CIVED
Journal of Civil Engineering and Vocational Education

EISSN: 2622-6774
Vol 11 No.1 March 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

Comparison of Composting Method using Black Slodier Fly Larvae and Takakura Method on Compost Quality and Quantity

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Received 26th Feb 2024; Revision 11th March 2024; Accepted 30th March 2024

ABSTRACT

Organic waste needs to be processed so as not to pollute the environment. Processing of organic waste can be done through composting. This study aims to see the effect of composting method using BSF larvae and composting using takakura method on the quality and quantity of compost produced. The variety of waste types in this study consisted of variations A (65% vegetable waste + 35% fruit waste) and B (60% vegetable waste + 40% food waste). Bioconversion using BSF larvae aged 7 days with bidaily litter as much as 0.5 kg for 14 days. The results of the analysis of the quantity, maturity, and quality of variations A1, A2, B1 and B2 meet compost standards according to SNI 19-7030-2004. The most optimal variation of the study (A2 variation). This variation produces compost for (20 days), the quality of physical and macro elements has met the quality standards of domestic waste compost and the quantity of compost produced is more than 1.10 kg.

Keywords: *Organic Waste; Composting; BSF Larvae; Variations; Takakura.*

INTRODUCTION

Waste can be sourced from various locations, one of which is urban. Municipal solid waste is organic and inorganic waste disposed of by the community from various locations in a city [1]. The composition of waste can differ in each region, one of which is due to the socioeconomic level. Generally, developing countries have waste characteristics with a higher dominance of organic waste compared to more developed countries [2]. The amount of waste in 2020 reached 67 million tons and was dominated by organic waste of 60% (40 million tons) which came from market waste of 17.94% (7 million tons) [3].

The resulting waste needs to be processed so that it does not just accumulate in the landfill. Processing for organic waste can be done through composting. Composting is the process of decomposition of organic material by utilizing microorganisms in a controlled environment with the final result in the form of humus and compost [4]. One simple composting method is the Takakura method. The Takakura method is a household-scale composting method using baskets. Takakura's method is simple and easy to apply on a household scale, but less effective on a larger scale, such as in market waste processing.

Another method of processing organic waste is composting using Black Soldier Fly (BSF) larvae or Hermetia illucens [5]. BSF larvae are able to consume food quickly into compost and biomass rich in protein and fat [6]. BSF larvae are able to reduce organic waste by

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47.75% of the total [7]. Variations in waste types in bioconversion using BSF larvae affect the results of the compost produced [8]. BSF larvae more easily decompose litter in small pieces or even in the form of slurry [9]. Therefore, this study was conducted to determine which variations in the type and size of waste that produce compost better in terms of composting time, quality, and quantity of compost and its comparison with the Takakura method.

METHODS

This research is a type of experimental research with the aim of determining the waste reduction index from composting organic waste using BSF larvae and analyzing the quality of compost produced with SNI 19-7030-2004, as well as its comparison with the Takakura method.

The composting process is carried out at the Sahabat Alam Waste Bank, Kampung Apar Village, South Pariaman. The compost quality test was carried out at the Solid Waste Laboratory of the Department of Environmental Engineering, Faculty of Engineering, Andalas University. The study was conducted from August-October 2021.

The tools and materials used in this study include plastic containers measuring 42 cm x 32 cm x 14 cm, digital balances, sitting balances, knifes, shredding machine, stationery, hollow baskets measuring 36 cm x 47 cm x 26 cm, chaff pads, cloth covers, cardboard and basket covers. The materials needed are market organic waste with a total of 3.5 kg for each research variation, 7 days old BSF larvae weighing 50 gr each reactor, finished compost and EM4 for composting the Takakura method

Research is carried out duplo for each data collection and testing. The process of giving market organic waste is carried out for 14 days, with a frequency of adding waste every 2 days, both composting with BSF larvae and composting the Takakura method. The design of research variations can be seen in table 1.

Table 1. Takakura Research Variations

No	Variations	Source of Wastes	Composition (%)			Method
			Vegetable Waste	Fruit Waste	Food Waste	
1.	A1	Market Waste	65	35	-	BSF
2.	A2		65	35	-	Takakura
3.	B1	Restaurant Waste	60	-	40	BSF
4.	B2		60	-	40	Takakura

The determination of the amount of organic waste included in each reactor is based on a *feeding rate* of 100 mg / larva / day [10], with the following calculation:

Weight 1 larva	= 0.02 gram
Total weight of larvae	= 50 gram
Number of larvae in 1 reactor	= 50 gram : 0.02 gram
	= 2,500 larvae
Feeding rate	= 100 mg/larva/day
Amount of waste	= Feeding rate x Number of larvae
	= 100 mg/larva/day x 2,500 larvae
	= 250,000 mg/day
	= 250 gram/day

Composting using BSF larvae is carried out in the following stages:

1. BSF larvae that have been aged 7 days are placed in a composting reactor in the form of a box-shaped plastic container. The number of larvae of each reactor amounts to 50 gr;
2. Litter is given every 2 days for 14 days with an amount of 500 gr/ 2 days;
3. The residue produced after 14 days is compostable;
4. The resulting compost is then weighed and compost quality tested for quality.

Composting using the Takakura method is carried out in the following stages:
1. The composting basket is arranged in such a way in the arrangement as shown in Figure 1;
2. Organic waste is put in as much as 500 gr every 2 days and the addition of finished compost;
3. EM4 is sprayed on the finished litter and compost mixture;
4. Stirring is carried out 1x24 hours until the compost is cooked;
5. Daily field control of temperature and pH.

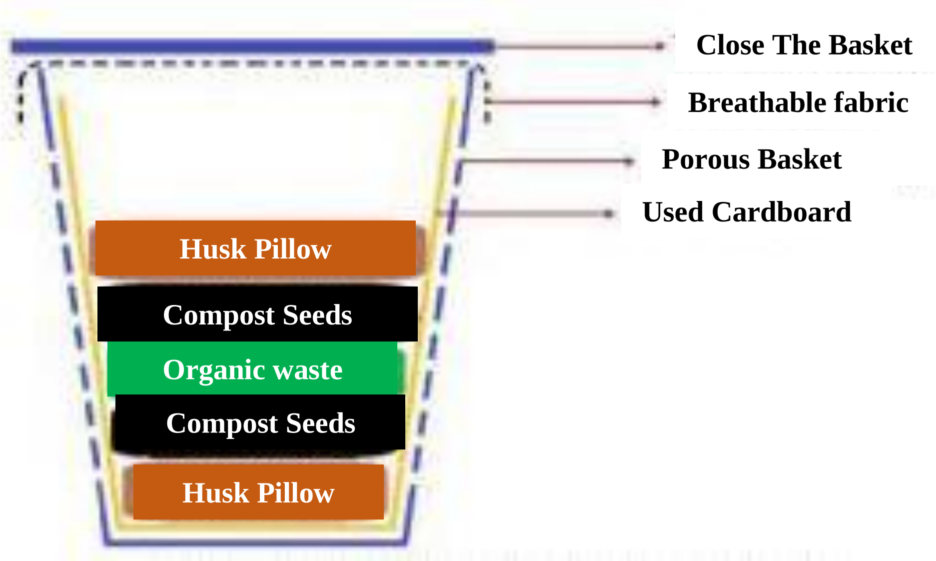

Figure 1. Takakura Composter Scheme

Compost quality testing is carried out to see whether the compost produced has met the requirements of SNI 19-7030-204 related to Compost Specifications from Domestic Organic Waste. The quality test of the comps is carried out on several parameters, which are as follows:
1. Determination of C-Organic by *Walkey Black method*;
2. Nitrogen Determination by titrimetric method;
3. Determination of Phosphore (P_2O_5) by spectrophotometric method;
4. Potassium measurement using SSA method.

Compost quantity testing is carried out by weighing the compost produced from each variation. The calculation of the quantity of compost can be seen as follows:

$$\%\text{Tingkat Reduksi} = \frac{A - B}{B} \times 100\%$$

Note:

A = Weight of initial raw material (g)

B = Weight of final raw material(g)

Data processing and analysis is carried out after all data is obtained starting from raw material analysis, maturity test, quantity test and quality test of the compost produced. The selection of the best compost variations is carried out by scoring methods including composting using BSF larvae and composting the Takakura method. The scoring system includes three criteria, namely:

- Criterion 1
  A value of 1 is given if the variation meets the quality standards of SNI 19-7030-2004 da. Parameters Included in criterion 1 are the parameters of compost quality and maturity;
- Criterion 2
  A value of 0 is given if the variation does not meet the SNI 19-7030-2004 quality standard. The parameters included in criterion 2 are quality and maturity parameters Compost;
- Criterion 3
  Criterion 3 is used on parameters that do not have quality standards. Scoring awarded based on ranking. The maximum score (4) is given to the variation with the highest score and Minimum score (1) for the variation that has the lowest score. Classified parameters Criterion 3 in the length of composting time and quantity of compost.

RESULTS AND DISCUSSION

This study discusses the level of reduction and analyzes the comparison of quality in each variation of treatment. A comparative analysis was carried out by scoring assessment comparing all compost quality parameters obtained from the test results with SNI 19–7030–2004 to determine which compost quality is better.

A. Analysis of Compost Reduction Rate and Quantity

The value of the waste reduction index resulting from composting organic waste using BSF larvae can be seen in Table 2**.**

Table 2. Composting Reduction Rate

Variasi	Initial Weight (kg)	Final Weight (kg)	Reduction Rate (%)
A1	3.5	0.20	94.29
A2		1.10	68.57
B1		0.25	92.86
B2		0.70	87.14

Based on the results in Table 2, composting using BSF larvae has a higher reduction rate than composting using the Takakura method. The reduction rate in variations A1 and B1 in this study is in line with the research of Nirmala et al (2020) which resulted in a reduction rate of 85-97% with the same type of waste [11].

Meanwhile, the rate of reduction produced through the takakura method shows results in the range 68-87%, which shows higher results than studies by Saputri (2021) which results in a reduction rate in the range of 52-65%. The higher rate of reduction produced in this study is due to the addition of EM4 activator which is carried out every time the addition of new waste, so that the decomposition process runs faster.

The higher rate of reduction in composting variations with BSF larvae than the Takakura method, shows that the BSF method has advantages in processing organic waste in terms of its ability to reduce organic waste.

Compost Quantity

The quantity of compost produced has an inverse relationship with the rate of composting reduction, the quantity of composting is the amount of compost produced by each variation. The higher the compost reduction rate, the less quantity of compost produced.

Compost Quantity Scoring

Based on Table 3, the scoring of the quantity of compost can be seen in the weight column of the compost produced. In the table, it can be seen the order of variations that produce the most quantities are A2, B2, and variations A1 and B1 with the same amount.

Table 3. Compost Quantity Scoring

Variation	Quantity Score
A1	1
A2	4
B1	2
B2	3

From these results, it can be concluded that in terms of the large amount of compost produced, composting the Takakura method produces more compost than composting using BSF larvae.

B. Compost Maturity Level Analysis

The maturity of the resulting compost is seen based on its physical elements, namely temperature, pH, texture, color and odor.

Composting Temperature Analysis

Temperature testing is designed to be done daily during the composting process for each variation. However, conditions in the field in composting using BSF larvae do not allow measurements to be taken every day due to the small amount of waste in the reactor. This also applies to pH measurements. Compost is declared mature according to SNI 19-7030-2004 if it has the same temperature as groundwater, which is ≤30°C. Changes in temperature during composting can be seen in Table 4.

According to research by Wakidah (2022), BSF larvae can grow optimally at temperatures in the range of 25 - 30 °C. This is reinforced by the results of research by Tomberlin et al. (2009) which states that BSF larvae cannot survive at >36°C. Too high a temperature will trigger the larvae to come out of the reactor and look for a cooler place. If the temperature is too low, it causes inhibition of larval growth because the larvae consume less litter.

Table 4. Changes in Composting Process Temperature

Variations	Initial Temperature (C°)	Final Temperature (C°)
A1	28	30
A2	28	29
B1	31	30
B2	30	29

The results of observations of compost maturity based on temperature, show that all variations have met the quality standards in SNI 19-7030-2004 concerning Compost Specifications from Domestic Organic Waste, which is ≤30°C, which shows that all variations have matured in terms of temperature

CIVED Journal of Civil Engineering and Vocational Education

EISSN: 2622-6774
Vol 11 No.1 March 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

Composting pH Analysis

Compost is declared mature according to SNI 19-7030-2004 if it has a pH with a range of 6.8 – 7.49. Changes in pH during composting can be seen in Table 5.

Table 5. Changes of pH Value in Composting Process

Variations	Initial Temperature (C°)	Final Temperature (C°)
A1	5,8	7
A2		6,8
B1	5,6	6,8
B2		7

By Table 5, pH in composting all variations there is an increase in the pH of the beginning and end of composting. The occurrence of an increase in composting pH is caused by the change of organic acids into CO_2 and the presence of base cations resulting from mineralization of organic matter [12]. Changes in pH during the composting process do not affect the growth of BSF larvae. BSF larvae have a wide pH tolerance of 0.7-13.[13] in [14].

Referring to SNI 19-7030-2004 concerning Compost Specifications from Domestic Organic Waste, compost is declared mature if it is in the pH range of 6.8 - 7.49. The pH measurement results of all variations show that they have met quality standards.

Texture Analysis

Composting texture analysis is carried out every day until the compost has a texture that resembles soil, in accordance with SNI 19-7030-2004. The results of composting texture observations can be seen in Figure 2**.**

Based on Figure 2, textures produced from composting using BSF larvae tend to take a long time to reach the soil texture. This is due to the high content of water stored in the composting reactor.

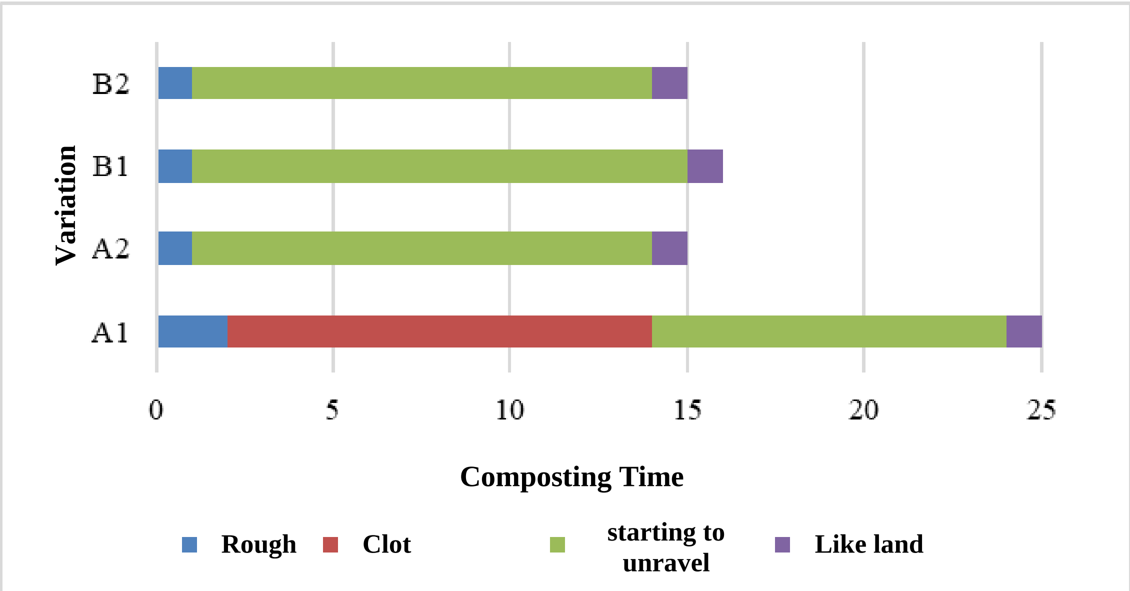

Figure 2**.** Texture Modification during Mixing

The faster change in texture in composting with the Takakura method is due to the maximum activity of microorganisms due to the addition of EM4 activator with each addition of new waste, and less moisture content due to the addition of finished compost and rice husks.

Color Analysis

Color analysis is observed daily during the composting process until the compost is declared mature in terms of color according to SBI 19-7030-2004. Discoloration during composting can be seen in Figure 3.

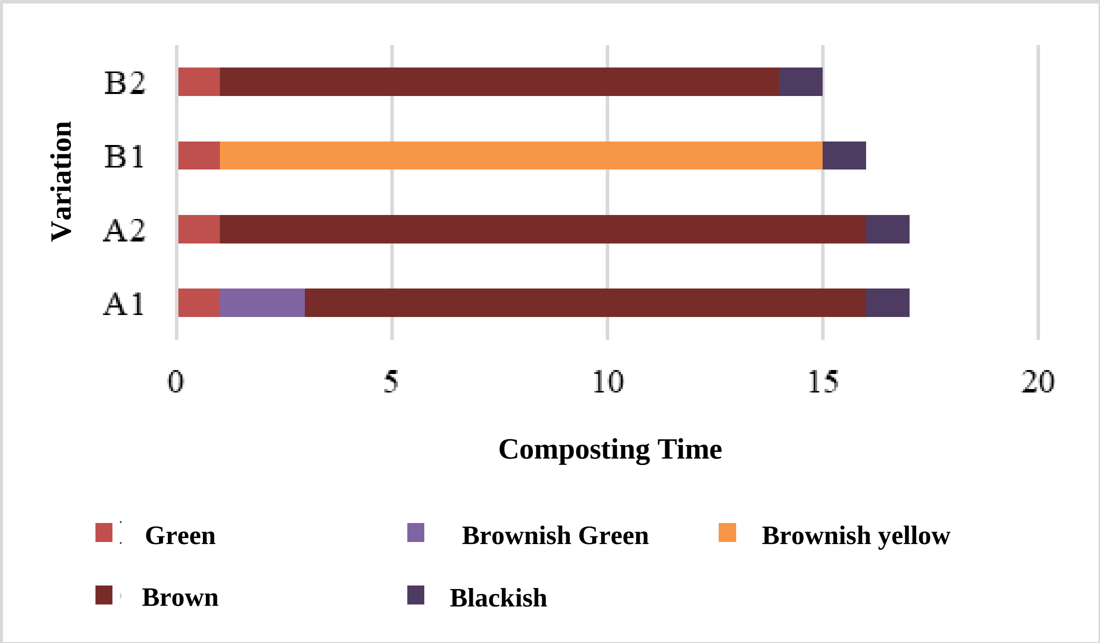

Figure 3. Color Changing during Composting

Based on color changes in Figure 3, It can be seen that the color change in composting by the Takakura method reaches blackness faster. According to Widyarini (2008), compost is declared ripe if it is close to soil color or turns close to blackish.

Variations with the Takakura composting method ripen faster in terms of color due to the faster decomposition process due to the addition of EM4 activator with each addition of new waste.

Odor Analysis

Analysis of odors during the composting process is carried out daily until the smell of compost resembles the smell of soil, in accordance with SNI 19-7030-2004. Observations of odors of all variations can be seen in Figure 4.

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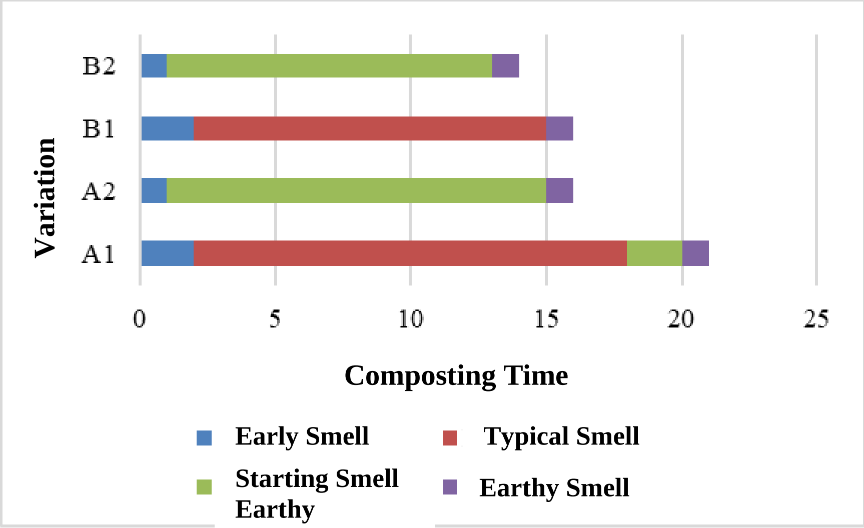

Figure 4. Odor Changing during Composting

Changes in smell during composting each variation show changes ranging from smelling fresh garbage, smelling typical of garbage, starting to smell of soil and smelling like soil. The stench produced in BSF composting variation A is influenced by a mixture of vegetable composition dominated by cabbage which if rotted will emit an unpleasant pungent odor. This is triggered by high levels of nutrients in cabbage accelerate decay in the vegetable [15].

Composting Time

The length of composting time of each variation can be seen in Figure 5.

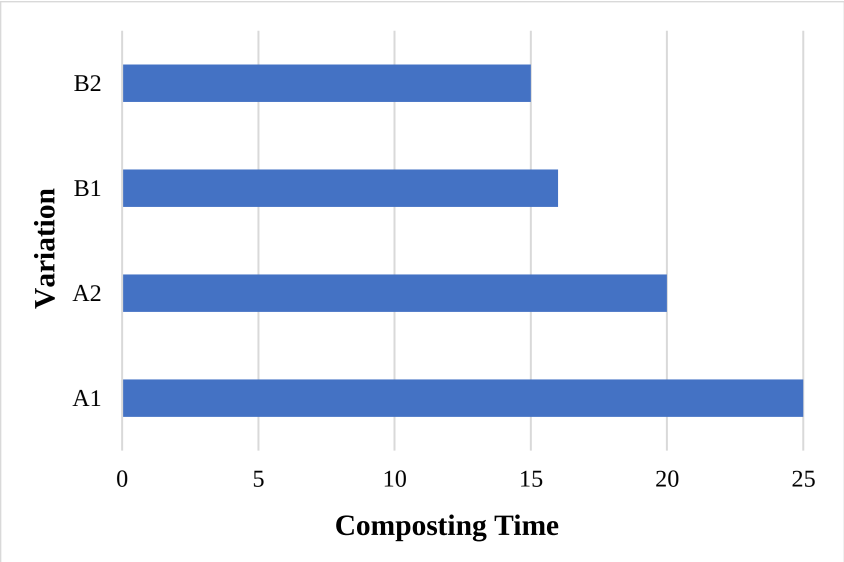

Figure 5. Composting Old Materials

Based on the image above, composting with the Takakura method runs faster than composting using BSF larvae. This is influenced by other physical elements of compost maturity, especially in texture. Compost produced through composting with BSF larvae takes longer to reach soil texture due to higher moisture content, when compared to compost from the takakura method which has rice husk pads as absorbers of excess moisture content.

Compost Maturity Scoring

A recapitulation of compost maturity scoring can be seen in Table 6.

Table 6. Compost Maturity Scoring

Variations	Temperature	pH	Texture	Color	Construction	Composting Time	Total
A1	1	1	1	1	1	1	6
A2	1	1	1	1	1	1	6
B1	1	1	1	1	1	1	6
B2	1	1	1	1	1	1	6

C. Compost Quality Analysis

Compost quality test parameters were carried out on nitrogen, carbon, C/N ratio, potassium and phosphorus content. The results of this study show that all variations have met SNI 19-7030-2004 standards with details that can be seen in Table 7. The fulfillment of this standard shows that the compost produced is of high quality and can be applied to plant fertilizer. This proves that the processed waste can be used as quality fertilizer/compost products and has the potential to provide economic benefits.

Table 7. Compost Quality Recapitulation

Parameter	Variations	Test Results	SNI 19-7030-2004	Evaluation
%C	A1	20.98	9.8 - 32%	Fulfil
	A2	22.45		Fulfil
	B1	11.46		Fulfil
	B2	23.75		Fulfil
%N	A1	1.54	≥0.4%	Fulfil
	A2	1.61		Fulfil
	B1	0.84		Fulfil
	B2	1.96		Fulfil
C/N	A1	13.62	10-20	Fulfil
	A2	13.94		Fulfil
	B1	13.69		Fulfil
	B2	12.14		Fulfil
$\%P_20_5$	A1	0.20	≥0.1%	Fulfil
	A2	0.62		Fulfil
	B1	0.30		Fulfil
	B2	0.58		Fulfil
$\%K_2O$	A1	0.80	≥0.20%	Fulfil
	A2	0.87		Fulfil
	B1	1.07		Fulfil
	B2	0.95		Fulfil
%Moisture Content	A1	7.90	≤50	Fulfil
	A2	17.72		Fulfil
	B1	23.23		Fulfil
	B2	21.85		Fulfil

CIVED Journal of Civil Engineering and Vocational Education

EISSN: 2622-6774
Vol 11 No.1 March 2024
http://cived.ppj.unp.ac.id/index.php/CIVED

The C/N ratio is one of the important aspects in nutrient balance [16]. The C/N ratio in this study has met SNI which means it can be used as compost. Comps with a C/N ratio large than 30 will interfere with the nitrogen content if applied to the soil. Conversely, compost with a C/N ratio below 20 will cause organic nitrogen mineralization to be inorganic suitable for plants [17].

The standard standard for potassium quality according to SNI 19-7030-2004 is ≤0.2. Meanwhile, the drinking value of phosphorus in compost is ≥0.1. The results of measuring P and K levels in all variations show results that have met SNI quality standards. The high level of P in the compost produced is influenced by the N content. The higher the N value, the higher the multiplication of microbes in remodeling P so that the higher the P content produced by compost [18]. Potassium plays an important role for plants as an enzyme activator [19].

Compost Quality Scoring

Scoring on compost quality can be seen in Table 8**.**

Table 8. Compost Quality Scoring

Variation	Moisture Content	C	N	C/N	P	K	Total
A1	1	1	1	1	1	1	6
A2	1	1	1	1	1	1	6
B1	1	1	1	1	1	1	6
B2	1	1	1	1	1	1	6

The score on compost quality shows a value of 1 for the overall variation in each parameter. This is because all variations have met the parameters required by SNI 19-7030-2004 related to C, N, C / N, P and K levels.

4. Determination of Optimum Compost Variation

Determination of the optimum compost variation is carried out by a scoring system. The variation with the highest total value is the optimum variation. A recapitulation of total scoring can be seen in Table 9.

Table 9. Recapitulation of total scoring

Variation	Quantity Score	Total Mature Scoring	Composting Time	Total Quality Scoring	Final Score
A1	1	6	4	6	17
A2	4	6	3	6	19
B1	2	6	2	6	16
B2	3	6	1	6	16

Based on Table 9, the optimum compost variation produced by A2 is composting market waste by the Takakura method.

CONCLUSIONS

Based on research on the influence of the type and size of market organic waste variations in composting using BSF larvae and their comparison with the Takakura method, the conclusion that can be obtained is that the overall variation of research has met SNI 19-7030-204 related to Compost Specifications from Domestic Organic Waste. The best composting variation was obtained from the A2 variation for (20 days) and produced the largest quantity of compost (1.10 Kg), and the Takakura composting method produced more compost than composting with BSF larvae (Takakura 0.70-1.10 Kg) and (BSF 0.20-0.25 Kg).

For further research, more comprehensive measurements can be made, material and energy inputs and outputs including gas emissions produced during the composting process, to be able to provide a more complete assessment in the comparison of the two composting methods, including the economic value of utilizing composting results.

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