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Investigating the Effect of Waste Process of Halva Ardeh Production on Vermicompost Quality

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ABSTRACT

Introduction: Currently, the conversion of waste from industrial processes to compost through vermicompost has been considered both in terms of health, environmental pollution, and economy. The aim of this study was to investigate the effect of waste process of Halva Ardeh production on vermicompost quality.

Materials and Methods: To determine the best combination of cow manure with Halva Ardeh processing waste according to national standard vermicompost methods; different percentages of cow manure and Halva Ardeh waste, were prepared for vermicompost during 90 days. SPSS software and ANOVA test were used to analyze the data.

Results: The results showed that during the process of vermicompost, pH initially increased in all treatments and then decreased significantly from the third week afterwards ($p \leq 0.001$). Also, the average organic carbon percentage (OC) decreased in all treatments significantly ($p = 0.02$) and the highest amount of OC was obtained in the control treatment and the lowest amount was related to 1C: 1S treatment. The trend of electrical conductivity changes in all substrates with different treatments was generally decreasing and this decrease was statistically significant ($p = 0.035$). Furthermore, the amount of carbon to nitrogen (C/N) in all treatments decreased and the average C/N in the control treatment was 56.8% and in the 1C: 1S treatment was 16.9% and this difference was statistically significant ($P = 0.023$).

Conclusion: Based on our findings, the compost quality of this study confirms to the standards of compost class A. This method can be used to convert the waste from Halva Ardeh production on vermicompost qulity.

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Introduction

Today, due to increasing population growth, industry development and lifestyle changes, municipal and industrial solid waste production is increasing [1, 2]. The major part of urban and industrial waste consists of organic materials. Recycling of these organic materials and utilizing them in various ways is considered by humans as a means of preventing damages to the environment and preserving human resources and energy [3]. One of the suitable methods for recycling these materials is to turn them into organic fertilizers, because on the one hand, the waste is converted into valuable products, and on the other hand, it controls the pollutants that result from an increase in population, urbanization, and more importantly, leads to the reduction of environmental and health problems [2].

There are several methods for converting organic matter to compost fertilizer. One of the most important methods is vermicompost. Vermicompost is the stabilization of organic substances as a result of the general activities of worms and microorganisms [4] which is obtained through the continuous and slow passage of organic substances from the digestive tract of species of worms and the excretion of these substances from the worm body [5]. Vermicomposting is a mesophilic process and it has a high microbial activity due to the passage of organic matter from the stomachs of worms and the regulation of plant growth and pest deficiency [6]. The final product of vermicompost has advantages such as; increasing the soil potential for water storage, making available food such as iron for plants, and preventing fluctuations in pH during absorption of the elements by the plant due to its tampon application [7, 9]. In order to achieve this, the use of earthworms characteristics helps to change, transform and stabilize organic matter to organic fertilizer [6.]

In various studies, the combination of various municipal and industrial wastes with other wastes such as sewage sludge and animal waste, has been used in the process of vermicompost [10- 12]. In the study conducted by Lim et al. soybean shell was used as a raw material in vermicompost [13]. In the process of production of Halva Ardeh, sesame seeds are used as raw material. Sesame shells are inedible because of their salinity, as such they are eliminated during the process and are considered as residues of this process [14]. Since most of the waste in the organic material industry can be used to produce fertilizers, therefore, this study was conducted with the aim of using waste products of Halva Ardeh production process and its composition with other waste products and its effect on vermicompost process.

Materials and Methods

This experimental study was carried out in a laboratory scale to investigate the effects of wastewater production process of Halva Ardeh and its composition with other waste materials in different proportions in the process of vermicomposting.

In this study, in order to determine the best composition, cow manure was mixed with Halva Ardeh waste and processed in four substrates with different percentages. A treatment made of cow manure was also provided as a control bed. Then, three other treatments, a mixture of cow manure and Halva waste were prepared in different proportions (Table 1).

Table 1: Different ratios of cow manure treatments with Halva Ardeh waste

Treatment	Treatment description
C	Cow manure
1C:1S	1 part cow manure: 1 part Halva Ardeh husk
1C:3S	1 part cow manure: 3 part Halva Ardeh husk
3C:1S	3 part cow manure: 1 part Halva Ardeh husk

The treatments were simultaneously examined for 90 days. In this study, the process of vermicompost was used in natural moisture content of 60 to 80%, and an ambient temperature of 20 to 30°C, which is an appropriate condition for soil biomass. In this study, parameters such as OC, pH, EC and C/N ratio as compost indices during the process were investigated. Sampling was carried out by combining different sections of each mass every 5 days with three repetitions according to National Standard No. 13320. In this study, fresh samples of 9.5 mm diameter were used to determine the pH. Dilution with a 5:1 ratio of compost and distilled water was prepared on a shaker for 180 revolution per minute for 20 minutes. Finally, the pH was measured by a pH meter after sedimentation. The mentioned method was also used to determine the EC, and eventually the EC was measured by an EC meter. Measurement of the amount of carbon samples was also carried out by placing humidified and weighed samples in the furnace at 550 ° C for 2 hours and weighing the samples again. The Kajdal method was also employed to determine the total rate of nitrogen. Finally, the data were entered into SPSS software and compared to the composting standards of Iran using ANOVA and t-test.

Results

Investigating the trend of pH changes

In this study, the trend of changes of parameters has been determined as the percentage of reduction / increase of the variable in different sampling periods. In Figure 1, the process of pH changes in different treatments has been shown in averages of all three replicates in different sampling periods. As it can be observed, during the process, the pH in all treatments increased initially and from the third week, the trend decreased to neutral. This decrease was statistically significant ($p \leq 0.001$).

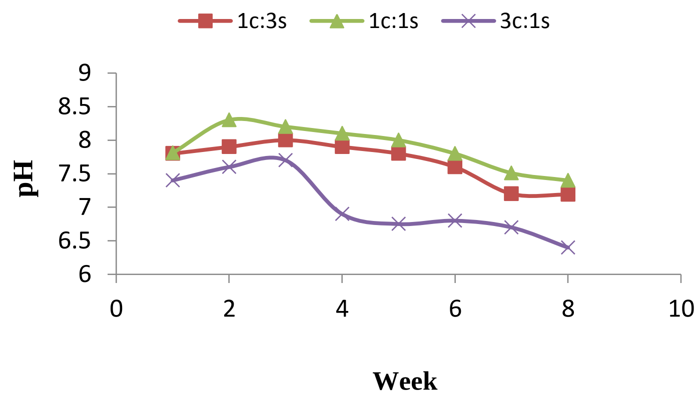

Figure 1: The trend of pH changes in different treatments.

Investigating the trend of organic carbon changes

Figure 2 shows the trend of OC changes in all substrates with different treatments. As it can be observed, the average OC percentage decreased in all treatments and this decrease was statistically significant ($p = 0.02$). The results showed that the highest amount of OC was in the control group and the lowest value was related to 1C: 1S treatment. Generally, the mean OC in the control treatment, 1C:3S, 1C:1S and 3C:1S was 42.22, 31.75, 41.7, and 30.45%, respectively.

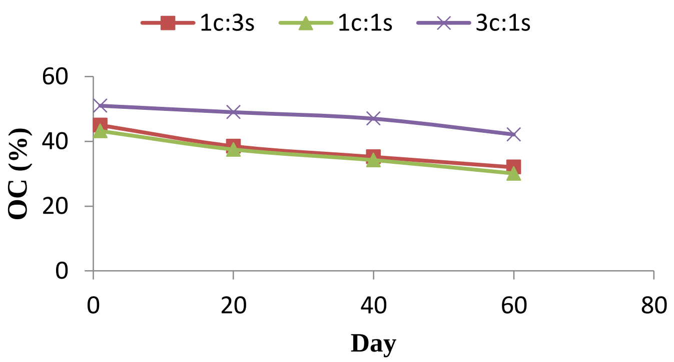

Figure 2: The trend of OC percentages in different treatments.

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Studying the trend of EC changes

Figure 3 shows the trend of EC changes in all treatments. As it can be observed, the process of changes in electrical conductivity during the process was generally reduced in all substrates with different treatments. The statistical test also demonstrated that this decrease was statistically significant (p = 0.035).

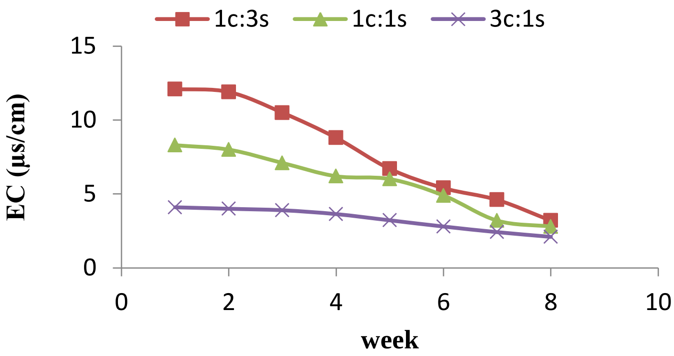

Figure 3: The trend of EC changes in different treatments.

Studying the trend of C/N changes

The trend of changes in C/N percentages in different treatments during the process is shown in Figure 4. The results revealed that C/N decreased in all treatments and the highest amount of C/N was related to the control treatment. In general, the average C/N in the control treatment was 56.8% and in the 1 C: 1S treatment was 16.9%. ANOVA test showed a significant difference in C/N treatments during vermicompost (P = 0.023).

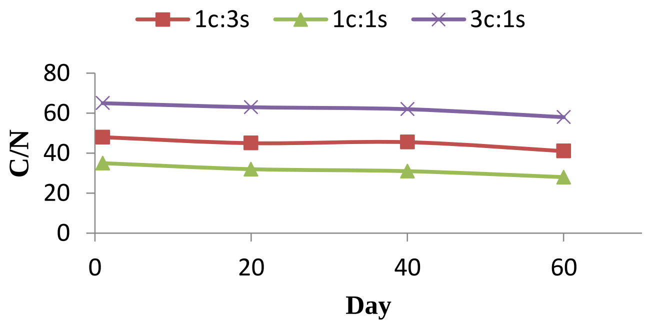

Figure 4: The trend of changes in C/N percentages in different treatments.

Comparison of the results with the standards

In table 2, the average values of the parameters studied in the final compost compendium are presented with the standard compost values. Comparison of the results obtained from this study with the standards for compost class A and Table 2 showed that the compost quality of this study conformed to the composting standards of class A.

Table 2: Comparison of the average of the parameters studied in the final product with compost standards of Iran [15, 16].

OC(Percent)	EC ms/cm	pH	Treatment
41.12	2.8	7	C
31.55	12.1	6.7	1C:3S
30.54	8.3	6.8	1C: 1S
42.12	4.1	6.6	3C:1S
40	< 5	5.5-6.5	Standard compost level 1
50	< 10	5-8	Standard compost level 2

Discussion

PH changes in the vermicompost process

The pH of the organic environment is an important parameter that has a significant effect on the vermicompost's viability and is a limiting factor for the survival and growth of the worms. Its acceptable range in the vermicidal process for the activity of worms and microorganisms was 5.5-8.5. In this study, at the beginning of the process (first week), pH in all treatments began to increase, which could be due to the evaporation of CO_2, fatty acid consumption and nitrogen mineralization by germs, thus indicating the progress of the vermicompost process [17, 18]. In the following process, and with time, pH in all treatments including control treatment began to decrease and to neutralize (Figure 1). It seems that this pH reduction is due to the production of carbon dioxide and organic acids by earthworms. Also, the biological conversion of organic matter and the intensive mineralization of nitrogen to nitrate and nitrite, as well as phosphorus to orthophosphate, could be the reasons for the reduction of pH in the vermicompost process [19].

In general, it can be said that various factors affect pH changes in the process. In a study by Pramanik et al. and Pramanik, the results showed that organic matter decomposition leads to the formation of ammonium (NH_4^+) and humic acid. The presence of carboxylic and phenolic groups in the structure of humic acid lowers the pH and the production of ammonium ion plays an important role in increasing the pH of the system [20, 21].

Organic carbon changes in the vermicompost process

In this study, the average percentage of OC in all treatments decreased significantly. Studies showed that during the vermicomposting process, the worms break down and homogenize the digested substances through the activities of the stomach and by adding mucus and enzymes to the digested substances thus leading to an increase in the surface area of microbial activity. The general activity of worms and microorganisms using the substrates has been responsible for the reduction of OC from organic waste as CO_2 [22, 23]. In other studies, it was stated that during the process of organic matter decomposition, available carbon is used as a source of energy by worms and microorganisms, and ultimately, CO_2 excretion leads to a decrease in OC [24, 25].

In the present study, OC reduction in 1C: 1S treatment was higher than other treatments, which can be attributed to faster respiration rates. In a study by Garg et al., a decrease by 58.4% in the amount of OC of bovine waste and 55.4% in horseracing after 90 days of vermicompost has been reported [26]. Kaviraj and Sharma have reported a 20-45% reduction in organic carbon in urban wastewater vermicomposting [27]. Sangwan et al. investigated vermicomposting with bovine wines and found a decrease of 23-6% in OC [28]. Finally, it can be said that the results of the studies are similar to the present study and the difference in carbon reduction in the vermicomposting process can be due to the difference in physical and chemical characteristics of the treatments.

EC changes in the vermicomposting process

EC is the salinity index resulting from changes in organic matter during the vermicomposting process [29]. In this study, the trend of changes in electrical conductivity during the process was generally reduced in all substrates with different treatments.

A study by Holtzclaw et al. showed that partial production of soluble metabolites such as ammonium and the sedimentation of soluble salts during vermicomposting led to a reduction in EC levels relative to the initial amount [30]. Occasionally, however, gradual increase in EC was observed due to the release of available ions from organic matter decomposition during digestion and disposal of earthworms [31].

C/N variations in the vermicomposting process

C/N is a parameter that is widely used as a composting and fertilizer quality indicator in agriculture, and the ratio of these substances affects the growth and production of the worm and its high ratio accelerates the growth and production of the worm. If the level of C/N is too low or too high, it will slow down the decomposition [32].

In this study, the highest rate of C/N was observed in the control treatment and the lowest value was related to 1C: 1S treatment. The results of this study demonstrated that the ratio of carbon to nitrogen (C/N) decreased during the 60-day vermicomposting process and this trend showed a decrease in the amount of material stabilization in all treatments and an improvement in degradation conditions and improvement in the quality of fertilizer produced by earthworms. Additionally, C/N reduction was also mainly due to the release of CO_2 as a part of the respiratory activity of the worms, and the production of mucus and nitrogen excrements was responsible for changes in the C/N ratio in vermicompost fertilizer [33, 35].

Studies on vermicompost have shown a decrease in the C/N ratio, although the decrease in this ratio is different for different wastes, and finally, the use of fertilizer produced by the vermicompost process as soil reformer improves soil, production of products and reduces waste disposal. Also, the quality of the compost produced is closely related to the degree of stability [36].

Conclusion

In this study, the efficacy of vermicomposting method was investigated for treating Halva Ardeh with cow manure in laboratory scale. Comparison of the efficiency of removal of variables in the main treatments with the control treatment showed a significant difference in the efficiency of removal of variables in the main treatments. The results revealed that during the process and with time, pH in all treatments including the control treatment began to decrease and to neutralize. Also, the rate of organic carbon decreased in all treatments compared to its initial value and had the highest amount in the control group and the lowest amount was related to 1C: 1S treatment. The amount of carbon to nitrogen (C/N) was reduced during the process and had the highest amount in the control treatment and the lowest amount was related to 1C: 1S treatment. Finally, due to the fact that the compost quality of this study is consistent to the standards of compost class A, this method can be used to convert the waste from Halva Ardeh on vermicompost production. In addition, using this process can help reduce environmental pollution and is economical.

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Conflict of interest

The authors declare no competing interests.

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