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Determination of Oil Content and Fatty Acid Composition of Safflower (*Carthamus tinctorius* L.) Genotypes

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Abstract
This Research was conducted at the University of Ondokuz Mayıs, Faculty of Agriculture, Field Crops Department in 2017-2018. In the research; 28 safflower genotypes and 2 registered safflower varieties (Balcı and Dinçer) were used in 20 different countries selected from the World Safflower Gene Collection. The result of the research is that the oil content is between 23,39% - 40,87%; the ratio of saturated fatty acid is between 5.97% and 8.83%, the ratio of unsaturated fatty acid is between 91.09% and 94.03%; the ratio of oleic acid is 7,14-14,05%, the ratio of linoleic acid is 74,65 - 84,31%. With regard to the oil content and saturated and unsaturated fatty acids; genotype 12 of Egypt origin; in terms of oleic and linoleic acid content; Kazakhstan genotype 17 and standard Balcı varieties were found to be more suitable than the other genotypes evaluated in this research. Therefore, it may be suggested to use these genotypes as genitors in the development of suitable varieties in terms of oil content and fatty acid composition in Samsun ecological conditions.

Keywords: Safflower, Oil Content, Fatty Acid Composition

INTRODUCTION

One of the most important organic substances that form the basis of human health and nutrition is oil. In addition to being a high energy source for the human body, organic substances are also important for their ability to contain oil-soluble vitamins, combine with proteins to form lipoproteins, and take part in metabolic activities [1], [2]. Vegetable oils show significant differences according to the plant species and the ecological conditions they grow [3].

The physical and chemical properties of the oils, the proportions and composition of the fatty acids that make up a large part of the oil are determined [4]. In general, palmitic (C 16: 0) and stearic (C 18: 0) acids are found as saturated fatty acids while oleic (C 18: 1), linoleic (C18: 2) and linolenic unsaturated fatty acid. Safflower oil also contains trace amounts of arachidic acid and eicosanoic acid. Safflower seeds contain 13-46% crude oil. Approximately 90% of this fat is composed of oleic and linoleic unsaturated fatty acids [5], [6].

Geographical conditions, Turkey is a country that should be on the yield of oil crops and many can be easily grown in most of the world average. However, unsolved problems in agriculture and unplanned production and inadequate capital show itself in the production of oil plants [7]. As a result, every year in Turkey 1.000.000- oil consumption is 1.2 million tons vicinity and it can only be achieved from production of about 650 000 tones. The remainder is provided by imports from foreign countries, with billions of dollars being paid each year. Therefore, Turkey, the maximum amount of foreign currency after the power supply, pays for the oil and oilseed imports. To reduce dependency on outside vegetable oil consumption, high tolerance to drought conditions, high seed yield, which can be grown as summer and winter, such as safflower oil crops, need to increase the production amount of Turkey.

Safflower; due to its high tolerance to cold and hot, it is a cultivated plant with dryland areas, tolerance to salinity, and because of the competition of weeds, it has more advantages than other cultivated plants in irrigated areas and coastal areas [8].

In order to reduce dependence on imports could reach Turkey in terms of vegetable oil, all oil plants, must be integrated into the production system in Turkey. Safflower is a plant with potentially important in increasing the production of vegetable oil in Turkey. Thus, adaptation experiments of Safflower plants should be carried out in all regions of Turkey. As a result, it is necessary to develop varieties which are high in terms of seed yield and oil content and suitable for fatty acids composition in terms of quality of edible oil. This research was conducted for these purposes.

MATERIAL and METHOD

The field experiment was carried out in the experimental field of Ondokuz Mayıs University, Faculty of Agriculture, during the winter season of 2016-2017. The altitude of the research area is 120 meters. The land area of the experiment area is clayey, slightly acidic, unsalted and with little organic matter accumulation (Table 1). As the average of the growing season and long terms; in the research area, a total of 526 mm of precipitation has fallen during the experiment period, which is much lower than the precipitation values (577 mm) for long periods. However, during the growing season, the average monthly temperature (14.2 °C) was lower than the average of long periods (13.8 °C) and less than the monthly relative humidity (Table 2).

Table 1. Some physical and chemical properties of the research area

	Texture (%)	pH	$CaCO_3$ (%)	Organic matter (%)	Total Salt (mmhos/cm)	P_2O_5 (ppm)	K_2O (ppm)
Conclusion	47.45	7.00	1.22	2.71	0.052	293	10.34
Grade	Clays	Mild Acid	Lime	Less	Without salt	High	High

Table 2. The research site, the research season and some climate data for many years [9].

Months	Temperature (°C)		Precipitation (mm)		Relative Humidity (%)	
	2016-2017	Long Years	2016-2017	Long years	2016-2017	Long Years
November	14,3	12,4	28,6	83,5	56,5	68,9
December	8,4	9,3	100	79,6	62,5	65,7
January	6,2	7,2	78,8	64,9	60,1	66,4
February	7,5	7,2	40,1	53,3	58,5	68,9
March	9,4	8,2	65,1	61,6	71,3	74,5
April	10,2	11,3	85,8	58,7	73,4	78
May	15,3	15,5	70,9	51,5	75,6	79
June	20,9	20,1	45,1	48,1	71,9	74,5
July	24,3	23,1	0,4	34,3	64,8	72,3
August	25,9	23,5	11,3	41,5	65,1	72,1

In the research; "Balci and Dinçer safflower varieties used as standard with 28 safflower lines in World safflower Collection (Table 3). The field experiment was planted in 4 replicates according to the Latis Experimental Design, 1 m between blocks and parcel. Each genotype was planted 2 meters long, in the form of two rows, with a distance of 10 cm between the plants and 40 cm between the rows. The harvest was made in such a way that it would be separate for each line, at the stage of reaching full maturity. Oil content analysis from the seeds from each line was performed using the Ankom XT15 extractor [10]. Fatty acid analysis from the seeds of each line was performed using GC-MS [11]. The SPSS program was used to evaluate the data obtained from the study.

Table 3. Verification of Origin and IP Numbers of the Evaluated Safflower Genotypes

Genotypes No	IP	Origin	Genotypes No	IP	Origin
1	304503	Turkey	**16**	312275	Hungary
2	301055	Turkey	**17**	262444	Kazakhstan
3	304437	Iran	**18**	262447	Kazakhstan
4	405999	Iran	**19**	369850	Kazakhstan
5	380800	Iran	**20**	369853	Uzbekistan
6	250833	Iran	**21**	369847	Tajikistan
7	253895	Syria	**22**	259997	Pakistan
8	532619	Cyprus	**23**	401581	India
9	253531	Bulgaria	**24**	279342	Japan
10	251262	Jorden	**25**	537608	ABD
11	286199	Kuwait	**26**	560175	ABD
12	306602	Egypt	**27**	262437	Unknown
13	262442	Spain	**28**	262438	Unknown
14	253570	Portugal	**Dinçer**	Dinçer	Turkey
15	253522	Italy	**Balcı**	Balcı	Turkey

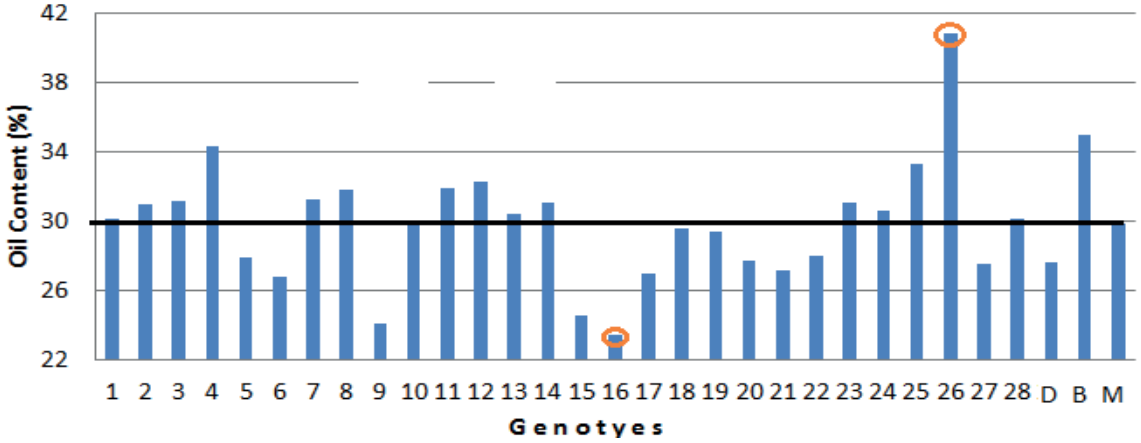
3. RESULTS and DISCUSSION

Oil Content

The data on the oil content obtained as a result of the research are given in Figure 1. As can be understood from the evaluation of Figure 1, the average oil content of the genotypes is 29.88%. The highest oil percentage was derived from the genotype of USA origin number 26 with 40.87% and the genotype number 16 from Hungary origin with the lowest oil content 23.39%. The oil content of 17 genotypes including 1, 2, 3, 4, 7, 8, 10, 11, 12, 13, 14, 23, 24, 25, 26, 28 and Balcı varieties was determined to be above the population average. On the other hand, only genotype 26 has been found to have higher oil content than the standard Balci variety.

Oil content; is a quantitative character under the influence of genetic factors and is predominantly under the control of environmental factors. When the previous researches are evaluated; oil content varied between 14.0% and 48.3% and had a wide variation [12] in this variation; genetic potentials of genotypes and adaptive abilities have significant influence. There was a significant negative correlation between oil yield and oil content and seed yield in the plant [13]. It has been determined that the oil content changes between 16.03% and 40.0% in Samsun ecological conditions [12] and in Ankara conditions it is 28.2-33.3% in winter sowing and 29.8-38.6% in summer sowing [14].

Figure 1. Distribution of oil contents of the genotypes evaluated in this research

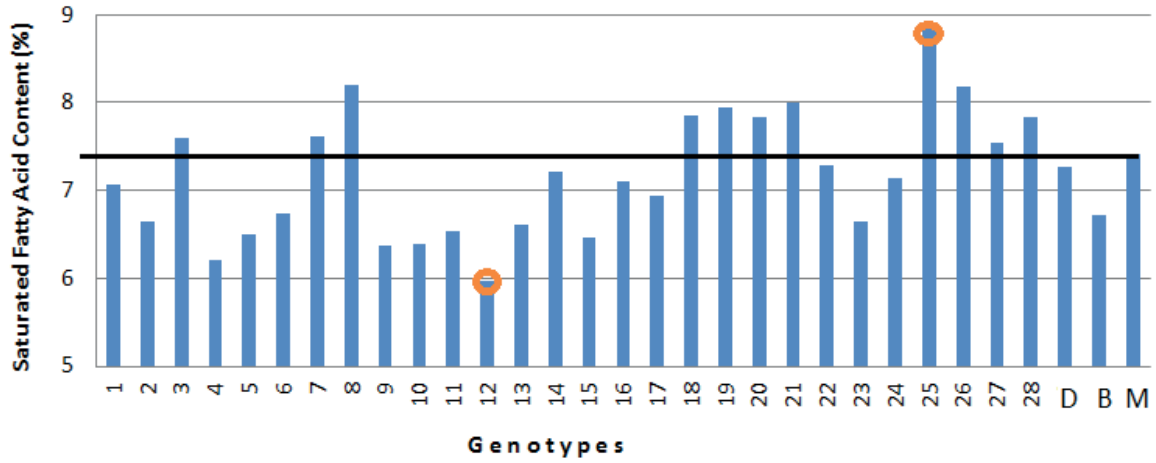


Saturated Fatty Acid Composition

The data on the saturated fatty acid composition obtained as a result of the research are given in Figure 2. As can be understood from the evaluation of Figure 2, the average saturated fatty acid content of the genotypes evaluated was 7.41%. The lowest saturated fatty acid content was obtained from Egypt genotype 12 with 5.97%, while the highest saturated fatty acid content was obtained from USA genotype 25 with 8.83%. The ratio of saturated fatty acids of 19 genotypes, 1, 2, 3, 5, 6, 9, 10, 11, 12, 13, 14, 15, 16, 17, 22, 23, 24, Dinçer and Balcı is below the population average.

When the previous researches are evaluated; the content of palmitic acid changed between 3.9-6.8% [5] and between 6.0-8.5% [15], the stearic acid content varied between 1.1-4.5% [5] and 2.0-3.1% [15]. The results of saturated fatty acids in this research are consistent with these previously reported results.

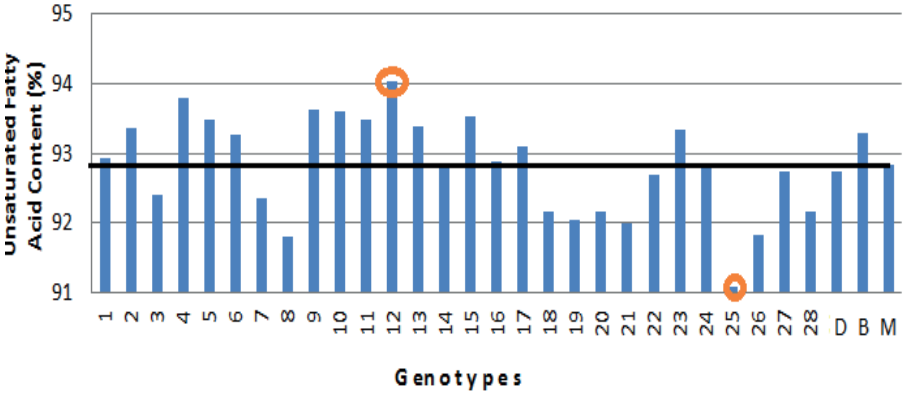
Figure 2. Distribution of saturated fatty acid contents of the genotypes evaluated in this research



Unsaturated Fatty Acid Composition

The data on the unsaturated fatty acid composition obtained as a result of the research are given in Figure 3. As can be understood from the evaluation of Figure 3, the average unsaturated fatty acid content of the genotypes evaluated was 92.83%. The highest unsaturated fatty acid content was obtained from Egypt genotype 12 with 94.03%, while the lowest unsaturated fatty acid content was obtained from USA genotype 25 with 91.09. The ratio of unsaturated fatty acids of 16 genotypes, 1, 2, 4, 5, 6, 9, 10, 11, 12, 13, 15, 16, 17, 23, 24 and Balcı is over the population average.

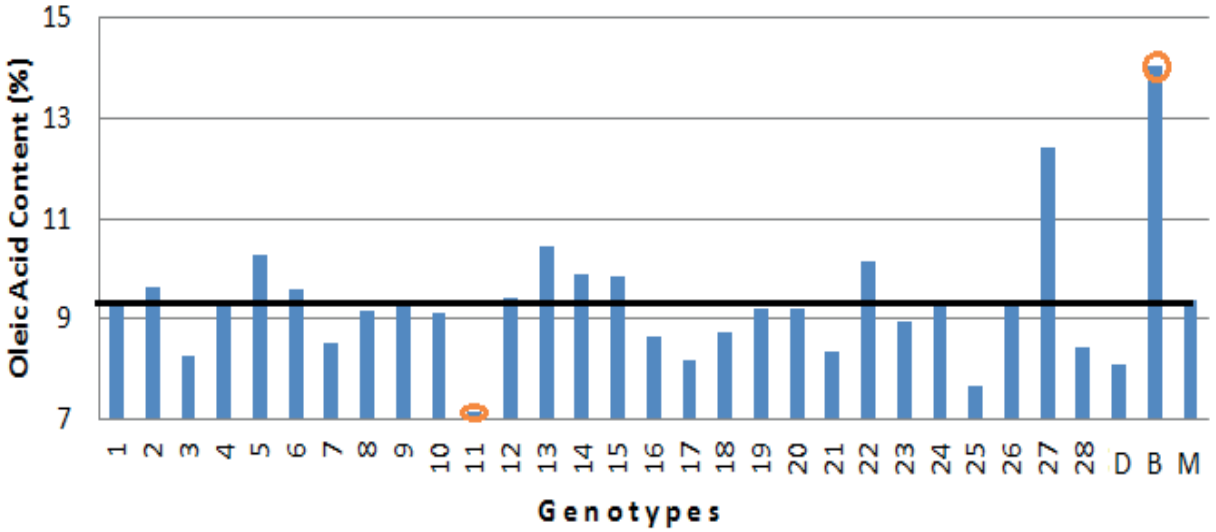
Figure 3. Distribution of unsaturated fatty acid contents of the genotypes evaluated in this research



The data on the oleic acid content obtained as a result of the research are given in Figure 4. As can be understood from the evaluation of Figure 4, the average oleic acid content of the genotypes evaluated was 9.36%. The highest oleic acid content was obtained from Turkey variety Balcı with 14.05%, while the lowest oleic acid content was obtained from Kuwait genotype 11 with 7.14%. The content of oleic acid of 12 genotypes, 1, 2, 5, 6, 9, 12, 13, 14, 15, 22, 27 and Balcı is over the population average.

When the previous researches are evaluated; the content of oleic acid changed between 6.2-81.9% [5]; 62.7-82.1% [16] and 7.8-30.6% [15]. The results of linoleic acid content in this research are consistent with these previously reported results.

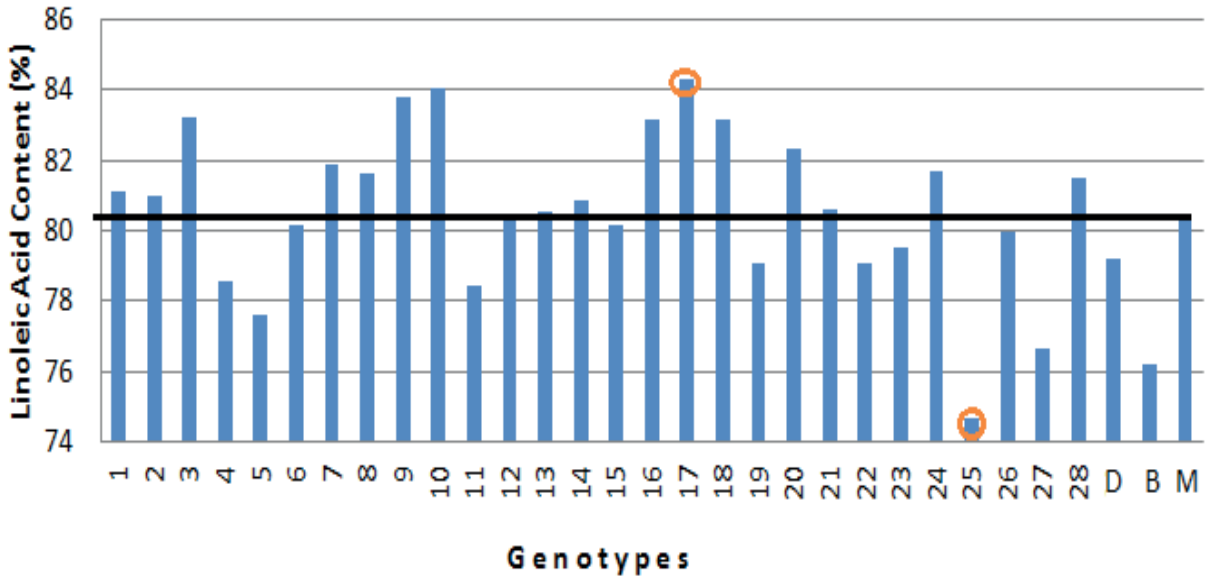
Figure 4. Distribution of oleic acid contents of the genotypes evaluated in this research



The data on the linoleic acid content obtained as a result of the research are given in Figure 5. As can be understood from the evaluation of Figure 5, the average linoleic acid content of the genotypes evaluated was 80.45%. The highest linoleic acid content was obtained from Kazakhstan genotype 17 with 84.13%, while the lowest linoleic acid content was obtained from USA genotype 25 with 74.65%. The content of linoleic acid of 17 genotypes, 1, 2, 3, 7, 8, 9, 10, 12, 13, 14, 16, 17, 18, 20, 21, 24 and 28 is over the population average.

When the previous researches are evaluated; the content of linoleic acid changed between 11.0-83.1% [5], 70.3-78.8% [16] and 60.0-81.6% [15]. The results of linoleic acid content in this research are consistent with these previously reported results.

Figure 5. Distribution of linoleic acid contents of the genotypes evaluated in this research



In previous studies; the effect of environmental conditions on oil ratio is high [17], the high temperature formed during the seedling ripening period affects the fatty acid composition [18] and there was a very high and negative correlation (-0.97) between oleic and linoleic acid [19], The results obtained from this research confirm the previously reported data.

4. CONCLUSION

In the 30 safflower genotypes evaluated; the highest oil content was obtained from the US genotype 26. The lowest saturated fatty acid content and the highest unsaturated fatty acid content were obtained from genotype 12 of origin of Egypt. The highest oleic acid content was obtained from the Balcı variety and the highest linoleic acid content was obtained from Kazakhstan origin genotype number 17. Research result; it was found that the content of linoleic acid among the fatty acids contained in the genotypes assessed was significantly higher than that of the other fatty acids. All of the genotypes assessed were found to have linoleic acid content higher than 70%. Therefore, it was determined that all the genotypes assessed in this study entered the linoleic type safflower group.

With regard to the oil content and saturated and unsaturated fatty acids; genotype 12 of Egypt origin; in terms of oleic and linoleic acid composition; Kazakhstan genotype 17 and standard Balcı varieties were found to be more suitable than the other genotypes evaluated in this research. Therefore, it may be suggested to use these genotypes as genitors in the development of suitable varieties in terms of oil content and fatty acid composition in Samsun ecological conditions.

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