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Effect of Vermicompost on Quality Index, Oxidation and Colour Ordinates of Hazelnut Oil

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Abstract

The present study aims to address this knowledge gap by investigating the impact of vermicompost (3-5 kg/Ocak; VM1 and VM2, respectively) on the linolenic/linoleic acid ratio (n3/n6), polyunsaturated/monounsaturated fatty acid ratio (PUFA/MUFA), monounsaturated/unsaturated fatty acid ratio (MUFA/SFA), and oil quality index values; Atherogenicity (AI) and thrombogenicity index (TI) values, hypocholesterolemic/hypercholesterolaemic fatty acids ratio (H/H) values and stability index (SI) value; fat oxidation parameters; oleic/linoleic acid ratio (O/L), free fatty acidity value (FFA, oleic acid %), rancimate value (RV, h) and colour properties. The lowest AI value was found in the VM1 treatment (0.05), while the highest value was found in the VM_2 and control (0.06) treatments. The highest H/H (16.92) and SI (7.24) values were also observed in the VM_1 treatment. Conversely, the highest RV and lowest FFA values were determined in the VM_2 treatment, while variability was observed in terms of colour characteristics. The application of VM_2 was found to be partially more prominent in terms of some traits, and when all these data were evaluated in general, it was concluded that it is of great benefit to continue the studies on vermicompost.

Keywords: fatty acid profiles, free fatty acids, oxidation of oil

Solucan Gübresinin Fındık Kalite İndeks Değeri, Oksidasyon ve Renk Özellikleri Üzerine Etkisi

Öz

Bu çalışma, solucan gübresinin (3-5 kg/Ocak; sırasıyla VM_1 ve VM_2) linolenik/linoleik asit (n3/n6) oranı, çoklu doymamış/tekli doymamış yağ asidi oranı (PUFA/MUFA), tekli doymamış/doymamış yağ asidi oranı (MUFA/SFA) ve yağ kalite indeksi değerleri üzerindeki etkisini belirlemek amacıyla yürütülmüştür. Çalışmada, aterojenisite (AI) ve trombojenisite indeksi (TI) değerleri, hipokolesterolemik/hiperkolesterolemik yağ asitleri oranı (H/H) ve stabilite indeksi (SI) değeri ile yağ oksidasyon parametreleri; oleik/linoleik asit oranı (O/L), serbest yağ asitliği değeri (FFA, oleik asit %), ransimat değeri (RV, h) ve renk özellikleri incelenmiştir. En düşük AI değeri VM_1 uygulamasında (0,05) bulunurken, en yüksek değer VM_2 ve kontrol (0,06) uygulamalarında bulunmuştur. Diğer yandan en yüksek H/H (16,92) ve SI (7,24) değerleri ise VM_1 uygulamasında gözlenmiştir. Buna karşılık, en yüksek RV ve en düşük FFA değerleri VM_2 uygulamasında kaydedilmişken, renk özellikleri açısından uygulamalar arasında değişkenlik göze çarpmıştır. VM_2 uygulamasının bazı özellikler bakımından kısmen daha ön plana çıktığı görülmüş olsa da tüm bu veriler genel olarak değerlendirildiğinde solucan gübresi ile ilgili çalışmaların devam ettirilmesinde büyük fayda olacağı sonucuna varılmıştır.

Anahtar Kelimeler: yağ asitleri kompozisyonu, serbest yağ asitleri, yağ oksidasyonu

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Introduction

Hazelnut (*Corylus avellana* L.) is a significant crop, ranking among the most widely cultivated hard-shelled fruits worldwide (Islam, 2018). The demand for hazelnuts has been steadily rising, driving continuous expansion in global production. These nuts are consumed in various forms, including raw and roasted, and find application in diverse industries, particularly the chocolate sector (Korkmaz et al., 2021). Hazelnuts are recognised as nuts with a high fat content (~60%) and are also abundant in oleic, linoleic and palmitic fatty acids (Müller et al., 2020; Negrillo et al., 2021). In addition, hazelnuts are considered to be adequate in macronutrients such as protein (~17%) and micronutrients such as vitamins B, E and tocopherol. Additionally, it is well-documented that the nuts of the hazelnut tree contain notable quantities of potassium, manganese, calcium, magnesium, iron, zinc, copper, manganese and boron (Müller et al. 2020; Negrillo et al., 2021; Özkutlu et al., 2016; Özkutlu et al., 2022). Consequently, hazelnuts are widely regarded as functional foods, which is evidenced by their ability to provide substantial health benefits to humans due to their high content of bioactive components, including flavonols, phenolic acids, tocopherols and sterols (Pelvan et al., 2018).

Hazelnuts, conversely, are distinguished by their elevated fat content, with triacylglycerols constituting the primary component. Additionally, the presence of substantial levels of monounsaturated fatty acids confers upon hazelnuts a notable nutritional value, coupled with a considerable sensitivity to autoxidation and/or degradation reactions under enzymatic catalysis. The formation of secondary fat oxidation products, especially carbonyl derivatives, poses a significant challenge for confectionery industries and can also affect the sensory properties of hazelnuts (Rosso et al., 2021). Consequently, numerous studies have been conducted and are ongoing to define the fat fraction of hazelnuts and to examine its changes during the storage period (Turan, 2018a).

It is widely accepted that oil oxidation is the primary factor contributing to the deterioration of high-fat foods, such as hazelnuts. Consequently, it is imperative to ascertain the shelf life of foods with high fat content. The shelf life of hazelnuts is predominantly influenced by the temperature and moisture content of the storage conditions (Hosseini et al., 2014; Shafiei et al., 2020; Turan, 2018b). The impact of fat oxidation on food products is twofold; firstly, it affects their sensory properties and secondly, it has a detrimental effect on human health, including the risk of developing pathogens such as cancer (Kalyanaraman, 2013). Unsaturated oleic and linoleic fatty acids are known to be sensitive to fat oxidation, therefore it is imperative that cultural practices in hazelnut production are carried out correctly and in a timely manner (Turan, 2019). Notably, fertilisation practices have been identified as a crucial aspect that is often overlooked in hazelnut cultivation. This is primarily due to the reluctance of hazelnut producers, who constitute a paradigm of traditional farmer structures, to apply fertiliser in accordance with soil analysis (Turan, 2023). As a consequence, yield and quality losses are frequently experienced.

The yield and quality of hazelnut production can be adversely affected by several factors. Firstly, the topography of the land, which is characterised by hills, can impede the efficient application of fertilisers, as the soils tend to be shallow. Secondly, the agricultural practices of the producers can also be a contributing factor. This includes errors in pruning, a lack of emphasis on bottom shoot cleaning, inadequate weed removal, and erroneous fertilisation techniques. Nitrogen fertilisers are among the most commonly used fertilisers in hazelnut production (Özkutlu et al., 2020), and consequently, deficiencies in other fertilisers inevitably lead to yield loss (Aydemir et al., 2023). Conversely, problems in accessing farm manure can be experienced from time to time. Another method of adding organic matter to the soil in the absence of farm manure is green manuring. Green manure plants suitable for hazelnut orchards include vetch, wild peas and oats, which should be sown in a ring-shaped band extending 50-100 cm beyond the projected branches in sloping terrain. This practice should be implemented in all gardens situated in flatlands, and the plants should be mowed and incorporated into the soil prior to flowering in spring (Turan, 2023).

In addition to the aforementioned fertilisers, vermicompost has recently been recommended (Tarakçıoğlu & Bender Özenç, 2022). However, the number of studies carried out on the effect of vermicompost on the yield and nut quality of hazelnuts is very limited. Therefore, the present study was undertaken to determine the effect of vermicompost on the fruit quality of the Tombul hazelnut cv in the country of Turkey. It is hypothesised that the data obtained will firstly contribute to the hazelnut economy and then guide future academic studies.

Material and Methods

Samples

The research was conducted between 2018 and 2020 in a ~30 years old, 5 da orchard of Tombul cv in Ülper village, central of Giresun province (40°51′34.52″N, 38°26′05.10″E, and altitude 233 m). The study was planned as 5 replications and was carried out with 3 ocak (at least 3 or more trunk) in each replication. The orchard was arranged as 5×5 between rows, 5×5 above rows, 5 branches/ocak and 50 ocak/da. Soil samples were collected from 0–20 cm and 20–40 cm depths, and analyzed followed by application of fertilization program (Duyar & Özenç, 2013). The soil analysis showed soil with a *pH* of 5.64, K_2O of 33.14 kg/da, P_2O_5 of 0.29 kg/da, lime of 0.47%, organic matter of 5.23%, total salt of 0.01%, saturation of 62.04%. The vermicompost is obtained from Yavuz Food Industry and Trade Inc. (Giresun, Turkey; 40°56′31.17″N, 38°10′28.32″E, and altitude 4 m). The vermicompost *pH* was 7.37 and electrical conductivity was 3.06 ms/cm, with a moisture rate of 43.02%. It consisted of organic carbon of 13.89%, organic matter of 31.11%, organic nitrogen of 2.00%, P_2O_5 of 0.20%, and K_2O of 1.11%. In the study, 150–250 kg/da (3–5 kg/Ocak; VM_1 and VM_2, respectively) of vermicompost recommended for hazelnut was used (Figure 1).

Figure 1. Application of Vermicompost for Hazelnut Orchard

The control treatment was based on traditional farmer practice, and these procedures were carried out according to Öztürk et al. (2022). Harvesting procedures were made according to method of Turan (2018a). The hazelnuts that reached a moisture content of ~25%, were harvested by hand, separated from their husks by hand, and left to dry naturally in the shade (Average temperature: 24℃, average sunshine duration: 3.5 h, average rainfall: 85 mm, and moisture value: 68%), and the drying process lasted ~18 days. After the samples were reduced to 6% moisture content, they were stored in a refrigerator at ~5℃ and ~65% relative humidity until the oil extraction.

Fatty Acid Composition

The extraction of hazelnut oil was accomplished through the utilisation of a cold press oil extraction system, while the subsequent analysis of fatty acids was performed via gas chromatography. This method was employed to ascertain the fatty acid content, with the subsequent generation of fatty acid methyl esters adhering to the techniques outlined by Turan (2018a) and Turan (2019), with minor modifications to align with the methodology established by Turan (2018b).

Quality Index

The values for the fat quality index were determined using the methods outlined by Bezerra et al. (2017) to calculate the atherogenicity (AI) and thrombogenicity index (TI) values, as well as the hypocholesterolemic/hypercholesterolemic fatty acids ratio (H /H) values were obtained with fatty acids formulation according to Fernandes et al. (2019) and Turan (2021). The stability index (SI) was described by Özdemir et al. (2001).

Oxidation

Free fatty acidity (method Ca 5a-40), and peroxide value (method Cd 8-53) were determined using AOCS standard method (AOCS, 2004). The Rancimat value was determined using the Rancimat 743 device (Velasco, 2004), and the iodine value (IV) was calculated using the percentage of fatty acids (Turan, 2021).

Clour Ordinates

The colour of hazelnut kernels was measured in accordance with the methods outlined by Mexis and Kontominas (2009) and Turan (2022). The chroma value, which is indicative of the tone of the product colour and ranges from low values in pale colours to high values in vivid colours, was determined in accordance with the methods outlined by Polatcı and Tarhan (2009). The hue angle (h^o) value refers to the colours corresponding to each angle in a 360° colour gradient (Polatci & Tarhan, 2009; Taşova & Güzel, 2017).

Statistical Analysis

The experimental phase of the study was conducted utilising a randomised blocks design, with each experimental unit being replicated thrice. The subsequent analysis involved the determination of descriptive statistics, which were then processed using SPSS v. 22.0 (Armok, New York: IBM Corp.). The execution of statistical tests was facilitated by SAS–JAMP v. 10.0. The identification of significant differences was achieved through the implementation of a t-test, with a significance level of P < 0.001.

Results and Discussion

Quality Indices of Hazelnut Oil

Atherogenicity (AI) and thrombogenicity index (TI) values, which are indicators of the global dietary quality of fats and their potential impact on the development of coronary diseases, are considered as a quality indicator of fatty acid content (Durmuş, 2019; Telahigue et al., 2019). These IA and IT index values proposed by Turan (2022) can better characterize the potential of fatty acids. While low values are considered favorable for human health, high values are considered harmful.

IA and IT values >1 have been reported to be harmful for human health (Stancheva et al., 2014). Musalima et al. (2019) reported that if the IT value is >1, blood clots form within blood vessels. Therefore, it is desirable that these properties are close to zero. In our study, the lowest IA value was obtained with VM_1 (0.05) treatment and the lowest IT value was obtained with VM_2 (0.44) treatment (Table 1), and these differences were found to be significant (P<0.001). The H/H ratio can be used to obtain information about the effect of fatty acids on the cholesterol mechanism and to determine the cholesterolemic effect index of the fat source (Fernandes et al., 2019).

Table 1. Quality Index of Different Cultivation Practices of Hazelnut

Parameters	Nut samples			Sign.
	VM_1	VM_2	C	
Linolenic/Linoleic acid	0.01±0.00b	0.01±0.00b	0.02±0.00a	**
PUFA/MUFA	0.11±0.00a	0.10±0.00c	0.11±0.00b	***
MUFA/SFA	1.17±0.00a	0.94±0.00c	1.13±0.00b	***
Atherogenicity index	0.05±0.00c	0.06±0.00a	0.06±000b	***
Thrombogenivity index	0.52±0.00a	0.44±0.00b	0.52±0.00a	***
Hypocholesterolemic/hypercholesterolenic	16.92±0.05a	16.24±0.03c	16.36±0.01b	***
Index of stability	7.24±0.01a	4.73±0.00b	2.91±0.00c	***

*VM: Vermicompost. C: Control. Data represent the mean ± std deviation of triplicates (n=3). Significant level *, **, *** and "ns" mean significance at p≤ 0.05, 0.01, and 0.001, and "not significant", respectively, between cultivation practices and control*

A higher H/H value is associated with a higher proportion of PUFAs and therefore a high H/H value is desirable for human health (Turan 2022; Turan et al., 2022). It is seen from the Table 1 that the highest H/H (16.92) and SI (7.24) values were determined after VM_1 treatment. Turan (2021) reported that H/H value varied from 17.45 to 18.27, IA from 0.16 to 0.23, and IT from 0.15 to 0.16 in Tombul cv. Özdemir (2001) reported that the SI value differed between the varieties and this characteristic was 6.30 in Tombul cv. Our study results showed that VM_1 can be recommended considering the quality index values.

Oxidation of Hazelnut Oil

Oils with a high content of PUFAs are more susceptible to oxidative degradation leading to off-flavors and discoloration. Lipid oxidation is a major cause of degradation of fats and oils. Lipid oxidation results in loss of quality and nutritional value and development of unpleasant flavors. Oxidative stability is known as resistance to oxidation under defined conditions and usually corresponds to a sudden increase in the oxidation rate (Gümüş-Bonacına, 2022). The difference in oxidation parameters between the VM_1 and VM_2 treatment groups was found to be statistically significant (P<0.001) and there was variability between treatments (Table 2).

Table 2. Oil Oxidation Parameters of Hazelnut

	Nut samples			
	VM_1	VM_2	C	Sign.
Parameters				
Oleic/linoleic acid	8.69±0.03c	10.35±0.04a	8.96±0.03b	***
Iodine value	91.42±0.06a	89.75±0.09b	91.54±0.02a	***
Ransimat value	5.63±0.01b	6.08±0.01a	6.14±0.04a	***
Free fatty acid	0.18±0.01b	0.17±0.01b	0.21±0.00a	***

*VM: Vermicompost. C: Control. Data represent the mean ± std deviation of triplicates (n=3). Significant level; *, **, *** and "ns" mean significance at p≤ 0.05, 0.01, and 0.001, and "not significant", respectively, between cultivation practices and control*

While oleic/linoleic (O/L; 10.35) value was high with VM_2 treatment, IV (89.75) and free fatty acids (0.17 %, oleic acid) values were low. On the other hand, the highest free fatty acids (0.21 % oleic acid) and IV (91.54) values were observed after the control treatment. Many studies have been carried out on oxidation parameters in hazelnut (Cui et al., 2022; Turan, 2019) and it has been observed that there is variability in the degree of oxidation of hazelnut oil depending on the processes. In conclusion, although there are some differences, based on these data, it can be said that VM_2 treatment is more effective on the shelf life of hazelnut.

Colour Ordinates of Hazelnut Kernel and Oil

The brightness or darkness of the color is represented by "*L*" and the numerical value of "*L*" varies between 0 and 100. The color gets darker as the value approaches 0 and brighter as it approaches 100. The redness or greenness value of the color is expressed by "*a*," and redness indicates positive values and greenness indicates negative values.

The yellowness or blueness value is symbolized by "*b*" Similarly, when "*b*" is at positive values, the yellowness of the color is dominant, and at negative values, the blueness of the color is dominant. Chroma (*C*) refers to the dominance of pastel tone or vivid tone of the color. As the numerical value of *C* increases, the vividness of the color increases. On the other hand, as the numerical value of *C* decreases, the pastel tone dominates the color. The hue angle (*h*°) represents the angle corresponding to the dominant color of the product (Turan, 2022). As shown in Table 3, the effect of treatments on hazelnut kernels and oil color characteristics was generally not significant (P>0.05), and this effect was similar among treatments for hazelnut kernels and oil. That is, the difference between the treatments in b* and *α* values was found to be statistically significant (P<0.001; Table 3), all other color parameters were found to be similar in terms of hazelnut kernels and oil color characteristics (P<0.05). It can be concluded that the treatments partially affect the color properties.

Table 3. Colour Ordinates of Hazelnut Kernel and Oil

Parameters	Nut samples			Sign.
	VM_1	VM_2	C	
Colour ordinates				
Kernel				
L* (Lightness)	35.71±0.40	34.55±0.14	35.24±0.23	ns
a* (Redness)	3.04±0.02	3.08±0.05	3.07±0.05	ns
b*(Yellowness)	0.22±0.00a	0.23±0.01a	0.09±0.00b	**
Chroma (*C*)	3.05±0.02	3.09±0.05	3.07±0.01	ns
Hue (*h*°)	14.03±0.20b	13.57±0.19b	34.10±0.50a	***
Oil				
L* (Lightness)	28.14±0.09	28.39±1.13	27.91±1.07	ns
a* (Redness)	2.14±0.01	2.16±0.01	2.13±0.02	ns
b*(Yellowness)	0.15±0.00a	0.16±0.01a	0.07±0.00b	***
Chroma (*C*)	2.15±0.01	2.17±0.02	2.13±0.01	ns
Hue (*h*°)	13.94±0.40b	13.60±0.47b	29.20±0.36b	***

*VM: Vermicompost. C: Control. Data represent the mean ± std deviation of triplicates (n=3). Significant level; *, **, *** and "ns" mean significance at p≤ 0.05, 0.01, and 0.001, and "not significant", respectively, between cultivation practices and control*

Conclusions

This study constitutes the inaugural investigation of its kind in the extant literature on the impact of vermicompost on the quality index values and oxidation parameters of the Tombul cv under Giresun conditions. The study revealed that, while the effect of fertiliser doses varied in general, VM_2 application was found to be more effective in terms of general characteristics, while VM_1 application was found to be more effective in some cases. In terms of colour characteristics, it was observed that there was variability according to the treatments. The findings of this study indicate a clear need for further research to be conducted on the subject of vermicomposting. In light of the evaluations conducted, it was determined that the VM_2 application is the most effective.

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Ethic

There are no ethical issues with the publication of this article.

Conflict of Interest

The author state that there is no conflict of interest.

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