Turkish Journal of FIELD CROPS

Turk J
Field Crops
2023, 28(2), 177-182
DOI: 10.17557/tjfc.1323673

DETERMINING OIL AND FATTY ACID PROFILES OF SELECTED SOYBEAN *(Glycine max L.)* CULTIVARS UNDER SECOND CROP CONDITION IN EAST MEDITERRANEAN AGROECOLOGY

Pinar CUBUKCU

Eastern Mediterranean Agricultural Research Institute, Adana, TURKEY
Corresponding author: pinar.cubukcu@tarimorman.gov.tr

Received: 06.07.2023

ABSTRACT

The objective of this study was to analyse the oil contents and composition of fatty acids (linolenic, stearic, oleic, palmitic and linoleic acids) of 20 distinct soybean (*Glycine max* L. Merrill) cultivars cultivated as the second crop in Cukurova Delta in the Mediterranean region of Turkey. Soybean cultivars Ilksoy, Traksoy maturity group II (MG: II), Atakisi, Arisoy, Cinsoy, Atem-7, Sa 88, Altinay, Asya, Bravo, Gapsoy, Kocaturk, Mitchell, Samsoy, Kristal, Umut-2002 (MG: III), Adasoy, ANP 2018, Nazlican, Lider (MG:3.8) were used. Field tests of this study were carried out in a randomized complete block design with three replications at the Eastern Mediterranean Agricultural Research Institute's Dogankent-Adana location in 2020-2021. Years, genotypes, and year x genotype interactions were all determined as significant in the variance analysis of the experiment's data. The fatty acid content of soybean cultivars varied between 10.00 and 12.64% for palmitic acid, 4.15 and 5.17% for stearic acid, 25.75 and 33.90% for oleic acid, 43.22 and 51.59% for linoleic acid, and 4.85 and 5.98% for linolenic acid, according to a 2-years average. Soybean cultivars' oil content ranged from 23.12 to 24.78 percent.

Keywords: Human nutrition, oil content, soybean, quality

INTRODUCTION

Soybean (Glycine max L.) is among the five crops dominating the world agriculture with maize, wheat, rice, and cotton (Karges et al., 2022). As the most widely grown oilseed crop in the globe, soybean is a significant source of food, animal feed and biodiesel (Ziegler et al., 2016). Seeds of soybean have an oil content of 18-24%, a protein content of 36-40%, a carbonhydrate content of 26-34% and a mineral content of 5-8% (Bakal et al., 2017; Gulluoglu et al., 2018; Ilker et al., 2018). In the planting season of 2021/22, soybean seed contributed to 67.9 % of the worldwide oil seed production. Also, in the 2021-2022 growing season, soybean oil accounted for 33.8% of the global vegetable sourced oil production (Ozcan, 2022). In addition to its use as a frying oil, salad dressing, and margarine, soybean oil is available in a wide range of uses such as ink, cosmetics, and biodiesel (Arıoglu, 2014).

The profiles of amino acids and fatty acids as well as the total oil and protein concentrations determine the quality of soybeans. Numerous QTL linked to fatty acids have been discovered. Attempts targeting to alter the seed nutrients of soybean seeds have been limited by the complex genetical architecture of quality attributes (Dubois et al., 2007). Past studies have discovered 221 and 304 QTL (quantitative trait loci) controlling seed oil and protein ratios in soybean respectively, using distinct population types and different mapping methodologies. They displayed pleiotropic effects in several cases (Akond et al., 2014; Zhang et al., 2018; Lee et al., 2019).

A major objective of soybean breeders is to improve the seed composition of soybeans for protein and oil quality. Protein and oil have traditionally been the main soybean seed quality attributes of interest, but in recent years, demand for modified fatty acid components for biofuel and human consumption, has increased significantly (Canakci and Kahyaoglu, 2012; Karges et al., 2022). As a result of interactions between various the environment and genes, oil and protein contents are polygenic quantitative features (Akond et al., 2014). Because soybean oil has a relatively short shelf life, it has become an important breeding objective to develop cultivars with modified oils that have higher oleic acid and lower linolenic acid (Reinprecht and Pauls, 2016).

Farno (2005) claims that soybean oil contains 14 fatty acids, of which five are necessary for optimal human nutrition and must be consumed in the diet. These five essential fatty acids (linolenic [C18:3], stearic [C18:0], palmitic [C16:0], oleic [C18:1], and linoleic [C18:2]) are widespread in vegetable oil and account for more than 98% of the fatty acids of soybean oil (Cakmakci and Kahyaoglu, 2012).

Both unsaturated and saturated fatty acids exist in soybean oil. Major unsaturated fatty acids (84%) are oleic acid, linoleic acid and linolenic acid, while the main saturated fatty acids (16%) are palmitic and stearic acids. For human consumption, soybean oil with increased contents of monounsaturated fatty acids (24%) like oleic acid and polyunsaturated fatty acids (60%) like linolenic and linoleic are preferable versus saturated fatty acids (Bellaloui et al., 2013).

Linoleic acids and linolenic acids are two major unsaturated fatty acids, comprising about 84% of the fatty acid composition. These fatty acids diminish cardiovascular disease risk. Linoleic is the best polyunsaturated fatty acid for avoiding cardiovascular disease and decreasing serum cholesterol, according to studies (Mzimbiri et al., 2014). Higher oleic acid ratios and lower linoleic acid and linolenic acid ratios are preferred because they improve the oil stability. Soybean oil's high ratio of polyunsaturated fatty acids makes it unsuitable for use in industries. Studies on fatty acid composition are essential for enhancing the soybean oil quality and stability (Abdelghany et al., 2020).

Genetics (cultivar and maturity genes) and environmental conditions, particularly drought stress and heat/temperature stress, as well as interactions, have been observed to have an effect on the oil content and composition (individual fatty acids) in soybean. Although the exact mechanism by which genetics and environment influence the oil level stability and composition is still not known, under such conditions, changes in oil ratio and composition was determined. It was claimed that seeds grown at higher temperatures had higher oleic acid concentrations but lower linolenic acid and linoleic acid concentrations. The development of germplasm and crops with desired fatty acid composition may use soybean genotypes with stable oleic and linolenic acids across environmental gradients (Bellaloui et al., 2013).

Oil contents and fatty acids development have been affected by the environment and seed-filling stage is the most critical growth and temperature is the primary factor as an environmental influence (Farno, 2005).

Many cultivated crop species have experienced genetic erosion as a result of modern plant breeding. Future improvements to traits of interest should be greatly facilitated by the identification of useful genetic diversity. As an example, the USDA Soybean Germplasm Collection currently has access to almost 20 thousands introduced accessions of the *Glycine* genus, but only a small number of these accessions were subject to extensive testing for seed composition traits (Lee et al., 2019).

In addition to containing a low amount of saturated fat, one of the major important trait that distinguishes soybean from other legumes is that it contains high protein, dietary fiber and isoflavones. In Turkiye, there was an increase in the use of soybean products as feed and food in recent years. However, the basis of the breeding programs still is to improve cultivars with high yields. Studies of improvement of oil and fatty acid compositions should be started as soon as possible. Soybean breeders concentrate on cultivars with improved oil characteristics, such as higher oleic, linoleic, or linolenic acids for human needs. Soybean cultivars that have been registered in Turkey must first have their fatty acid profiles determined in order to develop germplasm resources. Therefore, the aim of this study was to determine the oil contents and fatty acid composition of several soybean cultivars widely cropped in Turkey as a second crop.

MATERIALS AND METHODS

Experimental Materials

Indeterminate soybean [*Glycine max* (L.) Merr] cultivars such as "Ilksoy, Traksoy (MG: II), Atakisi, Arisoy, Cinsoy, Atem-7, Sa 88, Altinay, Asya, Bravo, Gapsoy, Kocaturk, Mitchell, Samsoy, Kristal, Umut-2002 (MG: III), Adasoy, ANP 2018, Nazlican, Lider (MG:3.8)" were plant material used in this research.

Soil and Climate Characteristics

The soil has a clay loam texture. Both years' soil testing revealed a pH of 7.9, with high K_2O concentrations (859 kg ha^{-1}) and low P_2O_5 values (26.6 kg ha^{-1}). Furthermore, the soil's organic matter and nitrogen concentration were quite low.

Table 1. The climate data during the 2020-2021 growing period and long term (LT) average temperature (1982-2019) precipititation (mm) and relative humidity (%)

Months	Average Temperature (°C)			Precipitation (mm)			Relative Humidity (%)		
	2020	2021	L.T	2020	2021	L.T.	2020	2021	L.T
June	24.12	26.88	25.2	2.3	-	14.0	81.77	65.76	69.0
July	28.29	29.02	27.1	-	3.1	7.5	85.63	66.84	69.9
August	28.31	29.00	27.6	-	2.9	5.7	80.18	65.13	69.6
September	27.71	25.14	25.1	0.1	33.6	15.2	84.93	64.76	64.7
October	22.58	20.70	20.5	-	1.1	43.9	65.34	53.07	60.8

During the research period (June-October), the average monthly air temperature ranged from 22.58 °C to 28.31 °C in 2020 and from 20.70 °C to 29.02 °C in 2021. The total amount of rainfall in the growing seasons of 2020 and 2021 was 2.4 mm and 40.7 mm, respectively. In 2020, the average relative humidity ranged from 65.34% to 85.63%,

while in 2021, it ranged from 53.07% to 66.84%. The relative humidity in 2020 was greater than in 2021 and more than the long-term average (Table 1).

Method

Experiments were carried out in 2020 and 2021 years as a second crop condition at the Eastern Anatolian Agricultural Research Institute research area in Adana, Turkey (Southern Turkey, 36°51'N, 35°20' E). Randomised Complete Block Design with three replications was used for the trial's design. The planting date was June 16, 2020 and June 22, 2021. Before sowing in the 2020-2021 growing seasons, 150 kg ha-1 of DAP (27 kg ha^{-1} N, 69 kg ha^{-1} P) fertilisers were applied, and all seeds were infected with the *Bradyrhizobium japonicum* bacteria. Cultivars were planted in 5m long plots with 4 rows in each plot. Row spacing was 70 cm. At maturity, 0.5 m from both ends of the rows as well as the two side rows were left out as side effects. When seed moisture was reduced by 13% in both years, seeds of each cultivar were harvested separately by combined harvest equipment. Harvesting dates were October 27, 2020 and October 6, 2021.

Using "Soxhlet equipment," the oil was extracted from the soybean seeds, and the AOAC (Association of Official Analytical Chemists) standards were used to calculate the oil percentage. The fatty acid composition of soybean oils were analyzed using Gas Chromatograph equipment in accordance with the AOAC (AOAC, 2010).

The data were analyzed statistically by using the SPSS software package in the Randomized Complete Block Design. The LSD (Least Significant Differences) test was applied for the comparison of the treatments at the 0.05 level (IBM, 2020).

RESULTS AND DISCUSSION

According to two-years average results, the data were analyzed by using year and cultivar factors. In Table 2, the variance analysis of the study's findings is presented. Table 2 shows that for a two-year average, the year, cultivar, and year x cultivar factors were statistically significant for whole analysed characters.

Table 2. The F-values of the variance components of the investigated characteristics of soybean varieties grown in the field trial combined over two-years

Source of Variations	Df	Oil Content	Palmitic Acid	Steraic Acid	Oleic Acid	Linoleic Acid	Linolenic Acid
Year (Y)	1	**	**	**	**	**	**
Variety (V)	19	**	**	**	**	**	**
Y x V	19	**	**	**	**	**	**

Df: Degree of freedom, **:p<0.01; *:p<0.05.

Oil Content

Statistically significant differences observed between soybean cultivar oil percentages in 2020 and 2021 (Table 3). Table 3 displays the average data on the oil content for different soybean cultivars. The mean of oil content of soybean cultivars was 24.72 % in 2020, but decreased to 23.32% in 2021.

Table 3. Oil content, palmitic and stearic acids percentage of soybean varieties in 2020, 2021 and average of two years

	Oil content (%)			Palmitic acid (%)			Stearic acid (%)		
Varieties	**2020**	**2021**	**Average**	**2020**	**2021**	**Average**	**2020**	**2021**	**Average**
Adasoy	25.22a	23.39a-f	24.30a-c	10.84g-ı	11.65ab	11.25b-d	4.28f	4.25de	4.27e-g
Altinay	24.76a	24.80a	24.78a	11.33c-h	11.59ab	11.46b-d	4.44d-f	4.16de	4.30d-g
ANP 2018	24.40a	23.83a-e	24.11a-c	12.06bc	11.68ab	11.87b	4.39d-f	3.91e	4.15g
Arisoy	24.69a	24.16a-c	24.42ab	10.61hı	10.03c	10.32f	4.23f	4.10de	4.17g
Asya	24.06a	23.97a-d	24.02a-c	13.16a	12.12a	12.64a	4.56b-f	4.63a-d	4.60c-e
Ataem-7	24.72a	22.43ef	23.58a-c	10.86f-ı	10.89a-c	10.87d-f	4.29f	4.22de	4.26e-g
Atakisi	24.72a	23.11b-f	23.91a-c	10.51ı	10.44bc	10.48ef	4.31ef	4.12de	4.22fg
Bravo	23.86a	23.25b-f	23.56a-c	10.93f-ı	11.08a-c	11.00c-f	4.95a-c	4.27de	4.61c-e
Cinsoy	24.97a	23.01c-f	23.99a-c	11.21dı	11.26a-c	11.23b-d	4.51c-f	4.15de	4.33d-g
Gapsoy	24.89a	22.03f	23.46bc	11.10e-ı	11.21a-c	11.15b-e	4.80a-e	4.49b-e	4.65cd
Kocaturk	25.16a	23.75a-e	24.45ab	11.11e-ı	11.43ab	11.27b-d	4.87a-d	4.31c-e	4.59c-f
Lider	24.59a	24.47ab	24.53ab	11.01f-ı	10.98a-c	10.00d-f	4.84a-d	4.32c-e	4.58c-f
Mitchell	25.57a	23.48a-e	24.53ab	11.84b-e	11.62ab	11.73bc	5.01ab	5.03ab	5.02ab
Nazlican	23.62a	22.63d-f	23.13c	11.60c-g	10.68bc	11.14b-e	4.41d-f	4.25de	4.33d-g
Sa 88	23.78a	22.44ef	23.11c	10.01f-ı	11.04a-c	11.02c-f	4.55b-f	4.89a-c	4.72bc
Samsoy	25.10a	22.82c-f	23.96a-c	11.23d-ı	11.64ab	11.44b-d	4.58b-f	4.14de	4.36c-g
Kristal	25.40a	23.52a-e	24.46ab	11.62c-f	11.45ab	11.54b-d	5.11a	5.23a	5.17a
Traksoy	25.08a	23.26b-f	24.17a-c	11.48c-g	11.49ab	11.48b-d	4.30f	4.05de	4.18g
Umut 2002	24.97a	23.15bf	24.06a-c	11.94b-d	11.60ab	11.77b	4.66a-f	4.23de	4.44c-g
Ilksoy	24.82a	22.96c-f	23.89a-c	12.39b	11.31a-c	11.85b	4.94a-c	4.50b-e	4.72bc
Mean	24.72	23.32	24.02	11.39	11.26	11.32	4.60	4.36	4.48
CV	2.89	1.97	2.49	2.16	3.75	3.06	3.47	4.46	3.92
LSD %5	2.21	1.42	1.3	0.76	1.31	0.73	0.49	0.60	0.37

In 2020 and 2021 the average oil ratios of soybean cultivars ranged from 23.62% to 25.57% and 22.03% to 24.80% respectively. The oil ratio means of the various soybean cultivars varied in 2020 (24.72%) compared to 2021 (23.32%). The average oil ratio of soybean cultivars was higher on average over two years. The oil content ranged from 23.11 to 24.78 % between the soybean cultivars, there was a statistically significant variation in oil content in 2020- 2021 and throughout a two-year period (Tables 2-3). The soybean cultivars Altinay (24.78%) and Sa88 (23.11%) had the greatest and lowest oil percentages respectively based on a two-year average. A significant interaction between the year and the cultivar of oil content was determined. The highest oil ratio was obtained from Mitchel (25.57%) and Kristal (25.40%) cultivars in 2020 and from Altinay (24.80%) and Lider (24.47%) in 2021.

The amount of oil percent is significantly influenced by the air temperature in September and October while seeds are being filled. The air temperature was higher in 2020 (27.71°C and 22.58°C) than in 2021 (25.14°C and 20.70°C) (Table 1). According to other researchers, high air temperatures especially during the pod-filling period enhanced the seed oil content of certain soybean cultivars (Wolf et al., 1982; Farno. 2005; Dombos and Mullen. 1992; 1996; Kane et al., 1997; Bellaloui et al., 2011; 2015).

Palmitic and Stearic Acids Contents

In Table 3, the average data on the ratios of palmitic and stearic acids in the different soybean cultivars is shown. The average ratios of palmitic and stearic acids in various soybean cultivars were 11.39% and 4.60% in 2020 and 11.26% and 4.36% in the growing season of 2021 respectively according to this data. For the ratios of palmitic and stearic acids there were statistically significant variances between the years (Table 2). The average palmitic and stearic acids percentage was higher in 2020 (11.39% and 4.60%) than in 2021 (11.26% and 4.36%) due to higher air temperature in 2020 than in 2021.

The palmitic acid ratios in soybean cultivars ranged from 10.01-13.16% in 2020 to 10.03-12.12% in 2021 with a two-year average of 10.00-12.64%. There was a significant shift in palmitic acid ratios between soybean cultivars in 2020-2021, and the two-year average. Means of palmitic acid percentages in soybean cultivars averaged 11.39% in 2020 and 11.26% in 2021 (Table 3). Palmitic acid content was highest in Asya (12.64%) and lowest in Lider (10.00%) soybean cultivars based on two-years average.

The contents of stearic acid in soybean cultivars varied from 4.23 to 5.11% in 2020. 3.91 to 5.23% in 2021 and 4.15 to 5.17% on average of two years (Table 3). In 2020- 2021 and a 2-years average differences in stearic acid % among soybean cultivars were statistically significant. In 2020-2021 and for two-year average the mean of stearic acid content of soybean cultivars were 4.60%, 4.36% and 4.48%. The highest and lowest stearic acid percentages were found in the soybean cultivars Kristal (5.17%) and ANP 2018 (4.15%) respectively over a two-year average.

For palmitic and stearic acid the interaction between year and cultivar was found to be significant. The max palmitic ratio was obtained from Asya (13.16% and 12.12%) and stearic acid was obtained from Kristal (5.11% and 5.23%) cultivars in both years.

Soybean oils have a variable fatty acid content. According to Cherry et al. (1985) the genotypic and environmental effects on the fatty acid composition of soybean seeds were both significant. The genotypes were the source of the variations in the ratios of palmitic acid and stearic acid. The constituents of soybean seed composition are genetically controlled. According to Wilcox and Cavins (1995), depending on genotypes and growth conditions, the palmitic acid concentration of soybean cultivars ranged from 10.01 to 13.00%. and the stearic level ranged from 2.20 to 8.25% (Copur et al., 2009; Eren et al., 2012; Arioglu et al., 2012; Bellaloui et al., 2013; Bakal et al., 2017; Gulluoglu et al., 2018; Golukcu et al. 2019; Abdelghany et al., 2020; Kaya, 2020; Ozturk et al., 2021).

Oleic, Linoleic and Linolenic Acids Contents

The averages of oleic, linoleic and linolenic acids ratios of soybean cultivars in 2020-2021 and two years average has been presented in Table 4. The differences between the years of soybean cultivars were statistically significant for the oleic, linoleic and linolenic acids percentages in 2020-2021 and 2-years average in Table 2.

The means of oleic acid percentage of soybean cultivars was 31.97% and 27.24%, linoleic acid was 45.59% and 49.54% and linolenic acid was 5.03% and 5.97% in 2020 and 2021 respectively. The means of oleic acid percentage of soybean cultivars was higher in 2020 compared to 2021; linoleic and linolenic acids were lower in 2020 than in 2021 (Table 4). According to Wolf et al. (1982), temperature had a significant impact on the composition of fatty acids. As the temperature ascended, linolenic and linoleic acid significantly dropped while oleic acid ratio increased. High air temperature during seed filling reduces linolenic acid ratio. The soybean genotype interacts with the environment to produce oil with low linolenic acid levels. As a result, during the seed-filling stage, oil quality and content change in reaction to air temperature (Gibson and Mullen, 1966; Dombos and Mullen, 1992).

The differences between the soybean cultivars were statistically significant for the oleic, linoleic and linolenic acids percentages in 2020-2021 and two years averages (Table 2- 4). The interaction between the year and cultivar of the oleic acid content was found statistically significant. The oleic acid percentage of soybean cultivars varied between 27.41-39.34% in 2020, between 23.57-31.33% in 2021 and 25.75-33.90% in 2-years average. The highest oleic acid percentage was obtained from Gapsoy (39.34%) and Ilksoy (31.33%) cultivars in 2020 and 2021 respectively. According to 2-years average, the highest oleic acid ratio was obtained from Gapsoy (33.90%) and the lowest from Asya (25.75%) among the tested soybean cultivars (Table 4).

Table 4. Oleic, linoleic and linolenic acids percentage of soybean varieties in 2020- 2021 and average of two years

	Oleic acid (%)			Linoleic acid (%)			Linolenic acid%		
Varieties	**2020**	**2021**	**Average**	**2020**	**2021**	**Average**	**2020**	**2021**	**Average**
Adasoy	29.94c-e	27.39a-d	28.66d-h	47.48a-c	49.22b-e	48.35b-e	5.47ab	6.17a	5.82ab
Altinay	28.12de	24.48cd	26.30gh	49.35a	51.53a-c	50.44a-c	5.37a-c	6.59a	5.98a
ANP 2018	29.68de	27.52a-d	28.60d-h	47.60a-c	48.78b-e	48.19b-e	5.26a-e	6.19ab	5.73a-c
Arisoy	30.02c-e	23.57d	26.80f-h	48.59ab	54.59a	51.59a	5.10a-h	6.35ab	5.72a-c
Asya	27.41e	24.10d	25.75h	47.84a-c	51.39a-c	49.62a-d	5.22a-e	6.33ab	5.78a-c
Ataem-7	30.76c-e	24.58cd	27.67e-h	47.23a-c	54.41a	50.82ab	5.14a-g	6.50a-c	5.82ab
Atakisi	29.92de	25.34b-c	27.63e-h	48.28ab	52.17ab	50.23a-c	5.46ab	6.48a-c	5.97a
Bravo	32.31be	29.29a-c	30.80a-e	45.60a-e	47.44b-e	46.52d-h	5.22a-e	5.59a-c	5.41a-f
Cinsoy	30.76c-e	25.85b-c	28.31d-h	46.83a-c	50.66a-d	48.75a-e	5.48a	5.97a-c	5.72a-c
Gapsoy	39.34a	28.45a-d	33.90a	38.57g	47.87b-e	43.22ı	4.46h	6.22a-d	5.34b-f
Kocaturk	29.91de	26.12b-c	28.02d-h	47.80a-c	49.73a-e	48.77a-e	5.28a-d	6.23a-d	5.76a-c
Lider	32.41b-d	29.79ab	31.10a-d	45.87a-d	47.64b-e	46.76d-h	4.82b-h	5.27a-d	5.04ef
Mitchell	34.21bc	27.12a-d	30.67a-e	42.64d-f	49.00be	45.82e-ı	4.62e-h	5.75a-d	5.19cb-f
Nazlican	32.13b-e	26.84a-d	29.48c-g	45.07b-f	50.45a-e	47.76b-f	5.06a-h	6.22a-d	5.64a-e
Sa 88	32.42b-d	26.93a-d	29.67b-f	44.95b-f	49.70a-e	47.32c-g	5.19a-f	6.18a-d	5.68a-d
Samsoy	35.85a	29.83ab	32.84ab	41.67e-g	46.92c-e	44.29g-ı	4.70d-h	5.50a-d	5.10d-f
Kristal	35.74a	29.86ab	32.80ab	41.03fg	46.30de	43.67hı	4.73c-h	5.79b-d	5.26b-f
Traksoy	31.90be	28.20a-d	30.05b-f	46.39a-d	49.21b-e	47.80b-f	4.51gh	5.22cd	4.87f
Umut 2002	32.31be	28.35a-d	30.33b-e	44.96b-f	48.23b-e	46.60d-h	4.97a-h	5.71cd	5.34b-f
Ilksoy	34.20bc	31.33a	32.76a-c	44.01c-f	45.67e	44.84f-ı	4.53f-g	5.17d	4.85f
Mean	31.97	27.24	29.60	45.59	49.54	47.56	5.03	5.97	5.50
CV	4.31	5.78	5.25	2.88	3.23	3.13	4.22	5.5	5.19
LSD %5	4.27	4.88	3.29	4.06	4.95	3.16	0.65	1.02	0.6

The linoleic acid percentage of soybean cultivars varied between 38.57-49.35% in 2020, 45.67-54.59% in 2021 and 43.22-51.59% in two-years average. The linolenic acid percentage of soybean cultivars varied between 4.46-5.48% in 2020, between 5.17-6.59% in 2021 and between 4.85-5.98% in a 2-years average. According to a two-year average, the highest linoleic and linolenic acids percentage was obtained from Arisoy (51.59%) and Altinay (5.98%), and the lowest from Gapsoy (43.22%) and Ilksoy (4.85%) soybean cultivars respectively. The variation in the oleic, linoleic, and linolenic acid compositions of the cultivars is related to genetic variances. It was determined that the interaction between year and cultivar was statistically significant for linoleic and linolenic acid %. The highest linoleic acid percentage was obtained from Altinay (49.35%) and Arisoy (54.59%), linolenic acid was obtained from Cinsoy (5.48%) and Altinay (6.59%) cultivars in 2020 and 2021 respectively. Gulluoglu et al. (2018) revealed that the fatty acid composition of soybean cultivars ranged from 10.76-12.23% for palmitic acid, 22.69-29.51% for oleic acid, 3.94-4.87% for stearic acid, 5.41-6.62% for linolenic acid and 48.40-54.14 for linoleic acid in double crop growing season. Many researchers reported that the oleic acids, linoleic acids and linolenic acids content values of soybean cultivars in different maturity groups ranged from 19.73% to 29.58% from 47.54% to 56.47% and from 3.66% to 9.55% respectively (Cherry et al., 1985; Kane et al., 1997; Wilson, 2004; Copur et al., 2009; Eren et al., 2012; Arioglu et al., 2012; Bellaloui et al., 2013; Arioglu, 2014; Bakal et al., 2017; Golukcu et al., 2019; Abdelghany et al., 2020; Kaya, 2020 and Ozturk et al., 2021).

CONCLUSIONS

The study's findings showed that soybean cultivars differ significantly in terms of their oil content and fatty acid compositions. Based on two-year average, the fatty acids composition of soybean cultivars ranged from 10.00% to 12.64% for palmitic acid, from 4.15% to 5.17% for stearic acid, from 25.75% to 33.90% for oleic acid, from 43.22% to 51.59% for linoleic and from 4.85% to 5.98% for linolenic acid in second cropped growing conditions. The oil content of different soybean cultivars ranged from 23.11-24.78% based on a two-year average. In September and October, when seeds were being filled, the air temperature was greater in 2020 than the same period in 2021. The air temperature has a significant impact on the oil content and fatty acid composition of different soybean cultivars. High air temperature during the seed filling phase reduces the content of linolenic and linoleic acids, although oil content, palmitic, stearic and oleic acids percentage increased with rising temperature. The findings will aid breeders in choosing cultivars with desirable characteristics. The results in this study indicated that Turkey's germplasm can deliver the right amounts of seed oil and fatty acid content to meet the dietary requirements of a cultivar of consumers.

ACKNOWLEDGMENT

I am thankful to staff of the Eastern Mediterranean Agricultural Research Institute for their help in the field and laboratory work.

LITERATURE CITED

Abdelghany, A.M., S. Zhang, M. Azam, A.S. Shaibu, Y. Feng, J. Qi, Y. Li, Y. Tian, H. Hong, B. Li and J. Sun. 2020. Natural variation in fatty acid composition of divers world soybean germplasm grown in China. Agronomy. 10(24):1-18.

Akond, M., S. Liu, M. Boney, S. K. Kantartzi, K. Meksem, N. Bellalou and M. A. Kassem. 2014. Identification of quantitative trait loci (QTL) underlying protein, oil, and five

major fatty acids' contents in soybean. American Journal of Plant Sciences. 15 (1):1-12.

AOAC. 2010. Official Methods of Analysis of the Association of Analytical Chemists. 18th edition. Washington. D.C. USA.

Arioglu, H., S. Ozyurtseven and L. Gulluoglu. 2012. Determination of oil yield and fatty acid contents of some soybean [Glycine max (L.) Merr] varieties grown under second crop conditions-II. Çukurova University Faculty of Agriculture Journal. 27(2), 1-10 (in Turkish).

Arioglu, H.H. 2014. The oil seed crops growing and breeding. The Publication of University of Cukurova. Faculty of Agriculture. No: A-70. 204 p.

Bakal, H., L. Gulluoglu, F.B. Zaimoglu Onat and H. Arioglu. 2017. The effect of growing seasons on some agronomic and quality characteristics of soybean varieties in Mediterranean Region in Turkey. Turkish Journal of Field Crops 22 (2):187-196.

Bellaloui, N., K.N. Reddy, A.M. Gillen, D.K. Fisher and A. Mengistu. 2011. Influence of planting date on seed protein. Oil, sugars, minerals and nitrogen metabolism in soybean under irrigated and non-irrigated environments. American J. of Plant Science 2(5):702-705.

Bellaloui, N., A.M. Mengistu and M.A. Kassem. 2013. Effects of genetics and environment on fatty acid stability in soybean seed. Food and Nutrition Sciences 4:165-175.

Bellaloui, N., H.A. Bruns, H.K. Abbas, A. Mengistu, D.K. Fisher and K.N. Reddy. 2015. Agricultural practices altered soybean seed protein. Oil. Fatty Acids. Sugars and Minerals in the Mid-south USA. Front Plant Science 6:31. Doi: 10.3389/fpls.2015.00031.

Canakci, S. and D.T. Kahyaoglu. 2012. An overview of the effects of fatty acids on health and nutrition. Academic Food. 10(1):103-113 (in Turkish).

Cherry, J.H., L. Bishop and P.M. Hasegawa. 1985. Differences in fatty acid composition of soybean seed produced in North and Southern Areas of USA. Polytochemistry. 24(2):237-241.

Copur, O., M.A. Gur, U. Demirel and M. Karakus. 2009. Performance of some soybean [*Glycine Max*. (L.) Merr.] genotypes double cropped in semi-arid conditions. Not. Bot. Hort. Agrobot. Cluj. 37(2): 85-91.

Dombos, D.L. and R.E. Mullen. 1992. Soybean seed protein and oil contents and fatty acid composition adjustments by drought and temperature. J. of the American Oil Chemists Society (JAOCS).69(3): 228-231.

Dubois, V., S. Breton, M. Linder, J. Fanni and M. Parmentier. 2007. Fatty acid profils of 80 vegetable oils with regard to their nutritional potential. Eur. J. Lipid Sci. Technol. 109:710-732.

Eren, A., M. Kocaturk, E.Z. Hosgun and N. Azcan. 2012. Determination of seed yield, oil-protein and fatty acid contents and the relationships between them in some soybean lines and varieties. SDU Faculty of Agriculture Journal. 7(1):1-9 (in Turkish).

Farno, L.A. 2005. Oil and Fatty Acid Profiles of Soybean (Maturity Groups IV. V and VI). Ph.D Thesis. Oklahoma State University. Faculty of Graduate College. Stillwater. Oklahoma-USA. 42p.

Gibson, L.R. and R.E. Mullen. 1996. Soybean seed composition under high day and night growth temperature. J. of the American Oil Chemists' Society (JAOCS) 73(6):733-737.

Golukcu, M., H. Tokgoz and M. Kocaturk. 2019. Investigation of oil content and fatty acid compositions of some soybean varieties and lines. Mediterranean Journal of Agriculture. 8(2):283-290 (in Turkish).

Gulluoglu, L., H. Bakal and H.H Arioglu. 2018. Oil content and composition of soybean genotypes grown in different growing seasons under Mediterranean conditions. Journal of Environmental Biology. 39(2):211-215.

IBM: SPSS Software (Version 25.0). 2020. https://www.ibm.com/analitics/spss-statistic-software

Ilker, E., M. Kocaturk, A. Kadiroglu, A. Yildirim, G. Ozturk, H. Yildiz, I. Koken. 2018. Adaptation Abilities and Quality Parameters of Selected Soybean Lines Under Double Cropping in The Mediterranean Region. Turkish Journal of Field Crops 23(1): 49-55.

Kane, M.V., C.C. Steel, L. Grabau, C.T. Mac Kown and D.F. Hildebrand. 1997. Early-maturing soybean cropping system: III. Protein and oil contents and oil composition. Agron. J. 89(3):464-469.

Karges, K., S. Bellingrath-Kimura, D. Watson, C. A. Stoddard, F. L. Halwani and M. Reckling. 2022. Agro-economic prospects for expanding soybean production beyond its current northerly limit in Europe. European Journal of Agronomy. 133. 126415.

Kaya, A.R. 2020. Determination of important quality characteristics of some soybean (*Glycine max.* (L.) Merill) varieties grown as main crops. KSÜ Agriculture and Nature Journal.23(4):1012-1020 (in Turkish).

Lee, S., K. Van, M. Sung, R. Nelson, J. LaMantia, L. K. McHale and M.R. Mian. 2019. Genome-wide association study of seed protein. oil and amino acid contents in soybean from maturity groups I to IV. Theoretical and Applied Genetics. 132. 1639-1659.

Mzimbiri, R., A.M. Shi, H. Liu and Q. Wang. 2014. A reviwer: peanut fatty acids determination using hyper spectroscopy imagine and its significance on food quality and safety. Food Science and Quality Management. 28:90-97.

Ozturk, F., F. Kızılgecit and A.K. Elcin. 2021. Investigation of the possibilities of growing soybean as a second crop under the conditions of Sırnak province. Turkish Journal of Nature and Science. 10(1):190-198 (in Turkish).

Ozcan, M. 2022. Product Report Soybean. Directorate of Agricultural Economics and Policy Development Institute. Ankara. 20s (in Turkish).

Reinprecht, Y. and K.P. Pauls. 2016. Microsomal omega-3 fatty acid desaturase genes in low linolenic acid soybean line RG10 and validation of major linolenic acid QTL. Frontiers in genetics. 7. 38.

Wilcox, J.R. and J.F. Cavin. 1995. Back crossing high seed protein to a soybean cultivar. Crop Science 35:1036-1041.

Wilson, R.F. 2004. Seed composition. Soybeans: improvement, production, and uses, 16p 621-677.

Wolf, R.B., J.F. Cavins, R. Kleiman and L.T. Black. 1982. Effect of temperature on soybean seed constituents: oil, protein, fatty acids, amino acids and sugars. J. of the American Oil Chemists' Society (JAOCS) 59(5):230-232

Zhang, J., X. Wang, Y. Lu, S. J. Bhusal, Q. Song, P. B. Cregan and G. L. Jiang. 2018. Genome-wide scan for seed composition provides insights into soybean quality improvement and the impacts of domestication and breeding. Molecular Plant. 11(3). 460-472.

Ziegler, V., L.J. Marini, C.D. Ferreira, I. A. Bertinetti, W.S.V. da Silva, J. T. S. Goebel and M. C Elias. 2016. Effects of temperature and moisture during semi-hermetic storage on the quality evaluation parameters of soybean grain and oil. Semina: Ciências Agrárias. 37(1):131-144.