Chapter 52

Vermicompost process as treatment of organic waste generated in vegetables

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ABSTRACT
The objective of the work was to deal with the organic waste generated in the horticultural sector by the vermicomposting process, which results in vermicomposting. An experiment was carried out in 10l plastic boxes, where organic waste generated in a food distribution trade, organic fertilizer, and earthworms of the Eisenia fetid species were added. After setting up the experiment, monitoring of temperature and internal and ambient humidity was carried out, and monthly collections for laboratory analysis were carried out, as well as at the end of the process, the earthworms were counted, which were classified into young and adult. The values of temperature, pH, electrical conductivity, and humidity for the three treatments were within the limit recommended by scientific articles and current legislation for this type of process, as well as the reproduction of earthworms, which went from 40 adult individuals initially, to five times more of that value at the end of the process. Thus, it is possible to state that vermicomposting is a viable alternative for the treatment of waste, as it generates a product with agronomic and environmental value.

Keywords: Vermicompost, Waste treatment, Worms, Recycling

1 INTRODUCTION

In the globalized world, we live in today, society's consumerist activity to meet its needs has been impacting the planet. With technological advances, the increase in supply and demand for new products has led to greater waste generation (PAVESE, 2011).

According to Pavese (2011), there were changes both in the diversity and in the quantity of these residues. Such an increase is related to several social and environmental problems experienced in recent decades, reflecting on the economy and quality of life of the population.

According to the Solid Waste Panorama of the Brazilian Association of Public Cleaning and Special Waste Companies (ABRELPE, 2019), in 2018, 79 million tons of Urban Solid Waste (MSW) were generated in Brazil. Each person on average generated 380 kg/year, of which 72.7 million tons (92%) were collected, but about 6.3 million tons were not even collected, indicating waste was disposed of in inappropriate places.

The same study also states that, of the waste collected, 43.3 million tons (59.5%) were sent to landfills, not offering risks or inconvenience to society and being able to gain new functions thanks to recycling logistics. But the rest, about 29.5 million tons (40.5%), were dumped in inappropriate places (ABRELPE, 2019).

The National Solid Waste Policy (PNRS), Law n. 12,305/2010, determines the prevention and reduction of waste generation. This law proposes the practice of sustainable consumption habits and a set of instruments to encourage increased recycling, the reuse of solid waste, and the environmentally appropriate disposal of waste (understood as waste, solid waste that, after exhausting all treatment and recovery possibilities by available and economically viable technological processes, do not present any other possibility than the environmentally appropriate final disposal) (BRASIL, 2010).

According to the Ministry of the Environment (MMA, 2017), more than 50% of the waste collected is of organic origin. In their study, Silva et al. (2016) found that when these wastes are improperly disposed of in landfills and dumps, they help in the proliferation of vectors, which are disease-transmitting agents. The composition with an organic fraction of these residues results not only in the formation of a liquid compound called leachate – which, combined with other residues, increases its contaminating potential in contact with the soil or water –, but also helps in the generation of toxic, asphyxiating and explosive gases. , which pose imminent risks to society (SILVA et al., 2016).

According to Siqueira and Abreu (2016), the generation of organic waste begins with the distribution of perishable foods to supply mainly urban centers. Agriculture and livestock are responsible for generating this food, and from there they go to the cities to supply supermarkets, fairs, and other distribution centers until they reach homes. During all stages from production to distribution of food, there is waste generation. They are of organic origin, and most of them end up in the streets, vacant lots dumps, and landfills (SIQUEIRA; ABREU, 2016).

In their study, Rosa et al. (2019), found that about 80 kg of organic waste was regularly generated per month in a fruit and vegetable trade, consisting of fruits and vegetables. Such waste was disposed of in violation of PNRS norms, becoming a nuisance. Therefore, on the other hand, composting techniques were applied as an alternative means of treating them, resulting in the reuse of 100% of the organic waste generated in commerce (ROSA, et al, 2019).

The PNRS (2010) brings composting as a practical solution for the disposal of organic waste generated in municipalities. One aspect of this practice is vermicomposting: an effective and simple-to-create biotechnological process that can add monetary value. Vermicomposting has earthworms as its main agents, usually of the Californian red species (Eisenia fetid), which are placed in a vermicompost with the function of accelerating the natural decomposition process of organic matter. At the end of the process, a vermicompost (humus) is obtained, which can be used in vegetable gardens or as fertilizer for the soil (SILVA et al., 2016).

The substances produced in the vermicompost operate as growth regulators, influencing seed germination, root elongation, nutrient absorption, and the photosynthesis process carried out by plants. These results are due to the activation of humic substances during the compost maturation process (ZANDONADI E SOUZA, 2012). This technique is advantageous because it alters the granulometry of the compound, making it smaller. At the same time, it transforms recent organic matter into a stabilized compost, clearly darker, without odors, and with pH and humidity in ideal conditions for use (SENA et al., 2019).

Faced with the above problem, this study aims to use the techniques of the vermicomposting process to treat organic waste generated in the horticultural sector in the food trade, as well as to analyze the physical-chemical and phytotoxic characteristics of the vermicompost produced.

2 MATERIALS AND METHODS

The experiment was carried out in the Ecotoxicology and Waste laboratory of a Higher Education Institution. Starting in November 2022 and ending in February 2023, the study was carried out over three months. The organic waste used was provided by a food distribution business located in the city of Pelotas, Rio Grande do Sul.

Six 10 L plastic boxes were used to make the vermicomposts. Small holes (approximately 1 cm in diameter) were made on the sides of the boxes to provide aeration during the process. A layer of organic fertilizer about 5 cm thick (1 kg) was deposited at the bottom of each vermicompost and then covered with 8 kg of organic waste cut into smaller fragments, about 5 cm to reduce its size. And, finally, another layer of 5 cm thick (1 kg) of organic fertilizer.

The experiment had three treatments and two replications. The treatments and the proportions used in each treatment are shown in Table 1.

Treatments	Organic waste	Stabilized fertilizer
T01	80% - (fruits)	20%
T 02	80% - (vegetables)	20%
T 03	40% (fruits) and 40% (vegetables)	20%

After filling the vermicompost with waste, 40 worms were added to each vermicompost of the adult Eisenia Fétida species, which were previously washed with distilled water and weighed. After the vermicompost assembly phase, the process was monitored:

The internal temperature was measured, which was measured daily at three points: at the base, at the center, and the top of each vermicompost. In turn, the ambient temperature was measured using a thermo-hygrometer that remained in place 24 hours a day until the end of the work.

The experiment lasted 90 days. During this period, samples were collected once a month, totaling four collections, being interpreted by an interval of 30 days (0, 30, 60, and 90) to perform laboratory analyzes of physical-chemical and phytosociological parameters.

Regarding the pH, a solution was made with the samples and distilled water of 1/10 (m/v) and homogenized for 1 hour. After that, the pH was measured in a previously calibrated brand pH meter (TEDESCO, 1995).

The electrical conductivity was made with a solution with the samples and distilled water of 1/10 (m/v) and homogenized for 1 hour. After that time, the electrical conductivity was measured in a previously calibrated conductivity meter (EMBRAPA, 1996, TEDESCO, 1995).

Moisture was measured on a dry basis, and the fresh sample taken from the treatments was placed in an oven for 24 hours at 105°C using the method proposed by the Association Of Official Analytical Chemists International Official Methods Of Analysis (AOAC, 1997).

The germination index: The phytotoxicity analysis was carried out according to the methodology of Tiquia (1988) and Zucconi (1988), where the seed species was used: lettuce (Lactuca sativa L), with 10 seeds arranged in Petri dishes with qualitative filter paper. Afterward, 5 ml of vermicompost solution was added to the plates, which were previously homogenized with a magnetic stirrer for 1 hour and filtered with qualitative filter paper. Then, the plates were taken to BOD (incubator) and remained at 25°C for 48 hours. In parallel, plates were made with the same seed species in the presence of distilled water, with them serving as a control or standard.

After 48 hours, the seeds were removed from the BOD and the amounts of germination and the length of the radicle were analyzed with the aid of a caliper (Carbografite brand), the germinated seeds were those with a size greater than 1 mm and the germination index, through equations 1, 2 and 3 (HIMANEN et al., 2012).

Seed germination index (G), root elongation (AL), and germination index (GI) were calculated according to the following equations:

$$G\ (\%) = \frac{(\text{NSC x NST})}{100}$$

on what:
G (%): Relative germination in percentage;
NSC: Number of germinated seeds in the vermicompost extract;
NSC: Number of germinated seeds in the control.

$$AL\ (\%) = \frac{\sum \text{ALC}}{\sum \text{ALB}}$$

on what:
AL (%): Relative radicle elongation in percentage;
ALC: Sum of elongation of rootlets in vermicompost;
ALB: Summation of elongation of rootlets in the blank.

$$IG\ (\%) = \frac{(\text{G\%}\ .\ \text{AL}\ \%)}{100}$$

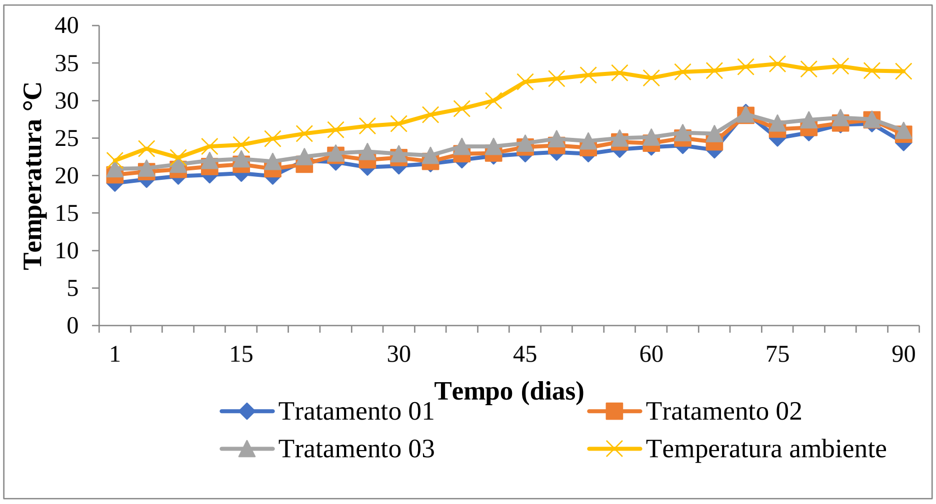
on what:

IG (%): Germination Index;
G (%): Relative germination;
AL (%): Relative elongation

3 RESULTS AND DISCUSSION

The temperature over the 90 days remained within the ideal average for this type of process (Figure 1), with day 70 having the highest recorded temperature of 28.4, 28, and 28.2°C for treatments 01, 02, and 03 respectively.

Figure 1: Process temperature over the 90 days

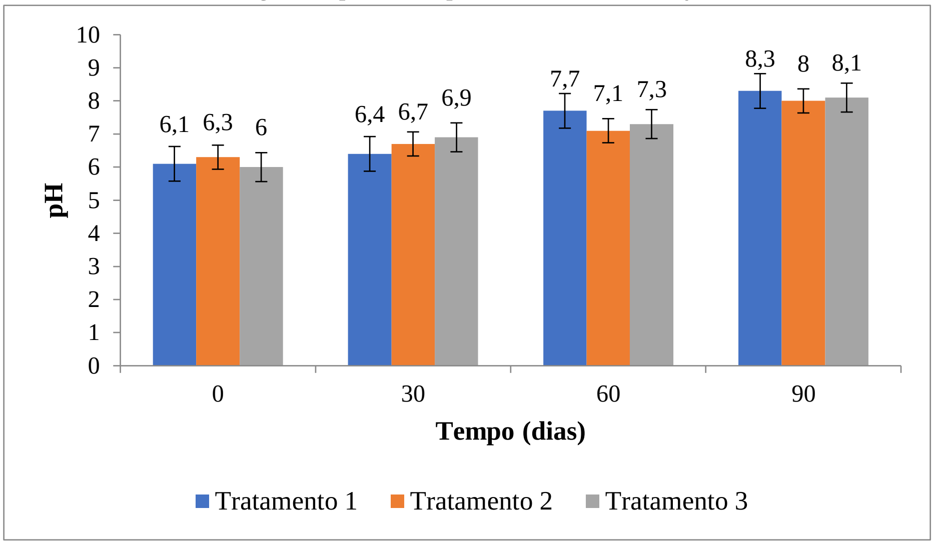


This result is similar to the work by Silva et al. (2019), in which a vermicomposting experiment was carried out with domestic organic waste generated in two residences in the city of Goiânia, Goiás, where it was recorded that the temperature was around 24°C to 28°C.

Unlike composting, where temperatures above 40ºC are expected, in vermicomposting the temperature mustn't exceed 35ºC, since in a natural environment the earthworms live in a narrow layer below the surface with mild temperatures. Thus, temperatures above this value can generate a hostile environment for earthworms, interfering with their development and may cause the death of individuals

(EDWARDS, 1995). The pH of the three treatments had similar behavior, starting in acid ranges, but increasing throughout the process, stabilizing in alkaline ranges (Figure 2).

Figure 2: pH of the process over the 90 days



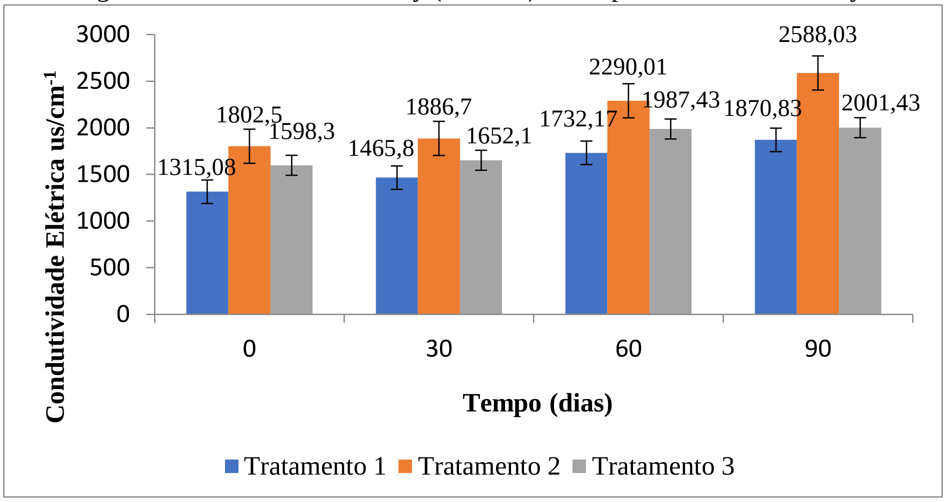
This result can be explained by two factors; the first is about organic residues, when they enter the degradation phase – at the beginning of the process –, they release organic acids, making the mass slightly acidic, therefore, during the process, the microorganisms present in the organic residue use these acids as substrate, releasing basic compounds, causing the pH to increase, ending in alkaline ranges (JIANG, 2011).

Another factor is concerning the earthworms that release calcium carbonate (CaCO 3) into the environment during the process, which is formed in their esophagus, contributing to an increase in the pH of the vermicompost (VERAS; POVINELLI, 2004). According to Turruella et al, (2002), the ideal pH range throughout the vermicomposting process is between 6.0 to 8.5; values lower than 6.0 can decrease the activities of earthworms in the process. Values above 8.5 can cause death.

According to current legislation, Normative Instruction n. 25/2009 of the Secretary of Agricultural Defense of the Ministry of Agriculture, Livestock and Supply (SDA/MAPA) in its Annex III, in the production of mixed and compound organic fertilizers, class A, B, C, and D from vermicomposting, the minimum value for the pH of vermicompost is 6.0. Therefore, the pH values found in this work fit within the value determined by current legislation.

Another parameter that indicates the degree of maturation is the electrical conductivity, which indicates the presence of salts in the vermicompost. In the present work, the three treatments throughout the process showed a gradual increase in this parameter (Figure 3), ending in values around 2000 us/cm-1.

Figure 3: Electrical Conductivity (us/cm-1) of the process over the 90 days

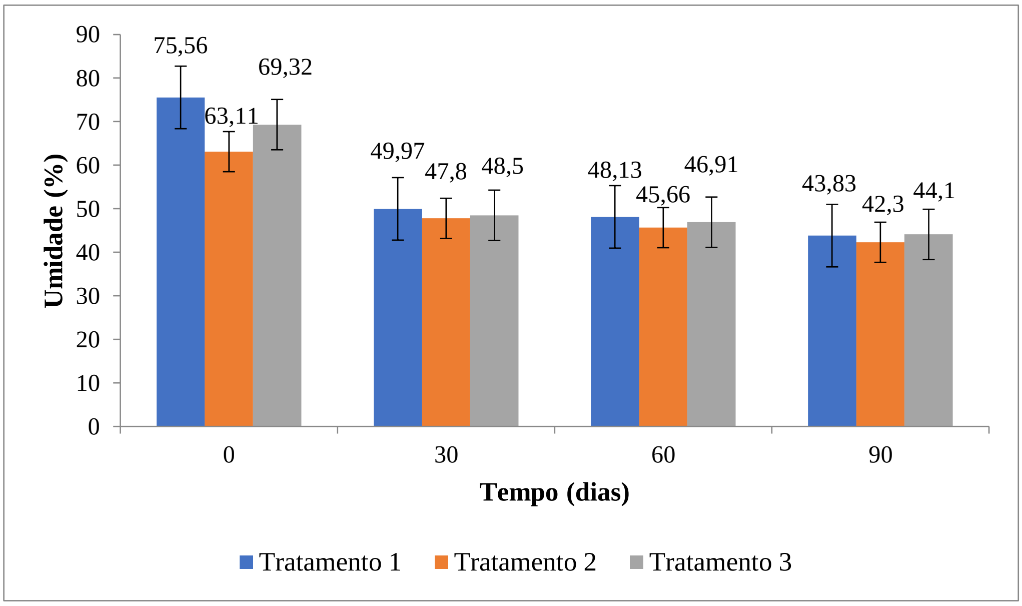


This result is in line with the study by Pirsaheb, Khosravi, and Sharafi (2013) who carried out a vermicomposting experiment with the same species of earthworm used in the present work (Eisenia Foetida) and with domestic waste generated in the city of Tehran in Iran, where electrical conductivity increased throughout the process.

Gonçalves (2014) argues that this increase in the vermicomposting process is associated with the mineralization of organic waste, a result of the action of earthworms and microorganisms present in their intestinal tract. However, all values found at the end of the process were within the limit recommended by scientific articles that describe that the ideal value for electrical conductivity in vermicompost is around 2500 us/cm -1 (LOURENÇO, 2014).

The three treatments started with a high moisture content, but throughout the process, they decreased and remained at an average of 40% (Figure 4).

Figure 4: Moisture on a dry basis (%) of the process over the 90 days

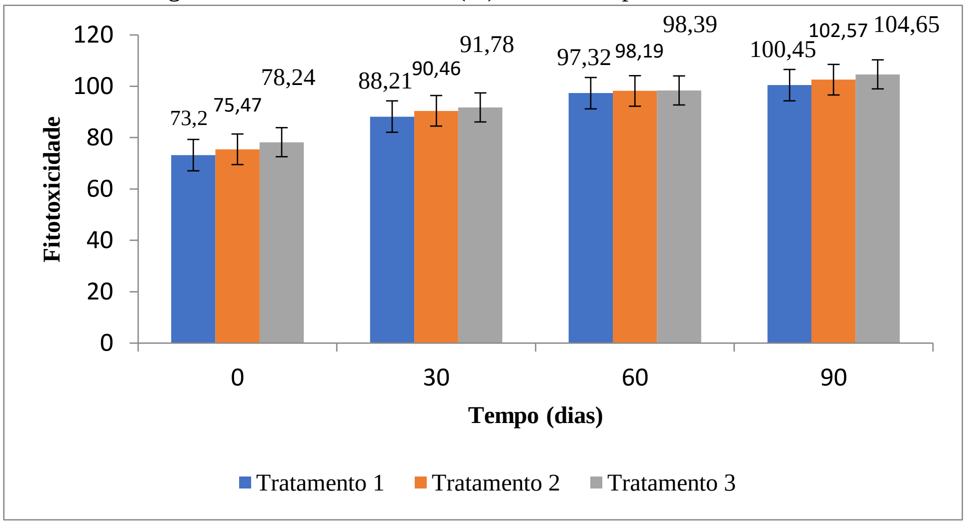


The moisture contents found in this work were better than those found in the study by Cotta et al. (2015), in which organic vegetable waste and cattle manure were treated through vermicomposting. As a consequence, the moisture content ended at 58.45%. According to Normative Instruction n. 25/2009, SDA/MAPA, in its Annex III, the maximum moisture value for class A, B, C, and D vermicompost is 50% (MAPA, 2009). Thus, the values reached for humidity in this work are within the value determined by current environmental legislation.

According to Anjos (2015), excessive or scarce moisture is one of the harmful factors in the process. Thus, when the humidity is too low, there is a risk of a considerable decrease in the performance of earthworms in the process. When there is excessive humidity, the water starts to fill the spaces that should be filled with air, making the process anaerobic causing the death of the earthworms, in addition to the emission of odors and attraction of vectors.

Based on the results obtained in Figure 5, it is possible to observe the germination rates of seeds exposed to the concentration of both vermicompost treatments. It starts with a comparative germination index for the blank of 100%.

Figure 5: Germination index (%) of seeds exposed to treatments



It is possible to observe that the lettuce seeds presented a germination index for both treatments, being lower in the first 30 days, around 70% to 80%. Subsequently, at the end of the vermicompost maturation process, when completed 90 days, it is noted that the germination index is greater than 100% for all treatments.

The fact that the germination rate is higher at the end of the process may be related to the production of humus in the vermicompost. In a short period of 15-20 days, the existence of hummus is already noticeable, reaching a usable volume after 50-60 days (FELICIO et al., 2018). According to Vione et al. (2016), vermicomposts that have germination rates above 100% are considered convenient for cultivation, as they generally contain substances that stimulate the germination process.

It should be noted that treatment 3 showed the best rates in all germination analyses throughout the vermicompost maturation process. Depending on the flow and characteristics of the feed used, the amount and quality of the vermicompost may vary (KIEHL, 2004).

The experiment lasted 90 days, ultimately generating a stabilized and matured vermicompost, obeying the evaluated parameters of the aforementioned Normative Instruction, as well as the class of compost that could be classified, taking into account only the results obtained in the work. After the end of the treatment, agronomic, economic, and environmental value is added (ROSA et al., 2019).

In addition, vermicompost has great nutritional potential serving as a natural fertilizer, since it is non-toxic to the environment. Furthermore, it can serve as a corrector for some soil elements, such as aluminum, iron, and manganese; aid in the resistance against diseases and pests in plantations; serve as a regulator of plant and root growth, in addition to improving the germination potential of seeds, making a more correct and productive disposal of organic waste generated daily in essential and household activities a viable alternative (CORRÊA; SANTOS, 2015).

4 CONCLUSION

Based on the main objective proposed by the research, that is, to use the techniques of the vermicomposting process to treat the organic waste generated in the horticultural sector in food trade and to analyze the physical-chemical and phytosociological characteristics of the generated vermicompost, it is concluded that the results obtained were satisfactory since the values of temperature, humidity, conductivity, and pH respected the parameters of the current legislation. Therefore, the phytotoxicity indices were within the values recommended by the consulted literature.

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