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Investigation of changes in macro, micro and toxic element accumulations of some commercially important oilseeds (sunflower, sufflower and corn)

Ayşegül Korkmaz[1], Mehmet Musa Özcan[2]*, Mustafa Harmankaya[1], Mustafa Mete Özcan[3], Fatma Gökmen Yılmaz[1], Nazlı Can Aydeniz[1], Nesim Dursun[1]

[1] University of Selçuk, Department of Soil Science and Plant Nutrition , Faculty of Agricultural, 42031, Konya-Turkey
[2] Department of Food Engineering, Faculty of Agriculture, University of Selçuk, 42031 Konya, Turkey
[3]Veterinary Clinical Practice and Development, Karapınar Aydoğanlar Vocational School, Karapınar-Konya, Turkey

**Corresponding author: mozcan@selcuk.edu.tr*

Abstract

In this study, the differences in macro, micro and toxic element accumulations of some commercially important oilseeds (sunflower, sufflower and corn) were investigated. Seed varieties were effective on macroelement contents of the seeds. Among macro elements, the highest amounts of P and K were found to be between 2414.60 (corn) and 4919.84 mg/kg (sunflower) to 2305.46 (corn) and 3466.77 mg/kg (sunflower), respectively. The highest amounts of macroelements among oilseeds were detected in sunflower seeds, followed by sufflower and corn in decreasing order. The Fe and Zn contents of the seeds were determined as 13.72 (Corn) and 61.91 mg/kg (Sufflower) to 8.87 (corn) and 33.43 mg/kg (sunflower), respectively. In general, the lowest microelement contents were determined in corn sample, while the highest microelements were determined in sunflower seeds (except Fe and B). In general, toxic element contents of the oilseeds were detected at very low levels. Mo and Se contents of seeds were found to be slightly higher than the amounts of other toxic elements detected in seeds. Mo and Se contents of seeds were determined to be between 0.1285 (sunflower) and 0.2266 mg/kg (corn) to 0.0602 (sunflower) and 0.1019 mg/kg (sufflower), respectively. As a result, the toxic element contents of the studied oilseeds were found to be at very low levels, creating a safe raw material source for health and food industry.

Key words: oil-bearing seeds, macro and microelements, toxic element, ICP-OES.

1. Introduction

Although oilseeds are mostly used as a source of vegetable oil, a large amount of residue and by-products are obtained after the extraction process. These by-products are evaluated and the effective evaluation of waste makes a significant contribution to the economy [1]. Important oilseeds produced worldwide include sunflower, rapeseed, corn, soybean and cottonseed [2]. Numerous factors such as genotype, soil type, agricultural practices, climate and processing conditions are the main factors affecting the nutritional values and composition of seeds [3]. The seeds are rich in dietary fiber, unsaturated fatty acids, antioxidants, flavonoids (quercetin, luteolin, apigenin and kaempferol), proteins (up to 20%), vitamins (E, B, folate and niacin) and minerals (especially calcium, copper, iron, magnesium, manganese, selenium, phosphorus, potassium, sodium and zinc) [4,5]. Sunflower, which has a high tolerance to heavy metals, is used to clean the soil in areas where heavy metals are concentrated [6,7]. Minerals and trace elements in foodstuffs play an important role in human metabolism, and interest in these elements is in the relationships between trace element status and oxidative disease [8]. Recently, the use of chemical fertilizers for better crop yield and productivity has systematically

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adversely affected crop yield, physical and chemical properties of soil, water resulting from surface runoff and microbial ecological imbalance [9]. Application of biofertilizers has been reported recently to some crops such as maize, legumes, tubers and oilseed [10,11,12]. Thus, cultivation of high-quality plant-based foods such as oilseed crops such as sunflower, rapeseed, safflower and soybean, fruits and vegetables are a dietary resource for humans [13,14]. Toxic elements accumulate in agricultural lands, underground water resources, air and food, polluting the ecosystem and negatively affecting the lives of all living things in the World. The main factors that cause the spread of toxic elements into the ecosystem are mining, gases coming out of motor vehicle exhausts, the increase in the industrial sector, chemical fertilizer and excessive pesticide use [15]. Labeling of mineral composition of oilseeds encourages the increasing interest in the assessment of macro- and microelements in various foods and provides the necessary information for a healthy diet based on nutritional properties [16]. The aim of this study was to reveal the differences in macro, micro and toxic element accumulations of some commercially important oilseeds (sunflower, sufflower and corn).

2. Material and methods

2.1. Material

The oil-bearing seed samples (Sunflower, Sufflower and Corn) were provided from Konya provinces in 2025 (Fig. 1 and Fig. 2). Before the analysis, the seeds were cleaned. HNO_3 and H_2O_2 are analytical grade and Merck company (Darmstadt, Germany).

Figure 1. Seeds used in this study

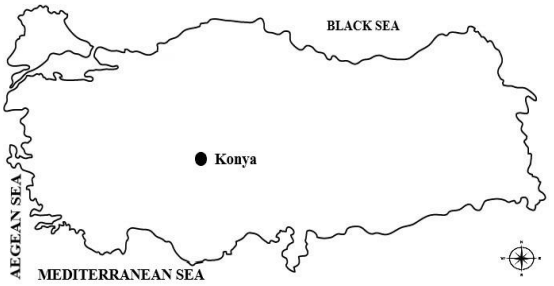

Figure 2. Location where the seeds used in this study were obtained

Macro, micro and toxic element contents of oil-seed samples

After 0.2 g seed samples were burned in a microwave device at 210ºC and 200 PSI pressure in 5 ml of concentrated HNO_3 and 2 ml of H_2O_2 (30% w/v), the volumes of the dissolved samples were completed to 20 ml with deionized water. Then, the seeds were separated and dissolved separately in the microwave device, and the elements were determined in the ICP-OES device. Then, macro, micro and toxicelement concentrations in seeds were defined by ICP-OES [17].

Statistical analysis

The statistical analysis of results obtained was determined by the JMP statistical program. Statistically differences were carried out by the analysis of variance (ANOVA) procedure in all data ($p<0.05$) [18].

3. Results and Discussion

The macroelement contents of different oilseeds of commercial importance are presented in Table 1. Seed varieties were effective on macroelement contents of the seeds. In general, macroelement contents in the seeds were high. Among macro elements, the highest amounts of P and K were found to be between 2414.60 (corn) and 4919.84 mg/kg (sunflower) to 2305.46 (corn) and 3466.77 mg/kg (sunflower), respectively. In addition, Ca contents of seeds varied between 38.38 (corn) and 1491.65 mg/kg (sunflower), while Mg contents of oilseeds are found to be between 787.70 (corn) and 1855.21 mg/kg (sunflower). The highest amounts of macroelements among oilseeds were detected in sunflower seeds, followed by sufflower and corn in decreasing order. This may be due to the metabolites secreted by sunflower root cells increasing the solubility of macroelements in compound form in the soil, allowing these nutrients to be easily taken by plants.

The microelement contents of different

oilseeds using ICP-OES are shown in Table 2. The microelement found in the highest amounts in the seeds was Fe, followed by Zn, Mn, Cu and B in decreasing order. The effect of seed varieties on the microelement contents of oilseeds was observed. The Fe and Zn contents of the seeds were determined as 13.72 (Corn) and 61.91 mg/kg (sufflower) to 8.87 (corn) and 33.43 mg/kg (sunflower), respectively. In addition, Cu contents of seeds varied between 0.76 (Corn) and 16.22 (sunflower), while Mn contents of seeds vary between 3.83 (Corn) and 20.07 mg/kg (sunflower). In addition, B contents of seeds were found between 5.20 (corn) and 17.11 mg/kg (sufflower).

In general, the lowest microelement contents were determined in corn sample, while the highest microelements were determined in sunflower seeds (except Fe and B). Microelement contents of safflower and sunflower seeds were higher than those of corn seeds.

Toxic element contents of different oilseeds are presented in Table 3. In general, toxic element contents of oilseeds were detected at very low levels. Mo and Se contents of seeds were found to be slightly higher than the amounts of other toxic elements detected in seeds.

Table 1. Macro element contents of oil-bearing seeds

Seeds	P	K	Ca	Mg
	---------- (mg / kg) ----------			
Sufflower	3736.92 B*	2992.69 B	1460.62 B	1657.43 B
Sunflower	4919.84 A	3466.77 A	1491.65 A	1855.21 A
Corn	2414.60 C	2305.46 C	38.38 C	787.70 C

***** $p<0.01$

Table 2. Micro element contents of oil-bearing seeds

Seeds	Fe	Zn	Cu	Mn	B
	---------- (mg / kg) ----------				
Sufflower	61.91 A*	22.06 B	11.28 B	11.27 B	17.11 A
Sunflower	39.61 B	33.43 A	16.22 A	20.07 A	14.78 B
Corn	13.72 C	8.87 C	0.76 C	3.83 C	5.20 C

*$p<0.01$

Table 3. Toxic element contents of oil-bearing seeds

Seeds	Al	Ba	Cd	Co	Mo	Cr	Ni	Pb	As	Se
	---------- (mg / kg) ----------									
Sufflower	0.0099 A*	0.0516 B	0.0047 C	0.0027 B	0.1598 B	0.0041 B	0.0022 C	0.0026 B	0.0321 B	0.1019 A
Sunflower	0.0091 B	0.0648 A	0.0068 A	0.0102 A	0.1285 C	0.0044 A	0.0208 A	0.0056 A	0.0799 A	0.0602 C
Corn	0.0026 C	0.0020 C	0.0055 B	0.0024 C	0.2266 A	0.0037 C	0.0035 B	0.0017 C	0.0329 B	0.0743 B

***** $p<0.05$

Mo and Se contents of seeds were determined between 0.1285 (sunflower) and 0.2266 mg/kg (corn) to 0.0602 (sunflower) and 0.1019 mg/kg (sufflower), respectively. In addition, the Ni content of sunflower seeds (0.02080 mg/kg) was higher than that of safflower (0.0022 mg/kg) and corn (0.0035 mg/kg) seeds. In addition, the Ba contents of safflower and sunflower were found to be higher than that of corn seeds. In addition, the Co content of sunflower was found to be higher than that of safflower and corn seeds. As a result, the toxic element contents of the studied oilseeds were found to be at very low levels, creating a safe raw material source for health and food industry. This situation creates confidence in terms of processing the seeds and using them as food. Factors affecting the uptake of nutrients by plants include the concentration of nutrient elements dissolved in the soil solution, ion exchange in the soil, root development, transport of nutrients to the root area, root secretions and the effects of mycorrhizae [19]. There are also differences among plants in terms of the nutrients taken up by plants, i.e. the amount

of nutrients taken up by plants [20]. In particular, due to the taproot system, high root cation exchange capacity and high vegetative development, sunflower plants remove more nutrients from the soil than safflower and corn plants. In previous study, Özcan [21] reported that sunflower kernels contained Mg (2251 mg kg); K (8754 mg/ kg); Cr (2.2 mg /kg); Mn (7.0 mg/ kg); Fe (49.7 mg/ kg); Ni (5.7 mg /kg); Cu (18.1 mg /kg) and Zn (36.5 mg/ kg). While the highest heavy metal concentrations in all the sunflower seed samples are obtained as iron (13.14-61.04 µg/kg), zinc (34.11-54.12 µg/kg), copper (15.68-20.7 µg/kg), and manganese (12.72-20.20 µg /kg), heavy metals of sunflower seeds were established as boron (4.82-10.33 µg/kg), aluminum (0-13.12 µg/kg), and nickel (0.88-7.74 µg/kg). Saad et al. [22] reported that sunflower and corn seeds contained 610 and 470 mg/100g K, 75 and 12.3 Ca, 320 and 211 Mg, 5.42 and 4.4 Fe and 1.77 and 0.5 mg/100g Cu. In previous study, the concentrations of Fe, Mn, Zn, and Cu elements in sunflower were found in the range of 100-200 µg/kg, 50-100 µg/kg, 50-70 µg/kg and 10-20 µg/kg, respectively [23]. In other study, the concentrations of Cu, Fe, Mn, Zn, Cd and Pb in sunflower seeds were 21.9-23.4 µg/kg, 59.8-66.4 µg/kg, 20.2-23.9 µg/kg, 73.1-112 µg/kg, 130-239 µg/kg, and 167-219 µg/kg, respectively [24]. Sánchez-Velázquez et al. [25] determined 77.2–327.3 mg/100g K, 25.0–165.5 P, 3.2–64.7 Ca, 0.0–141.3 Mg, 0.4–4.2 Fe, 0.4–0.9 Zn, 0.3–0.8 Mn and 0.1–0.2 mg/100g Cu in corn grain. The differences between our results and the literature results may be due to variety, genetics, harvest time, growing conditions and analytical conditions. The importance of consuming seeds high in mineral content has been noted and it has been suggested that the inclusion of sunflower oil in cooking methods may increase dietary intake of minerals [26].

4. Conclusions

Seed varieties were effective on macroelement contents of the seeds. The highest amounts of macroelements among oilseeds were detected in sunflower seeds, followed by sufflower and corn in decreasing order. In general, the lowest microelement contents were determined in corn sample, while the highest microelements were determined in sunflower seeds (except Fe and B). Microelement contents of safflower and sunflower seeds were higher than those of corn seeds In general, toxic element contents of oilseeds were detected at very low levels. Mo and Se contents of seeds were found to be slightly higher than the amounts of other toxic elements detected in seeds.

Conflicts of interest: No conflict of interest

Ethics declaration: not applicable

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