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Investigation of the Effects of Waste Olive Pomace on Vermicompost

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Abstract: The effects of olive pomace on the degradation of organic matter were investigated via vermicomposting. A biomass mixture of eggshells, cabbage, banana peel, napkins, nutshells, cattle manure, and soil was enriched with different quantities of olive pomace (0, 15, 30, 37.5%). These four mixtures, with a total of 2000g, were fed to 170 *Eisenia fetida* earthworms per mixture. Nitrogen adsorption-desorption, FT-IR, and elemental analyses analyzed samples collected from biomass at the end of 45 days. Results were evaluated to determine the effect of olive pomace on organic matter degradation and earthworm vitality. Nitrogen adsorption-desorption isotherms of feedstock revealed a decrease in void volumes, implying the formation of a compact structure with olive pomace addition. Vermicomposting of biomass enhanced biomass's compactness, further validated by decreases in BET surface areas, pore sizes, and pore volumes. The 31% increase of earthworm biomass in the presence of 37.5% olive pomace implied an affinity of *Eisenia fetida* towards olive pomace. This finding was further validated by FT-IR peaks obtained at 2850 and 2923 cm-1, showing increased biomass aromaticity due to the degradation of readily biodegradable aliphatic structure introduced by olive pomace. Ongoing organic matter degradation could be observed with the decrease of C/N ratios in the presence of olive pomace as high as 15%. However, a further increase in olive pomace increased the C/N ratio, which was explained by the increase in total nitrogen values during vermicomposting. Elemental analyses evaluated regarding C/N, O/C, and H/C ratios also indicated increased earthworm mobility with increasing olive pomace in the feedstock. The results obtained in the study were interpreted to introduce olive pomace as a preferable nutrition source for earthworms, which was the highlight of the present study.

Keywords: Vermicomposting, *Eisenia fetida*, olive pomace, C/N, biomass.

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1. INTRODUCTION

The daily production of solid wastes must be managed appropriately due to population growth. Composting has become a popular choice for disposing of solid waste because it produces an end product with high nutrient content. The biological breakdown of organic waste during composting produces a stable compound that resembles humic acid. The approach effectively reduces contaminants because of the ease with which organic residues decompose. Applying compost to the soil also lessens the negative consequences of soil salinization (Gutierrez-Micelli et al., 2007; Mohee and Soobhany, 2014; Lakhdar et al., 2009; Bello et al., 2022; Zhou et al., 2022). Despite the mentioned benefits, composting takes time and causes nutrient loss, such as nitrogen. Even though microorganisms are eliminated during the thermophilic composting stage, pathogens may still be present in the end product. Earthworms, used in vermicomposting, degrade organic residuals into smaller particles through digestion and aid in migrating microorganisms to the feedstock. Thus, it may be viewed as an expedited composting process. There are fewer human pathogens in the obtained vermicompost, another advantage (Gutierrez-Micelli et al., 2007; Mu et al., 2023).

Vermicomposting was one of the alternatives developed as a solution to the harm caused by chemical fertilizers. “Green Revolution” aimed to increase agricultural production and accelerate the destruction of microbial flora, which decreased soil yield and nutrient quality (Göçmez et al., 2019). Recent investigations validated the effects of vermicompost on the chemical properties of soil and vegetables. In research conducted by Azarmi et al. (2008), the effect of vermicompost on soil characteristics was investigated for different vermicompost amounts. Results indicated that vermicompost-added plots (15 t ha-1) had significantly higher total organic carbon levels and N, P, K, Ca, Zn, and Mn levels than the control (Azami et al., 2008). Yang et al. (2015) studied the effect of vermicompost on tomato yield, quality, and soil fertility compared to chicken compost, horse compost, and chemical fertilizer. Results indicated increased tomato yield and vitamin C content with vermicompost utilization for a 60-70% soil-water regime. Manivannan et al. (2009) investigated the effect of vermicompost on clay loam and sandy loam soils and compared the results with inorganic fertilizers. It was reported that applying 5 tonnes of ha-1 vermicompost had significantly increased pore space, water holding, cation exchange capacity, total organic carbon, micro and macronutrients, and microbial activity for both soil types.

On the other hand, a decrease in porosity, organic carbon content, and microbial activity was observed for both soil types, and this result was associated with the use of inorganic fertilizer (Manivannan et al., 2009). Ansari and Sukhraj (2010) have investigated the effects of vermiwash, vermicompost, and their combination on soil parameters and the productivity of okra (Abelmoschus esculentus). Results showed a 64.27% increase in the average yield of okra compared with the control. The fats and protein content of its fruits were 23.86 and 19.86%. The combination of vermicompost and vermiwash enhanced the micronutrients in the soil (Ansari and Sukhraj, 2010). In addition, vermicomposting contributed to carbon mineralization, as demonstrated by Chen et al.'s research (2023).

Olive oil, an essential food in many Mediterranean countries, has become more significant economically in the region due to growing demand. Olive is also one of Turkey's most important agricultural products. 2018 TUIK data revealed the presence of 177,843,966 trees in Turkey, 126,874,171 of which were utilized for olive oil production (Bellitürk et al., 2020). Despite the considerable potential for sustainable production, olive pomace produced during olive oil production harms the environment. To eliminate or at least mitigate the harm done to the environment, the by-products obtained at the end of the process should be utilized as raw material for fertilizer, compost, or vermicompost production. The traditional press mill method was recently replaced with a two-phase extraction method to reduce water needs. However, process change had little effect on environmental damage reduction, as olive pomace, obtained as a side-product during the process, was the primary contaminant source.

Olive pomace includes organic matter, polyphenols, oil, and organic acids acting as pollutants in soil and water. Hence, its disposal is imperative to minimize environmental damage (Canet et al., 2008; Dajko and Vasilikiotis, 2015; El Joumri et al., 2023).

Higher germination rates and stem and root growth were reported when olive pomace was used as a vermicompost feedstock (Dajko and Vasilikiotis, 2015). Olive pomace used as compost and vermicompost feedstock was stated to be effective in accelerating the degradation of triazine herbicides (Delgado-Moreno and Pena, 2009). Considering the amount produced in Turkey, olive pomace had strong potential in vermicomposting, which would produce economically feasible organic fertilizer (Kaouachi et al., 2013). Based on the literature survey, olive pomace must be considered an acceptable candidate for use as a feedstock component. Further investigations must be conducted to clarify its role in organic fertilizer production. Consequently, an attempt was made to provide information to the literature about the effect of olive pomace on the degradation of organic matter during vermicomposting. The evaluation of the results also revealed the availability of olive pomace as a nutrition ingredient.

Based on the literature, olive pomace, when utilized in vermicomposting, should meet these conditions:

- Olive pomace should not harm *Eisenia fetida* during vermicomposting. An aerobic digesting period of 15 days was added to prevent this before vermicomposting.
- Olive pomace utilization in aerobic digestion depended on *Eisenia fetida's* preference. In other words, earthworms should choose and process olive pomace as a nutrition source during vermicomposting.
- Vermicomposting should result in the aerobic digestion of olive pomace. This hypothesis was tested with characterization studies and analyses detailed below

2. MATERIAL AND METHOD

2.1. Vermicomposting process

Chemical fertilizers, widely used to supply plants with the nutrients they need to grow, mainly contain nitrogen, phosphorus, and potassium. Unfortunately, agricultural soils are primarily deficient in these nutrients. Therefore, nitrogen, phosphorus, and potassium should be sufficient and balanced in the fertilization program. In a study on municipal solid waste composting, biodegradable components of mixed paper, garden, and food waste were used. Food waste and mixed paper waste were found to affect NH_3 and CO_2 parameters in compost formation in particular (Komilis and Ham, 2006). This study included some organic wastes following the literature. The reasons are presented below. High K content was determined in banana waste compost (Venecio et al., 2005). A fertilizer mixture containing eggshells reduced soil acidity and calcium deficiency, producing a marketable compost rich in calcium (Soares, et al., 2013). C and N minerals in compost made from cabbage waste and cow, pig, or chicken manure were suitable for garden use (Adediren et al., 2004). In the compost study with hazelnut shells, it was possible to increase drainage, provide air circulation and moisture retention during compost formation, regulate soil temperature, conserve moisture, and improve soil structure. Hazelnut shells were evaluated as a source of fertilizer and a supporting material in advanced composting technology (Rashid, 2011). Paper napkins can be classified as a biodegradable and compostable material because their primary components are wood pulp and non-woven cotton (Kale et al., 2015).

The inoculums were prepared by mixing eggshells, cabbage, banana peel, napkin, nutshell, cattle manure, soil, and olive pomace (OP). Each ingredient was separately shredded in a food processor before mixing. Eggshells, cabbage, banana peel, napkins, and nutshells were frequent examples of domestic waste produced daily in houses. Their amounts were kept constant in the present study to focus on the effect of pomace on vermicomposting. The amount of household waste constituted 25% of the total organic load. Cattle manure, soil, and olive pomace were inoculated in varying amounts, constituting 75% of the final mixture. The amounts of ingredients used in composting and vermicomposting are given in Table 1. The mixtures were named Olive pomace (OP) 0, 15, 30, and 37.5% based on increasing olive pomace amounts.

Table 1. The amounts of inoculums used in vermicomposting.

Ingredient	Feedstock %			
	OP 0	OP 15	OP 30	OP 37.5
Eggshell	9.4	9.4	9.4	9.4
Cabbage	3.1	3.1	3.1	3.1
Banana peel	3.1	3.1	3.1	3.1
Napkin	3.1	3.1	3.1	3.1
Nutshell	6.25	6.25	6.25	6.25
Cattle manure	37.5	30	22.5	18.75
Soil	37.5	30	22.5	18.75
Olive pomace	0	15	30	37.5

Due to its facility, especially in laboratory conditions, the "Open-air composting" method was preferred for composting experiments. This method required constant monitoring, which is crucial for vermicompost systems prepared at identical conditions. Systems were monitored via temperature, pH, and moisture readings. Temperature readings were taken daily, while pH and moisture were determined at three-day intervals. The composting process differed from vermicomposting systems in aeration, which was conducted at 3-day intervals. Turning intervals and readings for monitoring were compliant with EPA (40 CFR Part 503) requirements. Composting was conducted mainly to compare organic matter degradation with vermicomposting. Hence, only total carbon and nitrogen amounts of compost samples were determined to emphasize the superiority of vermicomposting. All feedstocks were initially allowed to digest for 15 days before earthworm addition. This pretreatment ensured mesophilic temperature conditions during the process (Lleo et al., 2013). The digestion step was also essential to keep pH values at optimum levels due to pH values as low as 5.4 in the presence of olive pomace (Baddie et al., 2003). Low pH might create a hostile environment for earthworms; hence, pretreatment was conducted to prevent or decrease worm mortality and facilitate feedstock edibility. Both compost and vermicompost systems were monitored for 60 (15+45) days to determine changes in pH, moisture, and temperature.

The vermicomposting process was conducted in plastic bottles. The bottles were cut from the top, and the lit area was covered with mosquito nets. The top portion of the bottle was then placed at the bottom, forming a space between the lid and the bottom. The remaining bottoms collected from other bottles were attached to layers. Air holes with identical distances were drilled throughout the bottom to maintain constant aeration. Finally, the attached bottles were covered with stockings to prevent earthworm migration. The temperature of the systems was measured from 5 points daily. The moisture and pH contents were measured via sampling. pH remained between 7-8 throughout the experiment, and the moisture content of the systems was consistently above 50%. Hence, systems remained still to avoid stressing earthworms. System preparation was illustrated sequentially with images given in Figure 1.

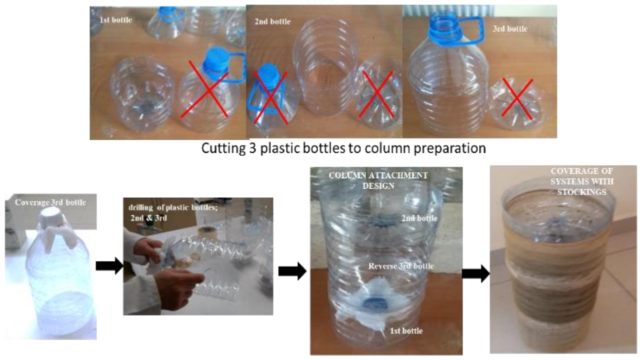


Figure 1. Composting column design

The total weight of each feedstock, placed in 5L bottles, was 2000g. This amount was adequate to feed 170 *Eisenia fetida* in each system for 45 days. The ratio of initial worm biomass per unit area of bedding (stocking density) was 5 for all systems. This ratio was previously stated as the optimum value of simultaneous vermicomposting and worm reproduction (Munroe, 2007). Bedding density and inoculum amount determined the duration of vermicomposting.

During the process, compost and vermicomposting systems' pH and moisture values varied between 6.5-8 and 70-75%. In the first week of digestion, the temperature increased from 21°C to 30°C, implying low thermophilic microbial activity. The temperature was then stabilized at 21°C until the end of the process.

2.2. Characterization studies

Elemental analysis of the feedstocks before digestion and the samples obtained after 45 days of composting and vermicomposting were conducted in LECO CHNS 628 device. Nitrogen adsorption-desorption isotherms were obtained via a Micromeritics Asap 2020 instrument. FT-IR analyses of the feedstocks before digestion and the vermicompost obtained afterward were conducted on a Perkin Elmer device in the 3800-4000 cm-1 range.

2.3. Statistical analysis

Elemental analyses and biomass determination were obtained as three replicated results expressed as mean values

± SD. The statistical evaluation was performed using SPSS 24.0 (SPSS Inc., USA). The evaluation of statistical significance was determined by ANOVA, followed by the Tukey Honestly Significant Difference test and t-test ($p < 0.05$).

3. RESULTS AND DISCUSSION

The Landfill Directive of the European Council mandated the reduction of organic wastes removed by landfilling, which gave rise to composting as an alternative method (Taşeli, 2007; EEA, 2009; EP, 2018). In all rapidly developing countries, the population is increasing; therefore, overall consumption increases, and there is a corresponding increase in the amount of solid waste produced. The By-law on Landfill of Waste (No:27533 2012/03) aimed to decrease the amount of biodegradable municipal waste landfilled in a scheduled period. According to the Turkish Ministry of Environment and Urbanization, a strategy to decrease the amount of biodegradable waste is ongoing (Gören and Özdemir, 2011). Organic content was mineralized during the process, and the product was re-evaluated in agriculture (Taşeli, 2007; EP, 2018). On the other hand, vermicomposting relied on the combined activity of microorganisms and earthworms, which would accelerate organic matter degradation. The first result presented in this study is a comparison of vermicomposting and composting activities to point out the superior performance of vermicomposting. Compost samples were obtained by keeping feedstocks for 45 days at identical conditions with vermicompost.

Results are given in Figure 2., regarding total C and N %. The increase in total C % values in compost and vermicompost systems depended on olive pomace addition (Figure 2a) except for the case of 37.5% olive pomace. The sudden decrease of total carbon in the presence of 37.5 olive pomace implied the occurrence of setbacks during sampling, which should have been emphasized considering the difficulty of working with an 8-ingredient feedstock. The increase in composts' total nitrogen % values could be explained by ammonia accumulation and evaluated as the presence of ongoing microbial activity. A comparison of three systems indicated higher degradation of organic matter in the presence of *Eisenia fetida*. The effect of earthworms on organic matter degradation could be seen with total nitrogen % values. The vice-versa trends of total nitrogen % for compost and vermicompost against feedstock indicated enhanced organic matter mineralization during vermicomposting (Fig 2b).

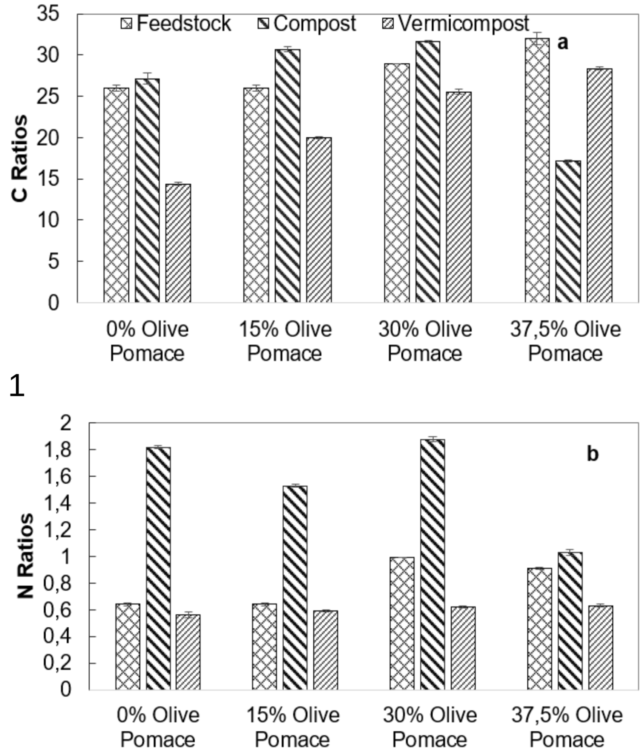
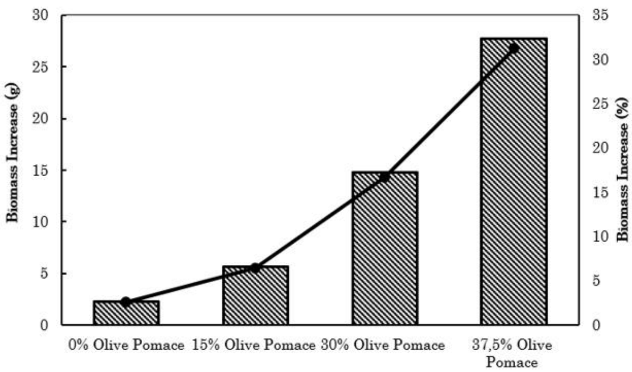


Figure 2. Comparison of a) Total C% and b) Total N% values of composting and vermicomposting processes according to different concentrations of olive pomace

Indicating the superior performance of vermicomposting against composting has only validated the results obtained in recent studies. On the other hand, olive pomace utilization as an ingredient of earthworm nutrition was a relatively new research object. Polyphenols and elevated salt concentration of olive pomace were two potential threats to increasing earthworm mortality during the trials despite the 15-day digestion period applied before the experiments. Hence, the initial task was to determine whether or not olive pomace was a suitable source of nutrition for earthworms. Hence, the most important goal during vermicomposting was to keep these earthworms alive, and 45 days was thought to be an adequate time to test this fact, considering a stock density of 5, which was high enough to create relatively harsh conditions for earthworms. Hence, earthworms were under no circumstances disturbed, and they were collected at the end of 45 days from systems to determine biomass change. Results indicated an increase of biomass with olive pomace supplement, reaching 31% for vermicompost prepared with 37.5% olive pomace. Preliminary results indicated an affinity of *Eisenia fetida* towards olive pomace (Figure 3).

Structural changes on feedstock during vermicomposting were shown by evaluating nitrogen adsorption-desorption isotherms and FT-IR results of feedstock and vermicomposts. Nitrogen adsorption-desorption isotherms supplied valuable insights on the effect of olive pomace and earthworms on organic matter structure.

Figure 4a-d indicated decreased adsorbed volume with increasing olive pomace in the feedstock. This decrease was thought to be due to the decrease in void volume. In other words, elevated olive pomace addition to biomass resulted in the formation of a compact structure. On the other hand, observing a general decrease in adsorbed volume, surface area, pore size, and pore volume after vermicomposting, independent of the olive pomace amount in the mixture, was fascinating.



Feedstock	Biomass Increase (g)	Biomass Increase (%)
0% Olive Pomace	2.27±0.05 a	2.56±0.06 a
15% Olive Pomace	5.68±0.11 b	6.4±0.12 b
30% Olive Pomace	14.77±0.03 c	16.63±0.03 c
37.5% Olive Pomace	27.7±0.03 d	31.19±0.03 d

Different letters indicate significant differences ($p<0.05$) in biomass increase of different feedstock values in the same column

Figure 3. Effect of olive pomace in the feedstock on earthworm biomass yield

Despite a less pronounced volume decrease in the case of 37.5% olive pomace addition, results indicated the formation of a compact organic structure, which could come in handy by enhancing the water-holding capacity of soil during crop cultivation. In a study by Zhang et al. (2023) investigating the adsorption-desorption properties of soil and vermicompost prepared using different proportions of organic raw materials, the physicochemical properties of vermicompost were correlated with the ratio of raw materials used. The study showed that adsorption increased, but desorption decreased in vermicomposts, depending on the mixture composition.

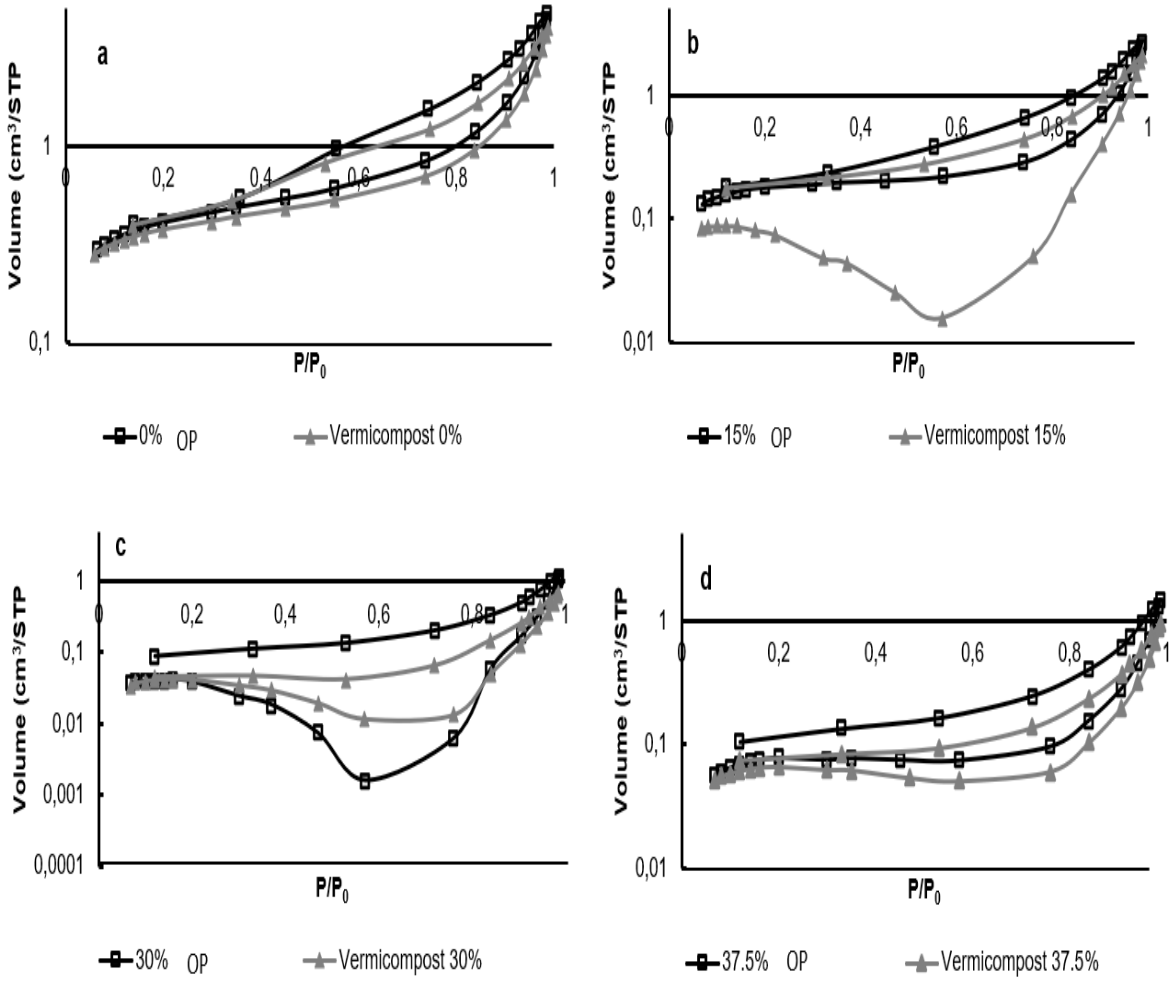


Figure 4. Nitrogen adsorption-desorption isotherms of feedstocks and vermicompost containing a) 0%, b) 15%, c) 30%, and d) 37.5% olive pomace

FT-IR analyses of feedstock and vermicompost were compared in Figure 5, and peak detail in Table 2. Figure 5a revealed a vice-versa earthworm behavior depending on olive pomace absence. In the case of an organic mixture without olive pomace, earthworms seemed to utilize all components and try to establish a balance between aromatic and aliphatic compounds, reflecting a decrease in intensities regardless of structure. On the other hand, introducing olive pomace altered earthworms' nutrition behavior. As seen from the figure, the intensities of peaks identifying aromatic structure increased while peak values obtained at 2850 and 2923 (Table 2) decreased (Baddi et al., 2003; Pospisilova and Fasurova, 2009; Helal et al., 2011). When the FT-IR graphs with different concentrations of olive pomace in Figure 5 are compared by the pre-decomposition and afterward of the feedstocks and the vermicompost, it is thought that aliphatic compounds are earthworms' feeding preference due to their easy degradability (Campitelli and Ceppi, 2008; Helal et al., 2011; Kumar et al., 2015).

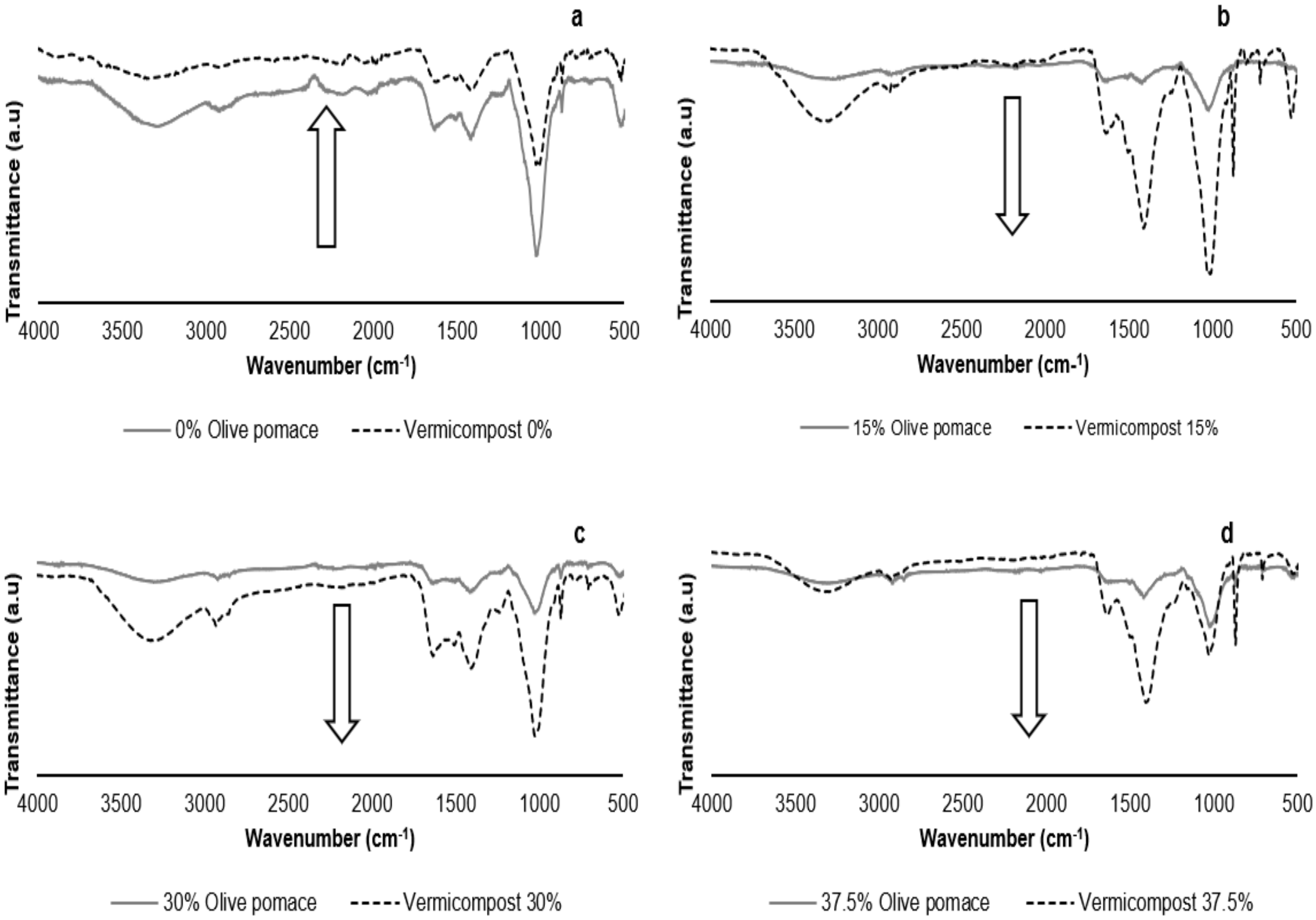


Figure 5. FT-IR analyses of feedstocks and vermicompost containing **a)** 0%, **b)** 15%, **c)** 30%, and **d)** 37.5% olive pomace

Table 2. Peak values were obtained with FT-IR analyses

Peak value, (cm^{-1})	Assignment	References
3280-3300	O-H stretch of alcohols and carboxylic groups	Sakellariadou 2006; Helal et al. 2011; Rajiv et al. 2013; Lim & Wu, 2015; Kumar et al. 2015;
2850; 2923	Aliphatic methylene	Campitelli and Ceppi 2008; Pospisilova & Fasurova 2009; Helal et al. 2011; Kumar et al. 2015; Das et al. 2015;
1632	Aromatic C=C double bonds	Baddi et al., 2003; Pospisilova and Fasurova, 2009; Helal et al., 2011;
1421	Phenol in humic content	Baddi et.al., 2003
874	C-H deformation of aromatic structure	Baddi et.al., 2003
1028	C-O stretching of polysaccharides, cellulose, and hemicelluloses	Baddi et al. 2003; Sakellariadou 2006; Campitelli & Ceppi 2008; Pospisilova &Fasurova 2009; Helal et al. 2011; El-Haddad et al. 2014; Kumar et al. 2015

The results of elemental analyses were also evaluated to validate findings obtained from characterization analyses, as illustrated in Figure 6, in terms of changes in C/N, O/C, and H/C ratios of feedstock and vermicompost. An increase in C/N ratios for vermicompost prepared with 0 to 37.5% olive pomace was observed. On the other hand, C/N ratios of the feedstock were decreased in the case of 0 and 37.5% olive pomace. This result was evaluated as an indicator of ongoing organic matter degradation, which seemed contradictory at first sight and could be justified by the observation of total nitrogen values in Figure 1. The change of vermicompost's total nitrogen values with increasing olive pomace was statistically significant ($p<0.05$) yet less pronounced than the total C% change. Consequently, increasing the C/N ratio by introducing olive pomace twofold higher than the previous loading amount was inevitable.

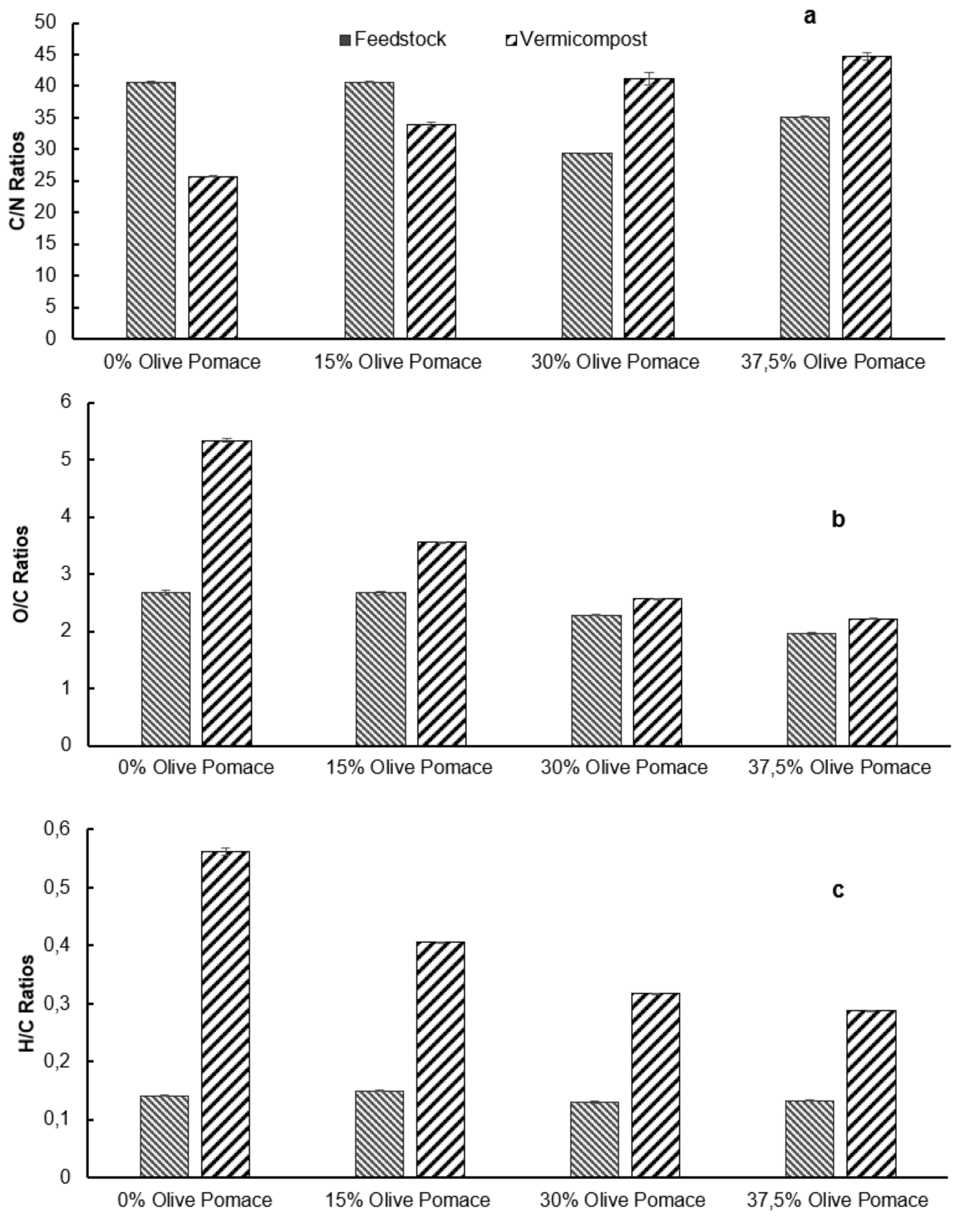


Figure 6. Elemental analyses results in terms of a) C/N, b) O/C, and c) H/C ratios of feedstock and vermicompost

H/C ratios of vermicompost were higher than its feedstock for all olive pomace % amounts. A statistically significant ($p< 0.05$) decrease of H/C with increasing olive pomace could be observed for all vermicompost, yet this decrease was evident only for 0 and 15% in the case of feedstock. The decrease of H/C ratios among vermicompost implied increased aromaticity. This result was consistent with previous findings obtained via characterization analyses. A comparison of feedstock and its vermicompost indicated an entirely different behavior with increased H/C ratios after vermicomposting. This was an entirely different situation, implying the effect of vital earthworm activity resulting in the introduction of water to the systems (Baldock and Smernik, 2002; Hammes et al., 2006).

O/C ratios followed a pattern similar to H/C ratios. The decrease of O/C ratios with increasing olive pomace % was also evaluated as the indicator of aromatization during the vermicompost process. On the other hand, the O/C ratio of vermicompost obtained higher than its feedstock values also revealed earthworm activity leading to aeration of feedstock during vermicomposting (Baddi et al., 2003). The aeration of feedstock enhances microbial activity, which results in nitrogen utilization. This observation also explains the lower nitrogen values of vermicompost compared to compost, as shown in Figure 1.

Evaluation of results indicated increased aromaticity upon vermicomposting. Organic matter degradation progressed through aliphatic content. It was our understanding that easily degradable aliphatic content was the primary source of nutrition for earthworms, which determined the pathway of degradation. Similar observations were also obtained in recent studies with decreased aliphatic content in a mixture of cattle manure and two-phase olive pomace (Plaza et al., 2008).

Results validated olive pomace as a valuable food source for vermicomposting. However, economic viability is the primary factor, and our findings and the literature could only provide partial insight limited to the benefits of processed olive pomace as an organic fertilizer. Studies investigating olive pomace utilization in terms of economic viability mainly focused on the massive amount of waste produced, especially in Mediterranean countries. This waste would allow for the sustainability of the process above all. Olive pomace as a compost ingredient was recently proven to increase soil organic matter, microbial biomass, and nutrients beneficial to soil fertility. Amounts as high as 90% could be evaluated via aerobic digestion. In the case of vermicomposting, which accelerated aerobic digestion, the economic-environmental benefit of the process would prevent or at least decrease the utilization of expensive methods, as in the production of chemical fertilizers (Muscolo et al., 2019). Investigations were also being conducted by certain companies utilizing olive pomace to produce a valuable product. Bio humus prepared by mixing olive pomace with harvest residues was among the latest cost-effective examples introduced as an alternative to chemical fertilizers (Rautenstrauch et al., 2014).

4. CONCLUSIONS

Olive pomace obtained from olive mill wastes was digested for 15 days and utilized as one of the main components in vermicomposting. The earthworm population increased with increasing olive pomace in the feedstock, which was the highlight of the study, indicating fine adaptation of earthworms to olive pomace presence. BET analyses revealed the formation of a compact structure with the potential to improve water-holding capacity when added to the soil. FT-IR analyses also indicated the change of structure with olive pomace addition. However, a more pronounced result was shown with the intensity change trend upon olive pomace addition. Olive pomace addition increased peak intensities, identifying aromatic structure. It was thought that the easily degradable aliphatic compounds introduced by olive pomace had been consumed by earthworms, implying a shift in earthworms' affinity towards olive pomace.

The results obtained from elemental analyses validated the increase in aromaticity. However, the evaluation of results in terms of ratios also supplied valuable information on the behavior of earthworms during vermicomposting. A feedstock and its vermicompost comparison revealed an increase in the H/C ratio, which implied water's introduction to the system. Considering that the system was undisturbed throughout the process, water formation was evaluated as a consequence of vital earthworm activity. The change of O/C ratios also revealed a similar increasing trend between feedstock and its vermicompost. This increase was attributed to the aeration of the system throughout the process. Consequently, adding biomass with olive pomace increased organic matter degradation, vital activity signs, and mobility.

Ethics Committee Approval
N/A

Peer-review
Externally peer-reviewed.

Author Contributions
Conceptualization: L.D.; Investigation: L.D., A.A.B.; Material and Methodology: L.D., A.A.B., Ö.C.D.; Supervision: L.D., A.A.B.; Visualization: L.D., A.A.B.; Writing-Original Draft: L.D.; Writing-review and Editing: L.D., A.A.B., Ö.C.D.; Other: All authors have read and agreed to the published version of the manuscript.

Conflict of Interest
The authors have no conflicts of interest to declare.

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