RESEARCH ARTICLE Open Access

Gema Lingkungan Kesehatan
Vol. 23, No. 1 (2025), pp 60-66
e-ISSN 2407-8948 p-ISSN 16933761
Doi: https://doi.org/10.36568/gelinkes.v23i1.160 Journal Hompage: https://gelinkes.poltekkesdepkes-sby.ac.id/

The Influence of Various Types of Local Microorganisms on Compost Quality Using the Berkeley Method on Kitchen Waste

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ABSTRACT

The problem of organic waste is a big challenge for the environment, especially in urban areas. One effective solution is composting with the Berkeley method, with a rapid decomposition process within 18–21 days. This method uses high temperatures and regular turning of the compost. Berkeley composting not only helps reduce waste but also supports sustainable agriculture by providing a natural source of nutrients for the soil. This study aims to analyze the effect of three different types of MoL on compost quality, with parameters of temperature, pH, potassium, nitrogen, and phosphorus. Research method: This research is an experimental research through the utilization of dormitory kitchen waste with the Berkeley method and using MoL made from natural materials, namely fruit peels, bamboo shoots, and cassava tapai. Data analysis and processing using descriptive. The results showed that there was an effect of three types of MoL on the quality of compost. Based on observations of the physical quality of compost, the temperature and pH parameters showed that the average temperature was 29 ^{0}C and the average pH was 3.5, and the chemical examination of compost found that the compost produced for potassium parameters was highest produced by bamboo shoot mole, namely 0.044%, while the highest nitrogen parameter was tape mole, namely 1.41%, the highest phosphorus content was produced by fruit leather mole, namely 0.73 and the highest water content was fruit leather mole, namely 74.65. Conclusion: there is an effect of three types of MoL on the quality of compost with the Berkeley method.

Keywords: Berkeley, Compost, MoL, EM4, Organic waste

INTRODUCTION

The waste issue in Indonesia remains a major concern. According to data from the National Waste Management Information System (SIPSN) KLHK 2022, national waste accumulation reached 21.1 million tons, with 65.71% (13.9 million tons) managed and 34.29% (7.2 million tons) unmanaged. In 2021, national waste reached 68.5 million tons, including 17% (11.6 million tons) plastic waste. This number increased from 67.8 million tons in 2020. The more waste generated, the greater its environmental impact if not properly managed. Major waste contributors include residential areas, offices, industries, and public places (Kemenko PMK RI, 2023).

Household waste not only causes pollution that can lead to social, economic, and health problems, but various efforts have been made to manage household waste. Proper management from the start can reduce waste accumulation, increase transportation efficiency, and prolong landfill lifespan (Rosmala, 2020). Three main principles of waste management are to prevent waste generation, reuse waste, and recycle waste to prevent the accumulation of waste that could harm the environment. To protect the environment, waste management must be carried out with the 6R principles (Refuse, Reduce, Reuse, Recycle, Replace, and Rot) (Sari, 2023).

Organic waste from households, such as vegetable scraps and food leftovers, contributes to one-third of the 1.3 billion tons of food waste worldwide annually. This waste causes global economic losses up to 400 billion USD per year and generates high greenhouse gas emissions, especially from the decomposition, transportation, and processing of food. Household food waste plays a significant role in limiting climate change by producing greenhouse gases and supporting anaerobic processes that cause foul odors and pollution (Badrus Z, 2022).

The processing of solid organic waste can be done through composting. Nutrient-rich compost has undergone decomposition due to interactions between bacteria or microorganisms that cause decay (Suhastyo, 2017). Composting helps limit the amount of waste that ends up in landfills, improves soil fertility, enhances soil quality and chemistry, creates a clean, healthy, and beautiful environment, and ultimately saves the Earth.

Economically, this method can save on fertilizer costs and protect the environment (Shah et al., 2019). The use of composting techniques is a positive step toward environmental sustainability and healthy agriculture (Hamidah, 2023). Soil structure improvement can be achieved by using organic fertilizers because they use fewer biological resources and have less negative impact on the environment and soil compared to other fertilizers. Compost is considered more environmentally friendly than other fertilizers (Yanti et al., 2023).

Rapid urbanization, including dormitories, increases the amount of waste. Most of the recyclable waste is collected by scavengers and taken to recycling facilities. However, waste piled in open spaces or made into compost contributes to air, water, and soil pollution through the release of harmful gases such as methane and carbon dioxide, as well as heavy metals like lead, cadmium, manganese, and mercury (Shah et al., 2019).

The Berkeley method, or quick composting, offers an ideal solution for composting in dormitories or small-scale settings as it can produce compost in just 2-3 weeks. This method utilizes two types of organic materials: cellulose-rich materials such as rice straw and sawdust, and nitrogen-rich materials such as vegetable waste. To accelerate the decomposition process, activators like EM4, Promi, and Stardec, each containing different microorganisms, are added, resulting in varied compost outcomes (Hija, Junus, and Kamaliyah, 2021). Previous research has shown that the N, P, and K content in the compost produced meets quality standards, and there is a significant difference in nitrogen content based on the type of activator used (Rani, 2021).

Another study on composting with the help of EM4 (Effective Microorganisms) showed that the compost could be used after 20 days. The compost's nutrient content indicated a C/N ratio of 18, potassium 2.11%, and phosphorus 0.26%, with physical properties of brownish-black color, odor, and soil-like texture with a moisture content of 13.98%, a temperature of 27°C, and a pH of 7 (Ekawandani, 2018). Composting is the best and most sustainable method, as it allows nutrients and organic materials to be returned to the natural cycle, maintaining a continuous flow between waste, soil, and plant production (Jakubus, 2020).

One of the waste producers is the dormitory, which serves as a place for students to live and study. Activities in the dormitory generate waste from various sources such as common kitchens, male and female dormitories, canteens, staff houses, or other gathering places (Zaman et al., 2021). If this continues, it can become a breeding ground for vectors like flies, rats, or cockroaches (Syahputro, 2018). Flies can cause diarrhea, affecting the health of the residents, and pests can create an unpleasant environment in the dormitory. In this study, an analysis was conducted over 8 consecutive days, and it was found that the total waste generated was 59.9 kg/8 days, or 0.010 kg/person/day; the composition of the waste was 49% organic waste, 40% plastic waste, 6% paper waste, and 5% other waste such as fabric, wood, glass, bottles, and skewers. One strategy to address this among students is promotion, and the results of this study show that students with high knowledge about waste management are willing to manage their waste in an environmentally friendly manner (with p = 0.003). Overall, the waste management behaviors chosen by students include before-after (41%), plogging (30%), composting (26%), and saving in waste banks (3%). Therefore, the most suitable strategy for promoting waste management among students is the before-after method, which reflects waste reduction behavior (Winahyu, 2021).

The novelty of this research lies in the use of a closed composting method, which is more optimal than the open method commonly used in Indonesia. The open method relies only on natural processes in open areas, while this study maximizes the heat from microbial respiration to accelerate composting. Heat retention in a container is more effective than an open pile, resulting in faster and more orderly compost (Robert D. Raabe, 2017). The expected output of this research is to contribute significantly to efforts to reduce household waste, especially in dormitories with high organic waste volumes, through the implementation of an effective composting method and identifying the best activator for organic material decomposition.

RESEARCH METHODS

This research is an experimental study designed to create a composting tool using a covered bucket to achieve optimal temperature conditions. The treatments in this study used three types of Local Microorganisms (MoL) activators, namely MoL from fruit peels, bamboo shoots, and cassava tapai, with EM4 as a comparison. The selection of MoL from fruit peels, bamboo shoots, and cassava tapai is based on their nutritional content that supports the composting process. Fruit peels are rich in sugars and vitamin C, which accelerate the growth of decomposing microbes. Bamboo shoots contain fiber and cellulose, providing nutrients for microbes to break down complex organic materials. Tapai is rich in yeast and lactic acid bacteria, accelerating decomposition and maintaining the compost's pH balance.

Compost quality testing was conducted according to SNI 7763:2018, using the Kjeldahl method for nitrogen (N), spectrophotometry for phosphorus (P), flame photometry for potassium (K), and gravimetry for moisture content. This testing ensures the compost is of high quality and meets standards.

This research was conducted at the Muhammadiyah Palembang Institute of Health and Technology campus, using kitchen waste from the student dormitories, which generates approximately 3-5 kg of organic waste daily. Waste is typically collected by staff every two days, providing an opportunity to convert food scraps into compost. The study took place from February to March 2024, with laboratory tests conducted at the Palembang Industrial Standards and Service Center, with results obtained by March 25, 2024. Temperature and pH measurements were conducted three times: on January 30, February 6, and February 13, 2024. Data processing and analysis were presented descriptively, including pH, temperature, and chemical quality of the compost, with the highest percentages of the three MoL types being presented descriptively. The stages of this research are as follows:

1. **Preparation of MoL and Activation**
   Prepare jars for MoL production, 1 L of coconut water, and separately prepare 1 kg of bamboo shoots, 1 kg of cassava tapai, and 1 kg of ground fruit peels. Activate EM4 by dissolving 20 grams of brown sugar as microbial nutrition in 200 mL of water. Add 200 mL of MoL materials and 4000 mL of water to the sugar solution. Mix these materials, close the jar tightly, and incubate at room temperature for 5 days. After the 5-day incubation, dissolve 20 grams of each MoL material in 4000 mL of clean water. A total of 12 L of activator will be required for 3 repetitions.
2. **Compost Production Stages**
   Prepare four plastic baskets or buckets with holes on the left, right, and bottom sides. Mix organic waste from food processing scraps at the Muhammadiyah Palembang kitchen until homogeneous. Cut the waste into small pieces of approximately 5 cm. Prepare 4 kg of waste for each bucket, then layer the materials sequentially: first the waste, then sprinkle with MoL, followed by a layer of dry leaves and humus soil, and water with MoL again. Repeat the layering process until the bucket is full, maintaining the same thickness for each layer. Compost materials are turned every week to ensure aerobic decomposition. Incubate for 3 weeks until the compost volume is reduced to 30%. Compost is observed for its color, pH, temperature, and texture. A mature compost indicator is dark brown color, crumbly texture, and an earthy smell. In the final stage, the compost is sent to the laboratory for N-P-K content testing.

RESULTS AND DISCUSSION

The research conducted from January 30 to February 13, 2024, began with the preparation of MoL (Local Microorganisms), including MoL from fruit peels, bamboo shoots, and cassava tapai. Laboratory testing of compost quality was conducted at the Palembang Industrial Standards and Services Center, Ministry of Industry, with results obtained on March 25, 2024. The temperature and pH parameters were measured three times during the composting process: the first measurement on January 30, the second on February 6, and the third on February 13, 2024. Each treatment was repeated three times, resulting in a total of 10 samples, consisting of 3 treatments with 3 repetitions and 1 control. The results of the study are presented in the table below:

Physical Quality of Compost

Figure 1 above shows that the average temperature of the compost in the first week was 29°C. At this stage, the compost materials were just beginning the decomposition process, so the temperature was still high. This phase is referred to as the mesophilic phase, which is the initial stage of compost decomposition. During this phase, sugars and simple carbohydrates are metabolized rapidly.

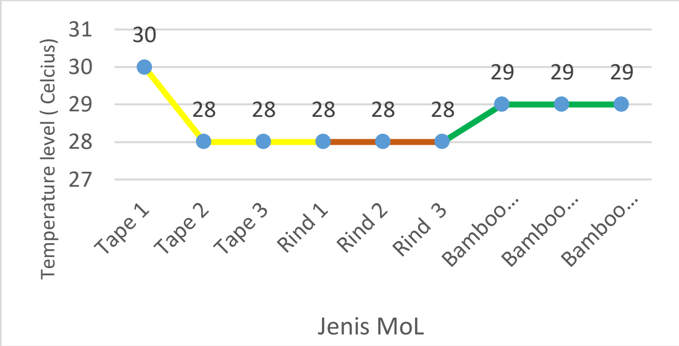

Figure 1. Compost Temperature Measurements in the First Week

This process is exothermic, meaning the temperature ranges from 15°C to 45°C. The microorganisms that are active during this phase are called mesophilic microbes. The temperature at the start of composting increases until day 7 due to the microbial activity in degrading the compost materials (Lucitawati & Erika, 2018).

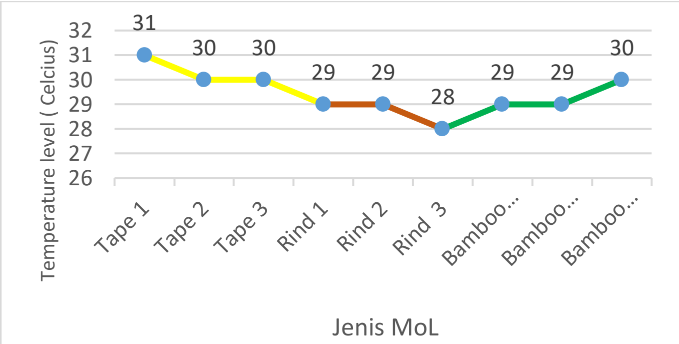

Figure 2. Compost Temperature Measurements in the Second Week

The temperature observations for the second week, as presented in Figure 2, show an average temperature of 29.4°C across the three types of MoL, indicating relatively similar values. The measurements were taken on day 12, with the highest temperature observed in the MoL tapai at 31°C, and the lowest in the MoL fruit peel at 28°C. The decomposition of organic materials using this heat method occurs rapidly within the temperature range of 30°C to 32°C. At this temperature, microorganisms utilize oxygen and generate heat energy, CO2, and water vapor. If the temperature is too low, the decomposition process does not proceed optimally, and microorganisms are unable to break down the organic material. This finding aligns with previous research that observed a temperature increase by day 5, with an average of 30°C (Fahruddin, 2018).

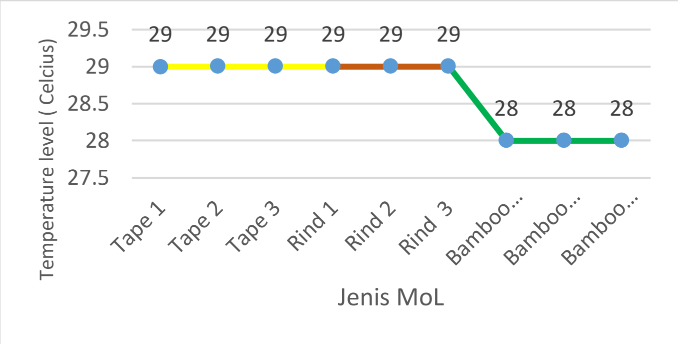

Figure 3. Compost Temperature Measurements in the Third Week

Figure 3 above shows that the compost temperature measurements on the third week, specifically on day 18, remained the same as those in the second week, with an average temperature of 29°C. Upon closer inspection, the compost temperature from the first week to the third week has met the SNI 19-7030-2004 standard, which ranges from 30°C to 32°C. The Berkeley composting technique, developed by the University of California, Berkeley, is a fast, efficient, and high-temperature composting method. This technique produces high-quality compost in 18 days. The temperature requirements for hot composting with the Berkeley method are maintained between 55°C and 65°C. At the end of the composting process, the compost's pH still falls within the SNI standard criteria, nearing neutral, ranging from 7 to 7.4. Meanwhile, in general hot composting, the temperature typically ranges from 40°C to 60°C. This method is faster and more efficient because the higher temperature accelerates microbial growth and decomposition. The decomposition of organic materials with the hot method results in a thermophilic temperature range of approximately 55°C to 65°C (Rani, 2021).

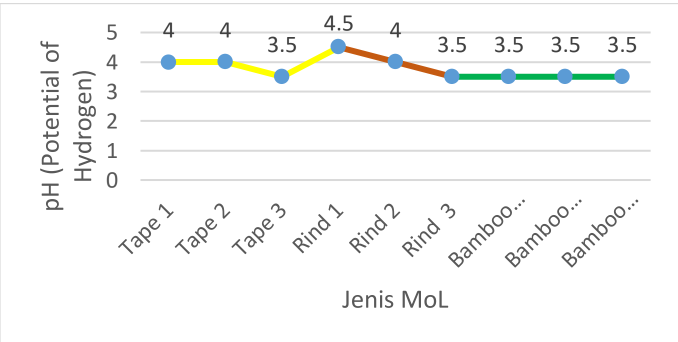

Figure 4. pH Measurement Results of Compost in the First Week

The pH measurement results for the compost in the first week show that the pH of the compost is below the SNI 10-7030-2004 standard, with the highest pH being 4.5 and the lowest at 3.5. When compared to the ideal pH range for decomposition, which is 6.8–7.49, the pH values were lower than expected. pH has an important effect on microorganisms that decompose organic material, as it influences the availability of nitrogen and can destroy insect larvae or eggs as well as other harmful organisms. An acidic pH is beneficial for composting. The varying pH values indicate the presence of bacterial activity in breaking down organic materials. In the initial stages of composting, the pH decreases, likely due to the production of acids by decomposing microorganisms. The decomposition of organic materials by microorganisms generates lactic acid and other organic acids (Yuriandala, 2021).

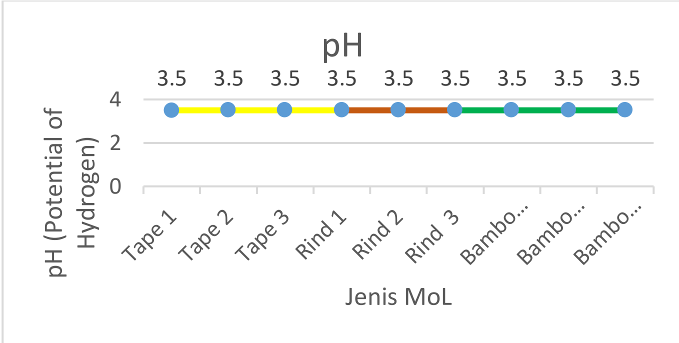

Figure 5. pH Measurement Results of Compost in the Second Week

In the second week, the compost pH remained stable with an average of 3.5. This is in line with the theory that the decrease in pH during the early stages of composting is usually caused by the activity of microorganisms that produce lactic acid and other organic acids. The decomposition of organic materials by microorganisms produces these weak acids. However, if the pH of the compost does not increase by day 14, several factors may influence this. One factor is the nitrogen content—if the nitrogen content in the compost is insufficient, it can affect the pH. Additionally, the availability of oxygen during the composting process plays a key role. If oxygen is inadequate, the activity of acid-producing bacteria may increase, which can lower the pH. Low oxygen levels will result in a greater pH drop, as facultative anaerobic microorganisms, which can produce more acids such as butyric, propionic, and acetic acids, thrive. Another factor is moisture content—improper moisture levels can also influence pH. Lastly, the type of microorganisms involved in the composting process can affect the pH. Bacteria prefer a neutral pH, while fungi thrive in slightly acidic conditions. This suggests a concentration of oxygen in the composting process. Microbes in composting work within a pH range of 5.5 to 8 (Wianthi, 2021).

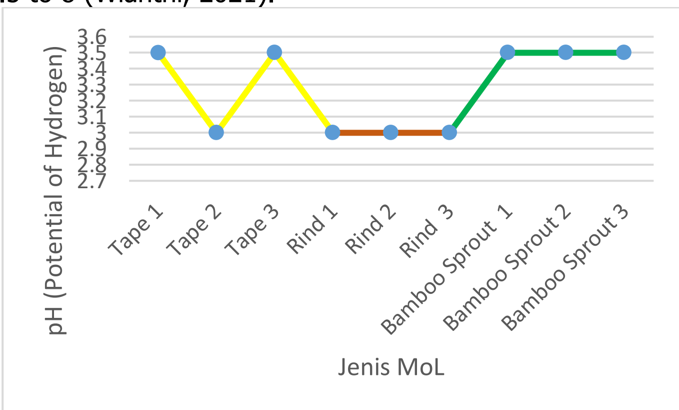

Figure 6. pH Measurement Results of Compost in the Third Week

In the third week, on day 18, as shown in Figure 6, the compost pH fluctuated between 3 and 3.5. This condition did not differ from the pH measurements taken in the previous weeks. In the case of the MoL (Microorganism Local) from fruit skins, the pH remained stable at 3, while MoL from bamboo shoots maintained a pH of 3.5. Throughout this composting process, the pH did not show a significant increase. According to Utomo (2018), the optimal pH for composting processes typically ranges from 6.5 to 7.5. The decomposition of organic materials during composting results in changes to both the material and its pH. Mature compost usually has a pH that is close to neutral.

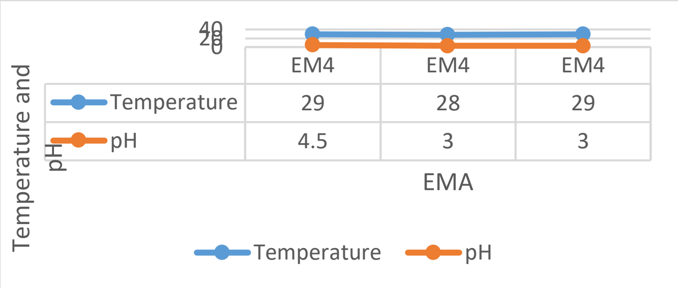

Figure 7. Temperature and pH Measurement Results of Compost with EM4 Activator

As shown in Figure 7, the use of the EM4 activator for composting resulted in an average temperature of 29°C and an average pH of 3.5 across the three types of MoL. Research using the EM4 bioactivator indicates that the physical quality of the compost produced meets the specifications for mature compost as outlined in SNI No. 19-7030-2004. During the maturation process, temperature fluctuations were observed. The optimal temperature for composting typically ranges between 55°C and 65°C. The pH of the compost during the composting process with EM4 did not show significant changes. The pH remained stable and did not experience drastic fluctuations throughout the composting process (SNI 19-7030-2004, 2004).

Chemical Quality

Chemical parameter tests for macro elements in compost, including potassium, nitrogen, phosphorus, and moisture content, were conducted on day 28 when the compost was fully mature.

Table 1.

Results of Chemical Quality Testing of Compost on Potassium, Nitrogen, Phosphorus, and Moisture Content

No	Test Parameter	Test Result (%)			MoL Comparative EM4	Standard Quality Requirements	Testing Method
		MoL Tapai	MoL of Rind	MoL of Bamboo shoots			
1	Potassium as K_2O	0.040	0.041	0.044	0.036	0.20	SNI 7763:2018 clause 6.7.8.1.1:6.7.4.2.2
2	Total Nitrogen	1.41	1.38	1.23	1.04	0.40	SNI 7763:2018 clause 6.6.1
3	Total Phosphorus as P_2O_5	0.58	0.73	0.62	0.68	0.10	SNI 7763:2018 clause 6.7.4.1.1:6.7.4.2.1
4	Moisture Content	68.77	74.65	71.22	68.95	50	SNI 7763:2018 clause 6.3

Source: Laboratory of the Standardization and Industrial Services Agency, Palembang, 2024
Note: SNI 19-7030-2004

Based on Table 1, the potassium levels as K_2 were measured for the different MoL types as follows: MoL tapai: 0.040%, MoL kulit buah: 0.041%, MoL rebung: 0.044%, and EM4: 0.036%. All three MoLs, including EM4, show potassium content significantly lower than the SNI standard (0.20%). Despite this, the differences in potassium levels among the MoLs are not significant. The low potassium content suggests that additional potassium fertilizer may be needed to meet the needs of plants, especially those requiring high potassium.

For total nitrogen, the following results were observed: MoL tapai: 1.41%, MoL kulit buah: 1.38%, MoL rebung: 1.23%, and EM4: 1.04%, while the SNI standard is 0.40%. MoL tapai had the highest nitrogen content (1.41%), which can be attributed to the fermentation process of tapai, which produces yeast and nitrogen-rich microorganisms. High nitrogen content is essential for compost application because nitrogen is a primary element for plant growth, particularly in leaf formation. All nitrogen results exceed the SNI standard, meaning that the compost produced by these three MoLs has great potential for significantly improving soil fertility.

For total phosphorus as P_2O_5, the results were: MoL tapai: 0.58%, MoL kulit buah: 0.73%, MoL rebung: 0.62%, and EM4: 0.68%. MoL kulit buah showed the highest phosphorus content, likely due to the high mineral content of fruit peels, which supports the decomposition process and the release of phosphorus. Phosphorus is crucial for root formation and helps plants absorb nutrients. All phosphorus results exceed the SNI standard (0.10%), indicating that compost made from these MoLs can significantly improve the availability of phosphorus in the soil.

Moisture content in all MoLs exceeded the SNI standard (50%), indicating that the compost tends to be wetter than desired. Excessive moisture can hinder the activity of aerobic microorganisms and slow down the composting process or cause odors. This compost should be further dried before use to avoid issues when applying it as fertilizer, especially in humid environmental conditions.

MoL tapai excels in nitrogen content, making it ideal for boosting the growth of plants requiring high nitrogen, such as leafy vegetables. MoL kulit buah has the highest phosphorus content, which is beneficial for plants needing better root and flower development. However, the high moisture content in all MoL samples needs attention, as it could affect compost quality. Drying or mixing with dry materials may be necessary before application. Overall, compost from these three MoLs has great potential as a high-quality organic fertilizer, particularly for supporting sustainable agriculture.

Chemical quality tests of the compost were conducted in the laboratory, where 0.5 kg of compost was sampled in a ziplock plastic bag. The compost's physical characteristics were observed, confirming that it met the quality standards: dark color, earthy smell, temperature matching the soil temperature, and texture similar to soil. During the composting process, turning the materials was done, which aligns with research by Arif et al. (2023), ensuring uniform decomposition. The layering of green and brown materials is critical for achieving a balanced C/N ratio and maintaining proper air circulation.

The highest potassium value was found in MoL rebung at 0.044%, while the highest nitrogen value was 1.41% from MoL tapai. The highest phosphorus level was 0.73%, compared to the required minimum of 0.10%. The highest moisture content was found in MoL kulit buah at 74.65%, with the standard set at 50%. Throughout the composting process, regular turning was done alongside temperature and pH measurements. The turning frequency helped maintain the porosity of the mixture and added oxygen to the system (Guidoni, 2018).

Potassium is already present in organic materials, but due to its complex biological structure, plants cannot absorb it directly. The breakdown of complex organic matter during decomposition makes potassium available for plant absorption. Potassium is essential for photosynthesis, as it helps plants form cellulose, strengthens stems, and produces proteins. The better the compost, the higher its potassium content, which benefits plant stem growth (Ekawandani, 2018).

Phosphorus is highest in MoL kulit buah at 0.73% and lowest in MoL tapai at 0.58%. This content meets the minimum phosphorus requirement for compost (0.10%). Microbial activity is crucial in transforming organic phosphorus molecules into forms that plants can absorb. Phosphorus supports photosynthesis, plant cell division, and tissue growth, and contributes to improved soil fertility and nutrient availability (Ekawandani, 2018).

Finally, MoL tapai contains the highest nitrogen content at 1.41%, surpassing the 0.40% standard, indicating good nitrogen quality in the compost. Previous research has reported nitrogen content as high as 1.58%, which is also above the minimum requirement for compost set by SNI 19-7030-2004 (Rani, 2021).

The highest moisture content was found in MoL kulit buah at 74.65%, surpassing the standard of 50%. Moisture content influences decomposition rates and temperature, with excess moisture slowing the process. Microorganisms require optimal moisture to break down organic material (Kurnia, Vaneza Citra, 2017).

The results show that the nutrient levels in the compost meet or exceed the established standards. The NPK values suggest that the compost can effectively support plant growth, particularly for chili plants. Overall, the three MoLs used in this study show great potential for producing high-quality compost using the Berkeley method.

CONCLUSION

This study concludes that there is an influence of three types of MoL on compost quality using the Berkeley method. The use of MoL rebung was found to provide the highest potassium content at 0.044%, making it an ideal choice for soils that require a high potassium supply. The highest nitrogen content was found in MoL tapai at 1.41%, while the highest phosphorus content was produced by MoL kulit buah at 0.73%. The highest moisture content was found in MoL kulit buah at 74.65%. These three elements meet the SNI 19-7030-2004 standards and are suitable for use as planting media.

RECOMMENDATIONS

It is recommended that further research be conducted by testing these MoLs with different types of waste and a longer composting duration to assess the stability of the compost. Additionally, this method can be applied at a household scale using kitchen waste as raw material and can be carried out collectively at the neighborhood level to achieve more efficient results, which could be economically beneficial for the community.

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