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Research Article

Effect of Vermicompost Treatment on Oil Quality and Fatty Acid Composition of Peanut (*Arachis hypogaea* L.)

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Abstract: This study examined the impact of vermicompost treatment on the oil quality and fatty acid contents of peanut (*Arachis hypogaea* L.) in 2020-2021 under the ecological conditions of Osmaniye. The research was designed in a randomized complete block design with three replications. Peanut variety NC 7 was used in the study. Vermicompost was applied in nine different doses. In the research oil content, linoleic acid, oleic acid, stearic acid, palmitic acid, arachidic acid, behenic acid, iodine value, and O/L ratio were examined. According to the results, it has been found that oil content varies between 48.38% (T9) and 50.43% (T5). The ratio of oleic acid was recorded between 56.90% (T9) and 59.42% (T5) while the ratio of linoleic acid was between 21.15% (T9) and 23.59% (T8). The lowest palmitic acid value (8.87%) was recorded for the T8 treatment whereas the highest palmitic acid value (9.21%) was obtained from the T6 treatment. The lowest O/L ratio (2.42) was obtained from the T8 treatment while the highest O/L ratio (2.77) was obtained from the T4 treatment. The iodine value varied between 85.56% and 90.28% for T9 and T5 applications, respectively. The findings indicate that under the ecological conditions of Osmaniye, soil and leave treatments of vermicompost show a significant increase in oil content, oleic acid, linoleic acid, and iodine values of peanut.

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1. Introduction

Peanut (*Arachis hypogea* L.) as a member of the legume family is a summer annual plant (Arioglu, 2014). It is regarded as a crucial source of nutrition for both humans and animals thanks to its greater protein, carbohydrate, vitamin, and oil content (Onat et al., 2017; Yasli et al., 2020; Kumar et al., 2021; Sahin et al., 2022). Peanut seeds are an oil plant and contain 44-56% oil and 22-30% protein (Kumari et al., 2022). Its oil is composed of 80% unsaturated fatty acids while the rest is comprised of saturated fatty acids (Barkley et al., 2013).

Peanut cultivation like other leguminous crops has a positive effect on the soil physico-chemical properties. Like other members of the legume family peanut has the ability to fix the free nitrogen of the air to the soil through Rhizobium bacteria. Rhizobium bacteria have a symbiotic relationship with the roots of leguminous plants in the soil (Asik and Arioglu, 2020; Raza et al., 2020). This bacterial species increases the soil's organic nitrogen pool by fixing the freely available nitrogen of the atmosphere into the soil. It has the ability to fix 20-30 kg da^{-1} of atmospheric N depending on the environmental conditions and plant species (Kadiroglu, 2022).

In Türkiye, the Mediterranean region ranked 1st in peanut production with 85.11% area followed by Southeastern Anatolia Region with 12.64% area. Osmaniye province is a major contributor in the marketing of peanuts (TUIK, 2022). Agronomy operations such as tillage, seed quality, planting density, fertilization, and irrigation play a vital role in obtaining better yield and quality in peanuts (Reddy et al., 2003) However, in order to fulfill the needs of the ever-increasing world population, the yield and quality of the product obtained from the unit area should be increased (Timsina, 2018). To obtain a higher yield per unit area application of high quality fertilizers should be practiced in addition to other cultural operations. Vermicompost is one of the most widely used fertilizers to achieve higher yields (Garg et al., 2010).

Vermicompost has been produced in most European countries and the United States of America for about 40 years and is actively used in agricultural production (Sorathiya et al., 2010). Among 3 000 worm types, the Red Californian worm has an important role in the production of vermicompost fertilizer (Ahmad et al., 2021). In vermicompost production, approximately 250 000 worms in 1 m^3 of raw material continue their activity for three months (Demir, 2010; Welka, 2016). This activity results in the production of a fertilizer highly enriched with plant nutrients. This obtained fertilizer is known as biohumus or vermicompost (Edwards and Bohlen, 1996).

Vermicompost application not only increases the quality and quantity of produce but also improves soil fertility by increasing the beneficial microorganisms present in the soil (Lim et al., 2015). In addition to plant growth and development, it also improves plant resistance against unfavorable environmental conditions (Yadav and Garg, 2015). In general, organic matter content is insufficient in the soils of the world and Turkey Vermicompost helps in the decomposition of organic wastes and returns them to the soil (Alloway, 2009). Vermicompost is vital for the preservation of the environment. Furthermore, the use of vermicompost will provide considerable benefits in organic agriculture (Ramnarain et al., 2019).

This research was carried out in Osmaniye province, the first biggest market of peanut where 90% of its marketing is made (Asik et al., 2018). This search was designed to determine the impact of vermicompost applied directly to the soil as well as to the leaves at various growth stages on oil and fatty acids components of peanut.

2. Material and Methods

This two-year experiment was conducted at the Oil Seed Research Institute (37°07′42”N; 36°11′47”E, 63 m) in 2020 and 2021. The data in the experiment consists of combined years. In this experiment, the most cultivated Virgina market type of peanut in Türkiye i.e., NC 7 variety was cultivated under the treatment of nitroverm liquid type organic vermicompost. Vermicompost has 20% organic matter and 1.5% total nitrogen with a pH of 4.2-6.2. A hundred percent organic vermicompost was obtained by Red California culture worms. Nine treatments were established including the control (Figure 2).

The details of average temperature, precipitation, and average humidity for both years and long years in which the research was practiced are shown in Figure 1. The average temperature during the crop growth period was 20.8 ºC in 2020 and 25.0 ºC in 2021. The total amount of rainfall was 237.3 mm in the first year and 88.0 mm in the second year of the experiment. Mean relative humidity was 66.3% in 2020 and 63.1% in 2021.

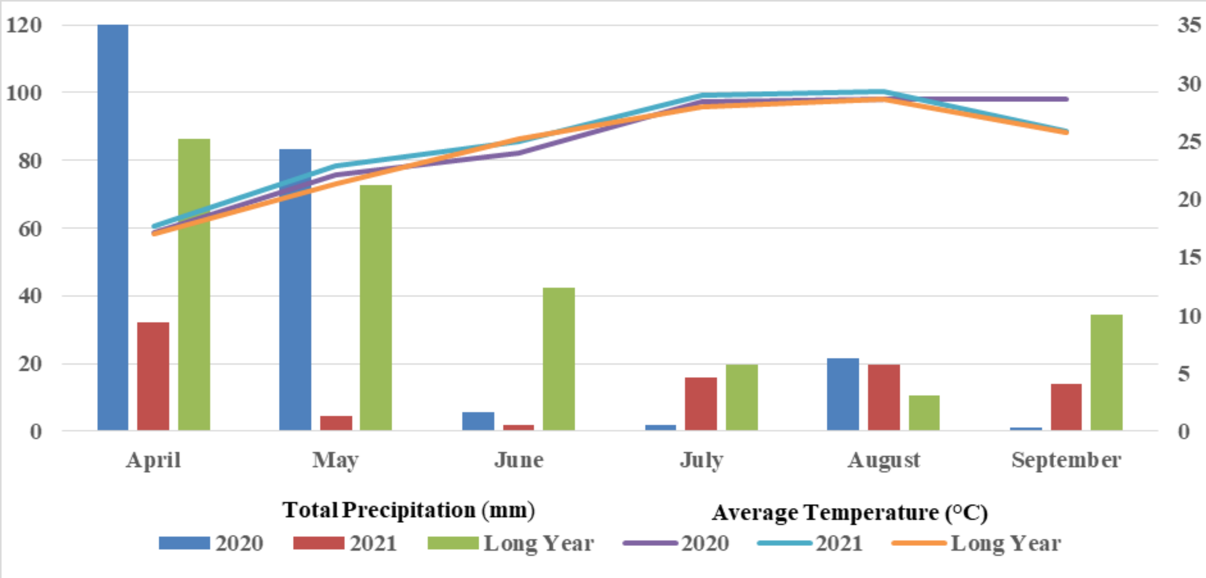

Figure 1. The research field's climate parameters (2020, 2021 and long-year average).

The soil of the experimental field was flat, slightly salty (1.99 dS m^{-1}), extremely calcareous (5.64%), slightly alkaline (pH 8.19), with high water holding capacity (clay), poor in organic matter (1.67%), rich in potassium (59.19 kg da^{-1}) with low phosphorus content (5.21 kg da^{-1}).

The experimental area was deeply plowed with a plow in the fall season. The field was left fallow in the winter season and plowed in the first week of April with a cultivator before sowing. After that, the soil was mixed with a disc harrow and the seedbed was prepared for planting the crop. Before sowing, Diammonium phosphate (18-46) fertilizer at the rate of 25 kg da^{-1} was applied to the soil. A total of 20 kg da^{-1} of urea (46% N) fertilizer was applied in two splits i.e., half before the first irrigation and the other half before the third irrigation. The sprinkler irrigation system was installed and irrigation was applied according to the needs and weather conditions. Each subplot consisted of 2.8 m wide and 5 m long four rows. The area of each subplot was 14 m^2.

The experiment was laid out in a randomized complete block design with three replications. Vermicompost was treated in two different ways (i.e. to the soil and leaves). Soil application was done at once while leave applications were completed in five different splits ((V3 (vegetative stage), R1 (beginning bloom), R2 (beginning peg), R3 (beginning pod), R4 (full pod)) (Figure 2).

Treatment times	Treatments	1. Treatment	2. Treatment	3. Treatment	4. Treatment	5. Treatment	6. Treatment	7. Treatment	8. Treatment	9. Treatment
pre-sowing	Soil treatment (2 L)	X	X	X	X					
V3 stage	Leaf treatment (0.5 L)	X	X	X	X	X	X	X	X	
R1 stage	Leaf treatment (0.5 L)	X	X	X	X	X	X	X	X	
R2 stage	Leaf treatment (0.5 L)		X				X			
R3 stage	Leaf treatment (0.5 L)			X				X		
R4 stage	Leaf treatment (0.5 L)				X				X	

Figure 2. Soil and leave treatments vermicompost time amount and treatments.

The sowing was done manually in the first as well as in the second year on April 25, 2020, and May 2, 2021, respectively. Cultural practices during the crop growth period were carried out properly on time as recommended for the crop. Harvesting of the crop in the 1st and 2nd year was done on September 10, 2020, and September 15, 2021, respectively. All the traits examined in this study were measured by selecting a total of 20 plants representing the middle two rows of each plot from each plot. The oil content of the obtained seeds was measured by Soxhlet. In monounsaturated fatty acids, Oleic acid (C18:1), in polyunsaturated fatty acids, Linoleic acid (C18:2) and Linolenic acid (C18:3) and in Saturated fatty acids; Palmitic acid (C16:0), Stearic acid (C18:0), Arachidic acid (C20:0), Behenic acid (C22:0) and Lignoceric acid (C24:0) were determined as "%" using the GC-FID system (Sahin and İsler, 2022).

Experimental contents were subjected to randomized complete block design analysis of variance using the SPSS 22 application. Duncan's multiple range test was used to combine the means.

3. Results and Discussion

A statistically significant difference was observed between the mean oil content of peanut applied with various vermicompost doses at different growth stages (p<0.01) (Table 1).

Vermicompost doses T1 ((pre-sowing (soil treatment 2 l) + V3 (leaf treatment 0.5 l) + R1 (leaf treatment 0.5 l)), T2 ((pre-sowing (soil treatment 2 l) + V3 (leaf treatment 0.5 l) + R1 (leaf treatment 0.5 l) + R2 (leaf treatment 0.5 l), T3 ((pre-sowing (soil treatment 2 l) + V3 (leaf treatment 0.5 l) + R1 (leaf treatment 0.5 l) + R3 (leaf treatment 0.5 l), T4 ((pre-sowing (soil treatment 2 l) + V3 (leaf treatment 0.5 l) + R1 (leaf treatment 0.5 l) + R4 (leaf treatment 0.5 l), T5 ((V3 (leaf treatment 0.5 l) + R1 (leaf treatment 0.5 l)), T6 ((V3 (leaf treatment 0.5 l) + R1 (leaf treatment 0.5 l) + R2 (leaf treatment 0.5 l)), T7 ((V3 (leaf treatment 0.5 l) + R1 (leaf treatment 0.5 l) + R3 (leaf treatment 0.5 l)), T8 ((V3 (leaf treatment 0.5 l) + R1 (leaf treatment 0.5 l) + R4 (leaf treatment 0.5 l)) and T9 (control). The lowest oil content (48.38%) was recorded for control treatment i.e., T9 while the highest oil content (50.43%) was recorded for treatment T5 (Table 2). It was observed that all vermicompost doses increased the oil content compared to the control group (T9). Sahin et al. (2022) in their two-year experiment conducted under Osmaniye conditions determined the average oil content of the NC 7 peanut variety as 49.37%. In this study, it was observed that the treatments of vermicompost caused an increase in the oil content. The 44-56% oil increase in peanuts provides an increase in both the amount of nutrients and the oil content pod yield (Arioglu et al., 2016). Samadzadeh Ghale Joughi et al. (2018), and Feizabadi et al. (2020) found that vermicompost application increased the oil rate in rapeseed; Atteya et al. (2021) *Moringa oleifera* seeds in worm castings improve oil rate and quality; Yururdurmaz (2022) determined that vermicompost applications increased the oil rate in cowpea. Samadzadeh Ghale Joughi et al. (2018), Feizabadi et al. (2020), Atteya et al. (2021) and Yururdurmaz (2022) also obtained results similar to the findings of this study.

Table 1. Results of the analysis of variance for characteristics studied in the experiment

SV	df	OC	OA	LA	PA	SA	BA	AA	LİA	O/L	IV
Block	4	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Year	1	ns	ns	ns	**	ns	ns	ns	ns	ns	ns
Treatment	8	**	**	**	**	**	**	**	**	**	**
Y x T	8	**	ns	ns	ns	**	ns	ns	ns	**	ns

SV: Source of variation, df: degree of freedom, CV: coefficient of variation, OC: Oil content, OA: Oleic acid, LA: linoleic acid, PA: Palmitic acid, SA: Stearic acid, BA: Behenic acid, AA: Arachidic acid, LİA: Lignoceric acid, O/L: Oleic/Linoleic ratio, IV: Iodine value.

Table 2. Average values of oil content, oleic acid, linoleic acid, palmitic acid, stearic acid

Treatments	Oil Content	Oleic acid	Linoleic acid	Palmitic acid	Stearic acid
T1	49.94 ab	58.27 abcd	22.82 b	8.97 bcd	3.65 a
T2	50.11 ab	58.84 abc	22.81 b	8.90 cd	3.66 a
T3	48.94 cd	58.46 abcd	22.03 cd	9.09 abc	3.68 a
T4	50.01 ab	59.15 ab	21.33 e	8.98 bcd	3.60 a
T5	50.43 a	59.42 a	22.62 bc	8.92 cd	3.48 b
T6	50.06 ab	58.78 abc	21.97 d	9.21 a	3.29 d
T7	49.70 abc	57.49 bcd	23.04 ab	9.14 ab	3.42 bc
T8	49.39 bc	57.16 cd	23.59 a	8.87 d	3.35 cd
T9	48.38 d	56.90 d	21.15 e	9.20 a	3.29 d
Average	49.66	58.27	22.37	9.03	3.49
CV (%)	1.0	2.6	2.4	1.8	2.0

CV: Coefficient of variation. Values with different letters in each column mean statistical differences according to Duncan test (P≤0.05).

Different doses of vermicompost applied at various growth stages of peanut had an important effect ($p<0.01$) on mean oleic acid values (Table 1). The ratio of oleic acid (C18:1), one of the monounsaturated fatty acids, and linoleic acid (C18:2), one of the polyunsaturated fatty acids, is close to 80% in peanut (Gursoy, 2019). The control i.e. T9 had the lowest mean oleic acid value (56.90%), while T4 and T5 treatment resulted in the highest mean oleic acid values i.e. 59.15% and 59.42%, respectively (Table 2). The oleic acid value of peanut in the control was found to be lower than all vermicompost doses. An average of 50% increase in oleic acid content of peanut varieties has been recorded however, this amount is found to be 75-80% and above in high oleic varieties (Hassan et al., 2005). Yilmaz (2022) observed that the oleic acid content increased up to 59.42% in the NC 7 variety with the treatment of vermicompost. It has been observed that the vermicompost treatment to peanut through the soil and leaves increased the oleic acid content. Joris and Mensink (2016) reported that consuming peanuts enriched with oleic acid reduces the incidence of cardiovascular diseases. According to Razzaghifard et al. (2017) found that vermicompost applications increased the rate of oleic acid in *Cucurbita pepo* L.; Samadzadeh Ghale Joughi et al (2018), and Feizabadi et al. (2020) found that vermicompost application increased the rate of oleic acid in rapeseed; Atteya et al. (2021). *Moringa oleifera* seeds oleic acid ratio in vermicompost was purified; Yururdurmaz (2022) found that vermicompost applications increased the rate of oleic acid in cowpea; Sánchez Roque et al. (2022) found that vermicompost applications increased the oleic acid ratio in peanuts. In our trial findings, the results were similar to the findings of other researchers.

Vermicompost applied to peanut in different doses at various growth stages was a statistically significant ($p < 0.01$) effect on linoleic acid values (Table 1). The lowest mean value (21.15%) of linoleic acid was obtained from the control application i.e. T9. The highest linoleic acid value (23.59%) was obtained from the T8 treatment (Table 2). It was determined that all vermicompost doses had higher linoleic acid content compared to the control (T9). Vermicompost treatments led to a simultaneous increase in both linoleic and oleic acid content. The increase in the two unsaturated fatty acids i.e., oleic acid and linoleic acid in peanuts is gaining importance in terms of health and nutrition (Arioglu, 2014). Razzaghifard et al. (2017) found that vermicompost applications increased the rate of linoleic acid in *Cucurbita pepo* L.; Samadzadeh Ghale Joughi et al (2018), and Feizabadi et al. (2020) found that vermicompost application increased the rate of linoleic acid in rapeseed; Atteya et al. (2021). *Moringa oleifera* seeds linoleic acid ratio in vermicompost was purified; Yururdurmaz (2022) found that vermicompost applications increased the linoleic ratio in cowpea; Sánchez-Roque et al. (2022) determined that vermicompost applications increased the rate of linoleic acid in peanuts. This study showed an increase in both oleic acid and linoleic acid values of vermicompost applied to peanut.

Saturated fatty acids in peanuts comprised of palmitic acid (C16:0), stearic acid (C18:0), arachidic acid (C20:0), behenic acid (C22:0) and lignoceric acid (C24:0). Vermicompost applications in different doses at various growth stages were found to have significant effect ($p<0.01$) on palmitic acid values in peanuts (Table 1). The minimum average palmitic acid value (8.87%) was recorded for the T8 treatment while maximum average palmitic acid values i.e. 9.21% and 9.20% were recorded for T6 and T9 treatments, respectively (Table 2). Hassan et al., (2005) reported that the low level of saturated fatty acids in peanuts is important in terms of nutrition, and also the palmitic acid value varies between 9.95-10.79%. Arioglu et al. (2020) determined that the palmitic acid value varies between 9.15-10.19%. In this study, it was seen that vermicompost treatment decreased the palmitic acid value and also the palmitic acid ratio was lower than other studies. Razzaghifard et al. (2017) found that vermicompost applications increased the palmitic acid ratio in *Cucurbita pepo* L.; Samadzadeh Ghale Joughi et al (2018), and Feizabadi et al. (2020) found that vermicompost application increased the palmitic acid ratio in rapeseed; Atteya et al. (2021). *Moringa oleifera* seeds palmitic acid ratio in vermicompost was purified; Yururdurmaz (2022) found that vermicompost applications increased the palmitic acid ratio in cowpea; Sánchez-Roque et al. (2022) vermicompost applications were found to reduce the palmitic acid ratio in peanuts. While it was observed that the palmitic acid ratio of vermicompost increased in other plants, it was determined that the palmitic acid ratio in peanut decreased.

Vermicompost treatments in different doses at different growth stages of peanut were found to have a significant effect ($p<0.01$) on stearic acid values in peanuts (Table 1). The control group i.e. T9 showed the lowest average value (3.29%) for stearic acid, while T3 treatment resulted in the highest value (3.68%) (Table 2). Gulluoglu et al. (2017) found that the value of stearic acid varies between 2.28-

4.16%. Asik et al. (2018) determined that the stearic acid value varies between 2.39-4.19% and a study conducted by Yol and Uzun (2018), showed the stearic acid value between 2.40-4.90%. Razzaghifard et al. (2017) found that vermicompost applications increased the stearic acid ratio in *Cucurbita pepo* L.; Yururdurmaz (2022) determined that vermicompost applications increased the rate of stearic acid in cowpea. The stearic acid value recorded in this study was found to be similar to Razzaghifard et al. (2017) and Yururdurmaz (2022).

Table 3. Average values of behenic acid, arachidic acid, lignoceric acid, O/L ratio, Iodine value

Treatments	**Behenic acid**	**Arachidic acid**	**Lignoceric acid**	**O/L ratio**	**Iodine value**
T1	2.69 c	1.67 b	1.16 cd	2.55 cd	89.66 ab
T2	2.76 ab	1.72 a	1.17 c	2.58 bcd	90.12 ab
T3	2.73 abc	1.72 a	1.18 bc	2.66 abc	88.41 d
T4	2.59 d	1.63 c	1.22 ab	2.77 a	87.82 d
T5	2.62 d	1.65 bc	1.15 cd	2.62 bc	90.28 a
T6	2.71 bc	1.59 d	1.25 a	2.67 ab	88.62 cd
T7	2.78 a	1.63 c	1.21 ab	2.49 de	89.35 bc
T8	2.79 a	1.63 c	1.22 ab	2.42 e	90.19 ab
T9	2.69 c	1.57 d	1.13 d	2.69 ab	85.56 e
Average	2.71	1.65	1.19	2.61	88.89
CV (%)	1.8	1.2	2.5	3.8	1.6

CV: Coefficient of variation. Values with different letters in each column mean statistical differences according to Duncan test (P≤0.05).

The behenic acid ratio in peanut was found to be significantly affected by treatments of vermicompost at various stages in different doses ($p<0.01$) (Table 1). The lowest readings came from T4 (2.59%) and T5 (2.62%) treatments, while the highest values were obtained from T7 (2.78%) and T8 (2.79%) treatments (Table 3). Gulluoglu et al. (2017) stated that the percentage of behenic acid varies between 2.11-3.25%; Asik et al. (2018) determined that it varies between 2.26-3.29% whereas Yol and Uzun (2018) documented that behenic acid value varies between 2.56-2.85%. Yururdurmaz (2022) found that vermicompost applications increased the behenic acid ratio in cowpea; Sánchez-Roque et al. (2022) determined that vermicompost applications increased the ratio of behenic acid in peanuts. The behenic ratio found in this study shows similarity with the values found in Yururdurmaz (2022) and Sánchez-Roque et al. (2022).

Different doses of vermicompost treatment at various growth stages significantly ($p<0.01$) affected the arachidic acid ratio in peanut (Table 1). The lowest value was derived from the control (T9) while the highest ratio was obtained from the T2 (1.72%) and T3 (1.72) treatments in the same group (Table 3). The arachidic acid value in the control group was lower than other treatments. Uckun et al. (2019) found that the arachidic acid ratio varies between 1.21-1.74% while Ergun and Zarifikhosroshahi (2020) found that the ratio of arachidic acid varies between 1.43% and 1.62%. Sánchez-Roque et al. (2022) stated that vermicompost applications increased the arachidic acid ratio in peanuts and the amount of vermicompost was important in increasing the arachidic acid ratio.

Lignoceric acid value, which is one of the saturated fatty acids; was significantly affected by vermicompost treatment at various stages in different doses ($p<0.01$) (Table 1). The lowest lignoceric (1.13%) was obtained from the T9 i.e., control while the T6 treatment resulted in the highest (1.25%) lignoceric value. All vermicompost treatments were found higher in lignoceric acid value than the control (T9) group (Table 3).

Vermicompost treatment in different amounts at different growth phases significantly affected the O/L ratio ($p < 0.01$) (Table 1). O/L ratio varied between 2.42 (T8) and 2.77 (T4) (Table 3). In addition, a high oleic/linoleic acid ratio means increased oxidative stability of oils and reduced trans fatty acid formation during the process (Mondal et al., 2018). Vermicompost treatment through both soil and leaves increases the O/L ratio value. Gali et al. (2021) recorded the O/L ratio value between 1.20 and 27.52 while Lopez et al. (2001) reported that the O/L ratio value varies between 0.8 and 2.5. Gali et al. (2021) reported less while Lopez et al. (2001) found a higher value for O/L ratio value. Yururdurmaz (2022) stated that vermicompost applications improve the O/L ratio in cowpea and the ratio of vermicompost is important in the O/L ratio. In this experiment, the O/L ratio findings in the trial were found to be similar to those of the Yururdurmaz (2022) trial.

Vermicompost treatments in different doses and stages were found to have a significant effect on iodine values ($p<0.01$) (Table 1). The lowest iodine value (85.56) was recorded for control i.e., T9 while T5 treatment resulted in the highest iodine value (90.28) (Table 3). Yilmaz (2022) reported that iodine value varies between 85.99 and 88.28. Yururdurmaz (2022) stated that vermicompost applications improve the iodine value in cowpea and the ratio of vermicompost is important in iodine value. In this study, according to adaptation-like studies, it was determined that vermicompost treatment increases the iodine value.

Conclusion

Vermicompost availability at ease increases production efficiency. Production area also increases with the easy access of vermicompost. An increase was recorded in the Oil content, Oleic acid (C18:1, monounsaturated fatty acid) and Linoleic acid (C18:2, polyunsaturated fatty acids) when the effect of vermicompost treatments on peanut oil quality and fatty acid compositions were examined under Osmaniye conditions. However, an increase in the iodine value, which is important in terms of nutrition was also recorded. According to the results, it can be concluded that the treatment of vermicompost to peanut would be appropriate in order to increase the amount of oil and unsaturated fatty acids.

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