Progress in Nutrition 2022; Vol. 24, N. 3: e2022112 DOI: 10.23751/pn.v24i3.13268

Original article

Fatty acid compositions o*f Zea mays* L. varieties in Turkey

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Abstract. The physical and chemical characteristics of oils are determined by the rate and composition of the fatty acids they have. Knowing the fatty acid composition of oils will enable the production of oils according to intended usage areas. The present study was conducted to determine the fatty acid composition of 20 different corn varieties grown in Turkey. The oil contents of the samples were determined with the Soxhelet Oil Extraction Device, and the fatty acid composition was determined with the GC-S/FID Device. The dominant fatty acids of the cultivars and lines that were examined in the scope of the present study were found to be linoleic acid (50.05-53.14%), oleic acid (31.09-33.21%), palmitic acid (11.07-13.16%), stearic acid (2.10-2.55%), linolenic acid (0.55-1.18%), and arachidic acid (0.36% - 0.53%). It was found that the differences between cultivars were very significant for all the characteristics studied here except for lauric acid. The findings of the study show that there is a wide variation in fatty acid composition in the existing cultivars and lines.

Key words: Fatty Acid, *Zea mays*, Varieties

Introduction

Maize kernels are used as the raw material for corn starch, oil, sugar, protein, cellulose and ethyl alcohol in various industries (1). The starch, protein, oil and mineral quantities designating the potential use of maize kernels largely rely on plant genetics, environmental factors and agronomic practices (2). Yield and quality traits of plant species and cultivars may exhibit large genetic variations in themselves. Newly developed breeds should be tested for yield and quality traits under different climate and soil conditions (3).

Previous researchers indicated significant effects of plant genetics on the fatty acid composition of different species. Effects of genetic variations on fatty acid composition were put forth in grass pea (4), bitter vetch (5), and in grass burnet (6) and guar bean (7). In this study, the seeds of maize varieties (*Zea mays* L.) obtained from different companies in Turkey are performed to determine the fatty acid composition.

After wheat and rice plant, corn is one of the most used plants in human nutrition, and is the most popular plant used especially in silage production as well as grain in animal nutrition. Previous studies show that corn has many usage areas, and each part of this plant has a separate economic value. According to Özcan (8), 60% of corn production is used to feed animals, 20% is used as human food (direct consumption), 10% is processed food, and 10% is seeds and other consumption types. According to Emeklier (9), corn grain has high carbohydrates (starch), protein, different sugar derivatives, fiber and fat contents along with iron (Fe), magnesium (Mg), potassium (K), and Vitamins A, B1, B3, B9, and C in terms of human nutrition. Corn grains have become indispensable in animal nutrition with high protein and vitamin A contents, and are added to feed rations at a rate of 15-65%.

The oil content of different corn varieties is between 3.1% and 5.7%, and 80% of this oil content exists in the embryo. It was determined in previous

studies that the fatty acid composition of corn changes depending on the type of the seeds, and ecological, morphological, physiological, and cultural practices as in other oil types (10). Many studies examine the factors affecting the fatty acid composition of corn oil. (11) reported that corn oil of warmer regions has higher saturated fatty acid rates than corn oil of colder regions. And genetic factors have a much greater effect than environmental factors (12).

Corn oil (*Zea mays* L.) is a vegetable oil that is used widely in the food industry with its good fatty acid composition. Corn oil, which is a good alternative for cooking in developing countries because of its low cost, has high omega-6 contents (52.68%) but also contains 12.57% palmitic acid (13). Corn seed oil is mainly used in the production of products such as salad and cooking oil with a fatty acid composition consisting of 40-68% linoleic acid, 20-32% oleic acid, and 8-14% saturated fatty acids (14). (15) reported that the fatty acid contents of 30 corn hybrids consisted of 9.2-12.1% palmitic acid, 19.5%-30.5% oleic acid, and 53.0-65.3% linoleic acid.

The purpose of the present study was to provide data on the variation in fatty acid compositions of some corn varieties. This article reports data on the differences and ranges of fatty acid compositions detected in corn cultivars.

Materials and Methods

Seed samples. In this study, the seeds of 20 corn varieties obtained from different companies in Turkey were used as plant material. The seeds taken from the companies were tested in Kahramanmaraş conditions and the seeds obtained from the field trial were used as material. Samples were dried at 70°C for 48 hours in 3 replications. Dried samples were then ground to pass 1 mm sieve and made ready for chemical analyses.

Oil extraction and preparation of fatty acid methyl esters (FAME). Impurities were removed from the seeds and the cleaned seeds were ground using mill into powder. The milled seed samples were homogenized in 10 mL of hexane / isopropanol (3:2) centrifuged at 5000 rpm for 10 min (16) 2.5 mL of 2% methanolic sulfuric acid was added and vortexed. This mixture is left to stand for 15 hours at 50 C. After 15 hours, the tubes are removed to cool to room temperature and vortexed by adding 2.5 mL of 5% NaCl. Fatty acid methyl esters (FAME) formed in tubes are extracted with 2.5 mL of hexane and the hexane phase was taken with a Pasteur pipette and treated with 2.5 mL of 2% KHCO3 and allowed for 1 hour to separate the phases. The solvent of the mixture containing methyl esters was then evaporated under nitrogen at 45 °C. It is dissolved in 1 mL hexane and analyzed by GC vials and analyzed on GC-MS. The upper part was removed and placed in a test tube by filtration.

Capillary GLC. The fatty acids in lipid extracts were converted to methyl esters in methanol with 2% sulfuric acid (v/v) (17). The fatty acid methyl esters were extracted with n-hexane. Then the methyl esters were separated and quantified by gas chromatography and flame ionization detection (FID). Chromatography was performed with a capillary column [GC-MS instrument (USA) of Agilent brand 7890A / 5970 C and SGE Analytical BPX90 100 m x 0.25 mm x 0.25 µm column (Australia) were used] using helium as carrier gas (flow rate 1 mL/min), H2 and air for FID detector N2 was used make up. The other chromatographic conditions are as follows; temperature starts from 120 °C to 5 °C / min to 200 °C, 4 min hold time, then 5 °C / min with final temperature reaches 260 °C and 8 min hold time, the total analysis time is 40 minutes. The injection volume is 1 microliter. Identification of the individual compound was performed by frequent comparison with authentic standard mixtures analyzed under the same conditions.

Results and Discussion

In this study, fatty acid compositions of the seeds of 20 different *Zea mays* L. varieties were detected, and the results are shown in Table 1. The main components in the seed oils of these varieties were palmitic, stearic, oleic and linoleic acids (Table 1). Undecanoic, lauric, myristic and lignoceric acids have been detected in trace amounts in the seeds of some corn varieties. While the highest undecanoic, lauric and myristic acids were detected in the seed of the Sakarya corn variety as 0.07%, 0.05% and 0.04%, respectively, the highest lignoceric acid was determined in the Famaso corn variety as 0.22%. The

Table 1. Fatty Acid Composition of Corn (*Zea mays* L.) Varieties.

Variety	11:0	12:0	14:0	16:0	16:1	18:0	18:1	18:2	18:3	20:0	20:1	22:0	22:1	23:0	24:0
ADA523	0.04	0.02	0.03	11.21	0.20	2.10	31.22	53.03	0.94	0.46	0.32	0.16	0.05	0.19	0.03
ADA 334	-	0.03	0.04	11.51	0.27	2.17	31.61	52.65	0.88	-	0.32	0.18	0.10	0.24	-
ADA313	0.06	0.05	0.04	11.20	-	2.17	31.56	52.68	0.88	0.47	0.33	0.19	0.07	0.25	0.05
ADA351	0.04	-	0.03	11.41	0.20	2.12	31.24	52.82	0.87	0.46	0.32	0.17	0.07	0.21	0.04
SAKARYA	0.07	0.05	0.04	11.84	0.30	2.20	31.43	51.94	0.85	0.45	0.31	0.20	0.05	0.24	0.03
ADA9510	0.03	0.01	0.03	11.33	0.18	2.17	31.47	52.55	0.85	0.47	0.32	0.19	0.06	0.24	0.10
ADA9516	0.03	0.01	-	11.40	0.13	2.11	31.26	52.96	0.84	0.46	0.35	0.17	0.05	0.20	0.03
P.31A34	-	-	0.04	12.00	0.14	2.10	31.24	52.43	0.80	0.44	0.30	0.16	0.06	0.20	0.09
P.31G98	0.04	0.01	0.04	11.98	0.11	2.11	31.16	52.60	0.80	0.44	0.29	0.17	0.05	0.20	-
P.31D24	0.03	0.01	0.03	11.34	0.19	2.22	31.83	52.19	0.82	0.48	0.32	0.22	0.05	0.27	-
P.1429	0.04	0.02	0.03	11.25	0.29	2.55	33.21	50.05	0.78	0.53	0.34	0.32	0.10	0.49	-
P.1921	-	-	0.03	11.36	0.09	2.14	31.60	53.14	0.83	-	0.33	0.17	0.05	0.22	0.04
P.2088	-	-	0.03	11.33	0.08	2.12	31.43	52.93	0.77	0.48	0.33	0.17	0.05	0.21	0.07
P.3394	-	-	0.03	11.37	-	2.12	31.45	52.90	0.82	0.47	0.32	0.16	0.06	0.21	0.09
DKC6589	-	-	0.03	11.69	0.11	2.12	31.34	52.64	0.78	0.46	0.31	0.16	0.16	0.20	-
DKC6724	0.03	-	0.03	11.07	0.22	2.28	32.28	52.53	0.55	0.36	0.22	0.06	0.04	0.33	-
DKC6876	0.06	0.03	0.03	11.99	0.46	2.19	31.77	51.50	0.68	0.48	0.33	0.20	0.07	0.17	0.04
KALUMET	-	0.04	0.04	13.16	-	2.10	31.09	51.74	0.76	0.41	0.28	0.14	0.05	0.16	0.03
FAMASO	-	0.02	0.01	12.17	-	2.13	31.37	51.72	1.18	0.36	0.31	0.18	0.08	0.25	0.22
SABIA	-	0.01	0.03	11.45	-	2.19	31.91	52.19	0.78	0.48	0.35	0.20	0.08	0.27	0.06
LSD (0.01)	0.0022	ns	0.0018	0.4722	0.012	0.0772	1.14	2.084	0.0316	0.021	0.01	0.0072	0.0032	0.0101	0.0063

C11:0 Undecanoic acid; C12:0 Lauric acid; C14:0 Myristic acid; C16:0 Palmitic acid; C16:1 Palmitoleic acid; C18:0 Stearic acid; C18:1 Oleic acid; C18:2 Linoleic acid; C18:3 Linolenic acid; C20:0 Arachidic acid; C20:1 Gadoleic acid; C22:0 Behenic acid; C22:1 Erusic acid; C23:0 Tricosanoic acid; C24:0 Lignoceric acid

findings we obtained about lignoceric acid were similar to the values obtained by some researchers as 0.09-0.27% (18), while it was lower than the values obtained by some researchers as 0.30% (19).

Palmitic acid was the highest saturated fatty acid (SFA) in Kalumet (13.16%), Famaso (12.17%), P31A34 (12.00%), DKC6876 (11.99%) and P31G98 varieties (11.98%), respectively. The lowest percentage of palmitic acid was found in the DKC6724 variety (11.07%). Palmitoleic acid was detected in all varieties except ADA393, P3394, Kalumet, Famaso and Sabia varieties, while high palmitoleic acid was obtained from the DKC6876 variety (0.46%), the lowest palmitoleic acid was obtained from P1921 variety (0.09%). Our findings about palmitic acid were similar to the values obtained by some researchers (19, 20). On the other hand, the value obtained by some researchers for palmitic acid was found to be higher than our values (18). The palmitoleic acid in seeds of 21 maize hybrids was determined to be 0.09-0.28% (18).

The highest stearic, oleic, arachidic, behenic and tricosanoic acids were obtained in the seeds of the P1429 variety with 2.55%, 33.21%, 0.53%, 0.32% and 0.49%, respectively. The lowest stearic acid was obtained in ADA523, P31A34 and Kalumet varieties (2.10%), the

lowest oleic acid in P31G98 variety (31.16%), the low arachidic and behenic acids in DKC6424 variety (036% and 0.06%, respectively), and tricosanoic acid in Kalumet variety (0.16%). The stearic, oleic and arachidic acids in *Zea mays* seeds were determined as 2.09-2.29%, 30.55-33.25% and 0.42-0.52% by some researchers (19), and 2.17-2.59%, 31.2-34.6% and 0.33-0.552% by some researchers (18), respectively. Our findings on behenic acid are similar to the findings obtained by some researchers (18, 19).

Linoleic acid was found in high quantities in all varieties. It ranged from 50.05 to 53.14% in all varieties. Table 1 showed the highest linoleic acid, an unsaturated fatty acid, was obtained in the P1921 variety, while the lowest linoleic acid was obtained in the P1429 variety. The findings we obtained about linoleic acid were similar to the values obtained by some researchers (20). while it was not in agreement with the values reported by some scientists (18, 19).

The lowest linolenic, gadoleic and erusic acids were obtained in DKC6424 variety with 0.55%, 0.22% and 0.04%, respectively. The highest linolenic acid was obtained in the Famaso variety with 1.18%, the highest gadoleic acid was obtained in ADA9516 and Sabia varieties with 0.35%, while the highest erusic acid was obtained in DKC6589 with 0.16% (Table 1). The findings we obtained about linolenic acid were similar to the values obtained by some researchers (20), while it was lower than the values of some researchers (19). On the other hand, our findings on gadoleic acid were similar to the findings obtained by some researchers (18, 19).

The total unsaturated fatty acid level (TUSFA) of studied *Zea mays* seeds was between 64.68% and 67.84% (Table 1). From the table presented it could be seen that the highest TUSFA was found in Kalumet variety, while the lowest percentage was found in the P1425 variety. Total saturated fatty acid level (TSFA) of studied *Zea mays* seeds was between 32.169% and 35.32%. P1429 variety has highest level of TSFA (35.32%); also, in DKC6876 variety (33.58%), DKC6424 variety (33.54%), P31D24 variety (33.39%) and Sabia variety (33.35%). The lowest percentages of TSFA were found in Kalumet variety. Some researchers reported that TUSFA and TSFA acids were found to be 83.51-85.91% and 14.65-16.49% in Peruvian Andean maize varieties (19), 79.7-86.4% and 13.8-20.4% in 21 maize hybrids (18).

Schuster et al. (14) found that the fatty acid composition of corn oil consists of 10% palmitic acid, 25% oleic acid, 58% linoleic, acid and 1% linolenic acid. Yeom et al. (21) reported that corn oil contains 10% palmitic acid, 27% oleic acid, 55% linoleic acid, and 3% linolenic acid. It was also reported in previous studies that corn oil is rich in terms of linoleic acid (22, 23).

Hamedi et al. (24) found that the fatty acid composition of corn oil consists of 10% palmitic acid, 25% oleic acid, 58% linoleic, acid and 1% linolenic acid. Yeom et al. (21) reported that corn oil contains 10% palmitic acid, 27% oleic acid, 55% linoleic acid, and 3% linolenic acid. It was also reported in previous studies that corn oil is rich in terms of linoleic acid (22, 23).

Conclusion

Corn oil (*Zea mays* L.) is a type of vegetable oil used widely in the food industry with its good fatty acid composition. Corn oil can be used widely as good quality edible oil since its percentage of linoleic acid is very high. In addition to the development of high-yielding corn varieties, future studies will lead to the development of varieties with high oil contents and superior characteristics in terms of the desired fatty acids for the oil industry and the expansion of the corn market.

Acknowledgments: The study is derived from the master's thesis supported by Kahramanmaraş Sutcu Imam University Scientific Research Projects (Project number 2017/7-181).

Conflict of Interest: The authors declare that there are no conflicts of interest related to this article.

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