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VARIATION IN OIL CONTENT AND FATTY ACID PROFILES OF PEANUT CULTIVARS ACROSS THREE MEDITERRANEAN LOCATIONS

TAHSIN BEYCİOĞLU[1], FATIH KILLI[2] AND MUSA TÜRKMEN*

Mustafa Kemal University, Faculty of Agriculture, Department of Field Crops, Hatay 31060, Turkey

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Abstract

The fatty acid profile of peanut oil is an important factor that affects the quality of peanut seeds and its products. Oil content and fatty acid composition vary significantly depending on cultivar and growing location.The analysis of variance revealed that the varieties differed in all traits examined in the study, that the locations had significant effects on fatty acids other than stearic, eicosenoic, and arachidic acids, and that their interactions were significant for all traits examined. Halisbey variety had the highest oil content and the Brantley variety, which is a high oleic variety, had the highest oleic acid, O/L percentage, and lowest linoleic acid and iodine value, while the Flower-22 variety had the highest linoleic acid and iodine value and the lowest oleic acid and O/L ratio.

Introduction

Peanut (*Arachis hypogaea* L.) is an annual oil plant from the legume family. According to 2022 statistics, the peanut cultivation area was 30.5 million hectares, production was 54 million tons, and yield was 1776 kg/ha in the world. In terms of both cultivated land and yield, peanuts make up a rather tiny portion of Turkey's agricultural output. The peanut cultivation area of Turkey is 45.7 thousand hectares with a production of 186 thousand tons and a yield of 4077 kg/ha (FAO 2022). Peanuts are used directly as a snack in human nutrition or in the production of many foods such as cakes, chocolate, desserts, and confectionery, with its oil, protein, carbohydrate, mineral substances, and vitamins in its seeds. Peanut seeds include 44-56% oil in addition 22-30% protein and are also a good resource of minerals vitamins, (Güler *et al.* 2022). Peanuts are important in food manufacturing in terms of physical sensorial and dietary factors (Hassan *et al.* 2012). The nutritional characteristic of oil is determined by its fatty acid composition. Oleic acid and linoleic acid, constitute 75-80% of the sum fatty acids in peanut oil. The fatty acid composition of peanuts varies dependent on their cultivars and locations, as well as ecological and many other factors (Baydar 2000). The fatty acid composition of peanut oil is not persistent and might vary depending on different varieties and locations (Yusuf *et al*. 2019). Singkham *et al*. (2010) concluded that G x E interactions are important for biomass, fruit yield, harvest index, and oleic, linoleic acids, and O/L ratios. Guo *et al*. (2019) informed that the oleic acid content was more stable in high-oleic peanut varieties than in varieties that contained normal oleic acid, but palmitic and linoleic acid contents were more stable in normal oleic acid varieties. The adverse effects of drought conditions on plants directly affect lipid biosynthesis and fatty acid profile (Sharma *et al*.2023, Nandhini *et al.* 2025). Research shows that peanut plants produce different fatty acid components under different climatic conditions, and this has significant effects on oil quality (Raziei *et al.* 2018, Patel *et al*. 2022). In the investigation, the purpose was to reveal the saturated and unsaturated fatty acid compositions and oil quality of different peanut cultivars in three different locations under the conditions of the Eastern Mediterranean Region.

*Author for correspondence: <turkmenmusa@hotmail.com>. [1]Pamukkale University, Faculty of Agriculture, Department of Field Crops, Denizli, Turkey. [2]Kahramanmaras Sütcü İmam University, Faculty of Agriculture, Department of Field Crops, Kahramanmaras, Turkey.

Materials and Methods

Arıoglu 2003, Batem 5025, Batem Cihangir, Brantley, Flower-22, Halisbey, NC-7, Osmaniye 2005, Sultan and Wilson peanut cultivars were utilized as the materials in the study. The seeds of the varieties were obtained from Çukurova University, Faculty of Agriculture, Department of Field Crops. Adana and Osmaniye, where the trial was conducted, have a Mediterranean climate, while Kahramanmaraş has a terrestrial climate. During the 2018 peanut growing season, the average monthly temperatures ranged from 20.1-29.6°C in Adana, 18.9-28.6°C in Osmaniye, and 18.4-29.1°C in Kahramanmaraş (Fig. 1). The highest rainfall was in Osmaniye in June, with 111.2 mm. The season was dry from April to October, and relative humidity ranged from 38.4 to 74.7%. In 2019 the monthly temperatures were 17.0-29.6°C in Adana, 16.6-28.5°C in Osmaniye, and 14.2-29.5°C in Kahramanmaraş. The highest rainfall was in Kahramanmaraş in April, with 78.4 mm. The dry season continued from April to October, and relative humidity ranged from 41.2 to 72.5%. The trial areas have a clayey-loamy soil texture and are salt-free and slightly alkaline. Adana is very calcareous (18.54%), Osmaniye is moderate in this respect (9.47%), and Kahramanmaraş is calcareous (2.19%). The soils of Adana and Osmaniye have low organic matter content, while Kahramanmaraş contains moderate levels of organic matter (Table 1). In terms of phosphorus, Adana and Osmaniye are sufficient, Kahramanmaraş is low, and in terms of potassium, Adana is high and the other two locations are low (Anonymous 2019). The trial was conducted in Adana, Osmaniye and Kahramanmaraş in 2018 and 2019 main crop growing season with 3 replications to the Randomized Complete Trial Design. The planting process was performed in the first week of May in Adana, Osmaniye, and Kahramanmaraş. Each plot was arranged as 4 rows and 14 m^2 (5 m - length of parcel x 2.8 m - inter-row sum) wide, with 70 cm between rows and 15 cm among rows in the trial (Kurt *et al.* 2016). For each location, 300 kg/ha DAP (18-46-0) fertilizer was used to the base before planting every two years, and 150 kg/ha field fertilizer was used with a fertilizer machine approximately 60 days after the emergence. Harvest varied depending on the location and was performed with a harvesting machine when the capsules were filled, and the plants were inverted and left to dry. Observations were made on 10 plants randomly selected from plots and rows of blocks within a single location. Oil content was determined using a Sokshelet apparatus using seeds ground from randomly selected plant samples from plots within blocks at harvest time in different locations. The fatty acid composition of the peanut samples was determined with the Gas Chromatography (GC) after the transesterification to Fatty Acid Methyl Esters (FAME) (Turkmen *et al.* 2022). Analysis of variance the data acquired in the work was performed by using the SAS package program (SAS 2014). The significance of the difference between the mean values was determined with the LSD test (Steel and Torrie 1960). Statistical analyses of the yield and related to quality traits were analyzed using JMP 13 Pro 17 software package by the Randomized Complete Block Trial Design assembled in split plots. Significant differences were contrasted by LSD multiple comparison test at $P < 0.05$ and $P < 0.01$ significance levels (Steel and Torrie 1980).

Results and Discussion

The highest oil content was detected in Adana and Kahramanmaraş, and the lowest in Osmaniye (Table 2). The lower oil content in Osmaniye may be attributed to higher rainfall during the growing season (Fig. 1), which can dilute oil accumulation in seeds. The oil composition of peanut varieties varied between 50.98-55.46%, and the Halisbey variety had the highest oil content, followed by Batem Cihangir (54.67%), Sultan (53.73%) and Arıoglu-2003 (53.26%). The Batem-5025 variety had the lowest oil content. Kurt *et al.* (2016) reported oil content values varying between 43.20-50.90%, and in peanuts, the oil ratio is a quantitative character directed by more than two allele gene pairs (Baydar and Erbaş 2014) and can be affected greatly by

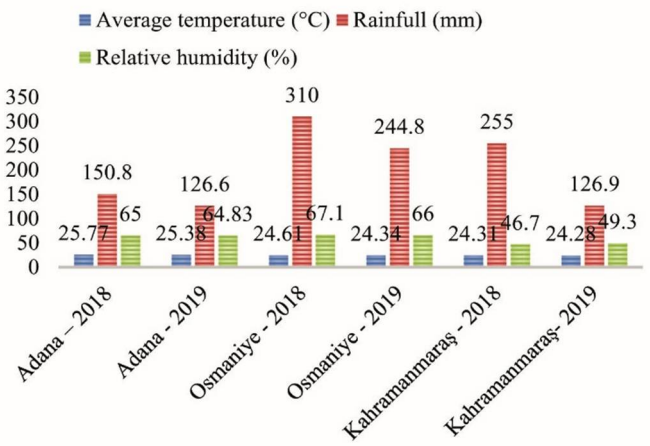

Fig. 1. Climate data of testing environments in 2018 and 2019 growing period (April-October).

Table 1. Soil characteristics at 0-30 cm depth of the experimental sites.

Characteristics	Adana		Osmaniye		Kahramanmaraş	
Texture (% Sat.)	58.30	Clayey-loamy	57.20	Clayey-loamy	59.40	Clayey-loamy
Salinity (%)	0.10	Salt-free	0.07	Salt-free	0.13	Salt-free
Organ. article %	1.58	Low	1.29	Low	2.65	Moderate
Lime $CaCO_3$ (Kg/da)	18.54	Too calcareous	9.47	Moderately calcareous	2.19	Calcareous
Total nitrogen (%)	0.09	Sufficient	0.06	Low	0.08	Low
Phosphorus	13.80	Sufficient	8.64	Sufficient	5.78	Low
Potassium	576.50	High	68.50	Low	112.10	Low
pH	7.66	Lightly akaline	7.63	Lightly alkaline	7.53	Lightly alkaline

Table 2. The average of the varieties and locations of the oil content values of the peanut cultivars.

Locations	Oil content (%)
Adana	54.65a
Osmaniye	49.79b
Kahramanmaraş	54.49a
LSD (0.05)	0.34
Varieties	Oil content (%)
Arıoglu-2003	53.26cd
Batem 5025	50.98f
Batem Cihangir	54.67b
Brantley	51.26ef
Flower-22	52.90d
Halisbey	55.46a
NC-7	52.82d
Osmaniye 2005	51.82e
Sultan	53.73c
Wilson	52.85d
LSD (0.05)	0.61

Mean having same letter/s are not significantly different.

environmental factors (Dwivedi *et al.* 1993). The high oil content observed in Halisbey makes it particularly suitable for oil extraction industries, while cultivars like Batem-5025 may be more appropriate for direct consumption or confectionery applications where lower oil content is preferred. Major saturated fatty acids include palmitic acid, stearic acid, arachidic acid, eicosenoic acid, behenic acid, and lignoceric acid. As a result of the variance analysis of the saturated fatty acid composition data (Table 3), it was found that year, YxL, genotype, GxL, GxY, and GxYxL variance sources were very significant for all saturated fatty acids that were evaluated, while location was important only for palmitic, behenic and lignoceric acid. However, location effects were significant only for palmitic, behenic, and lignoceric acids, while stearic, eicosenoic, and arachidic acids remained stable across locations. It was seen that palmitic acid was higher in Adana, behenic and lignoceric acid was higher in Osmaniye, and stearic, arachidic, and eicosenoic acids did not change at significant levels according to the locations (Table 4). The elevated palmitic acid in Adana can be attributed to higher average temperatures during seed maturation (Fig. 1), as increased temperature promotes the synthesis of saturated fatty acids (Hassan *et al*. 2005). High average temperatures in Adana in both years might have been effective in increasing

Table 3. Integrated analysis of variance results of the cultivars of saturated fatty acids evaluated for 10 groundnut varieties across two years and three locations.

Source of variation	df	Palmitic Acid	Stearic Acid	Eicosenoic Acid	Behenic Acid	Lignoceric Acid	Arachidic Acid
Year (Y)	1	29.40**	16.34**	12.78**	1.63**	11.35**	20.41**
Location (L)	2	0.84**	0.09	0.02	1.19**	1.03**	0.005
YxL	2	2.18**	0.70**	0.84**	4.95**	1.07**	0.94**
Block	12	0.14	0.09**	0.0025	0.05	0.01	0.005
Genotype (G)	9	24.82**	3.33**	0.43**	2.85**	1.25**	0.59**
GxL	18	0.61**	0.36**	0.08**	0.51**	0.24**	0.11**
GxY	9	0.37**	0.27**	0.08**	0.84**	0.10**	0.10**
GxYxL	18	1.58**	0.14**	0.04**	0.96**	0.11**	0.12**
Error	108	4.27	0.03	0.002	0.04	0.04	0.009
Coefficient of variation (%)		2.77	5.57	4.39	3.87	6.33	14.08

the palmitic acid content. Oil composition and fatty acid content in peanuts might vary depending on location, season, temperature, and environmental conditions (Dwivedi *et al.* 1993). These differences may reflect variations in soil organic matter and nutrient availability across locations (Table 1). The varieties showed significant differences in terms of their saturated fatty acid contents. Palmitic, stearic, and behenic acids were the dominant saturated fatty acids in peanut oil, varying between 7.03-11.02%, 2.67-3.94%, and 2.60-3.58%, respectively. Flower-22 variety had the highest palmitic acid content, followed by Arıoglu-2003 and Batem Cihangir varieties. Flower-22 variety, which had the highest palmitic acid value, yielded the lowest arachidic (1.89%), eicosenoic (0.95%) and behenic (2.60%) acid contents. Brantley variety, which had the lowest palmitic (7.03%), behenic (2.63%), and lignoceric acid (1.06%) contents, had the highest stearic (3.94%) and eicosenoic acid (1.54%) contents. Arıoglu-2003 variety attracted attention with its high palmitic acid, low stearic acid (2.67%), and arachidic acid (1.72%) contents. In some previous studies, palmitic acid values that ranged from 8.60-14.01% were reported (Mozingo *et al*. 2004, Söğüt *et al.* 2016). Özcan and Seven (2003), found an arachidic acid value of 1.53%. Shibli *et al*. (2019) reported eicosenoic acid values between 1.57-1.66%. In previous studies conducted on peanuts, it was reported that behenic acid varied between 1.2% and 3.57% (Özcan and Seven 2003, Kılınççeker 2019, Shibli *et al*. 2019). Regarding the lignoceric acid ratios in peanut oil,

Kılınççeker (2019) reported values between 0.82-2.06% and Bakal and Arıoğlu (2019) reported values between 1.49-1.87%. These cultivar-specific differences are primarily genetically determined but can be modulated by environmental conditions, particularly temperature during seed filling. The differences in saturated fatty acid composition between varieties might have resulted from genetic structures and environmental factors, especially temperatures near the harvest time (Hassan *et al*. 2005). The oleic acid content of the locations varied between 49.82-54.63%, and the linoleic acid content varied between 23.78-27.92% (Table 5). Osmaniye had the greatest oleic acid content, followed by Adana and Kahramanmaraş. Kahramanmaraş had the greatest linoleic acid content, followed by Adana and Osmaniye. The high linoleic acid content in Kahramanmaraş might have occurred because of the low-temperature effect. Bakal and Arioglu (2019) reported that variety and climatic conditions were important factors affecting the fatty acid composition of peanut oil. This finding has practical implications: peanuts grown in cooler Mediterranean regions like Kahramanmaraş may be less suitable for high-oleic oil production but

Table 4. The average of the varieties and locations of the saturated fatty acid values of the peanut cultivars.

Locations	Palmitic acid (%)	Stearic acid (%)	Arachidic acid (%)	Eicosenoic acid (%)	Behenic acid (%)	Lignoceric acid (%)
Adana	9.52a	3.24	2.06	1.29	3.02c	1.31c
Osmaniye	9.32b	3.19	2.04	1.28	3.30a	1.57a
Kahramanmaraş	9.30b	3.27	2.06	1.31	3.16b	1.40b
LSD (0.05)	0.09	ns	ns	ns	0.07	0.13
Varieties	Palmitic acid (%)	Stearic acid (%)	Arachidic acid (%)	Eicosenoic acid (%)	Behenic acid (%)	Lignoceric acid (%)
Arıoglu-2003	10.38b	2.67g	1.72g	1.23e	2.77e	1.43 bc
Batem 5025	8.60d	3.76b	2.34 a	1.22	3.56a	1.29d
Batem Cihangir	10.36b	2.82f	1.88 f	1.38b	3.57a	1.85a
Brantley	7.03e	3.94a	2.23b	1.54a	2.63f	1.06
Flower-22	11.02a	3.41c	1.89 f	0.95f	2.60f	1.22d
Halisbey	9.79c	2.97e	2.10cd	1.37bc	3.58 a	1.84 a
NC-7	8.55d	3.65b	2.16c	1.30d	3.07d	1.20 d
Osmaniye 2005	9.71c	2.95e	2.02e	1.34c	3.33b	1.55b
Sultan	9.73c	3.16d	2.07de	1.23e	3.29 bc	1.48b
Wilson	8.66d	3.01e	2.12 cd	1.39b	3.17 cd	1.33 cd
LSD (0.05)	0.17	0.12	0.06	0.03	0.14	0.13

Locations	Oleic Acid (%)	Linoleic Acid (%)
Adana	53.86b	24.34b
Osmaniye	54.63a	23.78c
Kahramanmaraş	49.82c	27.92 a
LSD (0.05)	0.30	0.42
Varieties	Oleic Acid	Linoleic Acid
Arıoglu-2003	48.32f	30.38b
Batem 5025	55.27c	22.94f
Batem Cihangir	46.04g	30.88ab
Brantley	69.85a	9.89h
Flower-22	46.57g	31.44a
Halisbey	49.03e	28.13c
NC-7	57.46b	21.29g
Osmaniye 2005	49.91d	28.26c
Sultan	50.09d	26.12d
Wilson	55.16c	24.15e
LSD (0.05)	0.55	0.77

Means having same letter/s are not significantly different.

Table 5. The average of the variety and location of unsaturated fatty acid values of the peanut cultivars.

Locations	Oleic Acid (%)	Linoleic Acid (%)
Adana	53.86b	24.34b
Osmaniye	54.63a	23.78c
Kahramanmaraş	49.82c	27.92 a
LSD (0.05)	0.30	0.42
Varieties	Oleic Acid	Linoleic Acid
Arıoglu-2003	48.32f	30.38b
Batem 5025	55.27c	22.94f
Batem Cihangir	46.04g	30.88ab
Brantley	69.85a	9.89h
Flower-22	46.57g	31.44a
Halisbey	49.03e	28.13c
NC-7	57.46b	21.29g
Osmaniye 2005	49.91d	28.26c
Sultan	50.09d	26.12d
Wilson	55.16c	24.15e
LSD (0.05)	0.55	0.77

Means having same letter/s are not significantly different.

Table 6. Integrated analysis of variance results (mean square) of the varieties O/L ratio and Iodine Value evaluated for 10 groundnut varieties across two years and three locations.

Source of variation	df	Oleic/Linoleic Acid	Iodine Value
Year (Y)	1	95.59**	64.32**
Location (L)	2	59.79**	167.39**
YxL interaction	2	39.44**	58.81**
Block/Year*location	12	0.005	4.48
Genotype	9	249.86**	469.18**
GxL interaction	18	36.97**	20.18**
GxY interaction	9	32.36**	25.38**
GxYxL interaction	18	37.07**	30.80**
Error	108	0.02	4.20
Coefficient of variation (CV) (%)		4.76	2.29

Means having same letter/s are not significantly different.

Table 7. The average of the variety and location of the O/L ratio and iodine values of the peanut cultivars.

Locations	O/L ratio	Iodine Value
Adana	2.21b	88.49b
Osmaniye	2.30a	88.18b
Kahramanmaraş	1.78c	91.21 a
LSD (0.05)	0.06	0.74
Varieties	O/L	Iodine Value
Arıoglu-2003	1.59g	94.17eu
Batem 5025	2.41c	87.27fg
Batem Cihangir	1.49h	93.09bc
Brantley	7.06a	77.21h
Flower-22	1.48h	94.51 a
Halisbey	1.74 f	90.89d
NC-7	2.70b	86.30g
Osmaniye 2005	1.76f	91.87cd
Sultan	1.92e	88.32ef
Wilson	2.28d	89.29e
LSD (0.05)	0.09	1.35

Means having same letter/s are not significantly different.

could be valuable for applications requiring higher polyunsaturated fatty acid content. The oleic acid content of peanut varieties varied between 46.04-69.85%, and the linoleic acid content varied between 9.89-31.44%. Brantley variety, which is a high oleic variety, had the greatest oleic acid and at lowest linoleic acid content. In terms of oleic acid content, Brantley was followed by NC-7 (57.46%), Batem-5025 (55.27%) and Wilson (55.16%) varieties. Flower-22 variety had the highest linoleic acid and lowest oleic acid content. In terms of linoleic acid content, the Flower-22 variety was followed by Arıoglu-2003 (30.38%) and Batem Cihangir (30.88%) varieties. The differences in oleic and linoleic acid contents in peanut varieties might have resulted from the genetic structures of the varieties (Onemli 2012, Bakal and Arioglu 2019). In previous studies, oleic acid values were determined by Jonnala *et al.* (2005) at 45.6-81.0%, Wang *et al*. (2013) found it to be between 38.97-62.04%. The oleic acid value of peanuts has a determining effect on the quantity, storage stability, and shelf life of peanut oil and the resulting outcomes. The shelf life and taste quality of peanuts with extreme oleic acid value were found to be higher than other peanut varieties with low oleic acid (Kilinççeker 2019). Bakal and Arioglu (2019) reported linoleic acid values to be 19.84-37.47%. As a result of the variance analysis of O/L acid ratios and iodine value data (Table 6), it was found that all variance components were quite significant. The O/L acid ratios of the locations varied between 1.78 and 2.21, and iodine values varied between 88.18 and 91.21 (Table 7). Osmaniye had the highest O/L acid ratio, followed by Adana and Kahramanmaraş. Kahramanmaraş had the highest iodine value, followed by Osmaniye and Adana. The inverse relationship between O/L ratio and iodine value is expected, as higher linoleic acid content increases iodine value, while higher oleic acid decreases it. The Oleic/Linoleic acid proportion of peanut cultivars differed among 1.48 and 7.06. It was found that the Brantley variety had the highest Oleic acid/Linoleic acid proportion followed by NC-7 (2.70%), Batem 5025 (2.41%), Wilson (2.28%), and Sultan (1.92%) cultivars, respectively. The lowest O/L acid ratio was obtained from the Flower-22 variety. The Oleic acid/Linoleic acid proportion is directly proportional to the amount of oil contained in peanuts. Higher oleic acid concentrations occur with lower linoleic acid content (Dwivedi *et al.* 1993). The Iodine values of the varieties varied between 77.21 and 94.51. The maximum iodine rate was obtained in the Flower-22 cultivar, while the lowest value was obtained in the Brantley variety. The proportion of oleic acid to linoleic acid and the iodine evaluate of peanuts determine the dietary property, preservability, and shelf life of peanut oil and its outcomes. Bakal and Arioglu (2019) reported iodine values ranging from 86.36 to 98.49, while Kılınçeker (2019) found values between 74.37 and 95.90. The findings obtained are consistent with findings. The dark blue dots in Fig. 2 indicate strong positive correlations, and the dark red dots indicate strong negative correlations. Other circles show the strength and direction of the correlation according to their color and size. There is a high positive correlation between palmitic acid and linoleic acid and iodine values. At the same time, there is a low positive correlation between salicylic acid and oleic acid. In addition, a high positive correlation was found between oleic acid and oleic/linoleic acid. There were also negative correlations between the traits analyzed. Palmitic acid had a high negative correlation with oleic acid and a low negative correlation with oleic/linoleic acid. In addition, a high negative correlation was observed between linoleic acid and oleic acid. Finally, a high negative correlation was found between iodine value and oleic acid and oleic/linoleic acid (Fig. 2). Similar correlations were reported by many previous researchers (Singkham *et al*. 2010, Hassan and Ahmed 2012, Onemli 2012, Yol *et al*. 2017). These findings emphasize the need for adaptive breeding strategies to maintain oil quality under changing climatic conditions. From a practical standpoint, high-oleic cultivars like Brantley are recommended for oil extraction and industrial processing in all three locations due to their superior oxidative stability and extended shelf life. Halisbey, with its high oil content, is ideal for oil production, while cultivars like Flower-22, with higher linoleic acid content, may be better suited

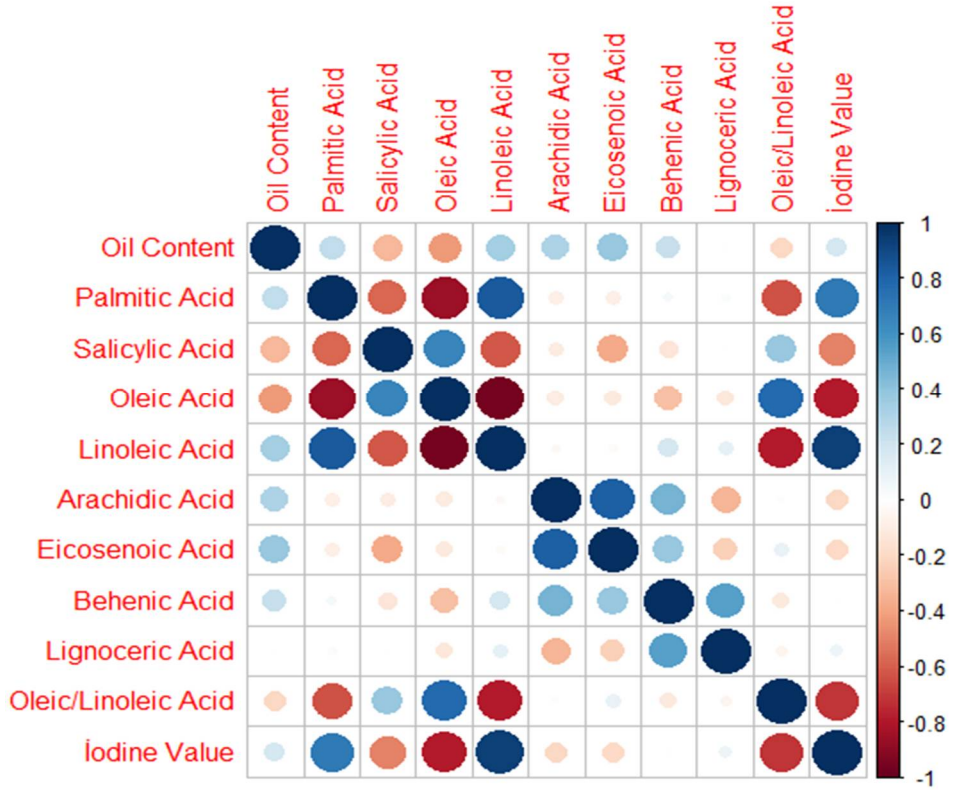

Fig. 2. Correlation coefficients among the fatty acid compositions, oil content, oleic/linoleic acid and iodine value.

for nutritional applications or markets preferring oils rich in essential fatty acids. Location-specific recommendations include prioritizing high-oleic cultivars in warmer regions like Adana and Osmaniye to maximize oil stability, while in cooler regions like Kahramanmaraş, cultivar selection should balance oil quality with yield considerations. As a result, the oil content, saturated and unsaturated fatty acid composition, oleic/linoleic ratio and iodine values that were evaluated in 10 different peanut varieties in three different locations for 2 years were affected by genotype and locations, genotype-location, genotype-year and genotype-location-year interaction variations were significant for all characteristics that were evaluated in the present study, and only stearic, eicosenoic and arachidic acid were not affected by locations. Adana and Kahramanmaraş produced higher oil content than Osmaniye. The oil content of peanut cultivars differed among 50.98-55.46%, with the highest oil content in the Halisbey variety and the lowest in the Batem-5025 variety. The varieties showed major differences in terms of saturated fatty acid contents. Palmitic, stearic, and behenic acids in peanut oil, which are predominant saturated fatty acids, varied between 7.03-11.02%, 2.67-3.94%, and 2.60-3.58%, respectively. The Flower-22 variety had the highest palmitic acid content, and the Brantley variety had the highest stearic acid content. Osmaniye came to the forefront in terms of oleic acid content, and Kahramanmaraş came to the forefront in terms of linoleic acid content. The oleic acid content of peanut varieties varied between 46.04-69.85%, and the linoleic acid content varied between 9.89-31.44%. These two fatty acids (oleic and linoleic) are important unsaturated fatty acids in peanut oil. Brantley variety, which is a high oleic variety, had the highest oleic acid, O/L ratio, and lowest linoleic acid and

iodine value contents, while the Flower-22 variety had the highest linoleic acid and iodine value and the lowest oleic acid and O/L ratio. These findings provide valuable insights for cultivar selection and breeding programs aimed at optimizing peanut oil quality under Mediterranean climate conditions, particularly in the context of climate change.

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