Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.03622

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Optimal preparation time in the vermicompost production process

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Abstract

Today, the vermicompost production process is considered one of the most economically, hygienically, and environmentally friendly methods for the stabilization of organic waste. The aim of this paper was to investigate the effect of food waste preparation time without initial modification and without continuous aeration on the vermicompost process before feeding the worms with organic waste material in order to pass the calorific stage of decomposition of organic matter and not to damage the worms that are sensitive to high temperatures, and the process of fertilizer production is faster, organic matter is composted for a while without the presence of worms. In this paper, four periods, including 0, 7, 14, and 21 days of waste preparation, were examined. The results showed that the difference in ratio between different preparation times was significant 7-14 days the most suitable time for waste preparation without initial modification was obtained.

Keywords: vermicompost; food waste; yield ratio; Eisenia foetida.

Practical Application: In the current study it was tried to investigate the impact of food waste preparation time without initial modification and without continuous aeration on the vermicompost process before feeding the worms with organic waste material.

1 Introduction

Rapid population growth, development, and advancement of technology, human tendency to increase consumption of materials, and consequently increase of waste materials are among the issues that have recently created huge crises in human societies (Padmavathiamma et al., 2008). Lack of control of urban and rural waste in the environment, due to the existence of different types of food waste in suitable humidity and temperature conditions in shelters that are always in the landfills, is one of the main causes of many human and animal diseases (Santos et al., 2022). Incineration and burial are the two most common ways to dispose of waste (Yuvaraj et al., 2021). Millions of tons of organic waste are buried and incinerated every year (Chen et al., 2020). In addition to causing many environmental problems, a lot of money will be spent on transporting, burying, and incinerating waste (Ramírez et al., 2021). In the method of landfilling, in addition to the problems and risks of entry of nitrate and other contaminants into groundwater, occupation space by waste is another disadvantage of this method (Santana et al., 2020).

Emission of toxic gases, pollution of surface water resources and groundwater, and greenhouse gas emissions such as methane are among the threats of this method (Biruntha et al., 2020). Therefore, the severity of the infection of waste materials and waste in cities and industrial centers that is the scientific and executive attention of experts towards disposal proper and principled recycling of these materials has attracted (Fan et al., 2020). One of the solutions that have long been tested by humans is to produce fertilizer from waste and return it to the production cycle (Lim et al., 2015). Since a large part of household waste is made up of perishable organic matter, which is the raw material for organic fertilizer production (Adiloğlu et al., 2018). This option can be used to dispose of a large amount of waste (Ferrari et al., 2021).

The process of producing organic fertilizer or compost itself is done in several ways, one of which is the use of earthworms to decompose organic waste, which is called vermicompost (Cooperband, 2002; Gupta, 2004). Reducing the amount of organic waste on the one hand and turning it into a valuable product, on the other hand, are the two main advantages of vermicompost technology (Doble & Kumar, 2005). The higher quality of this method and its positive effect on plants has been

Received 18 Jan., 2022
Accepted 15 June, 2022
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seen in many studies (Jeyabal & Kuppuswamy, 2001; Gutiérrez-Miceli et al., 2007). Vermicompost production is the technology of using special types of earthworms that, due to their ability to grow and reproduce very quickly, are used to consume a variety of waste materials, polluting the environment and out of the production cycle into a high-quality organic fertilizer (Burzyńska, 2019). One of the factors that affect the quality of fertilizer is the preparation time (Balachandar et al., 2021). Prior to feeding the worms with the waste material, so that the heat-seeking phase has passed and the worms, which are sensitive to high temperatures, will not be damaged, and the compost production process will proceed faster, and some pollution will occur (Negrão et al., 2021). Duration of this preparation in terms of the quality of the resulting compost, how to perform the vermicompost process (Karthika et al., 2020). The time required for composting, as well as the space and facilities needed for preparation, is effective.

Inadequate preparation time can disrupt the process and increase the time required to obtain vermicompost, eliminating worms, reducing the quality of the resulting fertilizer, and unnecessary occupation of space during preparation. Therefore, determining the appropriate duration of this preparation is effective and important in optimizing the vermicompost process (Chañi-Paucar et al., 2021). Therefore, in this paper, the effect of different preparation times on the speed of the process (speed of fertilizer) and the quality of the resulting fertilizer in terms of carbon (C), nitrogen (N), pH, and C/N ratio for 40 days in the vermicomposting process was investigated.

2 Material and methods

In this section, sampling methods and methods for determining pH, carbon, nitrogen, and process speed are described.

2.1 Methods and quantities of sample preparation

In this paper, food waste was poured into a container measuring 80 cm in length, 60 cm in width, and 60 cm in height and was stirred daily by hand using a shovel. This operation was performed for 21 days and every six days, and a new environment was created in a container 15 cm high and 12 cm in diameter from this waste. Thus, four environments with the characteristics of 350 g of bedding, ten worms in each environment with approximately equal and mature weight, and 100 g of food waste were created, on which 100 g of vermicompost cover was placed. The environments were named A_1 to A_4 over time, respectively, and pH, C%, N%, and C/N ratio parameters were monitored for 40 days in each medium to determine process progress. Sampling was performed every five days. So that the first sample was taken on the first day and the second sample on the sixth day from each environment. Sampling was done by removing the top cover so that the sample was not mixed with the top cover and mixed from different parts of the waste. Thus, 5 g of sample was taken each time.

2.2 PH determination method

To measure the pH of the samples, after removing them from 110 °C for 24 h, it was mixed with distilled water at five times the weight of the sample, and after 10 min of stabilization, it was passed through a strainer, and their pH was measured using a digital pH meter (Richard et al., 2009).

2.3 Method for determining the amount of carbon

The carbon content of the samples was measured by placing the dehumidified samples after weighing them in the Muffle furnace for 2 h at 55 ^{o} C. It was heated and weighed again and the amount of carbon was calculated by determining the value of Vs (Richard et al., 2009).

2.4 Method for determining the amount of nitrogen

The amount of nitrogen was measured on samples weighing 0.1 g by the Kjeldahl titration method (Csuros, 1997). For this purpose, after drying, the samples are crushed and thoroughly mixed to obtain a more accurate sample for testing. Multi-variable analysis and linear regression were used for statistical analysis.

2.5 The method used to determine the speed of the process

Multivariate analysis was used to investigate the differences between environments in terms of measured factors. In order to determine the speed of the process, the slope of the C/N ratio change regression line slope was used. Therefore, one of the indicators of compost handling is the C/N ratio, which decreases with the progress of the process and reaches 10% up to 15% in the compost (William, 2000).

3 Results and discussion

In this section, pH, carbon, nitrogen, C/N ratio, temperature values in 4 environments, A_1 to $A_{4,}$ are presented. Finally, the results are discussed.

3.1 Comparison of pH values of samples

The results of the experiments of environments are described in Tables 1-4. As can be seen from Tables 1-4, the highest pH is seen in the A_1 medium. While the largest amount of pH changes in the A_3 environment increased to 2.53. The lowest final pH value is in the A_4 medium, and the lowest change value is in the A_2 medium and is 2.05.

3.2 Comparison of carbon changes of samples

The highest decrease in carbon content among environments A is 34.89% and is related to environment $A_{3,}$ and the lowest amount of final carbon is related to this environment. The lowest reduction in carbon content was also observed in these environments by 25.57% in the A_1 environment. The highest final carbon content was obtained in the same medium with 27.43%.

3.3 Comparison of nitrogen changes of samples

The highest final nitrogen content was obtained in the A_2 medium at 1.3%. All media except A_4 showed an increase in the percentage of nitrogen, so that the highest amount of increase in the percentage of nitrogen was obtained in A_2 at 0.655%.

3.4 C/N ratio comparison

The lowest final C/N ratio was observed in the A_2 medium, and the highest value was related to the A_4 medium. Also, the highest decrease in the C/N ratio was obtained in the A_2 environment at 64.7, and the lowest reduction in this ratio was achieved in the A_4 environment at 36.58.

Table 1. Results for A_1 environment (zero-day preparation time).

pH	C%	N%	C/N
5.1	53	0.618	85.76
4.6	37.5	0.591	63.45
4.8	35	0.559	62.61
6.7	36.6	0.618	59.22
6.3	35.22	0.642	54.85
6.28	27.95	0.586	47.69
6.9	27.78	0.586	47.4
7.11	27.43	0.701	39.12

Table 2. Results for A_2 environment (7 days preparation time).

pH	C%	N%	C/N
4.75	52.35	0.645	81.16
5.45	32.3	0.73	44.24
6.8	26.44	0.674	39.22
5.2	24.8	0.786	31.55
6.31	23.77	0.955	24.89
6.43	23.5	0.955	24.6
6.1	22.76	1.174	19.38
6.2	21.4	1.3	16.46

Table 3. Results for A_3 environment (14 days preparation time).

pH	C%	N%	C/N
4.09	53.21	0.674	78.94
4.21	46.3	0.619	74.79
5.1	42.6	1.038	41.04
4.92	33.52	0.85	39.43
5.42	31.47	0.85	37.02
6.32	28.03	0.758	36.97
6.41	18.77	0.59	31.81
6.62	18.32	0.72	25.44

Table 4. Results for A_4 environment (21 days preparation time).

pH	C%	N%	C/N
3.68	49.52	0.646	76.65
4.65	48.88	0.73	66.95
4.8	39.47	0.59	66.89
5.91	38.97	0.646	60.32
5.31	33.75	0.59	57.2
5.52	32.42	0.618	52.45
5.82	30.75	0.59	52.11
6.03	22.52	0.562	40.07

3.5 Temperature change values of samples

Temperature monitoring during the preparation period also showed that in just three days from the fourth day of preparation to the seventh day, the ambient temperature reached about 47 °C and then decreased until the end of the preparation period to about 19 °C.

3.6 Data analysis

The results show that the difference in the C/N ratio between the groups is significant. This result was obtained from statistical analysis of data in an Excel environment and by multivariate analysis. Therefore, the results show the change in preparation time is effective on changes in the C/N ratio. In determining the slope of the resulting regression line from linear regression for changes in the C/N ratio, the following values were obtained for the environments A_1, A_2, A_3, A_4 respectively -5.48, -7.52, -7.16, -4.45, which indicates that the slope is higher negative is the line in A_2. Therefore, it can be concluded this environment has dropped faster than the C/N ratio, and as a result, the process has progressed faster in this environment.

The slope of the line is related to environment A_3, close to environment A_2. Figures 1 and 2 indicate that 7-14 days was a better time to prepare the waste. This may be due to the fact

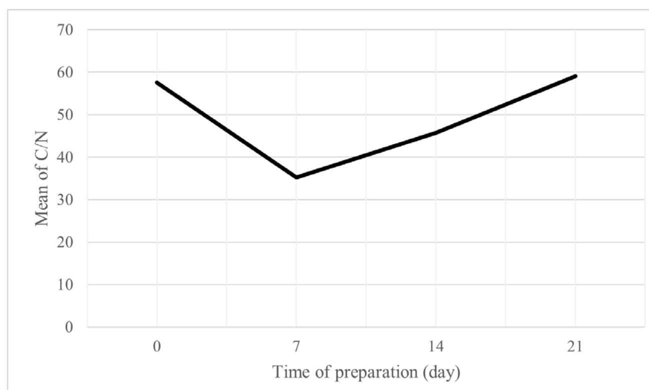

Figure 1. Mean values of C/N ratio in environments A.

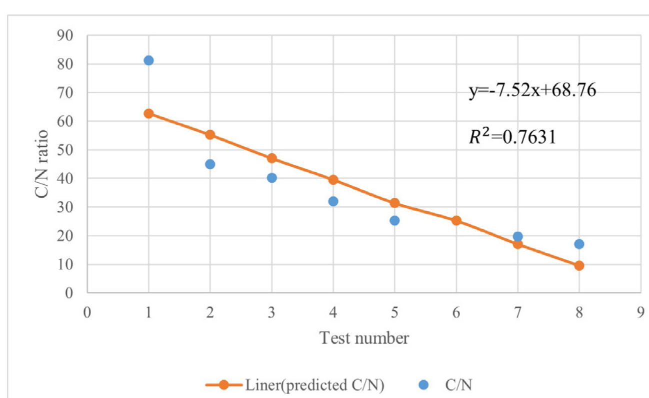

Figure 2. C/N regression line at seven days preparation time (environment A_2).

that at the time of lower preparation, the waste is not yet ready to enter the vermicompost process. Because the decomposition period of materials has not undergone rapid decomposition and their large components and molecules have not been broken. In the longer term, according to the structure of the material and what can be concluded from the pH values shown in the tables is that the progress of the process has been anaerobic. The trend of temperature changes also indicates the relative anaerobic conditions after the first few days of preparation, and this leads to a slower decomposition of the waste. On the other hand, an anaerobic environment is not compatible with a vermicompost aerobic environment, and transformation of the environment is time-consuming. Therefore, the results show that in food waste with no use of modifiers and no mechanical equipment to keep the environment aerobic, a time of 7-14 days can be a better time to prepare the material for the vermicompost process. Nair et al. (2006) the need for a thermal preparation resulted in a similar 9-day result. This time seems to be enough to pass the initial heating period of the compost and also to remove most of the pathogens (William, 2000).

The lowest C/N ratio is also observed in the A_2 medium after the 40-day test period, as shown in Table 2, which is due to a greater reduction in carbon content due to more interactions and a further reduction in organic matter as well as an increase in the percentage of nitrogen due to the activity of bacteria and worms. This process of decreasing the C/N ratio improves the quality of the fertilizer and improves its efficiency for the growth and increase of crop yields. The high values of the C/N ratio in the A_4 medium are also due to the reduction in the percentage of nitrogen and the lower percentage drop in the carbon content of the material compared to other environments, which can be due to the anaerobic progress of the process. One of the main reasons for the occurrence of anaerobic conditions in these environments can be due to the structure of the material, which with the progress of the process and the relative decomposition of waste, the process proceeds harmoniously and leads to the production of CO_2 and water. The wastes are broken down into smaller components, and with the production of water and cell mass, they form a paste, which causes an eroticization of the process due to the prevention of oxygen diffusion in the mass (Richard et al., 2009).

The maximum final pH in A_1 can be attributed to the fact that due to the short preparation time in this medium, nitrogen is present in the decomposition of larger molecules such as proteins, amino acids, and fats. During the vermicompost process, they are released as ammonia in the mass medium, which increases the pH of this medium (Sodaei et al., 2007). Ammonia gas can be released from the environment, but the contact of this gas with the moisture of the compost causes the formation of soluble ammonium ions and increases the pH (Miller et al., 1991).

4 Conclusion

The results showed that the difference in the C/N ratio between different preparation times was significant, and changing the preparation time was effective on the C/N ratio. 7-14 days, the most appropriate time for the initial preparation of food waste without initial modification and no use of mechanical equipment to keep the environment aerobic, was obtained. Among the reasons was the decrease in the amount of carbon and organic matter and the increase in the amount of nitrogen. During this period, the C/N ratio is also in more appropriate values , and the quality of the resulting fertilizer will be better due to having more amounts of nitrogen in the stabilized form.

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