*Research Article*

**The Use of Lumbricus Rubellus Earthworm Effect in Composting Process of Musa Paradisiaca L. Peel Waste**

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***Abstract***

*Conventional organic waste composting is one of the processing of organic waste that produces fertilizer. However. The conventional composting process for organic waste lasts 1-3 months. Vermicomposting is a type of composting that lasts a short time. In addition, vermicomposting produced compost and worms that have a high selling value. So in this study, Musa Paradisiaca L (MPL) peel and sawdust waste was composted using the vermicomposting method into compost. The primary data in this study consisted of monitoring the C/N ratio, temperature, pH, moisture content, texture, particle size of compost for 3 weeks of the composting process. Testing the analysis of the effect of using Lumbricus Rubellus (LR) earthworms in the composting process of MPL peel waste. and sawdust by using LR earthworms. The results of the study showed that the use of LR worms had no effect on temperature, pH, water content and C/N ratio during the composting process of MPL peel waste but did affect the texture, particle size and product of compost weight.*

***Keywords****: Musa Paradisiaca L* *peel,* *sawdust, vermicomposting*

1. **Background**

A biodegradable solid waste in Indonesia is the biggest composition of all solid waste. The composition of biodegradable solid waste in Indonesia reached 53.8% in 2020 (SIPSN, 2021). An organic solid waste will be decomposed by microorganism activity. Degradation of organic solid waste will be fasten by composting, but it will take a long time and slowly (Mulyono, 2016). Composting has a small economic value because the quality is lower than chemical fertilizer, therefore the price of compost is cheap ( Diener, 2011)

Vermicomposting is the one of the method to decompose organic material less than 30 days, decrease C/N ratio, and retain the nitrogen more than conventional composting (Wulandari, 2020)*.* The adding of earthworms of LR as decomposer increases composting rate process on organic solid waste (Rahmawati,2017). One of the component of organic solid waste from domestic activity is MPL peel waste. Based on measuremnet ini this research, MPL peel waste contains water content 80,72%, N total (0,55%), C-organic (45,46%), C/N ratio (82). The C/N ratio in MPL peel waste showed that it can be decomposed by vermicomposting method (Biruntha et al, 2020). Sawdust were needed as a bedding and bulking agent to increase the carbon value (Subandrio dkk 2012). Sawdust contains water content 12,36%, N total (0,48%), C-organic (52,97%), C/N ratio (110).

Vermicomposting is a biotechnology method that involve the earthworms as natural bioreactor to recycle solid waste and organic wastewater effectively (Bhandarkar, 2004). A nine grams earthworms Lumbricus rubellus on six hundred grams organic solid waste decomposed landscape waste up to 14.35% and increased the nitrate concentration up to 34% (Rahmawati, 2016). The using of EM4 as a bioactivator will increase the composting process rate and less odor (Natalina,2017). Besides that, EM4 give an advantage for soils because it will help the process of the sorption of the nutrientsin the soils. This research did composting with ratio 250 grams earthworms (*LR*) for 1 kilogram MPL peel waste. This research analyzed that the effect of LR earthworms utilization to MPL peel waste and sawdust composting.

1. **Research method**
   1. **Design of composter**

The following were the steps in making a vermicomposting reactor

a. Calculated composition of material compost based on the C/N ratio

In this study, the composted organic waste was MPL peel waste and sawdust as seeding. The formula for calculating the composition of MPL peel waste and sawdust in composting is as follows.

(1)

Where :

Rm = C/N rasio mix

WCMPL = Weight of carbon in MPL peel waste

WCSAWDUST = Weight of carbon in sawdust waste

WNMPL = Weight of nitrogen in MPL peel waste

WNMPL = Weight of nitrogen in sawdust waste

X = weight of sawdust mixed with 1 kg MPL waste

With C/N ratio mix (Rm) was 82, obtained that the weight of sawdust (0.02 kg) was mixed with 1 kg of MPL peel waste so that the percentage composition of the composted waste in this study consisted of sawdust (2%) and MPL peel waste (98%).

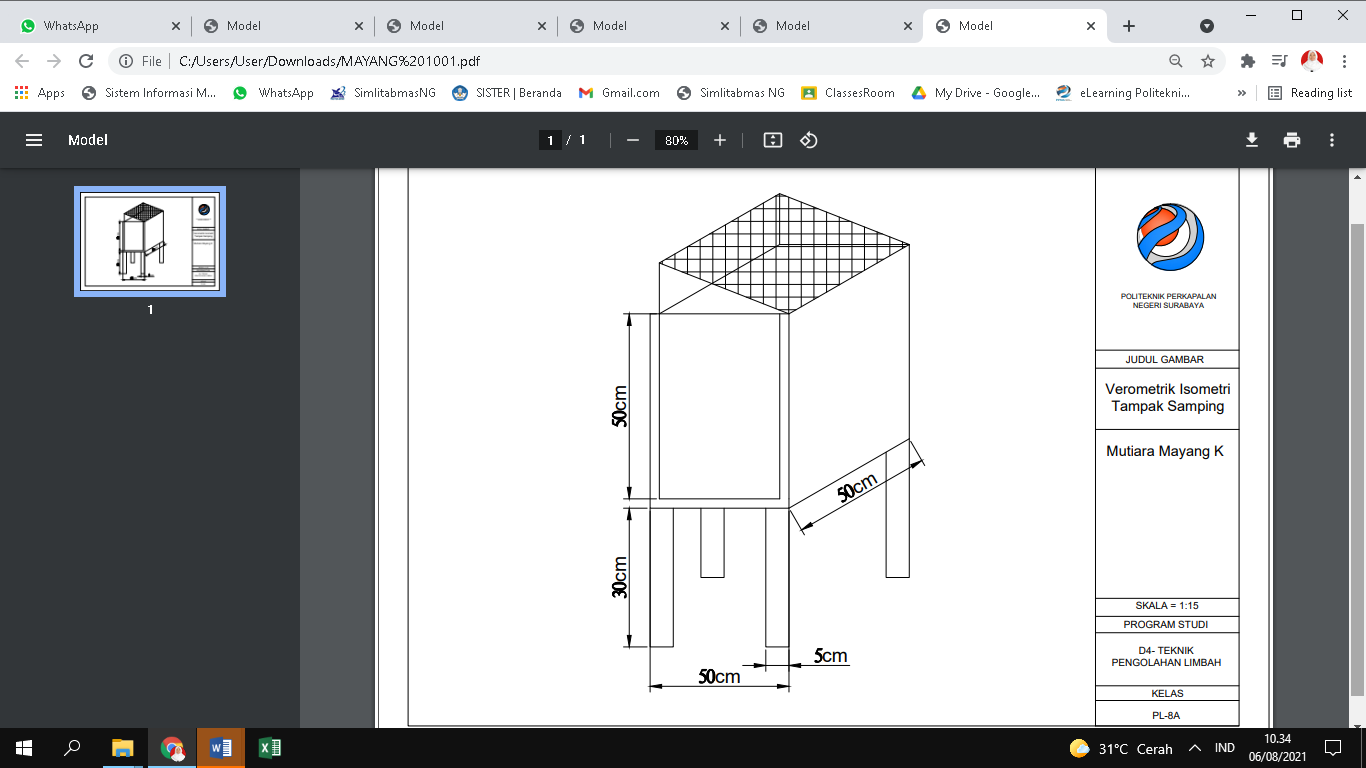
b. Calculated volume of material compost

In this study, the density of the compost mixture was measured to calculate the volume of the compost mixture. Measurement of the density of the compost mixture using the method of measuring the density of waste SNI 19-3964-1994. Based on the results of the measurement of the density of the compost mixture, the density of the compost mixture and the mass of composted waste in reactors 1 and 2 were 572 kg/m3 and 12.24 kg, respectively. Based on the results of calculations using the equation formula (2), it is found that the volume of compost material to be composted is 21377 cm3.

(2)

1. Designed Composter

The type of reactor in this study was a continuous flow bin type in the form of a cube. This reactor was made of wood and surrounded by sacks and cloth which serves to maintain humidity and air circulation in the reactor. The reactor is covered with paranet so that the availability of oxygen was sufficient in the composting process. The volume of the composting reactor used in this study was 85504 cm3 (4 x volume of compost material). Thus, lenght, height and wide of reactor was 50 cm, respectively.



**Figure 1.** Reactor 1 and 2

* 1. **Vermicomposting process**

1. Chopped compost material until size of particle was 2-3 mm

Composting is done to speed up the process of decomposition of organic compounds by microbes.

1. Mixed the MPL peel waste and sawdust homogeneously
2. Put mixture of MPL peel waste and sawdust into the reactor
3. Added EM4 to MPL peel trash and sawdust evenly

Made EM4 solution by mixing 20 ml of EM4 liquid with 10 ml of sugar and 500 ml of clean water. The dose of EM4 used in this study was 30ml/kg of compost material. In this study, the mass of the mixture of MPL peel waste and sawdust was 12.24 kg so that the total volume of EM4 solution required for each reactor was 367.2 ml.

1. Mixed compost material with earthworms LR

The LR earthworm added to the compost material was 250 gr/kg compost material. The mass of the compost material in this study was 12.24 kg so that the total LR worms added in the reactor was 2.76 kg (B2). The variables of this study can be seen in Table 2.

Table 2. **Reasearch** Variable

|  |  |
| --- | --- |
| Composition of compost material consists of MPL peel waste (98% ) and sawdust (2% ) with a dose of EM4 (30 ml/Kg material compost) | |
| No LR earthworm  (LR earthworm 0 gr/Kg compost material) | With LR earthworm  (LR earthworm 250 gr/Kg compost material) |
| B1 | B2 |

Keterangan:

B1 : Reactor 1 ; B2 : Reactor 2

1. Composting process in this study was 3 weeks.
   1. **Monitoring of composting process**
2. pH, moisture content, texture, temperature, texture, color and particle size

**Table 3**. Compost monitoring of physical parameters and pH

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters tested | Measurement Method | Measurement Tool | Measurement frequency |
| pH dan temperature | In situ | Soil meter 3 in 1 | Every day for 3 weeks of composting |
| Moisture content | Gravimetri | Oven in 1050C | Every day for 3 weeks of composting |
| Texture and color | In situ | Visual | Every day for 3 weeks of composting |
| Particle size | In situ | Compost sieve in 2mm | 3rd week (end of composting) |
| weight of LR earthworm and compost | In situ | Digital mass | 3rd week (end of composting) |

1. Macro element ( C/N ratio, C, N, P and K)

**Table 4.** Compost monitoring of Chemical parameters and macro elements

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters tested | Measurement Method | Measurement Tool | Measurement frequency |
| C-Organik | Walkey and Black | Spectrophotometer wavelength 651 nm and a standard solution of 5000 ppm C | 1st week and 3rd week |
| Total N | Kjhedahl Nitrogen | Titration with standard solution of H2SO4 0.05N | 1st week and 3rd week |
| C/N rasio | Hasil perhitungan | The calculation results | 1st week and 3rd week |
| Phospor | Spektrofotometri | Spectrophotometer wavelength was 693 nm | 3rd week (end of composting) |
| Kalium | Atomic Absorption Spectrophotometry (AAS) | Visible Spectrometer | 3rd week (end of composting) |

* 1. **Analyzed effect of the using LR earthworms to the composting process**

Test of effect of the using LR earthworms used statistical analysis ANNOVA One Ways. Parameters tested for their effect during the composting process were pH, temperature, air content, C/N ratio. The hypothesis of this research was as follows.

HoA = there was no effect of the use of LR earthworms in temperature of composting process

H1A = there was effect of the use of LR earthworms in temperature of composting process

HoB = there was no effect of the use of LR earthworms in pH of composting process

H1B = there was effect of the use of LR earthworms in t pH of composting process

HoC = there was no effect of the use of LR earthworms in moisture content of composting process

H1C = there wass effect of the use of LR earthworms in moisture content of composting process

HoD = there was no effect of the use of LR earthworms in C/N ratio of composting

H1D = there was effect of the use of LR earthworms in C/N ratio of composting

1. **Result and discussion**
   1. **Temperature of Compost**

**Figure 2. Temperature measurements in the composting process**

In this study, it was showed that the composting temperature occurred at a decrease to soil temperature (300c) at B1 and B2. There was only a slight difference in the composting temperature of the two reactors. Figure 2 showed that the composting temperature in both reactors is in the range (27-370C). The optimal temperature for earthworm growth was in the range of 15-370C (Kendie, 2009, Manyuchi et al 2012 and Gajalakshmi et al 2002). According to Meena et al 2021, the composting process have a mesophilic phase (temperature rise to 450C, temophilic and hygienic (45-600C) and mesophilic 2 (<400C) and maturation (20-300C).

**3.2 pH of Compost**

Figure 3. pH measurements in the composting process

In this study, there was no difference between the pH of the composting process in B1 and B2. It because there was no difference in the composition and type of compost material in B1 and B2 (Himanen and Hänninen, 2011). At the beginning of composting, the pH decreased, indicating the decomposition process of microorganisms produces organic acids and produces CO2 from the activities of microorganisms (González et al 2019). On the 4th day of pH, composting rose to 7 this was due to the activity of microorganisms in decomposing organic compounds into amides, amino acids, and ammonium into ammonia (Gusmawartati and Muhammad Yusuf, 2015). According to Khaerunnisa and Rahmawati in 2013, increasing of nitrogen compounds as ammonium (N-NH4+) indicates that the composting process is going well.

* 1. **Moisture Content of Compost**

**Figure 4. The results of measuring moisture content in the composting process**

Figure 4. showed that the composting in B1 and B2 was almost the same on day 1 to day 21. The range of **moisture** content in reactor B1 was 41-87% and B2 was 47-91%. The results of the study on B2 were comparable to those of González et al, 2019, Othman et al 2012, and Majlessi et al 2012. Moisture content was a parameter that indicated oxygen supply for worms and microorganisms (Domínguez et al, 2004, Gupta et al 2017 and Othman et al 2012). According to Gajalakshmi et al in 2002, the optimum moisture content for earthworm growth ranges from 50-80% in composting process.

* 1. **Color, Texture and Particle Size of Compost**

This study compared the physical condition of the compost from the results of composting using 250 gram of LR earthworm/kg waste and without LR earthworm. Worms used in composting can speed up the composting process. This was showed in the results of observations on both reactors. In the reactor that did not use worms, compost began to form on the 15th day. In the reactor that used worms, compost began to form on the 12th day. It was characterized by the color and texture of the compost which began to turn blackish brown and smooth. The condition of the waste in the two reactors was the same, which was bright, fresh, and has a rough texture. Although the compost located in B2 was faster than the compost located in reactor B1, the color and texture had not changed again after the 21st day. The results of observation of color and texture of compost fertilizer can be seen in Table 5.

**Table 5. Results of Observation of Color and Texture of Compost Fertilize**

|  |  |  |
| --- | --- | --- |
| Day | B1 | B2 |
| 1 | Bright and fresh color  Coarse texture | Bright and fresh color  Coarse texture |
| 3 | Bright and fresh color and rough texture | Bright and fresh color  Coarse texture |
| 6 | Light brown color  Slightly rough texture | Dark chocolate  Coarse texture |
| 9 | Dark brown color  Slightly rough texture | Dark chocolate  Coarse texture |
| 12 | Dark chocolate  Slightly rough texture | Dark chocolate  Slightly smooth texture |
| 15 | Dark chocolate  Slightly smooth texture | Dark chocolate  Smooth texture |
| 18 | Dark chocolate  Smooth texture | Dark chocolate  Smooth texture |
| 21 | Dark chocolate  Smooth texture | Dark chocolate  Smooth texture |

There were differences in the particle size of the compost in B1 and B2. The particle size in the first and second reactors was compared with SNI 19-7030-2004 regarding standart of compost quality. Fertilizer must have a particle size maximum 25 mm of the weight of compost. The compost that has been formed on the 21st day was harvested and sifted. Sifting was carried out to separate the finished compost from the waste that has not been composted or which was still lumpy. The sieving in reactor B2 aims to separate the compost from the worms. After sieving, the compost was analyzed for particle size. Based on the research results, the particle size of the compost in both reactors was 2 mm. The percentage of particle size of 2 mm in compost in B1 was 76%, while the percentage of particle size of 2 mm in compost in B2 wasA 85%. This proves that the use of worms in composting or vermicomposting can help reduce the particle size of the compost. Utilization LR earthworm in composting process can improve the physical quality in terms of color, texture, and particle size of the compost. The results of the observation of the particle size of the compost using the vermicomposting method can be seen in Table 6.

**Table 6.** Particle size of compost

|  |  |  |
| --- | --- | --- |
| Reactor | Particle size (SNI 19-7030-2004) | Particle size of compost |
| B1 | Maximum 25 mm | 2 mm (76%) |
| B2 | 2 mm (85%) |

* 1. **C/N ratio, C-Organic, N, P, and K of Compost**

**Figure 5. C/N ratio of composting process**

Figure 5. described that the C/N ratio in the composting reactor B1 was higher than that of the B2 reactor. This was due to the higher nitrification process in composting without worms/conventional than composting with worms (Hala I et al, 2003). According to Favoretto et al in 2016, the decrease in nitrogen was due to the denitrification process into ammonium carried out by earthworms. When compared with SNI 19-7030 2004, the value of C/N ratio in reactors B1 and B2 did not qualify SNI. This was because the raw material for this compost was MPL peel waste. Based on the results of the study, the initial C value of MPL peel waste was 45.46%, while the organic N value of MPL peel waste was 0.55%. The initial C/N ratio of MPL peel waste was 82 (Table 1). MPL peel waste contained high cellulose, so the C content was greater than the N value, so the C/N ratio was large.

The C, N, P, and K values ​​in compost qualified SNI 19-7030 2004. However, the C/N ratio in compost did not qualify SNI 19-7030 2004. It because the C value was still quite high. Therefore, the composting process need to be carried out for more than three weeks so that the C value can be further decreased, so that the C/N ratio can qualify the requirements. Although the C/N ratio did not qualify the requirements, the compost product produced has met the requirements when viewed from its physical characteristics (color, odor, texture, and particle size). The composition of the waste and the time of composting improved the quality of worms which can reduce C-organic as the N value increases rapidly. Therefore, the best C/N ratio in vermicomposting was 15 (Jamaludin and Mahmood, 2010).

The composting time factor can be considered as one of the factors that affect the difference in the concentration of N, P, and K. A longer composting period gave a longer treatment process as well. This caused the concentration values ​​of N, P, and K to increased along with the length of the composting process. The longer the time required for vermicomposting, the greater the concentration of N, P, and K obtained. For comparison, in the study of Othman et al (2021), the N, P, and K values ​​in vermicomposted compost for 14 consecutive days were 0.197%; 0.0285%; and 0.0136%. The content of N, P and K in the compost produced in B1 and B2 complies with SNI 19-7030 2004. This indicates that the compost produced in reactors B1 and B2 can be used as compost for plant growth (Table 7).

**Table 7.** NPK measurement results in compost

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Element | SNI 19-7030 2004 (minimum) | B1 | B2 | Analyzis |
| Nitrogen (%) | 0,4 | 1,17 | 0,96 | Qualified |
| P2O5 (%) | 0,1 | 0,57 | 0,5 | Qualified |
| K2O (%) | 0,2 | 0,52 | 0,5 | Qualified |

* 1. **Test the Effect of Using LR Earthworms on pH, Temperature, Moisture Content and C/N Ratio in Composting Process**

The results of the test of the effect of using LR earthworm (250 gr/Kg compost material) LR were as follows.

**Table 8.** The test of the effect of using LR earthworm

|  |  |  |  |
| --- | --- | --- | --- |
| Test | Nilai P-value | Analisis | Kesimpulan |
| Temperature | 1,000 | P-value > α 0,05 | HoA accept |
| pH | 0,469 | P-value > α 0,05 | HoB accept |
| Moisture Content | 0,862 | P-value > α 0,05 | HoC accept |
| C/N ratio | 0,829 | P-value > α 0,05 | HoD accept |

Table 8 showed that the addition of LR earthworms (250 gr/Kg compost material) had no effect on temperature, pH, moisture content and C/N ratio of composting. This was because the composting process period was not long (only 3 weeks) and the levels of earthworms in the composting process were not high enough so that it does not affect the temperature, pH, water content and C/N ratio of MPL peel waste composting. The results of this study were different from the results of research by González et al, 2019, where the pineapple peel composting process with the vermicomposting method lasts for 9 weeks so that it affects the pH, temperature and water content of the compost.

* 1. **Weight of LR** **earthworm and compost**

In this study, the weight of MPL peel waste and composted sawdust was 12.24 kg. In reactor B2, the weight of the worm added was 2.76 kg. After composting for 3 weeks, there was a decrease in the waste and an increase in the weight of the worms. The percentage of waste shrinkage in reactor B1 reached 66.5% and the percentage of waste shrinkage in reactor B2 reached 70.59%. Compost shrinkage in reactor B2 was greater than the shrinkage of waste in reactor B1. This shows that the worms added in B2 were able to consume waste well, so the depreciation value was large. The graph of compost shrinkage and worm weight gain can be seen in Figure 6.

**Figure 6. Weight of compost and LR earthworms before and after the composting process**

**The utilization of worms in B2 was 0.14 kg during the composting process (Figure 6). The percentage of worm weight gain in reactor B2 was 5.07%. This proves that worms can help decomposing microorganisms to decompose MPL skin waste. In general, the level of preference of worms to consume waste was influenced directly or indirectly by the chemical nature of the waste, thus affecting the efficiency of earthworms in the decomposition system. Bedding can also affect the growth of earthworms. Good bedding for worms was bedding that contains organic substances that were easily metabolized by worms, carbohydrates that were not assimilated, and did not contain substances that inhibit the growth of worms (Manaf et al, 2009).**

**5. Conclusion**

After conducting research, it can be concluded that the addition of LR earthworms of 250 g/Kg of compost material in composting MPL peel waste has no effect on temperature, pH, water content and C/N ratio. However, it affects the texture, and particle size and weight of the resulting compost.

**6. Supporting**

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