms' source in the composting process.

Composting technology adoption is one of the alternatives that can reduce the amount of waste production [5]. Composting is one of the methods that have proven to be efficient and effective in waste processing, from both economic and environmental points of view [6]. Many studies on composting using various types of microorganisms have been done with relatively effective results [7],[8]. The success of compost production is determined by the ability of decomposer microorganisms to decompose organic matter. Mancebo and Hettiaratchi [9] conducted an intensive study on assessment of the composting dynamics of different organic residues (i.e., food wastes, dewatered sludge, sawdust, and herbal). The aerobic composting process is a cost-effective technique for the treatment and sanitization of biodegradable solid wastes fractions [10-13]. Composting can also effectively improve soil condition and farm product quality [14]. Nowadays, different types of microorganisms are added to accelerate the composting process, one of which is EM4, which contains a mixed culture of microorganisms.

The objective of this research was to identify the ability of tofu liquid waste produced from the

TSA process to act as a microorganisms' source to help accelerate the decomposition process of composting. It was expected that the mixed-cultures bacteria contained in the tofu waste could accelerate the decomposition process of the compost.

2. RESEARCH METHODS

The materials used to make compost in this research consisted of rice husks, manure (the matured type), and tofu liquid waste produced from TSA reactor processing. The characteristic of tofu waste has been described previously [2].

2.1 Trial Design

This research used a nonfactorial completely randomized design with five treatments and four repetitions, which made a total of 20 trial units.

Types of treatment: P0: 2 kg rice husks + 1 kg manure; P1: 2 kg rice husks + 1 kg manure + 500 mL tofu liquid waste; P2: 2 kg rice husks + 1 kg manure + 1000 mL tofu liquid waste; P3: 2 kg rice husks + 1 kg manure + 1500 mL tofu liquid waste; P4: 2 kg rice husks + 1 kg manure + 2000 mL tofu liquid waste.

Data analysis was conducted using SPSS 16, where if the analysis of variance showed a significant difference, it would be followed by the Smallest Real Difference Test at the 5% level.

2.2 Experimental

2.2.1 Preparation of compost

The materials used to make the compost were rice husks and manure, at a ratio of 2:1. One (1) kg of trash-free dry rice husks was mixed with 2 kg of manure. The manure used in the process was matured manure that had characteristics of low temperature, less strong smell, and dry. All bacteria (tofu waste) were fed into the composter (with a capacity of 30 L and equipped with a temperature indicator). The temperature, pH, and relative humidity (rH) of the composting were observed on a daily basis for 60 days. The observation was limited to the C/N ratio, C organic, total N, and the number of decomposer microorganism colonies. The analyses followed the procedure given in standard methods for the examination of water and wastewater. Determination of total nitrogen was done based on the total Kjeldahl nitrogen content and carbon was measured by gravimetric analysis.

3. RESULTS AND DISCUSSION

3.1 Temperature Changes

Temperature is one of the key indicators in compost making. Heat is generated by microorganisms' activity when decomposing organic matter. Temperature can also be used to find out how well the composting process is and to what extent decomposition has taken place. The results of analysis of variance using SPSS 16 showed that the tofu waste volume treatment had a significant impact ($P = 0.001 < 0.05$) on the compost. The observation results revealed that the average composting temperature during each treatment showed irregular temperature fluctuation and this was almost the same in each treatment.

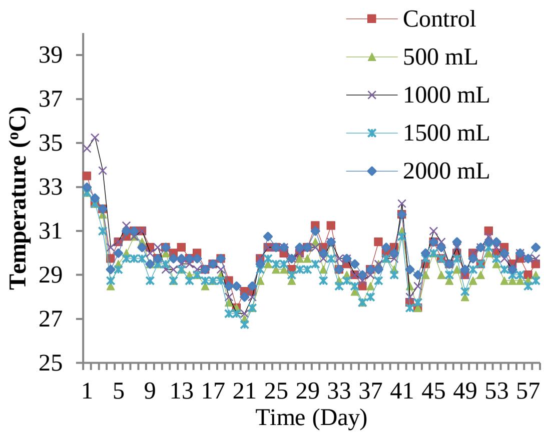

Fig. 1 Temperature as a function of time.

Figure 1 shows that the highest composting temperature of 34.75 °C occurred with the 1000-mL treatment during the first week of the composting period. In contrast, the lowest temperature of 26.75 °C occurred on the 1500-mL treatment during week 21. The observation results also revealed that adding tofu waste in various volumes caused significant temperature increases during the composting period.

The maximum temperature of the composting process involving thermophilic microorganisms is 45–59 °C, where at that point the composting process will be better [15]. In this study, the initial highest composting temperature was only 34.75 °C, which indicated that all treatment variations did not reach the required temperature for thermophilic microorganisms to grow and develop. In other words, mesophilic microorganisms played a role in this composting process. This was presumably caused by the high humidity of the pile, which prevented maximum heat production. This caused the compost to be unable to reach the optimum temperature required for thermophilic microorganisms to grow, resulting in a slow composting process. The compost temperature declined after the first week as microorganisms' activity to decompose organic matter reduced. The temperature decline could also mean that the compost had matured and mineralization process of nutrients had taken place.

3.1 Compost Characteristics (C/N Ratio, Organic C, and Total N)

On day 60, chemical analysis to find out compost quality was carried out. The compost testing consisted of C, N, and C/N ratio analyses. The results of laboratory analysis of the matured compost's chemical contents are shown in Table 1. Tables 2 and 3 show the standard compost criteria according to the Indonesian National Standard (SNI) and Regulation of the Minister of Agriculture No. 2/Pert/HK.060/2/2006, respectively [16].

Table 1 Compost's chemical contents

Treatment	C organic (%)	N total (%)	Ratio C/N	Tempe-rature (°C)	rH (%)	pH
Control	20.52	1.09	18.73	29.9	0	7
500 mL	19.03	0.94	20.42	28.7	12.4	6.7
1000 mL	18.48	0.87	21.09	29.9	20.2	6.5
1500 mL	17.94	0.9	20.1	29.1	44	5.6
2000 mL	17.51	0.7	25.08	29.9	53. 6	5.3

Table 2 Compost characteristics according to the Indonesian National Standard (SNI-19-7030-2004)

Limit	C organic (%)	N total (%)	Ratio C/N	Tempe-rature (°C)	rH (%)	pH
Min.	9.8	0.4	10	–	–	6.8
Max.	32	–	20	30	50	7.49

Table 3 Compost characteristics according to the Regulation of the Minister of Agriculture No. 2/Pert/HK.060/2/2006

Contents	C organic (%)	N total (%)	Ratio C/N	Tempe-rature (°C)	rH (%)	pH
Solid	≥12	0.4	10 ± 25	–	13 ± 20	4 ± 8

The C/N ratio is a comparison between carbon and nitrogen. The C/N ratio is widely used as an indicator of compost maturity [17]. The C/N ratio is used to identify the presence of microorganisms in an area because nitrogen is absorbed by plants and dead microorganisms leave carbon sediment.

A low C/N ratio of between 4 and 10:1 generally comes from the sea. Plants with wood vessels on land will provide sediment (organic matter pile) with C/N ratio <20 [18]. According to Setyorini et al.[19], the C/N ratio of good compost is 10–20, depending on the raw materials and humidity level.

Based on Table 1, the C/N characteristics of compost according to the SNI on the control treatment and the 1500-mL treatment with C/N ratio value were 18.73 and 20.1, respectively. Table 1 also shows that the C/N ratio from the highest compost treatments, i.e., in volume 2000 mL, was an average of 25.08 and the content of the N element was 0.7%, which was also the lowest of all treatments. We assume that the 2000 mL compost treatment requires longer decomposition to reach the level where the C/N ratio is <20.

As shown in Table 3, however, all treatments to the tofu waste compost with various volumes met the criteria of good solid compost. The analysis results also showed that organic C and total N contents on all treatments met the criteria of good compost for agriculture.

The high C/N ratio found in the 2000 mL volume treatment was presumably due to too much tofu waste being added to the compost, causing low temperature and a slow decomposition process. In contrast, the low C/N ratio in the control treatment was due to temperature rise, causing rapid microorganism effectiveness. The higher the temperature, the lower the C/N value will be [20]. The decline in C/N ratio was due to the increased microorganisms' activity during the organic matter break down process. The pile containing too little nitrogen would not produce heat for a rapid break down of matter, causing the C/N value to stay high.

3.2 Acidity (pH) and Humidity (rH)

3.2.1 Acidity (pH)

The results of data analysis using SPSS showed that the influence of tofu waste volume on compost pH was significant, where $P < 0.05$, thus H0 was rejected, which means that the average acidity (pH) of each volume treatment applied to the tofu waste was different. The pH change in the composting process varies vastly [21] depending on the types of composting materials and the microorganisms in it. Figure 2 shows the influence of waste volume on pH of compost. Compost acidity criteria are: very acidic <4.5, acidic 4.5–5.5, semi-acidic 5.6–6.5, neutral 6.6–7.5, semi-alkali 7.6–8.5, alkali >8.5. In Figure 2, the 1500 mL and 1000 mL volumes were included in semi-acidic, the 500 mL and control were included in the neutral criteria. Matured compost usually has a pH very close to neutral.

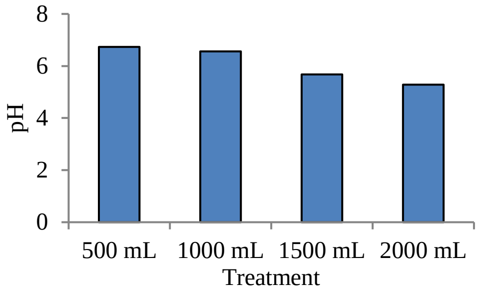

Fig. 2 Influence of waste volume on pH of compost

The pH of optimum composting ranged between 5.5 and 8.0. The pH of the 2000-mL treatment was included in acidic criteria as the activity of the microorganisms was to decompose organic matter and to produce simple organic acids. This signified that the composting process on that particular treatment was still continuing.

The composting process of organic matter can occur in a large pH range. The composting alone would cause changes to the organic matter and the pH. Although the pH of several treatments involving tofu waste was still in the acidic category, according to the standards in Table 3, all of the treatments with tofu waste met the criteria of compost used in agriculture, as the pH of the compost was higher than 4 and close to neutral.

3.2.2 Humidity (rH)

Humidity plays an important role in the metabolism process of microbes and indirectly influences oxygen supply. Microorganisms can utilize organic matter if the organic matter is dissolved in water. Sufficient humidity is required during the composting process [22]. High levels of humidity are harmful for efficient composting development because of decreasing the air void volume available for oxygen movement [22].

The results of data analysis showed that the influence of tofu waste volume on compost rH was significant, where the value of $P < 0.05$, so that H0 was rejected. In other words, the average humidity (rH) of each tofu waste volume treatment was indeed different.

Figure 3 shows the influence of tofu waste on compost rH. It can be seen that the smaller the volume of tofu waste in the composting process, the lower the humidity. Figure 3 also shows that the 500-mL treatment had humidity below the standard matured compost. The 1000-mL, 1500-mL, and 2000-mL treatments met the criteria of proper compost, as indicated in Table 3.

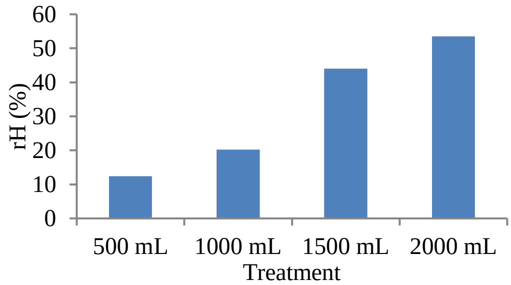

Fig. 3 Influence of waste volume on rH of compost

3.3 Number of Bacteria Colonies

Figure 4 shows the influence of various tofu waste volumes on the number of bacteria colonies in the compost. Analysis of variance showed that treatment of adding tofu waste did not have a significant influence ($P = 0.744 > 0.05$) on the number of microorganisms, especially bacteria. In other words, the number of bacteria colonies in each treatment was the same or no different from one another.

The maximum number of bacteria colonies was mostly found in the 1500-mL treatment. This was related to the value of C/N for that particular treatment. In the 1500-mL treatment, the bacteria had sufficient energy sources.

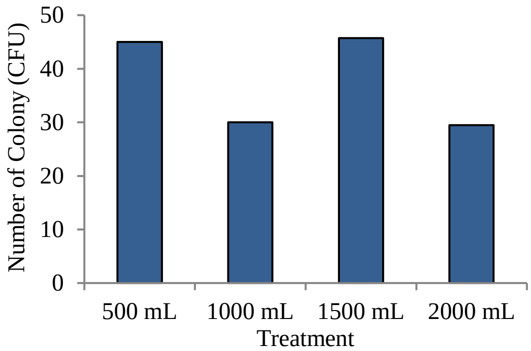

Fig. 4 the influence of various tofu waste volumes on the number of bacteria colonies

Although there was a difference between the analysis of variance and the number of bacteria colonies in each treatment, adding tofu waste in the composting process gave significant results. This is consistent with Hindersah's study [20], which found that adding tofu waste and bioactivator (cow manure) can increase the quality of compost microbiology. It is explained further that tofu waste can increase the total population of bacteria, fungi, Azotobacter sp. and phosphate-solubilizing bacteria. The basic components required as nutrients for microorganisms are carbon, nitrogen, and water. Microorganisms will use C compounds as an energy source to breed and use N to synthesize protein. During the composting process, many fungi and bacteria are responsible for the degradation of complex polymeric substrates, such as pectin, lignin, cellulose, and hemicellulose [8]. Li et al. [23] reported that, in general, the most efficient lignocellulose degraders are fungi due to the fact that their mycelial structure has a competitive advantage over bacteria.

The species of bacteria found in the compost on each treatment remain unknown. It was assumed that the decomposer bacteria that played a role in decomposing the organic material in the tofu waste compost were the lactate acidic bacteria (Lactobacillus sp.). Bacteria of this type are commonly found in composting material. Bacteria Lactobacillus sp. were able to reduce dangerous microorganisms and to decompose organic matter rapidly.

4. CONCLUSIONS

Microorganisms found in tofu waste generated using a TSA reactor can be used as decomposers in the making of rice husk compost. Increasing tofu waste volume can increase the population of microorganisms, which accelerates the organic material degradation process. All treatments of tofu waste compost involving various volumes meet the criteria of good solid compost. The analysis results also showed that organic C and total N contents in all treatments meet the criteria of good compost for agriculture. The highest number of bacteria colonies was mostly found in the 1500-mL treatment. Further research with various compost quality analyses (e.g., P, K, trace elements) will support this preliminary study.

5. ACKNOWLEDGEMENTS

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