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# Characterization of organic composts produced by family farming for lettuce cultivation

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## Abstract

Organic composts can be sustainably used for lettuce production in family farming by employing residues from the farm itself through composting. For an efficient and safe use of these wastes, monitoring the composting process and adopting good agricultural practices is necessary to produce safe food. Therefore, the objective of the present study was to identify and quantify pathogenic microorganisms, as well as to evaluate the chemical characteristics of organic composts and their effects on organic lettuce production. Six lettuce production cycles were studied, in which organic composts produced at the farm were used for planting and topdressing fertilization. Composting was carried out according to the method of revolved windrows, using crop remains, leaves and cattle manure. The results obtained for fresh mass and chemical analyses of composts, soil and plant were qualitatively compared. For microbiological analyses, results were evaluated according to current legislation. The composition of the used material and management of the composting process affected the chemical characteristics of organic composts to be applied to the soil. The organic compost used in each cycle was efficient for plant nutrition, except boron supply. Presence of thermotolerant coliforms was above the maximum acceptable limit, indicating contamination of the compost. In most cycles, the organic compost did not undergo proper composting. Using organic composts proved to be a sustainable alternative for organic lettuce production in family farms, but the present study indicated the need for technical training.

**Keywords:** organic cultivation, composting, microorganism, good agricultural practices

## Introduction

The concern over sustainably produced healthy food has currently increased. Food production can be obtained by the organic system, free of physical, biological or chemical contaminants (Martinelli & Cavalli, 2019). Family farming is appropriate for a sustainable production since it allows greater product diversification and integration of plant and animal activities (Carmo, 1988; Taveira et al., 2019).

Organic fertilization in small farms can use agricultural wastes, which are transformed into organic fertilizers through composting, reducing the activity costs and adequately reusing the farm residues (Ferreira et al., 2013).

The quality of the obtained organic compost is directly related to the composting time necessary for organic materials to reach the stability point and acceptable levels of pathogens. The pile size and shape,

aeration, moisture, temperature, C:N ratio, and number of revolutions also influence the compost quality. For affecting aeration and heat dissipation, the pile shape and size influence the composting speed (Kiehl, 2012).

Lettuce is the most consumed leafy vegetable in Brazil and is responsive to organic fertilizers (Chiconato et al., 2013; Silva et al., 2017; Vasconcelos et al., 2017). Since it is consumed raw, important aspects of its production system should be considered by the farmer, especially those related to good agricultural practices, due to contamination risk (Bartz et al., 2015).

In the cultivation stage, vegetables may be contaminated by pathogenic microorganisms, especially through contaminated water and organic fertilizers (Abreu et al., 2010; Arbos et al., 2010).

Lettuce contamination through organic fertilizers was studied by Santana et al. (2006), who verified the presence of parasites and fecal coliforms due to frequent

use of organic wastes. Among organic residues, chicken manure may contain *Salmonella* spp., while cattle and sheep manure may have fecal coliforms and other pathogens. However, if properly treated, such wastes become safe and efficient fertilizers for crop development (Cavalcante et al., 2019; Chiconato et al., 2013; Sete et al., 2015).

Thus, monitoring the composting process and adopting good agricultural practices is quite important to reduce contamination, ensuring product safety. Therefore, the current study aimed to identify and quantify pathogenic microorganisms, as well as to evaluate the chemical characteristics of composts used in each production cycle and their effects on lettuce produced in organic family farming.

**Material and Methods**
*Installing and conducting the experiment*

This study was conducted from April 2018 to April 2019 in a property that adopted family farming as the system for cultivating vegetables with organic certification. The experiment was installed under protected environment conditions in a plastic tunnel-type arched-roof greenhouse with open sides in Agudos Municipality – São Paulo State, Brazil (22°24'20" S and 49°03'50" W, at 526m altitude). According to Köppen, the climate is Cwa, high-altitude tropical climate, showing average annual temperature of 22.6 °C, and average annual precipitation of 1,331 mm. The soil was classified as Red-yellow Oxisol (Embrapa, 2018).

Seedlings of curly lettuce (*Lactuca sativa* L.), 'Verônica' variety, were used; they were produced and developed in the studied farm without associated mineral fertilizers and chemical pesticides. Six production cycles were evaluated as shown in Table 1.

The beds had their soil prepared with a garden tiller before cycle 1. Fertilization was performed with a product recommended for organic fertilization: 5kg Yoorin Master (17.5% $P_2O_5$, 18% Ca, 7% Mg, 0.10% B, 0.05% Cu, 0.30% Mn, 10% Si, 0.55% Zn) per bed for P supply. For planting and topdressing fertilization, organic composts were produced at the studied commercial farm (Table 1) by adopting the materials available in that area, such as crop remains, leaves and cattle manure, and composting was performed by the method of upturned windrows.

**Table 1.** Lettuce production cycles and organic composts applied for planting and topdressing fertilization.

| Treatment | Planting (MM/DD/YY) | Compost for planting fertilization | Compost for topdressing fertilization | Harvest (MM/DD/YY) |
|---|---|---|---|---|
| Cycle 1 | 04/26/18 | Semi-tanned manure and vegetables | Semi-tanned manure and vegetables | 06/04/18 |
| Cycle 2 | 06/26/18 | Semi-tanned manure and vegetables | Manure and water | 08/13/18 |
| Cycle 3 | 08/28/18 | Semi-tanned manure and vegetables | Castor bean cake | 10/08/18 |
| Cycle 4 | 11/07/18 | Semi-tanned manure and vegetables | Semi-tanned manure and vegetables | 12/10/18 |
| Cycle 5 | 01/09/19 | Semi-tanned manure and vegetables | Semi-tanned manure and vegetables | 02/11/19 |
| Cycle 6 | 02/27/19 | Semi-tanned manure and vegetables | Semi-tanned manure and vegetables | 04/02/19 |

No standard procedure was adopted by the farmer for compost preparation, and the materials employed in the composting process varied according to their availability in that area but basically included semi-tanned manure (tanned for seven days) and vegetables (especially leaves), except for topdressing fertilization in cycles 2 and 3, which used manure plus water and castor bean cake, respectively.

In most cycles, the mixture of vegetables and manure was not properly composted since it was used within one week after the composting pile preparation. Differently, for topdressing fertilization in cycle 4 and planting fertilization in cycle 5, the composting period was of 30 and 70 days, respectively.

The organic composts were applied at 2.8 kg m$^{-2}$ at planting and topdressing in all cycles, except for topdressing in cycles 2 and 3. In cycle 2, the compost for topdressing fertilization was prepared at the proportion of 40L water to 15L manure. Of this mixture, approximately 500 mL.m$^{-2}$ were applied. In cycle 3, topdressing fertilization was done with castor bean cake, which was prepared with 2L castor bean cake and 50 L water.

Experimental plots consisted of beds of 35m length x 1.20m width, and 0.25m spacing between

plants. Seedlings were distributed in five rows, and the three central rows were considered the usable area, from which 15 plants were evaluated.

*Evaluations*
*Evaluating the organic compost*
For chemical characterization and microbiological analysis of composts, before planting or topdressing applications, five individual samples were collected from different points of the composting pile, accounting for a composite sample.

For the organic compost used in each cycle, total levels of nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, moisture, organic matter and carbon were determined *in natura* as percentage (%), and total levels of sodium, boron, copper, iron, manganese and zinc were measured *in natura* as mg kg$^{-1}$. In addition, the chemical characteristics *in natura* such as pH and carbon/nitrogen ratio (C:N) were assessed according to the methodology described in the guide of the Brazilian Ministry of Agriculture, Livestock and Food Supply to official analytical methods for fertilizers and correctives (Brasil, 2014); subsequently, the obtained indexes were transformed to the dry basis.

Samples from the organic composts were also analyzed for detection of *Salmonella* (presence/absence in 10g) and quantification of thermotolerant coliforms and *Escherichia coli* (CFU.g$^{-1}$). Analysis of *Salmonella* was carried out in a ready-to-use Compact Dry® SI plate containing dehydrated chromogenic medium. Following pre-enrichment, selective enrichment, inoculation and incubation at 42ºC for 24h, reading was performed for plates that had the medium changed from blue to yellow and presented green or black colonies. Quantification of thermotolerant strains and *E. coli* was also performed on dehydrated chromogenic medium in ready-to-use Compact Dry® CF and EC plates, respectively. After inoculation and incubation, reading was performed. EC plates are incubated at 35ºC for 24h and enable the count of *E. coli*, which are represented by blue colonies. CF plates are incubated at 45ºC for 24h, and blue colonies on it indicate thermotolerant coliforms.

*Chemical analysis of the soil*
In cycles 1, 3 and 6, ten individual soil samples were collected from the usable area in a bed, forming one composite sample for chemical characterization of the soil according to Raij et al. (2001).

*Evaluating the nutritional status and fresh mass of lettuce*
At harvest, in cycle 6, plants were cut close to the soil for shoot fresh mass determination and nutritional status evaluation (Malavolta et al., 1997). At the end of each cycle, 15 lettuce heads were randomly harvested from the usable area in a bed and individually weighed for fresh mass production calculation.

*Analyzing the results*
All six lettuce production cycles were regarded as treatments. The obtained fresh mass and results of chemical analysis for the composts, soil and plant were qualitatively compared. The results of microbiological analyses were evaluated according to the Normative Instruction no. 64 of December 18, 2008 (BRASIL, 2008).

**Results and Discussion**
The chemical characteristics of composts over the cycles (Table 2) evidenced that the lack of standardization and the use of diversified materials according to their availability in the area influenced the quality of the composting process and the compost itself. C:N oscillated from a value considered high for an organic compost in final composting stage already in cycle 1 to values below 20:1 in the remaining cycles.

The characteristics of organic compost are also important for stabilization of the produced humus or organic fertilizer. C:N of the obtained compost is a quality indicator for both the composting process and the compost, and its recommended values are generally equal or inferior to 18:1 (Kiehl, 2012, Souza et al., 2020).

The C:N value of 27:1 found for the compost in cycle 1 (planting and topdressing) can be explained by its short composting period, i.e., there was not enough time for the microorganisms to decompose the wastes. On the other hand, low C:N values were found for composts applied at topdressing in cycles 2 and 3, probably due to the composition of composts, which consisted of a mixture of fresh manure and water in cycle 2 and a mixture of castor bean cake and water in cycle 3. In cycle 5 (planting), the lower C:N was related to the longer composting time.

Moisture was low in composts used for planting and topdressing fertilization in cycle 1 but higher and considered adequate in those of the remaining cycles. During the composting process, moisture is expected to decrease due to the increasing temperatures and can reach values inferior to 40%, which will reduce and even cease microbial activity (Kiehl, 2012). In case such low values are reached during the composting process, the quality may be affected, resulting in an immature compost. The present data indicate that moisture and temperature were not monitored and that application of

composts to the beds occurred before the composting process was complete, except in cycle 5 (planting). This is justifiable since the experiment involved the

farmer's learning and improvement of techniques for the composting practice from cycles 1 to 6.

**Table 2.** Chemical characterization of organic composts, dry basis, used as organic fertilizers in lettuce production, at planting and topdressing, in six cycles.

| Cycles | Period | N | $P_2O_5$ | $K_2O$ | Ca | Mg | S | M | O.M. | Total C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ----------- % dry basis ----------- | | | | | |
| 1 | P | 0.4 | 0.3 | 0.3 | 1.8 | 0.2 | 0.1 | 19 | 19.8 | 11.1 |
| 1 | T | 0.4 | 0.3 | 0.3 | 1.8 | 0.2 | 0.1 | 19 | 19.8 | 11.1 |
| 2 | P | 0.7 | 0.2 | 0.5 | 0.3 | 0.2 | 0.1 | 45 | 23.6 | 12.7 |
| 2 | T | 0.8 | 0.2 | 1.3 | 0.4 | 0.3 | 0.1 | ----- | 6.0 | 3.0 |
| 3 | P | 0.9 | ND | 0.6 | 0.1 | 0.3 | 0.1 | 51 | 18.4 | 10.0 |
| 3 | T | 1.1 | 0.9 | 0.9 | 1.0 | 0.8 | 0.2 | ----- | 10.0 | 6.0 |
| 4 | P | 0.5 | 0.2 | 0.3 | 0.3 | 0.1 | 0.1 | 35 | 15.4 | 9.0 |
| 4 | T | 0.6 | 0.1 | 0.2 | 0.4 | 0.3 | 0.1 | 35 | 18.5 | 10.0 |
| 5 | P | 0.6 | 0.2 | 0.1 | 0.6 | 0.3 | 0.1 | 27 | 12.3 | 7.0 |
| 5 | T | 0.8 | 0.2 | 0.1 | 0.4 | 0.3 | 0.1 | 44 | 19.6 | 11.0 |
| 6 | P | 0.5 | 0.6 | 0.2 | 0.8 | 0.2 | 0.1 | 43 | 17.5 | 9.0 |
| 6 | T | 0.8 | 0.4 | 0.2 | 1.1 | 0.2 | 0.1 | 49 | 25.5 | 14 |
| | | Na | B | Cu | Fe | Mn | Zn | C:N | pH | |
| | | | | ----------- % dry basis------ | | | | | | |
| 1 | P | 402 | 84 | 22 | 5376 | 170 | 54 | 27/1 | 7.4 | |
| 1 | T | 402 | 84 | 22 | 5376 | 170 | 54 | 27/1 | 7.4 | |
| 2 | P | 1134 | 85 | 18 | 2053 | 171 | 27 | 17/1 | 7.5 | |
| 2 | T | 151 | 5 | ND | 80 | 9 | 1 | 4/1 | 8.2 | |
| 3 | P | 1120 | 16 | 4 | 1651 | 233 | 47 | 12/1 | 6.9 | |
| 3 | T | 48 | 2 | 1 | 118 | 11 | 5 | 6/1 | 5.1 | |
| 4 | P | 895 | 42 | 8 | 1854 | 168 | 38 | 17/1 | 5.8 | |
| 4 | T | 914 | 34 | 20 | 7254 | 234 | 46 | 16/1 | 6.0 | |
| 5 | P | 596 | 44 | 22 | 6163 | 237 | 36 | 11/1 | 6.6 | |
| 5 | T | 459 | 38 | 16 | 5591 | 232 | 36 | 14/1 | 7.3 | |
| 6 | P | 1470 | 16 | 18 | 5844 | 228 | 60 | 17/1 | 7.2 | |
| 6 | T | 1490 | 14 | 18 | 5792 | 278 | 65 | 17/1 | 7.1 | |

P - planting; T – topdressing; M: moisture; O.M.: organic matter; ND= not defined.

The composts had pH values varying from 5.1 to 8.2, which indicates slightly acidity and alkalinity. According to Kiehl (2012), the pH of composts increases at the end of the composting process and can reach values superior to 8.0. Although some composts showed pH close to 8.0, it cannot be assured that they reached the end of the process, requiring evaluation of other parameters. Based on the Brazilian Normative Instruction (NI) no. 25 (Brasil, 2009), the compost must contain at least 25.86% total organic matter; pH 6.0; 0.5% total nitrogen; and 1% sulfur, calcium and magnesium. Maximum C:N ratio should be 20:1.

It must also be considered that chemical and physical transformations caused by microbial activity directly depend on the physico-chemical characteristics of the mixture of wastes used in the composting process (Souza et al., 2020). Thus, the pH of 5.1 found for the mixture of castor bean cake and water is justified by the carbon level in this material, which is 450 g.kg$^{-1}$, as stated by Raij et al. (1997).

The organic matter percentage in the different

composts widely ranged, from 6% to 25.5% (Table 2), especially due to the composition of the used residues. Studies have indicated that the compost must contain at least 25% - 30% organic matter, presenting percentages superior to those in manure, and water content inferior to that in fresh manure (Kiehl, 2001). Organic matter percentages close to the above-mentioned values were found for the composts used at planting in cycle 2 and at topdressing in cycle 6.

The composts used in the remaining cycles had lower organic matter values, differing from the 37.0% mean organic matter reported for composts containing the mixture of cattle manure and grass (Oliveira et al., 2014); such a difference can be explained by the composting time, since those authors employed completely decomposed material.

Carbon levels (Table 2) were inferior to those established by NI no. 25 for (Brasil, 2009) organic composts: minimum 15% organic carbon; however, some of the obtained levels were close to the minimum value.

Chemical analysis revealed differences in macro and micronutrients (Table 2). The more expressive values of nitrogen, phosphorus, potassium and calcium can be attributed to the composition of the residues used in the elaboration of some composts, including manure and castor bean cake, as well as to the production form and to other previously mentioned factors that interfere in the composting process, such as C:N, which can predict the potential of N release rate during the composting process (Silva et al., 2013).

The highest nitrogen level was 1.06%, which is inferior to the value considered adequate by Souza & Resende (2006) to increment the commercial productivity of vegetables, since N levels equal or superior to 2.5% can increase productivity by up to 50%, compared to mean levels of 1.5%. On the other hand, Silva et al. (2010) observed that organic composts with N levels varying from 1.2% to 2.5% met the nitrogen demands of the crop in the first cycle.

The organic composts of the present study did not reach those N levels; however, they were elaborated by the farmer and represent an important source of this nutrient, which can be further increased by adopting appropriate composting techniques, including simple but effective measures like monitoring the time necessary for reaching compost maturation, the temperature and the moisture, besides the C:N of wastes to be composted.

Considering phosphorus, the compost using castor bean cake presented higher P levels than composts prepared with manure, even though tanned manure has higher phosphorus percentages in its composition (Raij et al., 1997).

The composts applied at topdressing in cycles 2 and 3, which used manure and castor bean cake, respectively, had higher potassium levels (Table 2). These results confirm the importance of the waste composition in the composting process, since both residues have high potassium levels (21 g.kg$^{-1}$ in tanned manure, 6 g.kg$^{-1}$ in fresh manure and 11 g.kg$^{-1}$ in castor bean cake, according to Raij et al., 1997).

In general, calcium levels were variable in the composts used in the different cycles (Table 2). Residues from manure and castor bean cake, which have high calcium levels in their composition (Raij et al., 1997), did not lead to higher values in the final compost, showing the need for monitoring during the composting process, as previously suggested.

For magnesium, the higher levels found in castor bean cake residues led to increased levels in the final material used for topdressing in cycle 3, whereas the remaining wastes showed low Mg level. Sulfur percentages were reduced in all composts (Table 2), reflecting its low level in the wastes (Raij et al., 1997).

Micronutrient levels also varied among the different cycles (Table 2), especially due to the maturation degree of composts. The C:N ratio obtained for most composts confirms that a longer composting time was required for producing adequate nutrient content.

The levels of B, Cu, Fe, Mn, Zn and Na were lower when C/N was inferior, especially for topdressing composts of cycles 2 and 3 (Table 2), which were liquid composts, indicating that the levels of such nutrients were acceptable by the legislation for organic fertilizers.

In general, application of the organic composts contributed to increasing the nutrient levels in the soil (Table 3), improving its chemical attributes and enhancing the availability of nutrients (Montemurro et al., 2010; Cardoso et al., 2011; Oliveira et al., 2014); however, the effect of composts in the short or medium term depends particularly on the available nutrient content. Therefore, the availability of nutrients for a compost in the soil-plant system can only be properly estimated if the major forms of each element in the compost are known (Barral et al., 2011).

**Table 3.** Chemical characterization of the soil in different production cycles.

| Cycles | P (resin) | O.M. | pH | H+Al | K | Ca | Mg | SB | CTC | V% |
|--------|-----------|------|------|------|------|------|------|------|------|------|
| | mg dm$^{-3}$ | g dm$^{-3}$ | (CaCl$_2$) | --------------mmolc dm$^{-3}$-------------- | | | | | | % |
| 1 | 29 | 24 | 6.0 | 16 | 2.1 | 49 | 12 | 64 | 80 | 80 |
| 4 | 272 | 33 | 5.5 | 13 | 7.6 | 50 | 26 | 84 | 97 | 87 |
| 6 | 237 | 34 | 5.8 | 12 | 3.9 | 67 | 25 | 96 | 109 | 89 |

Phosphorus level in the soil before application of the organic compost in cycle 1 was 29 mg dm$^{-3}$, increasing to 272 mg dm$^{-3}$ in cycle 4 and reaching 237 mg dm$^{-3}$ after cycle 6. This rise in phosphorus level over the cycles can be justified by its residual effect and by the application of fertilizer Yoorin Master in cycle 1.

Organic matter values were higher in soil samples in cycle 4 and after cycle 6, compared to values from the soil prior to fertilization (Table 3).

The greatest organic matter levels in cycles 4 and 6 can be related to the sample containing the mixture of soil and compost. It must be highlighted that the increase in the soil organic matter with the use of organic composts represents one of the greatest benefits

provided by organic fertilization.

Higher potassium levels in the soil (Table 3) resulted from the used organic compost, which contributed to supplying 50% of the K level recommended for lettuce fertilization shown in Bulletin 100 (Raij et al., 1997).

Addition of the organic compost led to a slight decrease in pH values between the application before cycle 1 (6.0) and that after cycle 6 (5.8). Increased levels in the soil were observed only after cycle 6 for calcium and in cycles 4 and 6 for magnesium, which is justified especially by the composition of organic composts.

Base saturation values increased over cycles, even though the value was already appropriate (v% = 80) before addition of the compost, which indicates that there is no need for limestone application.

Applying the composts led to greater micronutrient levels in the soil (Table 4), which peaked in cycle 4, highlighting the benefit of using organic composts.

**Table 4.** Micronutrient levels in the soil in different production cycles.

| Cycles | B | Cu | Fe | Mn | Zn |
|---|---|---|---|---|---|
| | ----------------------mg dm$^{-3}$---------------------- | | | | |
| 1 | 0.17 | 1.7 | 29 | 2.3 | 3.0 |
| 4 | 0.91 | 9.3 | 138 | 48.5 | 18.9 |
| 6 | 0.36 | 6.2 | 54 | 5.3 | 10.3 |

Several authors have reported certain differences as to the appropriate mean levels of nutrients in the plants, especially considering the sampled tissue, the cultivation system and the sampling period, and most authors have adopted shoot analysis at the harvesting point. Despite the existing divergence, Martinez & Maia (2010) cited appropriate mean concentrations for curly lettuce, without the head, as g kg$^{-1}$: N (50), P (8), K (75), Ca (18), Mg (3).

Using organic composts for lettuce planting and topdressing fertilization in cycle 6, in which the composting process employed wastes of tanned manure and leaves, resulted in appropriate nutrient levels for lettuce, except B. The obtained N level of 39.7 g kg$^{-1}$ is within the range recommended for lettuce leaves: 30 to 50 g kg$^{-1}$ (Trani, 2007). P level was 4.3 g kg$^{-1}$, which is also within the suitable range of 4 to 7 g kg$^{-1}$ (Trani, 2007), although approaching the inferior limit. The levels of K, Ca, B and Zn were 61.7 g kg$^{-1}$ 9 g kg$^{-1}$, 23.7 mg kg$^{-1}$ and 40.7 mg kg$^{-1}$, respectively, below the range considered appropriate by Trani (2007).

Composts with castor bean cake had higher nutrient levels, especially N and K (Table 2), which contributed to enhancing the production in cycle 3.

Considering all cycles, the first two had smaller mean production, 137 g.foot$^{-1}$, which increased over the cycles, reaching the maximum value of 213 g.foot$^{-1}$ in cycle 5, with subsequent fall to 165 g.foot$^{-1}$. Such a result obtained for cycle 5 corroborates the values found by Silva et al. (2017) using cattle manure for lettuce cultivation. Several studies have evidenced increased lettuce production with the application of organic composts (Chiconato et al., 2013, Nazareno et al., 2010, Santana et al., 2012); however, higher or lower responses will depend on the nutritional value of the compost (Oliveira et al., 2014). As previously reported, the composts used in the first two cycles had inadequate C:N ratio, consequently presenting inferior N levels (Table 2), which may have led to the low production.

On the other hand, using composts that contained manure but underwent appropriate composting, as observed for cycles 4 (topdressing) and 5 (planting), resulted in adequate nutrient levels, leading to greater production. The same was not observed for cycle 6, possibly due to the losses caused by the heavy rainfall of 273 mm recorded in that period.

The maximum acceptable limit for thermotolerant coliforms in organic composts is 1,000 CFU.g$^{-1}$ = 3 log CFU.g$^{-1}$, besides absence of *Salmonella* in 10g compost (Brasil, 2008). In the present study, thermotolerant coliform levels were above the maximum limit in most cycles (Figure 1), which indicated that the composting process was not correctly performed, evidenced by C:N ratio, moisture and composting time; thus, the process was not efficient in sanitizing the compost. This demonstrates that the composting practice, if not appropriately performed, will negatively influence the microbiological quality of both the compost and the lettuce, as reported by Arbos et al. (2010), who evaluated the quality of lettuce in 13 farms and detected fecal coliforms and *Salmonella* sp., probably due to the use of organic fertilizer without adequate composting time, according to those authors.

The compost containing castor bean cake, used in cycle 3 (topdressing), had lower microorganism levels since it naturally shows less pathogenic microorganisms in its composition. Reduced microorganism levels were also found in the compost applied at planting in cycle 5 (Figure 1), already after 70 days of composting.

The bacteria *Escherichia coli* was detected in the compost of all cycles, with counts similar to the thermotolerant coliforms (Figure 1). The pathogen *Salmonella* was detected only in the planting compost from cycle 1.
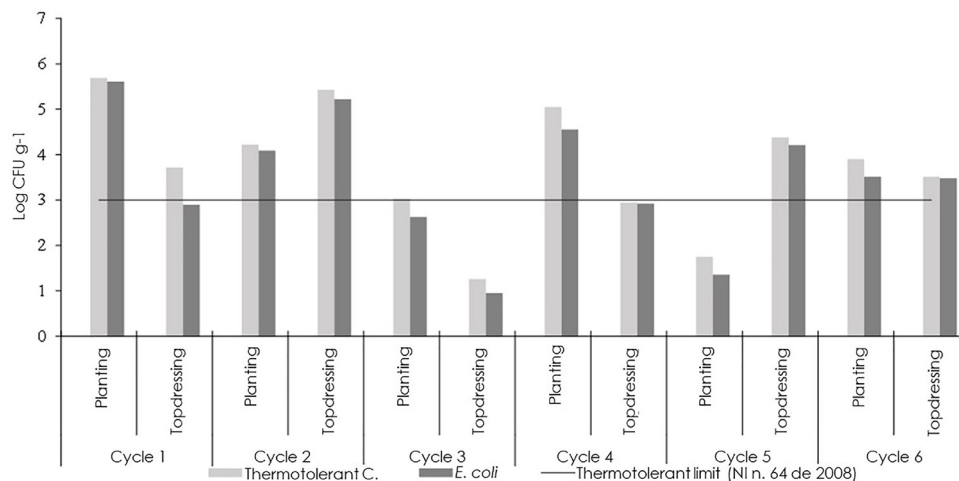
**Figure 1.** Count of thermotolerant coliforms and *Escherichia coli* in organic compost used as fertilizer in planting and in topdressing.

## Conclusions

The composition of the used material and management of the composting process influenced the chemical characteristics of organic composts to be applied to the soil.

The added organic composts were efficient for plant nutrition, except for boron supply.

Thermotolerant coliforms exceeded the maximum acceptable limit, indicating contamination of the compost.

Composting was not properly performed in most cycles. Using organic composts proved to be a sustainable alternative for organic lettuce production in a property adopting family farming; however, the present study evidenced the need for technical capacitation.

## References

Abreu, I.M.O., Junqueira, A.M.R., Peixoto, J.R., Oliveira, S.A. 2010. Qualidade microbiológica e produtividade de alface sob adubação química e orgânica. *Food Science and Technology 30*: 108-118.

Arbos, K.A., Freitas, R.J.S., Stertz, S.C., CARVALHO, L.A. 2010. Segurança alimentar de hortaliças orgânicas: aspectos sanitários e nutricionais. *Ciência e Tecnologia de Alimentos* 30: 215-220.

Barral, M.T., Paradelo, R., Dominguez, M., Díaz-Fierros, F. 2011. Nutrient release dynamics in soils amended with municipal solid waste compost in laboratory incubations. *Compost Science & Utilization* 19: 235-243.

Bartz, S., HesseL, C.T., Rodrigues, R.Q., Póssamai, A.,

Perini, F.O., Jacxsens, L., Uyttendaele, M., Bender, R.J., Tondo, E.C. 2015. Insights in agricultural practices and management systems linked to microbiological contamination of lettuce in conventional production systems in Southern Brazil. *International Journal of Food Contamination* 2: 1-13.

Brasil. 2008. Instrução Normativa N° 64, de 18 de dezembro de 2008 do Ministério da Agricultura, Pecuária e Abastecimento. Dispões sobre o Regulamento Técnico para os Sistemas Orgânicos de Produção Animal. Brasília, *Diário Oficial da República Federativa do Brasil*.

Brasil. 2009. Instrução Normativa MAPA n° 25. Estabelece normas sobre as especificações e as garantias, as tolerâncias, o registro, a embalagem e a rotulagem dos fertilizantes orgânicos simples, mistos, compostos, organominerais e biofertilizantes destinados à agricultura. Brasília, *Diário Oficial da República Federativa do Brasil*.

Brasil. 2014. *Manual de métodos analíticos oficiais para fertilizantes minerais, orgânicos, organominerais e corretivos*. MAPA/ SDA/CGAL, Brasília. 220 p.

Cardoso, A.I.I., Ferreira, K.P., Vieira Júnior, R.M., Alcarde, C. 2011. Alterações em propriedades do solo adubado com composto orgânico e efeito na qualidade das sementes de alface. *Horticultura Brasileira* 29: 594-599.

Carmo, M.S. 1998. A produção familiar como lócus ideal da agricultura sustentável. In: Ferreira, A.D.D., Brandenburg, A. *Para pensar outra agricultura*. UFPR, Curitiba, Brasil. 275 p.

Cavalcante, L.F, Bezerra, F.T.C., Souto, A.G., Bezerra, M.A.F., Lima, G.S., Gheyi, H.R., Pereira, J.F.S., Beckmann-Cavalcante, M.Z. 2019. Biofertilizers in horticultural crops. *Comunicata Scientiae* 10: 415-428.

Chiconato, D.A., Simoni, F., Galbiatti, J.A., Franco, C.F., Caramelo, A.D. 2013. Resposta da alface à aplicação de biofertilizante sob dois níveis de irrigação. *Bioscience Journal* 29: 392-399.

Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA, Centro Nacional de Pesquisa de Solos. 2018. *Sistema brasileiro de classificação de solos*. Embrapa, E-book, Brasília.

Ferreira, A.G., Borba, S.N.S., Wizniewsky, J.G. 2013. A prática da compostagem para a adubação orgânica pelos agricultores familiares de Santa Rosa/RS. Revista Eletrônica do Curso de Direito da UFSM, p.307-317.

Kiehl, E.J. 2012. *Manual de Compostagem: maturação e qualidade do composto*. Esalq, Piracicaba. 171p.

Kiehl, J.C. 2001. Produção de composto orgânico e vermicomposto. *Informe Agropecuário* 22: 40-42, 47-52.

Malavolta, E., Vitti, G.C., Oliveira, S.A. 1997. *Avaliação do estado nutricional de plantas: Princípios e aplicações*. Potafós, Piracicaba. 308 p.

Martinelli, S.S., Cavalli, S.B. 2019. Alimentação saudável e sustentável: uma revisão narrativa sobre desafios e perspectivas. *Ciência & Saúde Coletiva* 24: 4251-4262.

Martinez, H.E.P., Maia, J.T. 2010. Diagnose foliar na cultura da alface. In: *Nutrição de plantas: diagnose foliar em hortaliças*. FCAV/FAPESP/CAPES/FUNDUNESP. Jaboticabal, 376 p.

Montemurro, F., Ferri, D., Tittarelli, F., Canali', S., Vitti, C. 2010. Anaerobic digestate and on-farm compost application: Effects on lettuce (*Lactuca sativa* L.) crop production and soil properties. *Compost Science & Utilization* 18: 184193.

Nazareno, G.G., Junqueira, A.M.R., Peixoto, J.R. 2010. Utilização de matéria orgânica para o controle de nematóides das galhas em alface sob cultivo protegido. *Bioscience Journal* 26: 579-590.

Oliveira, L.B., Accioly, A.M.A., Santos, C.L.R., Flores, R.A., Barbosa, F.S. 2014. Características químicas do solo e produção de biomassa de alface adubada com compostos orgânicos. *Revista Brasileira de Engenharia Agrícola e Ambiental* 18:157–164.

Raij, B. van, Andrade, J.C., Cantarella, H., Quaggio, J.A. 2001. *Análise Química para Avaliação da Fertilidade de Solos Tropicais*. Instituto Agronômico. Campinas, 285p.

Raij, B. van, Cantarella, H., Quaggio, J.A., Furlani, A.M.C. 1997. *Recomendações de Adubação e Calagem para o Estado de São Paulo*. Boletim Técnico 100. Campinas, 285p.

Santana, C.T.C., Santi, A., Dallacort, R., Santos, M.L., Menezes, C.B. 2012. Desempenho de cultivares de alface americana em resposta a diferentes doses de torta de filtro. *Revista Ciência Agronômica* 43: 22-29.

Santana, L.R.R., Carvalho, R.D.S., Leite, C.C., Alcântara, L.M., Oliveira, T.W.S.; Breno da M. Rodrigues, B.M. 2006. Qualidade física, microbiológica e parasitológica de alfaces (*Lactuca sativa*) sob diferentes sistemas de cultivo. *Ciência e Tecnologia de Alimentos* 26: 264-269.

Sete, P.B., Melo, G.W.B., Oliveira, B.S., Freitas, R.F., Magro,

R.D., Ambrosini, V.G., Trapp, T., Comin, J.J., Gatiboni, L.C., Brunetto, G. 2015. Perdas de nitrogênio do solo e resposta do pessegueiro à adição de composto orgânico. *Ciência Rural* 45: 651-657.

Silva, A.F.T., Avelino, R.C., Brito, L.P.S., Anjos, J.C.R., Silva Júnior, J.V., Beckmann-Cavalcante, M.Z. 2017. Crescimento e produtividade de cultivares de alface sob fertilização orgânica e diferentes ambientes. *Comunicata Scientiae* 8: 265-274.

Silva, F.A.M., Villas Bôas, R.L., Silva, R.B. 2010. Resposta da alface à adubação nitrogenada com diferentes compostos orgânicos em dois ciclos sucessivos. *Acta Scientiarum. Agronomy* 32: 131-137.

Silva, N., Junqueira, V.C.A., Silveira, N.F.A., Taniwaki, M.H., Santos, R.F.S., Gomes, R.A.R. 2010. *Manual de métodos de análise microbiológica de alimentos e água*. Livraria Varela. São Paulo, 624 p.

Silva, V.M., Ribeiro, P.H., Teixeira, A.F.R., Souza, J.L. 2013. Qualidade de compostos orgânicos preparados com diferentes proporções de ramos de gliricídia (*Gliricidia sepium*). *Revista Brasileira de Agroecologia* 8:187-198.

Souza, J.L., Resende, P.L. 2006. *Manual de horticultura orgânica*. Aprenda Fácil. Viçosa, 843 p.

Souza, L.A., Carmo, D.F., Silva, F.C., Paiva, W.M.L. 2020. Análise dos principais parâmetros que influenciam a compostagem de resíduos sólidos urbanos. *Revista Brasileira de Meio Ambiente* 8: 194-212.

Taveira, L.R.S., Carvalho, T.S., Teixeira, A.F.S., Curi, N. 2019. Sustainable productive intensification for family farming in developing tropical countries. *Ciência e Agrotecnologia* 43: e012819.

Trani, P.E. *Calagem e adubação para hortaliças sob cultivo protegido*. 2007. http://www.infobibos.com/Artigos/2007_1/cp/index.htm<Acesso em: 11/8/2020>

Vasconcelos, U.A.A., Costa, C.C.; Oliveira, M.N., Barbosa, J.W.S., Medeiros, A.B., Sobrinho, T.G. 2017. Efeito residual do esterco ovino no cultivo da alface em diferentes espaçamentos. *Revista Verde de Agroecologia e Desenvolvimento Sustentável* 12: 508-511.