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DETERMINATION OF FATTY ACID COMPOSITION ON DIFFERENT FALSE FLAX (*Camelina sativa* (L.) Crantz) GENOTYPES UNDER ANKARA ECOLOGICAL CONDITIONS

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ABSTRACT

This research was conducted to determine fatty acid composition of different false flax (*Camelina sativa* (L.) Crantz) genotypes (Vinimik 17, PI 304269, CR 476/65, CR 1674/90, Ames26665, Ames26667, Ames26673, Ames26676, Ames26680, Ames26686 and Ames28372) in terms of oleic, linoleic, linolenic, steraic, eicosenoic and erucic acids in 2010 and 2011. Results showed that having highest linolenic acid content, Ames28372 could be suggested to be used as oil crops for oil industry or as medicine plant / as biodiesel fuels. Though the content of erucic acid in camelina genotypes used in this study was too beyond the permitted value of 1 %, they could be safely used with erucic acid level decreased under codex limit by breeding programs.

Key words: False flax (*Camelina sativa* (L.) Crantz), oil content, fatty acid composition

INTRODUCTION

False flax (*Camelina sativa* (L.) Crantz), as an ancient-seed crop, has been cultivated since ancient times not only in Europe but also Asia (Zubr, 1997; Koncıus and Karcauskıene, 2010). This crop had been cultivated and used for human nutrition, medicine and illumination by 1940's, and then it has replaced with canola (Crowley and Fröhlich, 1998). The adaptability of false flax genotypes to the different environment causes considerable variation in the oil content and fatty acid profile (Koncıus and Karcauskıene, 2010). Even though, spring-habit false flax genotypes exist, there are also winter-habit genotypes (Crowley and Fröhlich, 1998). Being a green plant, false flax has great potential to be used as oil crop with less chemical fertiliziers, and this features makes false flax superior crop if compared to the other oil crops (Putnam et al., 1993; Kurt and Seyis 2008).

With almost high seed yield and oil content, false flax has been collected attention of oil enterprises on itself (Kurt and Seyis, 2008; Koncıus and Karcauskıene, 2010). In recent years, importance of false flax originated omega-3 concept has been put on agenda. Breeding programs have intensified on genotypes having high content of omega-3 in some countries, including mainly Germany. Moreover, in the breeding programs, special-purposed genotypes for high level of linolenic acid, erucic acid level in genotypes were limited to zero percent, edible purposed genotypes having less linolenic acid (Karvonen et al., 2002).

Vegetable oils have been used for different purposes, including human nutrition, pharmacology, industry, biodiesel etc. and composition of fatty acids plays important role determining usability/coherence of vegetable oils (Grombacher et al., 1993). Due to less oxidation stability, once some vegetable oils having higher linolenic content are not preferred to be used as edible oil, with easily combustibility, use of them are increasing more and more as biodiesel fuels (Frohlic and Rice, 2005; Abromovic et al., 2007; Sabzalian et al., 2008).

The suitability of a vegetable oil for a particular use such as nutritional, industrial or pharmaceutical use are determined by its fatty acid profile which is formed by both genotypic potential and environmental conditions (Sabzalian et al., 2008; Koncıus and Karcauskıene, 2010). It is therefore important that new genotypes having suitable oil acid composition are improved, which has been achieved in the other oil crops (Putnam et al., 1993; Vollman and Rajcan, 2009; Vollman et al., 1996; Zubr, 2003; Urbaniak et al., 2008; Koncıus and Karcauskıene, 2010). A number of studies related to fatty acid composition in camelina oil have been reported (Putnam et al., 1993; Budin et al., 1995; Agegnehu and Honermeier, 1997; Angelini and Moscheni, 1998; Zubr and Matthaus, 2002; Francis and Campbell, 2003; Abromvic and Abram, 2005; Ehrensing and Guy, 2008; Hrastar and Kosır, 2011; Sipalova et al., 2011). The purpose of this study was to determine and evaluate fatty

acid profile of eleven false flax (*Camelina sativa* (L.) Crantz) genotypes under Ankara ecological condition.

MATERIALS AND METHODS

This study was carried out in research area of Central Research Institute for Field Crops in Turkey in 2010 and 2011 years. Genotypes, Vinimik 17, PI 304269, CR 476/65, CR 1674/90, Ames26665, Ames26667, Ames26673, Ames26676, Ames26680, Ames26686 and Ames28372 were gathered from Thrace Agricultural Research Institute.

Soil characteristics were given in Table 1. Research area had lime-loamy soil structure, 8.06 pH, 0,041 % salt, 1.57 % organic matter and 2.65 % lime. Besides, climatic conditions during two years were given Table 2.

Table 1. Soil Characteristics of Research Area

Structure	Lime (%)	Total Salt (%)	Plant-Available Phosphorus (P_2O_5) (kg/da)	Plant-Available Potassium (K_2O) (kg/da)	pH	Organic Matter (%)
Clay-Loam	2.65	0.041	11.41	215.233	8.06	1.57

Source: Soil Fertilizer and Water Resources Research Institute.

Table 2. Climatic Data of the Study Area in Ankara

Years	January	February	March	April	May	June	July
Total Rainfall (mm)							
2010	56.2	39.4	41.0	13.8	22.0	76.0	20.2
2011	28.0	5.0	42.0	35.0	86.0	37.0	13.0
1975-2010	39.2	33.6	36.1	50.0	49.7	35.1	16.0
Mean Temperature (°C)							
2010	1.2	4.0	7.0	9.4	15.0	19.0	21.0
2011	0.2	-0.6	3.0	8.0	12.0	17.0	23.0
1975-2010	0.3	2.1	6.2	11.3	16.0	20.2	23.5
Years	**August**	**September**	**October**	**November**	**December**	**Tot/Mean**	
Total Rainfall (mm)							
2010	0.0	3.0	16.5	26.4	65.6	379.9	
2011	0.2	0.0	81.6	24.0	50.0	401.8	
1975-2010	12.4	18.9	32.5	36.0	42.6	402.1	
Mean Temperature (°C)							
2010	25.5	16.7	14.5	5.2	3.4	11.8	
2011	21.0	17.0	12.3	8.7	4.6	10.5	
1975-2010	23.2	18.7	13.0	6.8	2.2	12.0	

[1/]Data were taken from Ankara Regional Meteorological Service.

Total rainfall in 2010 and 2011 (379.9 mm and 401.5 mm, respectively) were lower than long-term-year rainfall (402.1 mm). Total rainfalls in 2010 and 2011 crop growing periods (March-June), were 172 mm and 213, respectively. Besides, rainfalls, important for yield in early development stage (in May), were 22 mm in 2010 and 86 mm in 2011. Mean temperatures (Table 2) in 2010 and 2011 (11.8 °C and 10.5 °C, respectively) were lower than long-term-year temperature (12.0 °C). This study was conducted in randomized complete block design with three replications. Plot size and row spacing were 1.2 x 5.0 = 6.0 m^2 and 30 cm, respectively. Plants were sown in the middle of March (12 March in the first year and 15 March in the second year). No fertilizer was given and genotypes were harvested in the middle of June (15 June in the first year and 20 June in the second year). One row at both sides and 0.5 m in both edges were removed and 5 m^2 harvested area was evaluated.

The seeds obtained from the experimental field were properly grounded and the oil was extracted by n-hexane in a Soxhlet extractor for four hours. Recovered crude oils were taken to dry out in a rotator at 35 °C. The oil content was calculated on dry mass basis.

Fatty acids were etherified as methyl esters and analysed by Agilent 6890N Network with equipment with DB - 23 capillary columns (JW Scientific 122 - 2362 DB - 23; 60.0 m x 250 µm x 0.25 µm) GC and FID detector. Helium was used as carrier gas at a flow rate of 1 mL / min. Temperature of injector and detector were 260 °C and 240 °C, respectively. Column temperature was kept at 220 °C for 69 min. Samples of 0.5 µl was injected by hand and in the split mode (20:1). FAMEs were identified by comparison of their retention times with those of reference standards. The content of fatty acids was calculated from corresponding integration data. Results of

the erucic acid (%), the eicosenoic acid (%), the linolenic acid (%), the linoleic acid (%), the oleic acid (%), and oil content (%) were analyzed in TARIST, Minitab 15 pocked statistical programs.

RESULTS AND DISCUSSION

In this study, oil content and levels of fatty acids (erucic acid, linolenic acid, linoleic acid, oleic acid and eicosenoic acid) in *Camelina sativa* genotypes were analyzed. Variance analyses and means were presented in Table 3 and 4. Table 3 showed that differences between years in linolenic acid and oil content were found as significant at 1%. Differences in years for oleic acid and eicosenoic acid were significant at 5 %, while it was insignificant ($p > 0.05$) in linoleic acid. Genotype x year interactions were found as significant at 1 %. Responses versus years among genotypes differently reflected. So, these phenomena made interactions significant. Bigger F values in genotypes (Table 3) assigned that differences in genotypes had more significant effect than yearly differences.

Table 3. Variance Analysis Table of Some Fatty Acid, evaluated.

Source of Variation	D.F.	Oleic acid (%) Sum of Means	F Value	Linoleic acid (%) Sum of Means	F Value	Linolenic acid (%) Sum of Means	F Value
Replication	2	0.002	0.007	0.030	0.020	0.006	0.402
Years	1	22.563	76.237*	23.045	15.877ns	79.333	5075.089**
Error$_1$	2	0.296		1.452		0.016	
Genotypes	10	1.918	227.262**	8.568	303.992**	12.905	841.393**
Year x Gen.	10	1.088	128.899**	3.843	136.347**	11.762	766.843**
Error$_2$	40	0.008		0.028		0.015	
Mean	65	0.824		2.327		5.026	
C.V.(%)		0.296		1,452		0,016	
Source of Variation	**D.F.**	**Eicosenoic acid (%) Sum of Means**	**F Value**	**Erucic acid (%) Sum of Means**	**F Value**	**Oil Content (%) Sum of Means**	**F Value**
Replication	2	0.001	0.008	0.001	0.60	1.53	2.53
Years	1	12.143	87.495*	1.979	108.708**	788.33	1304.65**
Error$_1$	2	0.139		0.002		0.60	
Genotypes	10	0.282	60.811**	0.265	28.294**	51.16	41.48**
Year x Gen.	10	0.809	174.571**	0.362	38.649**	41.72	33.83**
Error$_2$	40	0.005		0.009		1.23	
Mean	65	0.362		0.133		27.24	
C.V.(%)		0.139		0.002		18.36	

C.V. = coefficient of variation; ns = nonsignificant; *: significant at $P < 0.05$; **: significant at $P < 0.01$

Means of erucic acid (%), linolenic acid (%), linoleic acid (%), oleic acid (%), eicosenoic acid (%) and oil content (%) in false flax genotypes were given in Table 4. Erucic acid level in the first year (3.389%) was found as lower than the second year (3.043%). Ames26686 in the first year (3.900%), Ames26676 in the second year (3.487%) and Ames26673 in the mean of both years (3.833%) had the highest erucic acid content. Lowest erucic acid contents belonged to PI 304269 (2.290 % in the second year), CR 476/65 (2.920 % in the first year and in mean of both years). First year had the higher linolenic acid than the second year. The highest linolenic acids were taken from Ames26665 in the first year, Ames228372 in the second year. The lowest linolenic acid levels belonged to PI 304269 in the first year and Ames26676 genotype in the second year. As a means of years, in joint analysis, Ames28372 genotype had the highest linolenic acid, as the lowest one belonged to Ames26676 genotype (Table 4). The highest linoleic acid was determined in Ames26676 genotype and the lowest value belonged to CR 1674/90 genotype in the first, second years and joint analysis. In oleic acid, the first year had the higher oleic acid than the second year. In the first year CR 476/65 and Ames28372 genotypes had the highest and lowest oleic acid levels, respectively. In the second year and joint analysis, the highest and the lowest oleic acid levels belonged to CR 1674/90 and Ames26680, respectively (Table 4). Eichosenoic acid level in the first year was higher than the second year. While CR 1674/90 genotype had the highest eicosenoic acid level and lowest one was found as Ames26676 genotype in the second year. The first year and joint analysis draw same trend that CR 476/65 genotype had the highest eicosenoic acid level and lowest level was determined in Vinimik 17 genotype (Table 4).

Oil content in genotypes was higher in the second year than that of the first year. The highest oil content in the first year, the second year and joint analysis were found in Ames26667, CR 1674/90 and Vinimik 17 genotypes, respectively. Moreover, the lowest oil content in the first, second years, in joint analysis were in CR476/65, Ames28372 (in the second year and joint analysis), respectively (Table 4).

Table 4. Means of Some Fatty Acid in False Flax (*Camelina sativa*).

	Oleic acid (%)			Linoleic acid (%)			Linolenic acid (%)		
	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean
Vinimik 17	16.770**C**	14.733**EF**	15.752**EF**	20.333**B**	19.787**D**	20.060D**E**	31.710**C**	30.760**D**	31.235**D**
PI 304269	16.853**BC**	15.380**D**	16.117**D**	20.140**B**	20.050**D**	20.095**D**	29.920**E**	31.850**C**	30.885**E**
CR 476/65	17.587**A**	15.550**CD**	16.568**C**	19.650**C**	19.873**D**	19.762**F**	31.113**D**	29.833**F**	30.473**F**
CR 1674/90	17.027**B**	17.047**A**	17.037**A**	18.167**G**	18.740**F**	18.453**H**	31.667**C**	32.250**B**	31.958**B**
Ames26665	16.103**D**	14.920**E**	15.512**G**	18.413**EFG**	21.567**C**	19.990**DEF**	34.363**A**	29.623**F**	31.993**B**
Ames26667	16.107**D**	15.623**C**	15.865**E**	18.307**FG**	21.303**C**	19.805**EF**	34.173**AB**	29.117**G**	31.645**C**
Ames 26673	17.527**A**	15.917**B**	16.722**B**	19.013**D**	22.957**B**	20.985**C**	31.930**C**	26.163**H**	29.047**G**
Ames26676	17.030**B**	14.597**FG**	15.813**E**	21.247**A**	23.570**A**	22.408**A**	31.223**D**	24.853**I**	28.038**H**
Ames26680	15.750**E**	14.483**G**	15.117**H**	21.230**A**	21.490**C**	21.360**B**	31.060**D**	30.153**E**	30.607**F**
Ames26686	16.170**D**	15.917**B**	16.043**D**	18.777**DE**	18.443**F**	18.610**H**	31.807**C**	31.650**C**	31.728**C**
Ames28372	15.690**E**	15.583C	15.637**FG**	18.637**EF**	19.133**E**	18.885**G**	34.063**B**	32.657**A**	33.360**A**
Mean	16.601**a**	15.432**b**	16.017	20.628	19.447	20.037	32.094**A**	29.901**B**	30.998
L.S.D.(%)	Year: 0.576,Gen: 0.143, YearxGen=0.203			Year: 1.276,Gen: 0.262, YearxGen=0.371			Year: 0.305,Gen: 0.193, YearxGen=0.273		
	Eicosenoic acid(%)			**Erucic acid (%)**			**Oil Content (%)**		
	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean
Vinimik 17	12.980**D**	14.600**BC**	13.790**F**	3.397**C**	2.993**CDE**	3.397**DE**	28.13	37.30	32.72**A**
PI 304269	12.997**D**	14.590**CD**	13.793**F**	3.403**C**	2.290**F**	3.403**DE**	25.63	35.53	30.58**BC**
CR 476/65	13.353**C**	14.860**A**	14.107**BC**	2.920**E**	2.930**CDE**	2.920**F**	22.17	37.07	29.62**CD**
CR 1674/90	14.363**A**	14.443D**E**	14.403**A**	3.647**B**	2.830**DE**	3.647**CDE**	24.50	39.77	32.13**AB**
Ames26665	13.367**C**	14.743A**B**	14.055**CD**	3.153**D**	3.200**BC**	3.153**DE**	23.50	33.77	28.63**DE**
Ames26667	13.263**C**	14.733**ABC**	13.998**DE**	3.093**DE**	3.253**B**	3.093**DE**	28.60	30.70	29.65**CD**
Ames 26673	14.267**A**	14.073**F**	14.170**B**	3.833**AB**	3.303**AB**	3.833**A**	24.43	30.67	27.55**EF**
Ames26676	13.983**B**	14.007**F**	13.995DE	3.387**C**	3.487**A**	3.387**AB**	26.40	28.43	27.42**EF**
Ames26680	13.990**B**	14.343**E**	13.995**B**	3.417**C**	3.327**AB**	3.417**BC**	25.07	27.90	26.48**F**
Ames26686	14.327**A**	14.610B**C**	14.468**A**	3.900**A**	2.743**E**	3.900**BCD**	23.63	25.60	24.62**G**
Ames28372	13.287**C**	14.610B**C**	13.948E	3.133**DE**	3.117**BCD**	3.133**E**	22.70	24.07	23.38**G**
Mean	14.510**A**	13.652**B**	14.081	3.389A	3.043B	3.216	24.98 **B**	31.89 **A**	28.43
L.S.D.(%)	Year: 0.395,Gen: 0.106, YearxGen=0.150			Year: 0.104,Gen: 0.151, YearXGen=0.214			Year:1.90 ,Gen:1.74 , YearxGen=2.45		

A: denotes significant at 1 %, a: denotes significant at 5 %

Correlation analysis was given in Table 5. As seen in Table 5, while relationship between oil content and erucic acid, oleic acid and ecosenoic acid, linoleic acid and linolenic acid, oleic acid and linoleic acid, oil content and oleic acid were found as negative and significant at 1 %; relationship between oil content and linolenic acid, linolenic acid and eicosenoic acid were determined as negative and significant at 5 % (Table 5). Relationship between fatty acids was mostly negative and no significant relationship was observed between fatty acids and oil content but erucic acid that had significant and negative relationship with oil content. On the other hand, by evaluating regression coefficients of genotypes for oil content and fatty acids, adaptabilities of genotypes were given in Figure 1.

Table 5. Correlations among Parameters False Flax (*Camelina sativa*) Genotypes.

	Erucic Acid	Ecosenoic Acid	Linolenic Acid	Linoleic Acid	Oleic Acid
Ecosenoic acid	-0.176ns				
Linolenic acid	-0.175ns	-0.251*			
Linoleic acid	0.129ns	0.110ns	-0.856**		
Oleic acid	0.218ns	-0.405**	0.348**	-0.445**	
Oil content	-0.477**	0.492**	-0.258*	0.201ns	-0.340**

ns = nonsignificant; *: significant at P < 0.05; **: significant at P < 0.01

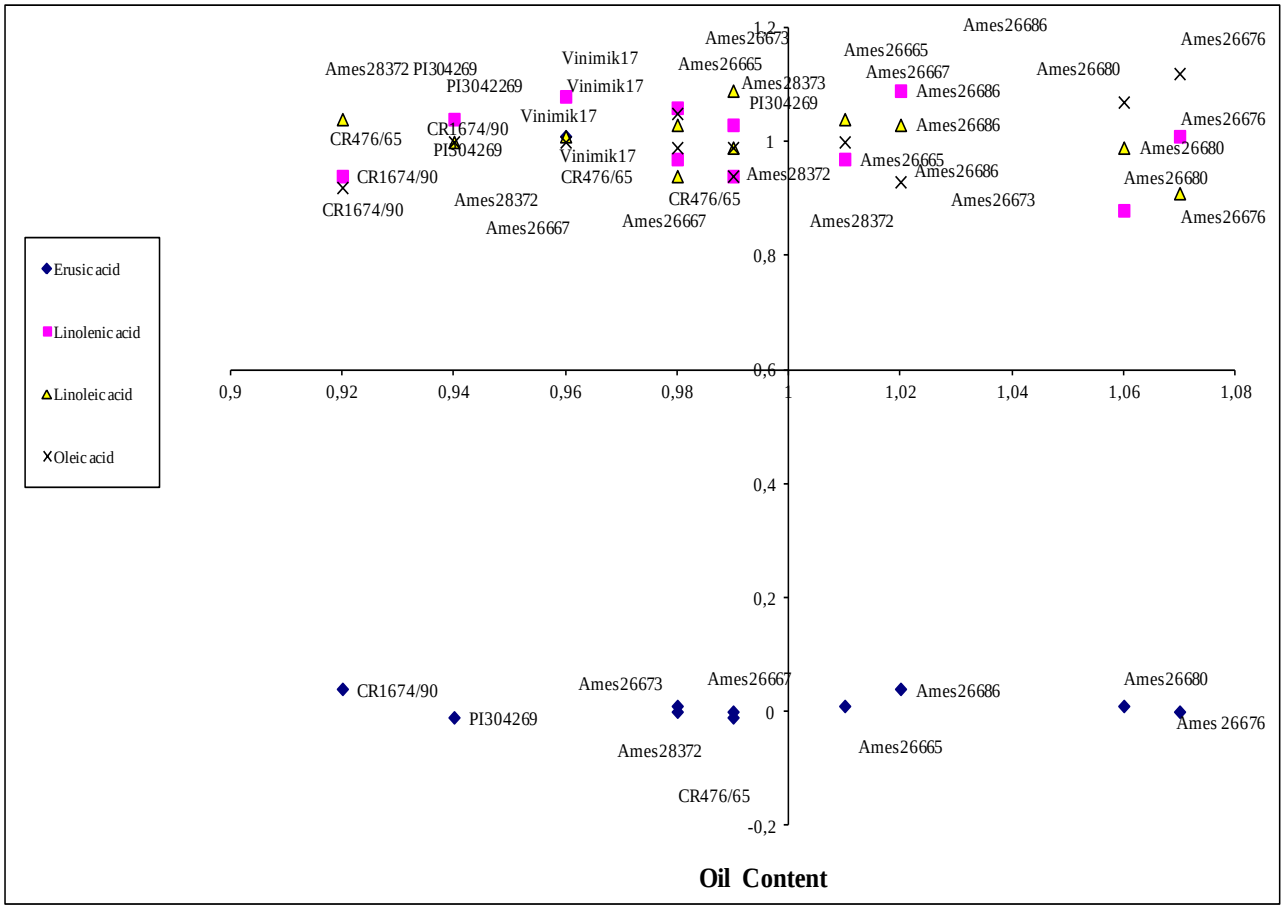

Figure 1. Regression coefficients of genotypes for oil content and fatty acids.

Regression coefficient is a measurement of reactions to different components/conditions in genotypes (Grabowski, 1998; Joshi and Press, 2007). Genotypes, having regression coefficient bigger than 1, can be well adapted to appropriate environmental conditions and high amount of fatty acids could be obtained. If r < 1, performance of genotype is low in poor conditions. Regression coefficient of genotype should therefore be as close as to 1. Vinimik 17, CR1674/90, PI 304269, Ames28373, Ames26680 and Ames26676 were observed more stabile than the other genotypes for components, evaluated.

CONCLUSION

Fatty acid profile of a oil crop determines its usability/suitability for nutritional, industrial or pharmaceutical value. This situation encourages looking for new sources of oil or new fatty acid profiles in different plant species (Sabzalian et al., 2008). Fatty acids are known as important ingredients, influenced by both environment and genotype and form quality of oil so they lead usage of oils (the purpose of industrial or edible consumption) (Crowley and Frohlich, 1998). Having fatty acids such as erucic, linolenic, linoleic, oleic acids in different levels, vegetable oils could be used as edible/ industrial purposes (Crowley and Frohlich, 1998; Geçgel et al., 2007).

In our study, years and genotypes significantly differed from each other in all characters; this is more likely to assign that responses of genotypes significantly varied in years and genotypes. Significant year x genotype interactions confirm this phenomena. So, similarly Seehuber (1987), Crowley and Frohlich (1998) and Francis and Campbel (2003) concluded that level of fatty acids profile and oil contents could significantly be sensitive to differences of years and genotypes. Seehuber (1987) and Francis and Campbel (2003) found that genotypic differences are more important than the effect of environmental conditions for fatty acids and oil contents. Valeri and Meirelles (1997), Tat and Vangerpen (1999) and Mc Crady (2007) revealed that plenty of genotypes with higher oil content and lower level of erucic acid were developed and served to use of industrial/edible purpose. Besides, legally admissible level of erucic acid in genotypes is accepted as 1-2 % of total fatty acid composition (Putnam et al. 1993; Taşan and Geçgel 2007).

Erucic acid, a monounsaturated fatty acid, is produced in wide range of oil crops especially in brassica family, and is known as brassidic acid (Vollman and Rajcan 2009). Permitted level of erucic acid in edible oils by codex is 1 % (Budin et al. 1995; Taşan and Geçgel 2007) and erucic acid level was found as higher than this level of 1 % in our study (Table 4). This stress that the genotypes have erucic acid levels over 1 %, and ranging from 2.920

to3.833 %, no usability of genotypes used are possible as edible oil crop, all they could be used in industrial purpose. Ames26673 and Ames26676 genotypes had the highest erucic acid levels with 3.833 % and 3.387 %, respectively. Because of higher level of erucic acid than acceptable level for edible purpose (max 2 % of total fatty acid cprofile), it could only be used as a surfactant/lubricant/precursor to biodiesel (Budin et al. 1995; Orlovius 2003; Taşan and Geçgel 2007). Erucic acid is monosaturated fatty acid and its content differs with not only years but also genotypes (Crowley and Frohlich 1998). Besides, erucic acid content in vegetable oil leads suitability of it for edibility (Sampath 2009) and in recent years, genotypes having almost zero erucic acid level were developed and presented to commercial use (Taşan and Geçgel 2007; Hrastar and Kosır 2011).

Oleic, linoleic and linolenic acids, essential components of fatty acid profile, should be taken regularly for health, besides vegetable oil, having rich amount of oleic, linoleic and linolenic acids, are more likely to be suitable for cooking (withstands up to more than 300°C) purposes (Hrastar and Kosır 2011). It was revealed that false flax is rich in oleic, linoleic and linolenic acids (Abromovic and Abram 2005, Hrastar and Kosır 2011). Common vegetable oils such as olive oil, corn and sunflower oils have less than 1 % of linolenic acid; whereas rapeseed or soybean oils have almost 8 %, and linseed oil with up to 60 % is the richest source of linolenic acid (Abromovic and Abram, 2005). Linolenic acid is the most abundant fatty acid in camelina oil and is almost 25-30 % (Zubr and Matthaus 2002; Abromovic and Abram 2005; Hrastar and Kosır 2011; Sipalova et al. 2011) and linoleic and oleic acids are, abundant in false flax, are classified as unsaturated omega-6 and monounsaturated omega-9 fatty acids, and they must be consumed properly for health (Crowley and Frohlich, 1998, Geçgel et al., 2007). Similar to in our study, levels of linolenic , linoleic and oleic acids were found as 30.998 %, 20.037 % and 16.017 %, respectively. It could be assumed that genotypes used are rich enough for these fatty acids. Meanwhile, Ames28372 genotype in linolenic acid, Ames26676 genotype in linoleic acid and CR1674/90 genotype in oleic acid were the richest genotypes. Many oil crops are of eichosenoic acid that is a monounsaturated fatty acid (Abromovic and Abram, 2005). With 14.468 %, Ames26686 genotype had the highest eichosenoic acid level in the study.

Oil content and its fatty acid composition are important characters for genotypes, since value of genotype is measured by the level of oil content and its fatty acid composition and this value determines the acceptability/usability of genotypes (Ehrensing and Guy 2008; Sampath 2009). Vinimik 17 possessed advantage for oil content, since the highest oil content (32.72 %) belonged to this genotype. The results showed that genotypes, used in this study were determined as industrial purpose. Having the highest levels of linolenic, linoleic, oleic acids and oil content, stability, Vinimik 17, CR 1674/90 and PI 304269 genotypes could be suggested to be used in oil industry. However more detailed researches are needed for further studies.

LITERATURE CITED

Abromovic, H., V. Abram, 2005. Physico-chemical properties, composition and oxidative stability of *Camelina sativa* oil. Food Technol.Biotechnol. 43 (1): 63–70.

Abromovic, H., B. Butinar, V. Nikolic, 2007. Changes occurring in phenolic content, tocopherol composition and oxidative stability of *Camelina sativa* (L.) Crantz oil during storage. Food Chemistry 104. 903-909.

Agegnehu, M., B. Honermeier, 1997. Effects of seeding rate and nitrogen fertilization on seed yield, seed quality and yield components of false flax (*Camelina sativa crtz*). Die Bodenkultur 48 (1).

Angelini, L., E. Moscheni, 1998. Camelina (*Camelina sativa [L.] Crantz*). In: Oleaginose Non Alimentari, pp. 82–85. Ed. G. Mosca. Bologna: Edagricole.

Budin, J.T., WM. Brene, D.H. Putnam, 1995. Some compositional properties of camelina (*Camelina sativa* l. crantz) seeds and oils. J. Am. Oil. Chem. Soc. 72(3): 309-315.

Crowley, J.G., A. Fröhlich, 1998. Factors affecting the composition and use of camelina. A Teagasc publication. Crops Research Centre, Oak Park, Carlow, Ireland.

Ehrensing, D.T., S.O. Guy, 2008. Cameliana. 'Oilseed Crops'Oregon State Unıversity. EM 8953-E.

Francis, C.M., M.C. Campbell, 2003. New high quality oil seed crops for temperate and tropical Australia. A report for the Rural Industries Research and Development Corporation. Crawley,Australia.

Frohlic, A., B. Rice, 2005. Evaluation of *Camelina sativa* oil as feedstock for biodiesel production. Ind. Crops Prod. 21(1). 25-31.

Geçgel, U., M. Demirci, E. Esendal, 2007. Fatty acid composition of oil from developing seeds of different genotypes of safflower (*Carthamus tinctorius* L.). J. Am. Oil Chem. Soc. 84. 47-54.

Grabowski, M.S., R.L. McCormick, 1998. Combustion of fat and vegetable oil derived fuels in diesel engines. Prog. Energy Combust. Science 24.125-164.

Grombacher, A., L. Nelson, D. Baltensperger, 1993. Crambe production. In Field Crops File G1126 University of Nebraska Extension Services.

Hrastar, R., I.J. Kosır, 2011. *Camelina sativa* (L.) Crantz as an alternative oilseed. J. Hmeljarski bilten, Vol. 18 pp. 85-92.

Joshi, R.M., M.J. Pregg, 2007. Flow properties of biodiesel fuel blends at low temperatures, Fuel 86. 143-151.

Karvonen, H.M., A. Are, N.S. Tadpole, I. Saline, M.I.J. Uusitupa, E.S. Sarkkinen, 2002. Effect of alpha-linoleic acid-rich *Camelina sativa* oil on serum fatty acid composition and serum lipids in hypercholesterolemic subjects. Metab. 51. 1253–1260.

Koncıus, D., D. Karcauskıene, 2010. The effect of nitrogen fertilizers, sowing time and seed rate on the productivity of *Camelina sativa.* Agrıculture,Vol. 97, No.4, p: 37-46.

Kurt, O., F. Seyis, 2008. An alternative oilseed crop: Camelina (*Camelina sativa* (L.) Crantz). Journal of OMU Agr. Fac. 23 (2). 116-120.

McCrady, J.P., 2007. Biodiesel Property Definition for Fuel Anomization and Combustion Modeling. Master's Thesis. University of Ilinois at Urbane Champaigh. Department of Agricultural and Biological Engineering. Urbana.

Orlovius, K., 2003. Oil seed rape (Fertilizing for High Yield and Quality), IPI Bulletin. Basel, 16.125.

Putnam, D.H., J. T. Budin, L.A. Field, and W.M. Breene. 1993 Camelina: A promising low-input oilseed. In J. Janick and J.E. Simon (Eds.), *New crops* (pp. 314-322). New York: Wiley.

Sabzalian, M.R., G. Saeidi, A. Mirlohi, 2008. Oil content and fatty acid composition in seeds of three safflower species. J. Am. Oil Chem. Soc. 85.717-721.

Sampath, A., 2009. Chemical Characterization of Camelina Seed Oil. The degree of Master of Science. New Brunswick, New Jersey. p. 180,

Seehuber, R., J. Vollman, M. Dambroth ,1987. Application of the single seed-descent method in false flax to increase the yield level. Landbauforsch. Voelkenrode (Germany) 37: 132-136.

Šipalova, M., T. Losak, J. Hkusek, J. Vollmann, J. Hude, R. Filipcik, M. Macek, S. Kracmar, 2011. Fatty acid composition of *Camelina sativa* as affected by combined nitrogen and sulphur fertilisation. Afr. J. Agric. Res. 6(16). 3919-3923.

Taşan, M., Ü. Geçgel, 2007. Examination of fatty acid compositions in mixtures of vegetable oils. J. of Tekirdağ Agricultural Faculty 4(1).

Tat, M.E., J.H. Van Gerpen, 1999. The kinematic viscosity of biodiesel and its blends with diesel fuel. J. Am. Oil Chem.Soc. 76(12).1511-1513.

Urbaniak, SD., C.D. Caldwell, V.D. Zheljazkov, R. Lada, L. Luan, 2008. The effect of cultivar and applied nitrogen on the performance of *Camelina sativa* L. in the Maritime Provinces of Canada. Can.J.Plant Sci. 88.111-119.

Valeri, D., A.J.A. Meirelles, 1997. Viscosities of fatty acids, Triglycerides, and their binary mixtures. J. Am. Oil Chem. Soc. 74:1221-1226.

Vollman, J., A. Damboeck, A. Ecki, H. Schrems, P. Runckenbauer, 1996. Improvement of *Camelina sativa*, an underexploited oilseed. In Progress in New Crops (Eds: J. Janick). ASHK Press, Alexandria, pp.357-362.

Vollman, J., I. Rajcan, 2009. Oil Crops. Volume 4 ISBN 978-0-387-77593-7 e-ISBN 978-0-387-77594-4 DOI 10.1007/978-0- 387-77594-4 Springer Dordrecht Heidelberg London New York.

Zubr, J., 1997. Oil-seed crop: *Camelina sativa*. Indust. Crops Prod. 6: 113-119.

Zubr, J., B. Matthaus, 2002. Effects of growth conditions on fatty acids and tocopherols in

Camelina sativa oil. Ind. Crops Prod. 15: 155-162.

Zubr, J., 2003. Qualitative variation of *Camelina sativa* seed from different locations. Indust. Crops Prod. 17: 161-169.