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Quality Analysis of Coffee Waste Compost with the Addition of Cassava Tapai Local Microorganism (LMO) Bioactivator

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ABSTRACT

Coffee waste contains a large amount of nutrients, making it a potential raw material for compost fertilizer. The nutrients contained in coffee waste include N, P, K, Mg, and Ca. Utilization of coffee waste as compost requires bioactivators to accelerate the decomposition process. This study aims to determine the difference in compost quality from coffee waste by using bioactivators in the form of local microorganisms (LMO) of cassava tapai. This study was conducted from April to May 2023 at the greenhouse of LPP Polytechnic Yogyakarta, consisting of two stages: making the LMO and making the compost. Cassava tapai LMO was prepared as a treatment for composting coffee waste. Each treatment was repeated three times. After that, the fermentation results in the form of compost were tested, then the results were compared with the standards of the Decree of the Minister of Agriculture No. 261/KPTS/SR.310/M/4/2019 on the minimum technical requirements for organic fertilizers, biological fertilizers, and soil conditioners. The results reveal that the provision of cassava tapai LMO bioactivator affected the quality of coffee waste compost produced. The quality of composts produced from control, cassava tapai LMO of 90 ml, and EM-4 treatment does not meet the standards of the Decree of the Minister of Agriculture in the parameter of chemical properties, namely the C/N ratio. The quality of compost produced from cassava tapai LMO of 120 ml meets the standards of the Decree of the Minister of Agriculture and SNI 2004 in all parameters of physical properties, chemical properties, and nutrient content.

1. Introduction

Coffee is one of the leading plantation commodities that has an important role in Indonesia's economic activities. Coffee plantations play a role in Indonesia's economic growth in earning foreign exchange, expanding employment, and of course a source of income for coffee farmers. In Indonesia, the development of coffee plantations in terms of area, production, and productivity has fluctuated in recent years. Based on statistical data, Indonesia's coffee plantation area reached 1,279,570 ha in 2021, with coffee production reached 780,869 tons (Central Bureau of Statistics, 2022).

Currently, coffee is growing quite rapidly as the most popular drink in the world. This increase in coffee consumption will generate more demand for coffee, which will spur coffee plantations to continue to develop to produce high coffee production. The current development of coffee plantations will also indirectly increase the amount of coffee waste produced (Juwita et al., 2017). The increase in coffee consumption also will increase the amount of coffee waste produced, both in the form of post-harvest processing waste and coffee brewing waste. The first one generally produces coffee fruit peel, while the second one generally produces dregs resulted by the coffee extraction process.

A study by Melisa (2018) showed that coffee fruit peel contains organic C of 45.3%, nitrogen of 2.98%, phosphorus of 0.18%, and potassium of 2.26%. Based on the nutrient content, coffee peel waste has the potential to be used as one of the raw materials for composting. Coffee waste contains 2.28% of nitrogen, 0.06% of phosphorus, and 0.6% of potassium. The pH of coffee waste is slightly acidic, around 6.2. In addition, coffee waste contain elements of magnesium, sulphur, and calcium that are useful for plant growth (Adikasari, 2012).

Efforts can be made to utilize coffee waste for agricultural purposes by converting coffee peel waste into compost. Compost is organic material that has undergone decomposition with the assistance of living organisms, such as microorganisms. Organic matter contained in compost can derive from vegetables, fruit or food waste, and chicken manure (Mardwita et al., 2019). One way to optimize composting is by using bioactivators, namely bioactive materials that can break down organic matter in general. In addition to accelerating the composting process, the advantages of using bioactivators are that the quality of the product is more guaranteed and the production process is relatively simple.

The bioactivator on the market that contains many bacteria is Effective Microorganism-4 (EM-4). The use of this bioactivator can also be replaced with bioactivators from natural materials, namely local microorganisms. Local microorganisms (LMO) are collection of several microorganisms that can be cultivated and function as a starter (Roeswitawati, 2018). Natural materials that can be used as LMO bioactivators are cassava tapai, which is relatively cheap and easy to obtain and contains many microorganisms. According to Santoso and Prakosa (2010), cassava tapai can be used as a bioactivator because it contains various microorganisms, such as *Saccharomyces cerevisiae*, *Rhizopous oryzae*, *Endomycopsis burtonii*, *Mucro* sp., *Candidia utilis*, and *Saccharomycopsis fibuligera*, which are able to decompose organic waste into quality compost.

The making of bioactivators takes a longer time than using activators on the market, such as EM-4, which can be used immediately. Therefore, it is necessary to conduct a study to investigate the use of cassava tapai LMO bioactivator to assess the quality of compost produced from coffee waste in order to increase the potential in coffee waste so that it can be utilized in agriculture or plantations.

2. Methods

This study was conducted from March to May 2023 at the greenhouse of LPP Polytechnic, Wedomartani, Sleman, Yogyakarta. Chemical analysis was conducted at the Soil Laboratory of Yogyakarta Muhammadiyah University.

The equipment used were decomposer containers, tarpaulins, scales, stirrers, bottles, pH meters, thermometers, stationery, and documentation equipment. The materials used were coffee waste obtained from coffee farmers, cassava tapai, shrimp paste, brown sugar, water, and EM-4 (Effective Microorganisms-4).

This study was conducted using cassava tapai LMO bioactivator. Each treatment was repeated three times. The composting results were tested, then compared with the standards of the Decree of the Minister of Agriculture of the Republic of Indonesia No. 261/KTSP/SR.310/M/4/2019. The treatments given were Control (P0), EM-4 of 100 ml (P1), cassava tapai LMO of 30 ml (P2), cassava tapai LMO of 90 ml (P3), and cassava tapai LMO of 120 ml (P4).

2.1 Implementation stage

The implementation consisted of two main stages, namely making the LMO and making the compost. LMO was made using 200 gr of cassava tapai, 200 gr of shrimp paste, 5 gr of sugar, and 1,200 ml of water. Furthermore, LMO was made by fermenting all these ingredients in a 1,500 ml bottle for four days. After the fermentation, LMO was ready to be used as a composting activator.

The composting process was carried out for four weeks using the aerobic method. The basic ingredients used were 50% coffee peel and 50% coffee waste, mixed in the composter container that has been prepared. The composting process began by weighing the coffee peel and coffee waste at a ratio of 1:1, then they were mixed evenly in a tarpaulin. All materials that had been mixed were put into the composter container, then activators are added to each barrel according to the specified treatment. Composting was carried out for four weeks and compost stirring was carried out once a week to regulate moisture, aeration, and composting temperature.

2.2 Observation parameter

2.2.1. Physical properties

Temperature

Temperature observation was carried out once week for four weeks using thermometer, then the results were input into the observation table.

pH

pH observation was carried out once week for four weeks using soil pH meter, then the results were input into the observation table.

Color

Color observation was carried out once a week for four weeks by looking at the color of the compost, then the results were input into the observation table. The color was determined based on the color indicator in SNI 19-7030-2004, as presented in Table 1.

Table 1. Color indicator of compost fertilizer.

Code	Color indicator
1	Pale brown
2	Brown
3	Blakish Brown
4	Black

Aroma

Aroma observation was carried out once a week for four weeks by sensing the smell of the compost, then the results were input into the observation table. The aroma was determined based on the aroma indicator in SNI 19-7030-2004, as presented in Table 2.

Table 2. Aroma indicator of compost fertilizer.

Code	Aroma indicator
1	Smells horrible
2	No soil-smelling
3	Slighly soil-smelling
4	Soil-smelling
5	Strongly soil-smelling

2.2.2 Chemical properties

The chemical properties of compost, namely organic C content, C/N ratio, and compost pH, were observed at the end of the study. Organic C content and C/N ratio were determined through laboratory tests. The compost chemical properties test was conducted by compositing three replicates of each treatment into one laboratory test. Observation of nutrient content was conducted at the end of the study through testing of the elements contained in the compost (NPK) by compositing three replicates of each treatment into one laboratory test.

2.3 Data analysis

There were three data obtained in this study, namely data on physical properties, chemical properties, and nutrient content. Observation data on physical properties were analyzed directly each week, while observation data on chemical properties and nutrient content were tested in the laboratory. All of these observation data were then compared with the Decree of the Minister of Agriculture No. 261/KPTS/SR.310/M/4/2019 on the minimum technical requirements for organic fertilizers, biological fertilizers, and soil conditioners.

3. Results and discussion

3.1 Compost physical properties

3.1.1 Temperature

Temperature plays an important role in the microorganisms' activities during the composting process. Ridanar (2021) stated that temperature is one of the important factors that affect the rate of composting because each decomposing microorganism has an optimum temperature in its activity. Composting temperature is strongly influenced by bacterial activity and the surrounding air. The observation results on temperature changes during the composting process are presented in Table 3.

Table 3. Average temperature change per week (^{o}C).

Treatment	SNI 2004	Temperature at the …th Week			
		I	II	III	IV
P0 (Without Bioactivator)		29.1*	29.0*	30.3*	29.9*
P1 (EM-4 of 100 ml)		29.2*	29.2*	30.5*	29.8*
P2 (Cassava tapai LMO of 30 ml)	≤ 30°C	29.2*	29.2*	30.4*	29.8*
P3 (Cassava tapai LMO of 90 ml)		29.1*	29.1*	30.6*	29.8*
P4 (Cassava tapai LMO of 120 ml)		28.9*	29.2*	30.5*	29.4*

*Description: *Meet the criteria of SNI 19-7030-2004*

Table 3 shows that the temperature from the first week to the third week tended to rise, but then decreased in the fourth week. This decrease in the last week was due to decreased microbial activity in breaking down the levels of available organic matters and indicates that the compost has entered the maturity phase (Siagian et al., 2021). During the composting time, the highest average temperature in each treatment occurred in the third week, and that was the peak temperature during the composting process. The composting process requires oxygen, CO_2, and H_2O, and produces heat energy. The overall reaction during composting is presented as follows.

$$\text{Organic matters} + O_2 + H_2O + CO_2 = \text{nutrients} + \text{humus} + \text{energy}$$

The higher the temperature, the more oxygen consumption and the faster the decomposition process. The high oxygen consumed will produce CO_2 from microbial metabolism so that organic matters decompose faster. The peak temperature reached by composting in this study is still classified as mesophilic temperature and had not reached thermophilic temperature. According to Cahaya and Nugroho (2009), there are three stages of composting process: mesophilic, thermophilic, and cooling stages. In the mesophilic stage, microorganisms grow rapidly, and the temperature tends to increase. Mesophilic microorganisms live at a temperature of 10–45°C and will reduce the particle size of compost raw materials to speed up the composting process.

In the thermophilic stage, the temperature will increase to 60°C, allowing thermophilic microorganisms to accelerate the breakdown of cellulose and hemicellulose in compost raw materials. The third stage is the cooling stage, where the number of thermophilic microorganisms decreases as the nutrients in the compost raw materials decrease (Subula et al., 2022). The temperature increase in this study was only up to 31°C, so it is thought that the decomposing microorganisms that were able to multiply in the composting of coffee waste were only mesophilic bacteria. According to Pandebesie and Rayuanti (2013), mesophilic conditions in composting are more effective because the microorganism activities that take place are dominated by protobacteria and fungi.

Based on SNI 2004, the standard temperature of compost that can be said to be mature is ≤ 30°C. The final temperature of composting coffee waste in this study has met the standard temperature of mature compost, namely around 29–30°C in all treatments. According to Ruskandi (2006), in the aerobic composting process, there are two phases, namely the mesophilic phase (23–45°C) and the thermophilic phase (45–65°C). The maximum temperature reached by the coffee waste compost did not reach the thermophilic stage due to the low compost pile so that the compost could not conduct enough heat.

According to Setyorini et al. (2006), the higher the volume of the compost pile, the greater the heat transfer rate and the easier the pile becomes hot. A pile that is too shallow will lose heat quickly, because there is insufficient material to retain heat and avoid its release. Cahaya and Nugroho (2008) stated that at the beginning to middle of the compost maturation process, thermophilic microorganisms should be present and play a role to degrade the organic matters.

The aerobic composting method runs under open conditions so that air circulation and good weather are needed. This environmental factor is the main cause in this method. The location of the composting site in this study was quite closed, and the weather was uncertain during composting, which is one of the causes of the lack of thermophilic temperature. According to Wahyono and Sahwan (2008), oxygen availability affects microbiological activity. The higher the oxygen absorption rate, the higher the temperature. The amount of material, the number of piles, and the composting method affect the temperature increase (Wang et al., 2015). A study by Siagian et al. (2021) also mentioned that weather conditions during composting also have an impact on compost temperature.

3.1.2 Compost color

Color is one of the indicators to determine the maturity level of compost. The observation results based on the color produced during the composting process are presented in Table 4.

Table 4. Compost color observation.

Treatment	Color at the …th Week			
	I	II	III	IV
P0 (Without Bioactivator)	2	3*	3*	3*
P1 (EM-4 of 100 ml)	2	2	3*	3*
P2 (Cassava tapai LMO of 30 ml)	1	1	2	2
P3 (Cassava tapai LMO of 90 ml)	2	2	2	3*
P4 (Cassava tapai LMO of 120 ml)	2	2	3*	3*

*Description: *Meet the criteria of SNI 19-7030-2004; Pale brown (1), Brown (2), Blackish brown (3), Black (4)*

Based on the observation of the color of compost, there was a change in the color from the first week to the last week. The final results showed that P0, P1, P3, and P4 treatments produced blackish brown compost, while P2 treatment produced brown compost. P0 treatment produced the fastest compost color change, namely in the second week.

Based on SNI 2004, mature compost exhibits blackish color like soil. Elda et al. (2017) also stated that the blackish color of compost indicates that the compost has matured. The decomposition process carried out by bacteria causes changes in the physical properties of compost, such as changes in color from yellow-brown to blackish brown (Andriany et al., 2018). Changes in the color of compost depend on the materials used. Fresh materials will contain very high levels of carbon and nitrogen. Composting is carried out to reduce carbon and nitrogen levels so that the resulting color will be dark, which also means that nitrogen levels are low (Dewi, 2017).

The final results show that the color of compost in all treatments has a difference. Compost from 30 ml of cassava tapai LMO exhibits a brown color, meaning it does not meet the criteria for mature compost based on SNI 2004. This is thought to be due to the non-optimal decomposition ability on the organic matters because the thermophilic temperature was not reached during the composting process. Therefore, the compost produced from 30 ml of cassava tapai LMO can be said to be immature or the composting process is still occurring because the color produced is not blackish brown. Djuarni et al. (2005) also stated that the composting process that is still occurring shows a brownish color, and compost that has matured shows darker approaching a blackish color.

3.1.2 Compost aroma

The observation results based on the aroma produced during the composting process are presented in Table 5.

Table 5. Compost aroma observation.

Treatment	Aroma at the …th Week			
	I	II	III	IV
P0 (Without Bioactivator)	2	2	3	4*
P1 (EM-4 of 100 ml)	2	2	3	4*
P2 (Cassava tapai LMO of 30 ml)	2	2	2	3
P3 (Cassava tapai LMO of 90 ml)	2	2	3	3
P4 (Cassava tapai LMO of 120 ml)	2	2	3	4*

*Description: *Meet the standards of SNI 19-7030-2004; Smells horrible (1), No soil-smelling (2), Slightly soil-smelling (3), Soil-smelling (4)*

The observation results show that the aroma of compost changed from the beginning to the end of composting. Changes in composting aroma did not occur from the first week to the second week, but occurred in the third week to the last week. At the end of the observation, the compost from P0, P1, and P4 treatments exhibited a soil-smelling aroma, while P2 and P3 treatment produced compost with a slightly soil-smelling aroma.

Based on SNI 2004, mature compost exhibits a soil-smelling aroma. This means the compost aroma produced by P0, P1, and P4 treatments meets the criteria of mature compost based on SNI 2004. On the other hand, the compost aroma produced by P2 and P3 treatments does not meet the criteria. This is thought to be because the thermophilic temperature was not reached during the composting process so that the decomposition process of organic matters by microorganisms was also not optimal.

A study by Isroi (2008) show that mature compost is characterized by soil-like aroma. If there is an unpleasant smell, it means anaerobic fermentation has occurred and the compost has not yet matured. This is in line with Setyaningsih et al. (2017), that compost that has matured (whose organic matters have been completely degraded) will smell like humus or less pungent. Based on SNI, good compost is the one whose aroma matches the smell of soil (Ubaidillah et al., 2018).

3.2 Chemical properties observation

Observations on compost chemical parameters aim to determine the level of availability of chemicals contained in compost, such as the content of pH, organic C, organic matter, total N, C/N, total P, and total K in organic fertilizer in the form of coffee waste compost with various bioactivators. All observation parameters were compared with the minimum technical requirements of organic fertilizers, biological fertilizers, and soil conditioners based on the Decree of the Minister of Agriculture of the Republic of Indonesia No. 261/KPTS/SR.310/M/4/2019.

3.2.1 pH

The degree of acidity (pH) is one of the factors that affect the growth of microorganisms involved in the composting process (Rosalina et al., 2020). Observation results of pH changes in the composting process are presented in the following table:

Table 6. Compost pH.

Treatment	Decree of the Minister of Agriculture	pH at …th Week			
		I	II	III	IV
P0 (Without Bioactivator)	4–9	5.7*	6.2*	6.4*	6.2*
P1 (EM-4 of 100 ml)		5.6*	6.0*	6.4*	6.1*
P2 (Cassava tapai LMO of 30 ml)		5.6*	6.0*	6.2*	6.1*
P3 (Cassava tapai LMO of 90 ml)		5.8*	6.2*	6.3*	6.2*
P4 (Cassava tapai LMO of 120 ml)		5.9*	6.2*	6.4*	6.2*

*Description: *Meet the standards of Decree of the Minister of Agriculture of the Republic of Indonesia No. 261/KPTS/SR.310/M/4/2019*

Based on the results in table 6, the pH of the compost fluctuated greatly from the first week to the last week. The highest level of acidity in all treatments occurred in the third week, ranging from 6.2–6.4. Triyadi et al. (2015) revealed that changes in pH during the composting process are caused by microbial activity. The increase in pH to alkaline conditions is supportive for the composting process because alkaline conditions can inhibit the growth of pathogens, such as fungi that can live in acidic conditions. Increasing and decreasing pH is a sign of microorganism activity in decomposing organic matter (Firdaus, 2011).

The ideal pH of compost based on the standards of the Decree of the Minister of Agriculture of the Republic of Indonesia No. 261/KPTS/SR.310/M/4/2019 ranges from 4–9. Therefore, the final pH of compost from all treatments is considered meets the standard. According to Marlina (2009), the acidity of raw materials is acidic at the beginning of the composting process, then microorganisms begin to convert inorganic nitrogen into ammonium so that the pH increases rapidly to alkaline condition. According to Manuputty et al. (2012), the increase in pH is thought to be due to the reaction of base cations, especially potassium and sodium, which are strong base-forming alkali metals; in addition to calcium and magnesium which are liberated during the decomposition process. According to Astari (2011), a pH value that is in the neutral range will be easily absorbed and used by plants, and is useful for reducing soil acidity because the original nature of the soil is acidic.

3.2.2 Organic C

Organic C content is an indicator of decomposition in composting and compost maturity (Mirwan, 2015). Total organic C in fertilizer is influenced by the quality of organic matters and the activity of microorganisms involved in the decomposition of organic matter. Analysis results on organic C content are displayed in Table 7.

Table 7. Compost organic C content.

Treatment	Decree of the Minister of Agriculture	Organic C (%)
P0 (Without Bioactivator)	Minimum 15%	74.28*
P1 (EM-4 of 100 ml)		78.04*
P2 (Cassava tapai LMO of 30 ml)		78.23*
P3 (Cassava tapai LMO of 90 ml)		76.42*
P4 (Cassava tapai LMO of 120 ml)		67.25*

*Description: *Meet the standards of the Decree of the Minister of Agriculture of the Republic of Indonesia No. 261/KPTS/SR. 310/M/4/2019*

Based on the Decree of the Minister of Agriculture No. 261/KPTS/SR.310/M/4/2019 on the minimum technical requirements of organic fertilizers, biological fertilizers, and soil conditioners, the minimum organic C content is 15%. The results in Table 7 show that the organic C content is very high in all treatments. High organic C indicates a lot of carbon content in the waste so that microorganisms release a lot of carbon into the air (Sari et al., 2020). During the composting process, organic matters will decrease and carbon dioxide will be released due to the activity of microorganisms, thus affecting the C-organic content of the resulting compost (Sutedjo, 2008).

The high organic C content is thought to be influenced by the physical condition of the compost, such as temperature. It is known that the temperature obtained in this study was not able to reach the thermophilic temperature so that the microorganisms' activity was low and caused chemical properties, such as the organic C content of compost, to increase. The organic C value of compost depends on the condition of microorganisms, because the presence of microorganisms in compost will break down the long-chain arrangement of polysaccharides into short-chain saccharides that can be absorbed more quickly and easily by plants (Harsono, 2012). This is in line with a study by Puspita et al. (2017), that the lack of microorganism activity in the compost decomposition process causes the organic C content to be relatively higher, presumably due to the characteristics of coffee waste, which contains high organic C. High organic C content in compost can also improve soil texture and soil aggregation. This will positively affect plant growth so that plants are able to absorb high nutrients to optimize the growth process. Besides, the use of compost also can reduce dependence on chemical fertilizers.

3.2.3 C/N ratio

The C/N ratio is the ratio between organic C and nitrogen. Carbon and nitrogen are needed by microorganisms to break down organic matters from raw materials. The C/N ratio in this study was measured by comparing the organic C content with the total N content. The analysis results on the C/N ratio value are presented in Table 8.

Table 8. Compost C/N ratio.

Treatment	Decree of the Minister of Agriculture	C/N ratio
P0 (Without Bioactivator)		26.247
P1 (EM-4 of 100 ml)		29.673
P2 (Cassava tapai LMO of 30 ml)	≤ 25	24.447*
P3 (Cassava tapai LMO of 90 ml)		31.579
P4 (Cassava tapai LMO of 120 ml)		22.643*

*Description: *Meet the standards of the Decree of the Minister of Agriculture of the Republic of Indonesia No. 261/KPTS/SR.310/M/4/2019*

Based on the Decree of the Minister of Agriculture No. 261/KPTS/SR.310/M/4/2019, the minimum value of the C/N ratio in compost is ≤ 25. The results in Table 8 show that the C/N levels produced by P2 and P4 treatments meet the standards of the Decree. On the other hand, the results from P0, P1, and P3 treatments exceed the minimum requirements by the standards. The results of these three treatments are quite high, therefore they do not meet the standards. The higher the C/N ratio value in the compost indicates that the compost has not decomposed completely or is not mature, due to the high amount of ammonia and nitrogen trapped in the pores of the compost pile. The high amount of ammonia and nitrogen released into the air causes the microorganisms activity to reduce carbon levels cannot occur optimally (Cahaya & Nugroho 2008).

A study by Mohamad et al. (2021) stated that another factor is the thermophilic temperature that was not reached during composting process so that only mesophilic microorganisms play an active role in degrading the organic matters. Mesophilic microorganisms have the ability to break down cellulose in organic matters, but their ability is not as good as thermophilic microorganisms. As mentioned before, the peak temperature of composting in this study only reached the mesophilic temperature.

A C/N ratio that is too high will impede the decomposition process. Similarly, if the ratio is too low, although initially the decomposition process occurs rapidly, it will still slow down the process due to lack of C as an energy source for microorganisms (Pandebesie & Rayuanti, 2013). A high C/N ratio will cause the composting process to take longer. Therefore, the C/N ratio of compost raw materials needs to be lowered. According to Rahmawanti and Dony (2014), a high C/N ratio (> 30) indicates that C has not been completely oxidized into CO_2 and N has not been mineralized. Organic matter that has C/N ratio close to or equal to C/N ratio of the soil can be used directly by plants. Principally, composting aims to reduce the C/N ratio of organic matters so that the ratio reaches the same level as that of the soil (< 20) (Dewi & Tresnowati, 2012).

The higher C/N value of compost indicates that the organic matters have not been completely decomposed. Conversely, the lower C/N value of compost indicates that the organic matters have been completely decomposed or are almost composted. Changes in the C/N ratio are influenced by the organic C levels of the material (which tends to decrease), and changes in N levels (which are relatively constant) so that the C/N ratio will decrease at the end of the composting process (Ismayana et al., 2012). A study by Budiwanti (2021) stated that the C/N ratio value of coffee peel is relatively high, generally above 30, thus coffee fruit peel must be composted first before being applied to plants. Therefore, compost fertilizer cannot be applied directly to plants if the C/N ratio is still relatively high.

3.2.4 Compost nutrient

The analysis results of NPK nutrient content in coffee waste compost in various treatments show different results between each treatment. However, all of them meet the standard of the Decree of the Minister of Agriculture No. 261/KPTS/SR.310/M/4/2019 (Table 8).

Table 8. Compost nutrient.

Treatment	Decree of the Minister of Agriculture	Macronutrient (N + P_2O_5 + K_2O) (%)
P0 (Without Bioactivator)		3.10*
P1 (EM-4 of 100 ml)		2.91*
P2 (Cassava tapai LMO of 30 ml)	Minimum 2%	3.49*
P3 (Cassava tapai LMO of 90 ml)		2.70*
P4 (Cassava tapai LMO of 120 ml)		3.27*

*Description: *Meet the standards of the Decree of the Minister of Agriculture of the Republic of Indonesia No. 261/KPTS/SR.310/M/4/2019*

The highest NPK content, namely 3.49%, was resulted by P2 treatment, while the lowest NPK content, namely 2.70%, was resulted by P3 treatment, which also meets the standard.

N is the main macronutrient element that is very important for plant growth, which plays a role in protein formation and plant reproduction,. Lack of N element can cause inhibition of plant growth, which shows symptoms of yellowing or pale leaves. P and K are also major macroelements in soil and plant growth. P is an essential macronutrient that is very important for plant growth, but its content in the soil is generally lower than that of N, K, and Ca. P plays a very important role in supporting soil fertility, photosynthesis processes, and plant chemical physiology. P is also required in cell division, tissue development, and plant growth stages (Widarti et al., 2015). There are three main symptoms of P deficiency in plants: greatly reduced root growth, premature yellowing of old leaves, and plants dwarfing.

K element plays an important role in the formation of protein and cellulose, which serves to strengthen plant stems (Ekawandani & Kusuma, 2018). One of the symptoms of K deficiency in plants is brown leaf margins. The K element binder comes from the decomposition of organic matter by microorganisms in the compost pile (Trivana & Pradhana, 2017). Compost material, which consists of organic matters, contains complex organic form of peels that cannot be utilized directly by plants for their growth. Decomposition activities by microorganisms convert these complex organics into simple organics that produce K element that can be absorbed by plants (Widarti et al., 2015). The higher the K content in compost, the better for plant stem growth (Ekawandani & Kusuma, 2018).

3.3 Discussion

Based on the results obtained from all parameters, each composting treatment showed different results. The quality of composts produced from cassava tapai LMO at doses of 30 ml and 90 ml does not meet the criteria of SNI 2004 in the parameters of physical properties, namely color and aroma. Meanwhile, the quality of compost produced from control and EM-4 treatment meets the requirements of SNI 2004 in all parameters of physical properties.

The quality of composts produced from control, cassava tapai LMO of 90 ml, and EM-4 treatment does not meet the standards of the Decree of the Minister of Agriculture in the parameter of chemical properties, namely the C/N ratio. Meanwhile, the quality of composts produced from cassava tapai LMO of 30 ml and 120 ml meets the standards of the Decree of the Minister of Agriculture in all parameters of chemical properties. Nutrient content parameters (NPK) in all treatments meet the standards of the Decree of the Minister of Agriculture.

Control and treatment using bioactivator cassava tapai LMO in this study produced almost the same results in all parameters observed. This is thought to be due to the physical properties of compost, namely temperature. This study used aerobic composting method, where temperature can affect the type of microorganisms that live in compost media. The peak temperature in this composting did not reach the thermophilic temperature, causing the microorganisms activity in the bioactivator to be less than maximum. Composting temperature that did not reach thermophilic temperature is thought to be caused by weather factor and composting location. Rainy weather during composting caused the temperature in the composting environment to decrease, and the composting location was closed enough to facilitate adequate air circulation during the composting.

In addition to the weather and the location of the study, the conditions of the compost heap of raw materials were on a laboratory scale so that microorganisms could not retain heat sufficiently. The higher the total volume of compost raw materials, the greater the rate of heat splitting will be, thus the compost will easily reach the temperature at which thermophilic microorganisms will grow. This allows thermophilic microorganisms to accelerate the decomposition of cellulose and hemicellulose in compost raw materials. The quality of compost produced, between using bioactivator and without bioactivator, did not show significant differences due to the absence of thermophilic microorganisms in the bioactivator. Mesophilic microorganisms that were present in composting process were only able to reduce the particle size of compost raw materials, thus affecting the composting results.

The compost produced from cassava tapai LMO of 120 ml is most recommended in this study because the quality meets the standards of the Decree of the Minister of Agriculture and SNI 2004 in all parameters of physical properties, chemical properties, and nutrient content. Meanwhile, the quality of composts from control and EM-4 treatment does not meet the standards of the Decree of the Minister of Agriculture and SNI 004 in parameters of chemical and physical properties.

4. Conclusions

Based on the results of this study, it can be concluded that there are differences in the quality of compost between cassava tapai LMO treatments and control in all parameters. The quality of composts produced from control, cassava tapai LMO of 90 ml, and EM-4 treatment does not meet the standards of the Decree of the Minister of Agriculture in the parameter of chemical properties, namely the C/N ratio. The quality of composts produced from cassava tapai LMO of 30 ml and 90 ml does not meet the criteria of SNI 2004 in the parameters of physical properties, namely color and aroma. The quality of compost produced from cassava tapai LMO of 120 ml meets the standards of the Decree of the Minister of Agriculture and SNI 2004 in all parameters of physical properties, chemical properties, and nutrient content.

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