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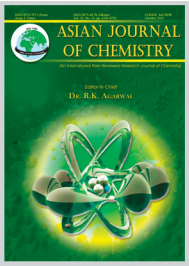

Determination of Saturated and Unsaturated Fatty Acids by Gas Chromatography in Linseed (*Linum usitatissimum* L.) Genotypes

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The aim of this study is to determine the saturated and unsaturated fatty acids in nine varieties of linseed oil genotypes (Atalanta, Raulinus, Maroc SM, Avangard, Antares, Sari-85, P-Kulu, P-Cihanbeyli and P-Halfeti) grown in different sowing times (April 6, April 16, April 26, May 6). The main fatty acid components of genotypes identified by gas chromatography were linolenic acid (51 %), linoleic acid (13 %), oleic acid (22 %), palmitic acid (6 %), stearic acid (7 %), palmitoleic acid (1 %) and myristic acid (0.041 %). The growth of linseed was highly affected by the sowing times. According to the results, oil rates of genotypes were in the range of 31-35 and 13 % of this ratio was saturated, 23 % was monounsaturated and 64 % polyunsaturated fatty acids. It was also found that delaying sowing times caused decrease in the amount of saturated and polyunsaturated fatty acids and increase in the amount of monounsaturated fatty acids.

Key Words: Linseed, Sowing times, Gas chromatography, Saturated and unsaturated fatty acids.

INTRODUCTION

Flax (*Linum usitatissimum* L.), belongs to the Linaceae family, which contains 9 genera and 150 species, is the only economically important plant species. Flax seed with its high oil content (30-45 %) can be used in edible and non-edible industrial oil production. The quality of oil depends upon its fatty acid composition which ultimately determines its utilization in industry[1]. Flax oil contains single and multiple unsaturated fatty acids in high proportion (90 %) and very low proportion of saturated fatty acids. Linolenic acid which makes up a high proportion of unsaturated fatty acids, is commonly used in manufacture of paints and varnishes[2]. While presence of the large amounts of unsaturated fatty acids increases the drying quality and the industrial quality of the oil, it reduces the edible oil quality[3,4]. Because the fatty acids that have two or more double bonds, cause the deterioration of oil and offensive smell in oil[5].

ω-3, ω-6 and ω-9 fatty acids found in the linseed oil are very important for nutrition and medical aspects ω-3 (α-linolenic acid = ALA) and ω-6 (linoleic acid = LA) are the most important basic (essential) fatty acids. Linoleic acid is one of the essential fatty acids, is more important than the other unsaturated fatty acids in human nutrition. This fatty acid can't be synthesized like the others so it has to be taken from outside. α-Linolenic acid has a preventive effect on the heart, brain, neurological disorders, constipation, cholesterol and the development of the cancer cells[6].

The amount of oil and fatty acids composition of the oil crops are variable and they are under the influence of the various genetic, physiological, ecological and cultural factors.

In many oil plants, fatty acids are sensitive to the various climatic conditions especially to the temperature[7,8]. Therefore it is very important to give a place to the adaptation studies aimed at increasing the oil and fatty acid quality of linseed that has multipurpose uses, to research the new oil linseed varieties and to determine the most suitable sowing times. With this study, saturated and unsaturated fatty acids were determined on the linseed genotypes grown in different sowing times.

EXPERIMENTAL

In this study, domestic and foreign nine linseed genotypes (*Linum usitatissimum* L.) which are obtained from different sources, were used as plant material. Five of the varieties and populations used in this study (Atalanta, Raulinus, Maroc SM, Avangard, Antares) are German-originated pickled pepper linen genotypes which were obtained from Aegean University Faculty of Agriculture. One of the indigenous materials, obtained from Ankara University Faculty of Agriculture, is

Sari-85. It is the only registered linseed variety. The other three populations were obtained from different regions.

This research was conducted on the experiment field of Konya Land and Water Resources Research Institute in the wet conditions in 2008. Research was established in aqueous conditions in 2008. Sowings were carried out in four different times (April 6, April 16, April 26, May 6). Harvest was made when they had golden yellow capsules the full nutrition periods. Plants harvested with roots from each plot were left to dry naturally. With roots from each plot harvested plants are left to dry naturally.

Chemical properties: 5 g sample was taken from the extracted and crushed seeds and oil analysis was made. Crude oil ratios were determined by using the solvent method with petroleum ether extraction. The sequence was as follows: grinding-Soxhelet-evaporation[9].

Determination of fatty acids: Triglycerides avaible in the chemical structure of oil were determined by gas chromatography device[10]. The working conditions of gas chromatography were as follows: Instrument: Shimadzu GC-14B, Constant phase: 10 % diethylene glycol succinate (DEGS) Support matter: Chromosorb W(AW-DMCS) (60-80 mesh), Detector: FID (flame ionization detector), temperatures: column: 180 ºC, injector: 200 ºC, detector: 200 ºC, flow rates: carrier gas (N_2): 30 mL/min, Burnt gas (H_2): 28 mL/min, dry gas (O_2): 220 mL/min, Printer: Chromatopac CR 6A (Shimadzu), injection amount: 0.5 µL.

Statistical analyses: The results of the research were analyzed by analysis of variance in MSTAT statistical program according to "split plots on randomized complete block" with three replicants.

RESULTS AND DISCUSSION

Oil ratios, saturated and unsaurated fatty acid contents belonging to the genotypes are given in Table-1. The percentage of myristic acid ranged from 0.039 (Avangard, Antares and Sari-85) to 0.043 (Maroc SM and P-Halfeti); palmitic acid ranged from 5.3 (Sari-85) to 6.1 (P-Kulu); stearic acid ranged from 6.0 (Avangard and P-Cihanbeyli) to 7.2 (Maroc SM); palmitoleic ranged from 0.072 (Antares) to 0.100 (Maroc SM, P-Kulu and P-Halfeti); oleic acid ranged from 17.0 (Avangard) to 24.0 (Antares); linoleic acid ranged from 11.0 (Avangard) to 15.0 (Atalanta and P-Kulu) linolenic acid ranged from 47.0 (Raulinus and Maroc SM) to 55.2 (Sari-85). Among the fatty acids linolenic acid was found to be major acid in all the genotypes. The greatest variability was found in the linolenic acid fallowed by the oleic acid. Carson and McGregor[11] obtained smilar results in different *Linum* varieties in respect of the linolenic acid (46.2-54.6 %) and the oleic acid (24.4-31.8). Green and Marshall[12] also found variability within *Linum* species in the oil composition, linolenic acid (45.5-64.2 %) oleic acid (13.3-25.2 %) which is in close agreement with the present finding. The main fatty acid components of genotypes identified by gas chromatography were linolenic acid (51.0 %), linoleic acid (13.0 %), oleic acid (22.0 %), palmitic acid (6.0 %), stearic acid (7.0 %), palmitoleic acid (1.0 %), myristic acid (0.041 %) (Fig. 1). Baydar *et al.*[13] obtained smilar results in *Linum* varieties in respect of the myristic acid 0.14 %, palmitic acid 5.7 %, palmitoleic acid 0.09 %, stearic acid 3.7 %, oleic acid 13.8 %, linoleic acid 12.2 % and linolenic acid 64.3 %. According to the mean results, oil rates of genotypes were in the range of 31-35 % (Raulinus and Sari-85) and 13 % of these ratio was saturated, 23 % was monounsaturated and 64 % polyunsaturated fatty acids[13].

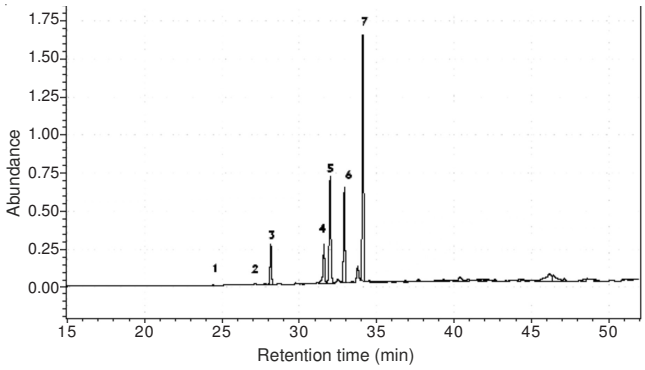

Fig. 1. GC-chromatogram of linseed fatty acids (1) myristic acid, (2) palmitic acid, (3) palmitoleic acid, (4) stearic acid, (5) oleic acid, (6) linoleic acid, (7) linolenic acid

The highest values among the polyunsaturated fatty acids belong to the linolenic fatty acids and the highest values among the monounsaturated fatty acids belong to the oleic fatty acids (Figs. 2 and 3). Vaisey-Genser and Morris similarly found that oil rates in flax seeds were in the range of 35, 40 and 9 % of this ratio was saturated, 18 % was monounsaturated and 73 % was polyunsaturated (linolenic 57 %, linoleic 16 %) fatty acids[14].

TABLE-1
OIL CONTENT, SATURATED AND UNSATURATED FATTY ACIDS IN LINSEED GENOTYPES

Genotypes No	Genotypes	Oil content (%)	Saturated fatty acid (%)			Unsaturated fatty acid (%)			
			Myristic C:14	Palmitic C:16	Stearic C:18	Palmitoleic C:16:1	Oleic C:18:1	Linoleic C:18:2	Linolenic C:18:3
1	Atalanta	31.1	0.042	6.0	7.0	0.09	23.6	15.0	47.1
2	Raulinus	31.0	0.041	6.0	7.1	0.080	23.6	14.0	47.0
3	Maroc SM	31.2	0.043	6.0	7.2	0.100	23.7	14.1	47.0
4	Avangard	33.1	0.039	6.0	6.0	0.09	17.0	11.0	59
5	Antares	31.1	0.039	6.0	7.0	0.072	24.0	14.0	49.0
6	Sari-85	35.0	0.039	5.3	6.2	0.081	18.3	12.0	55.2
7	P-Kulu	33.6	0.042	6.1	6.2	0.100	20.8	15.0	48.0
8	P-Cihanbeyli	32.2	0.041	6.0	6.0	0.094	23.8	12.0	53.3
9	P-Halfeti	32.5	0.043	6.0	6.3	0.100	20.5	12.3	53
	Mean	32.3	0.041	6.0	7.0	0.09	22	13	51

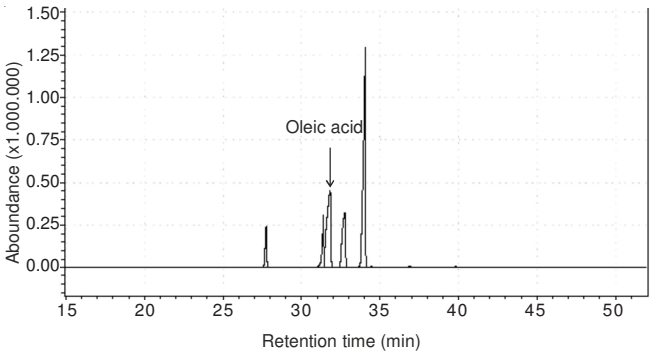

Fig. 2. GC-Chromatogram of antares genotype belonging to oleic fatty acid

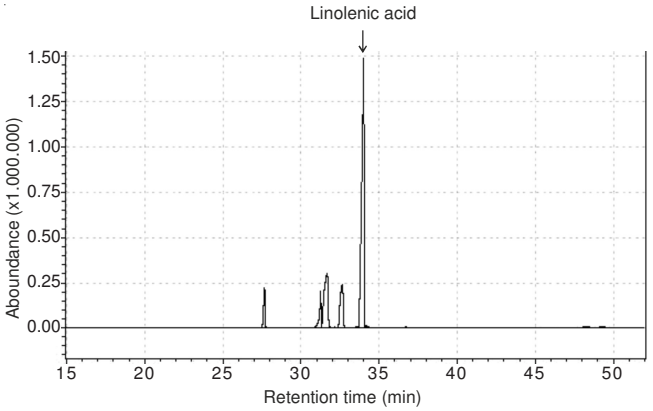

Fig. 3. GC-Chromatogram of Sari-85 genotype belonging to linolenic fatty acid

Saturated and unsaturated fatty acid values in different sowing times were given in Table-2. Sowing times have been effective on fatty acids statistically at the level of $p < 0.01$.

The highest myristic acid ratio was obtained from May 6 (0.043 %), the lowest myristic acid and linolenic acid rate was obtained from April 6 (0.040 %). The highest palmitic acid rate was obtained from April 6 (5.8 %), the lowest palmitic acid rate was obtained from the May 6 (5.6 %). The highest stearic acid rate was obtained from April 6 (6.7 %), the lowest stearic acid rate was obtained from May 6 (6.2 %). The highest palmitoleic acid ratio was obtained from May 6 (0.092 %), the lowest palmitoleic acid rate was obtained from April 6 (0.091 %).

The highest oleic acid ratio was obtained from May 6 (22.0 %), the lowest oleic acid rate was obtained from April 6 (21.0 %). The highest linoleic acid ratio was obtained from May 6 (13.3 %), the lowest linoleic acid rate was obtained from April 6 (12.6 %). The highest linolenic acid ratio was obtained from April 6 (52.0 %), the lowest linolenic acid rate was obtained from May 6 (50.1 %). Delaying sowing time caused increas in temperature and increasing temperature had an effect on the amounts of fatty acids. It was also found that delaying sowing times caused decrease in the amount of saturated and polyunsaturated fatty acids and increase in the amount of monounsaturated fatty acids. Sekin emphasized that oil crops rich in unsaturated fatty acids such as oleic acid and linoleic acid are adapted to warm climate and oil crops rich in linolenic acid are generally adapted to cool climates[5]. Broun and Somerville[15] determined that as a result of rising in temperature, enzyme activity that catalyzes the synthesis of linoleic acid and linoleayl acid from oleic acid decreased so the amount of linolenic acid decreased and the amount of oleic acid increased.

Conclusion

In this study, saturated and unsaturated fatty acids were determined on the linseed genotypes grown in different sowing times on Konya ecological conditions.

It was determined that the most suitable genotypes that can be recommended in terms of mainly crude oil content, saturated and unsaturated fatty acid composition for the region, were Sari-85, Antares, Maroc SM and Avangard. It must be dwelt on Sari-85 as it is used particularly in cooking oil with its high crude oil content. Antares and Maroc SM have been remarkable genotypes with their high oleic acid content that are important in terms of biological nutritional value.

Linoleic acid content is in negative correlations with several yield components. This negative correlation is considered positive in terms of animal nutrution and negative for the paint industry. Genotypes are asked to be very high in terms of linolenic acid content for paint and varnish industry. In this research Avangard and Sari-85 are rich in linolenic acid content, are recommended for using in industrial purposes. To be able to use on oil as an edible oil, it must have low linolenic oil acid. In present studies, P-Kulu with low linolenic acid content may be able to use for cooking through breeding of Maroc SM and Raulinus.

Delay in sowing times showed positive effect on characters such as the oleic acid and linoleic acid and negative effect on characters such as the crude oil content, stearic acid, palmitic acid and linolenic acid. Delaying sowing times caused increas in temperature and increasing temperature had an effect on the amounts of fatty acids. It was also found that delaying sowing times caused decrease in the amount of saturated and polyunsaturated fatty acids and increase in the amount of monounsaturated fatty acids.

TABLE-2
SATURATED AND UNSATURATED FATTY ACID VALUES IN DIFFERENT SOWING TIMES

Sowing times	Saturated fatty acid (%)			Unsaturated fatty acid (%)			
	Myristic C:14	Palmitic C:16	Stearic C:18	Palmitoleic C:16:1	Oleic C:18:1	Linoleic C:18:2	Linolenic C:18:3
April 6	0.040 a	5.8 a**	6.7 a**	0.091 a	21.0 c	12.6 b	52.0 a**
April 16	0.040 a	5.7 a	6.5 b	0.091 a	21.2 c	13.0 a	51.2 ab
April 26	0.040 a	5.6 b	6.3 bc	0.092 a	21.6 b	13.1 a	50.2 b
May 6	0.043 a**	5.6 b	6.2 c	0.092 a**	22.0 a**	13.3 a**	50.1 b
Mean	0.041	5.7	6.4	0.092	21.5	13.0	51.0

**Significant at $p < 0.01$.

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