GRASAS Y ACEITES, 57 (2),
ABRIL-JUNIO, 211-218, 2006,
ISSN: 0017-3495

Determination of the mineral compositions of some selected oil-bearing seeds and kernels using Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)

By **M. Musa Özcan**

Department of Food Engineering, Faculty of Agriculture, Selçuk University, 42031 Konya, Turkey.
E-mail: mozcan@selcuk.edu.tr

RESUMEN

Determınacıón de la composición en minerales de algunas semillas oleaginosas utilizando ICP-AES (Inductively Coupled Plasma Atomic Emission Spectrometry).

La finalidad del trabajo es establecer el contenido en elementos minerales de semillas oleaginosas tales como ca cahuetes, trementina, avellana, sesamo, maiz, almendras, girasol, utilizando ICP-AES. Se han observado diferencias significativas en la composición de minerales entre cosechas. Todas las semillas contienen cantidades elevadas de Al, Ca, Fe, K, Mg, Na, P y Zn. Los contenidos de B, Cr, Cu, Li, Ni, Sr, Ti y V, sin embargo, fueron bajos. Los contenidos de K y P en todas las semillas estudiadas fueron superiores a las de otras semillas. El contenido medio de K osciló entre 1.701,1 mg/kg (maiz) a 20.895,8 mg/kg (soja), el P entre 3.076.9 mg/kg (trementina) a 12.006.5 mg/kg o 2.617,4 mg/kg (semilla de algodón), y Ca de 68,4 mg/kg (maiz) a 13.195,7 mg/kg (adormidera). Estos resultados indican que los valores obtenidos pueden ser interesantes para deducir informaciones nutricionales de las mismas. En particular, los resultados muestran que las semilla de soja, piña y adormidera representan una buena fuente de K, P y Ca, respectivamente mientras que los piñones tienen un contenido elevado de Zn.

PALABRAS-CLAVE: Composición mineral - ICP-AES - Semıllas oleaginosas.

SUMMARY

Determination of the mineral compositions of some selected Oil-Bearing seeds and kernels using Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)

The aim of this paper was to establish the mineral contents of oil-bearing seeds and kernels such as peanut, turpentine, walnut, hazelnut, sesame, corn, poppy, almond, sunflower etc., using Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES). Significant differences in mineral composition were observed among crops. All seeds and kernels contained high amounts of Al, Ca, Fe, K, Mg, Na, P and Zn. B, Cr, Cu, Li, Ni, Sr, Ti while V contents of the crops were found to be very low. The levels of K and P of all crops in this study were found to be higher than those of other seeds and kernels. The results obtained from analyses of the crops showed that the mean levels of potassiumcontent ranged from 1701.08 mg/kg (corn) to 20895.8 mg/kg (soybean), the average content of phosphorus ranged from 3076.9 mg/kg (turpentine) to 12006,5 mg/kg to 2617.4 mg/kg (cotton seed), and Ca from 68.4 mg/kg (corn) to 13195.7 mg/kg (poppy seed). The results show that these values may be useful for the evaluation of dietary information. Particularly the obtained results provide evidence that soybean, pinestone and poppy seed are a good source of K, P and Ca, respectively. Whereas pinestone is a good source of zinc.

KEY-WORDS: ICP-AES - Mineral composition - Oil-bearing seed.

1. INTRODUCTION

A number of mineral ions are recognized as essential plant nutrients that are directly incorporated into organic compounds sythesized by the plant. Of these, potassium, phosphorus, calcium, magnesium and sodium are the most important quantitatively and are recommended for composition analysis (Anonymous 2004b). Recently, the significance of oil-bearing seeds and kernels in the nutrition of human populations is increasing for several reasons. The seeds of oil-bearing crops (sunflower, corn, peanuts, hazelnut, walnut, mustard, black cumin, soybean, sesame etc.) have several food value and curative properties (Özdemir et al., 2001; Özcan, 2004; Glew et al. 1997; Anonymous 2004a). Sunflower seeds are probably the most familier of all edible seeds. The larger kernels are generally used for edible purposes while the smaller ones for crushing into edible oil. Sunflower was introduced in Europe in the 16th century. Sunflower kernels are well above average in protein, phosphorus and iron concentrations. So, the flour made from sunflower seeds is one of the richest sources of iron in any food. It is, therefore, highly beneficial in the prevention and treatment of anemia (Anonymous 2004a). The phosphorus present is fairly available because of the phytase activity within the grain. The low Ca:P ratio requires the inclusion of ground limestone or similar to supplement the Ca level (Wiseman, 1987). Baş et al.(1986) and Açkurt et al.(1999) reported compositions of major commercial Turkish hazelnut varieties. In addition, Ayfer et al.(1986) and Çalışkan (1995) reported physical properties of the major commercial Turkish hazelnuts. Pumpkin (Cucurbita sp) and melon (Cirrullus sp) seeds are used directly for human consumption as a snack after salting and roasting in Arabian countries (Al-Khalifa, 1996). Smith et al.

(1996) have also reported on the nutritional composition and uses of wild foods common to Burkina Faso and Niger. Moreover, Enujiupha (2003) reported chemical and functional properties of the conophor nut purchased from the Oja-oba market at Akure. Dugo et al. (2004) determined some mineral contents of commercial vegetable oils using derivative potentiometric stripping analyses.

In the earlier part of this century, scientists could qualitatively detect small amounts of several mineral elements in living organisms. The trace elements found in living organisms may be essential, fortuitious reminders of our geochemical origins or indicators of environmental exposure (Macrae et al.1993 a,b). Human, as well as animal, studies originally showed that optimal intakes of elements such as sodium, potassium, magnesium, calcium, manganese, copper, zinc and iodine could reduce individual risk factors, including those related to cardiovascular disease (Anke et al., 1984; Mertz,1982; Sanchez-Castillo et al., 1998). Throughout the world, there is increasing interest in the importance of dietary minerals in the prevention of several diseases.Minerals are of critical importance in the diet, even though they comprise only 4-6% of the human body. The major minerals serve as structural components of tissues and function in cellular and basal metabolism and water and acid-base balance (Macrae et al.1993a; Nielsen,1984; Smith,1988). However, very little information has been reported on the mineral contents of oil-bearing seeds and kernels (Özdemir et al.2001; Enujiugha, 2003; Glew et al.1997; Baş et al.,1986; Açkurt et al.1999; Ayfer et al.,1986; Özcan and Akgül, 1995; Özcan, 2000; Özcan and Seven, 2003; Özcan, 2004).

Therfore, the aim of this work is to established the mineral contents of oil-bearing seeds and kernels via ICP. In addition, other physico-chemical and functional properties of seeds and kernels are also studied.

2. MATERIAL AND METHODS

2.1. Material

Oil-seeds and kernels (Table 1) were purchased from bazaar in Konya in Turkey in August 2003. The materials were transported in polypropylene bags and held at room temperature. Materials were cleaned by a combination of manual and mechanical means to get rid of all foreign matter as well as crushed or immature fruits.

2.2. Method

Determination of mineral contents

About 0.5 g dried and ground materials was put into a burning cup and 15 ml of pure HNO_3 were added. The sample was incinerated in MARS 5 Microvawe Oven at 200 ^oC temperature and the solution was diluted to the desired volume with water. Concentrations were determined with an ICP-AES (Skujins, 1998).

Working conditions of ICP-AES: Instrument: ICP-AES (Varian-Vista). RF Power: 0,7-1,5 kw (1,2-1,3 kw for Axial). Plasma gas flow rate (Ar): 10,5-15 L/min. (radial), 15 L/min. (axial). Auxilary gas flow rate (Ar): 1,5 L/min. Viewing height: 5-12 mm. Copy and reading time: 1-5 s (max.60 s). Copy time: 3 s (max. 100 s).

Table 1
Crops used in experiment

General name	Botanical name	Family	Used parts
Almond	*Prunus amygdalus* L.	Rosaceae	Kernel
Apricot	*Prunus armeniaca* L.	Rosaceae	Kernel
Black cumin	*Nigella sativa* L.	Ranunculaceae	Seed
Safflower	*Carthamus tinctorius*	Asteraceae	“
Corn	*Zea mays*	Gramineae	Germ
Cotton	*Gossipium hirsitum*	Malvaceae	“
Hazelnut	*Corylus avellana* L.	Corylaceae	Kernel
Linen	*Linum utitassimum* L.	Linaceae	Seed
Peanut	*Arachis hypogaea* L.	Leguminoseae	Seed
Pinestone	*Pinus pinea* L.	Pineceae	Kernel
Pistachio nut	*Pistachia vera* L.	Anacardiaceae	Kernel
Poppy	*Papaver somniferum* L.	Papaveraceae	Seed
Rape	*Brassica napus* L.	Cruciferae	Seed
Sesame	*Sesamum indicum* L.	Pedaliaceae	Seed
Soybean	*Soja max*	Leguminoseae	Seed
Sunflower	*Helianthus annuus* L	Compositeae	Seed
Turpentine	*Pistachia terebinthus* L.	Anacardiaceae	Fruit
Walnut	*Juglans regia* L	Juglandaceae	Fruit

3. RESULTS AND DISCUSSIONS

The mineral contents of oil-bearing seeds and kernels are presented in Table 2. Mineral values were established to vary widely depending on the different seeds and kernels.

Results have shown that Al, Ca, Fe, K, Mg, Na, P and Zn were major minerals of all oil-bearing seeds and kernels (Fig 1). B, Cr, Cu, Li, Ni, Sr, Ti and V contents of crops were found to be very low. Mn was not established in cotton seed, turpentine, pistachio nut, sesame, aspir, corn, almond or apricot. In addition Sr was not determined in corn or pistachio nut, respectively. The levels of K and P of all crops in this study were found to be higher than those of other seeds and kernels. The potassium content was high in most cases and ranged from 1701.08 mg/kg corn to 20895.78 mg/kg soybean. The phosphorus content ranged from 3076.87 mg/kg turpentine to 12006.46 mg/kg pistachio nut (Fig 1). The magnesium content varied from 1153.99 mg/kg in corn to 2617.38 mg/kg in cotton seed. The Lithium contents of seeds and kernels were found in similarly small percentages in all the species analyzed, ranging from 1.63 mg/kg soybean to 2.76 mg/kg black cumin. Ca was found to be high, ranging from 68.40 mg/kg in corn to 13195 mg/kg in poppyseed. Cr content was found to be very similar to those of other crops. Fig 1 provides evidence that Ca is present in very low amounts but poppy seed presented the highest mean concentrations of Ca 13195.67 mg/kg. Pine stone kernels also presented the highest average amounts of zinc (85.57 mg/kg) and turpentine fruit the lowest (8.29 mg/kg). Copper concentrations found in this work were lower than those published for black cumin, whereas the levels of B and Zn are similar to those determined in black cumin (Özcan,2004).

Minerals are of interest due to their pro-oxidant activity and health benefits (Alphan et al.,1996; Pala et al., 1996; Parcerisa et al.,1995; Pesrshern et al.,1995). Özdemir (1985) and Özdemir et al.(2001) determined the Fe, Cu, Mn, K, Zn, Na, Mg and Ca contents of some commercial and new hybrid hazelnut varieties, and Ca, Mg and K contents were found higher than those of other elements. Hazelnut was rich in mineral matters such as Ca (209.0 mg/100 g), Mg (162.5 mg/100 g), P (337.0 mg/100g) and K (704.0 mg/100 g) (Şimşek and Aslantaş,1999). From a human nutritional point of view, hazelnut is rich in Ca, K, Mg and P. The seeds of Sorghum vulgaris contain relatively large amounts of Mg (1520 µg/g), P (3030 µg/g),Ca (202 µg/g) and Fe (35 µg/g).

We concur, too, with their? results that dried sesame, copper, mustard and peanut contain high concentrations of Cu, Mg, Z and Fe. Our data on mineral contents are in accordance g with their? data in that we found that soybean contains large quantities of Al, Ca, K and Ni.

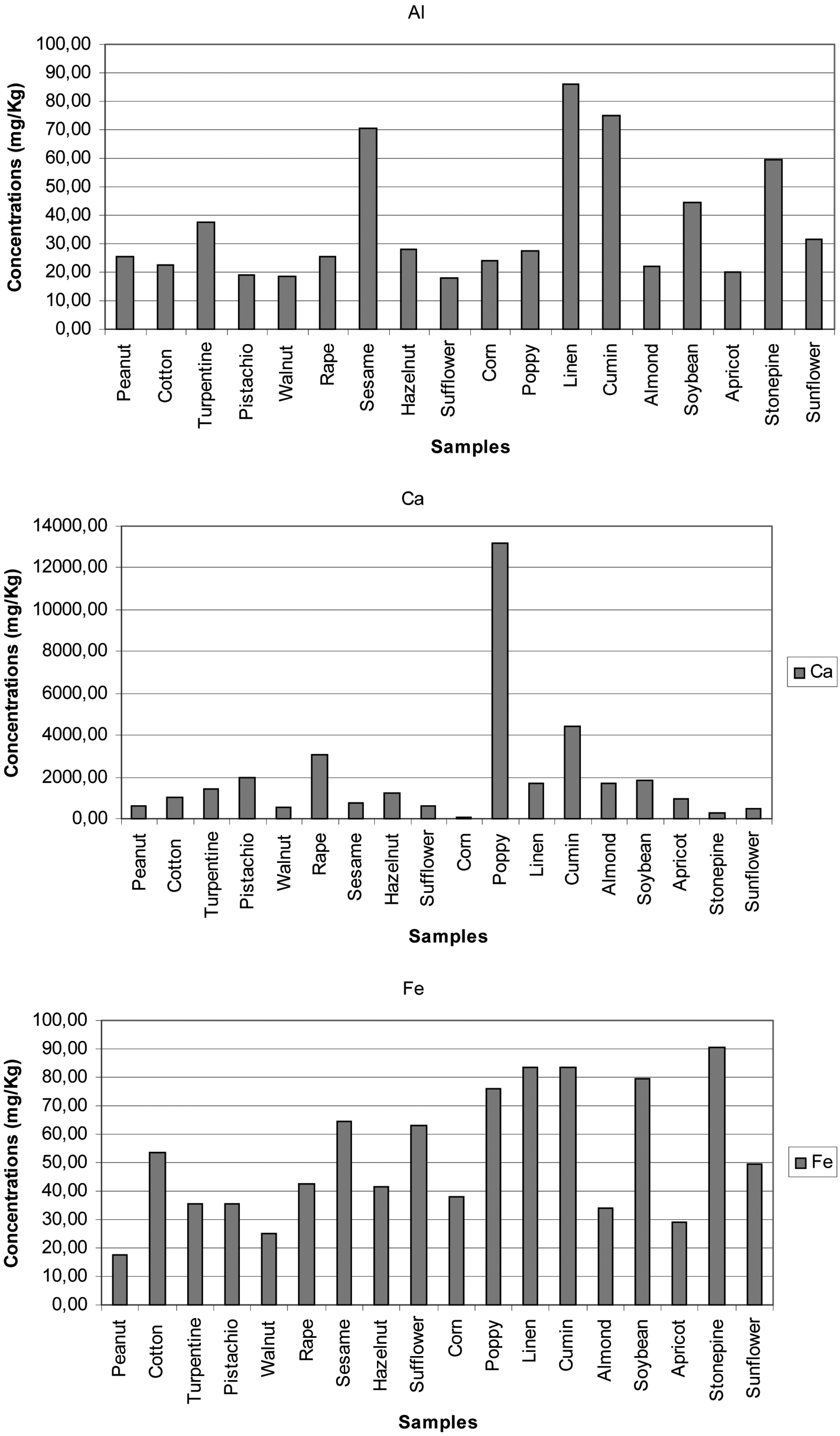
It is noteworthy that trace minerals are important not only for human nutrition, but for plant nutrition as well. Mineral-efficient varieties of plants are more drought resistant and require less irrigation (Botta and Giovanni,1996; Bouis,1996; Glew et al.,1997).

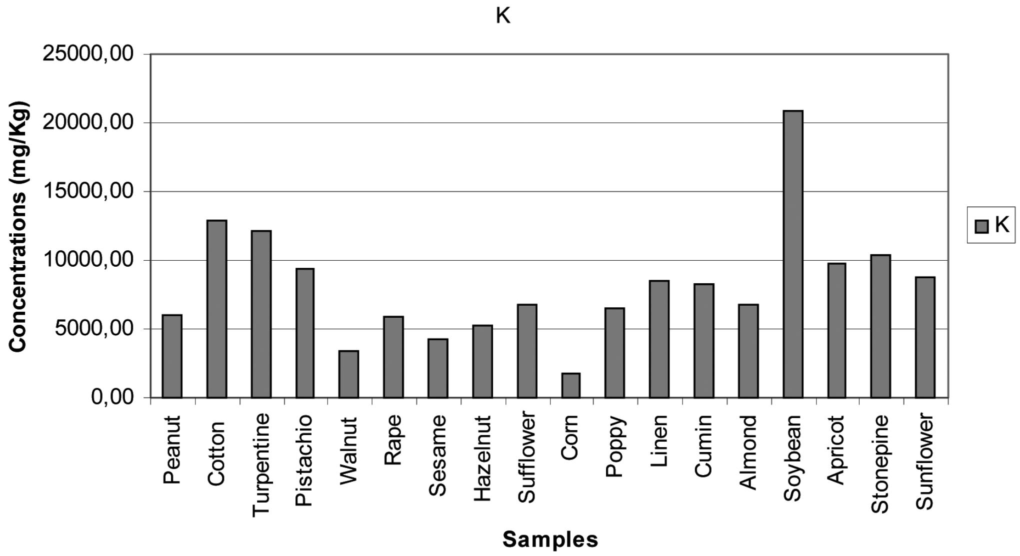
Table 2
The mineral contents of oil-bearing seed and kernels

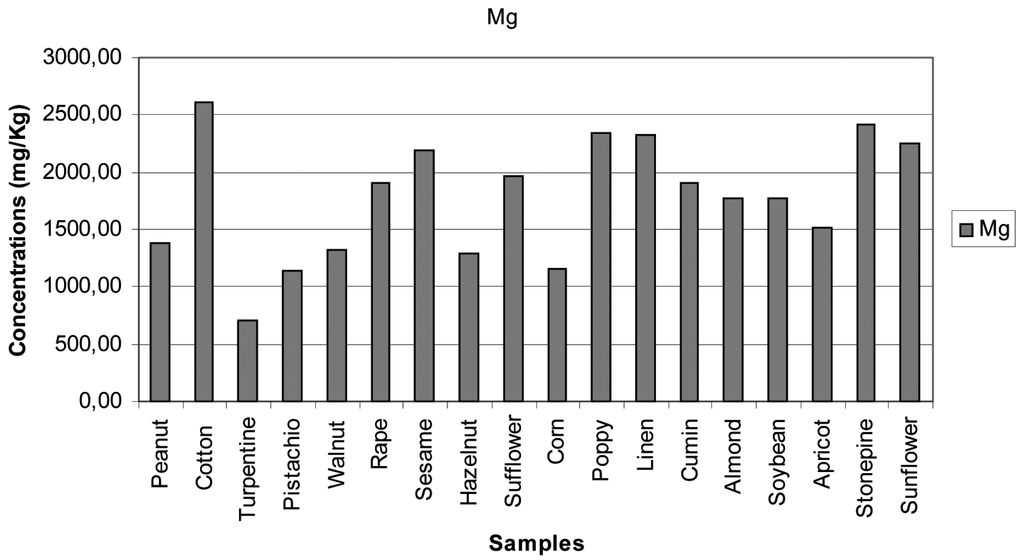
Samples	Minerals (mg/kg)																
	Al	B	Ca	Cr	Cu	Fe	K	Li	Mg	Mn	Na	Ni	P	Sr	Ti	V	Zn
Peanut	25.60	26.66	644.56	1.84	7.41	17.62	6035.9	1.93	1377.2	4.49	787.4	1.69	3972.3	0.26	5.96	5.98	26.59
Cotton	22.55	16.73	1025.63	2.08	9.47	53.52	12926.8	1.73	2617.4	ND	722.8	3.37	9425.6	2.66	0.59	16.20	38.04
Turpentine	37.65	16.64	1460.37	2.94	4.95	35.36	12095.7	1.94	708.7	ND	826.9	0.62	3076.9	1.08	3.24	3.89	8.29
Pistachio	18.83	10.57	1998.09	1.66	6.79	35.67	9361.65	1.87	1145.6	ND	788.6	0.85	4753.8	3.38	7.02	7.57	15.80
Walnut	18.27	11.59	511.12	1.66	3.76	24.81	3379.2	1.77	1321.1	11.79	650.4	2.42	4380.9	0.33	7.12	5.51	13.88
Rape	25.29	11.26	3070.47	1.29	2.17	42.32	5900.2	1.75	1897.9	22.89	654.9	1.21	6633.9	12.49	1.18	14.01	23.86
Sesame	70.34	11.22	723.57	3.82	11.58	64.48	4295.7	1.81	2191.4	ND	1138.8	0.95	8308.9	12.33	0.91	10.13	28.16
Hazelnut	27.88	19.21	1192.68	2.06	10.66	41.65	5310.3	1.82	1284.4	26.18	674.2	1.15	3800.3	2.48	4.53	6.51	16.91
Sufflower	18.19	14.35	640.09	1.66	16.93	62.82	6801.9	1.77	1959.7	ND	747.9	1.02	7864.1	0.38	1.21	9.50	61.56
Corn	23.76	3.51	68.40	2.38	2.85	37.89	1701.1	1.72	1153.9	ND	535.8	0.79	5244.3	ND	7.11	3.63	33.55
Poppy	27.47	13.51	13195.67	1.42	14.94	75.90	6468.8	1.83	2343.5	58.68	844.6	1.11	7945.0	4.49	0.35	39.52	58.09
Linen	85.91	10.96	1693.18	1.57	8.23	83.49	8445.7	2.01	2318.8	7.88	1031.6	1.35	6651.6	2.25	5.91	13.53	26.58
Cumin	75.18	14.70	4418.60	2.37	8.67	83.30	8288.7	2.76	1902.5	7.27	835.9	4.31	7494.8	24.22	1.52	16.12	29.64
Almond	22.19	8.20	1692.76	1.70	5.85	34.04	6794.9	1.81	1771.0	ND	650.4	0.49	6261.8	1.16	2.19	10.22	21.85
Soybean	44.43	24.18	1867.21	4.83	8.75	79.64	20895.8	1.63	1762.7	4.61	757.8	4.73	5972.2	5.09	ND	10.56	23.36
Apricot	20.14	11.29	928.70	2.50	10.06	28.84	9730.4	1.99	1515.7	ND	697.8	3.27	5068.1	2.32	5.76	6.99	30.28
Stonepine	59.65	17.02	278.71	1.93	24.48	90.57	10392.2	1.78	2418.7	36.92	871.2	3.16	12006.5	ND	2.08	12.28	85.57
Sunflower	31.75	7.33	464.84	2.17	18.11	49.66	8753.8	1.64	2251.3	6.95	1026.7	5.71	9607.9	3.72	0.51	11.29	36.54

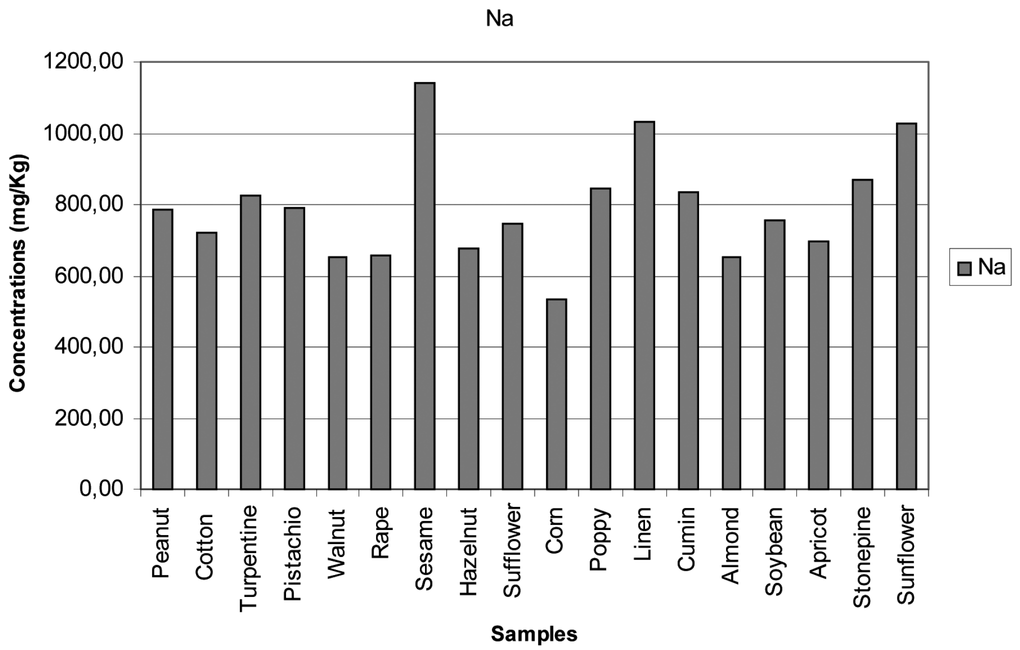
ND:Non Detected

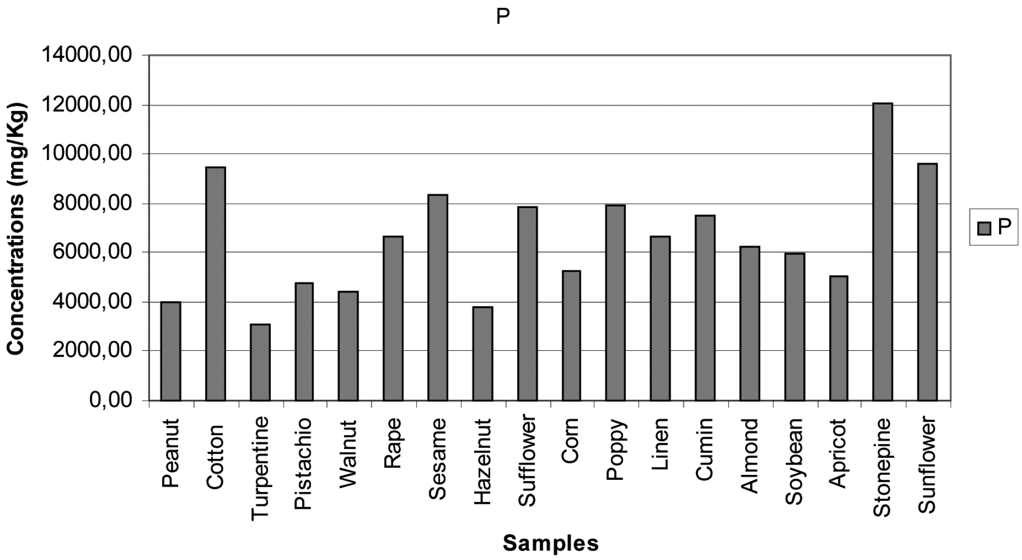
Figure 1
Major minerals of oil-seed and kernels (mg/kg)

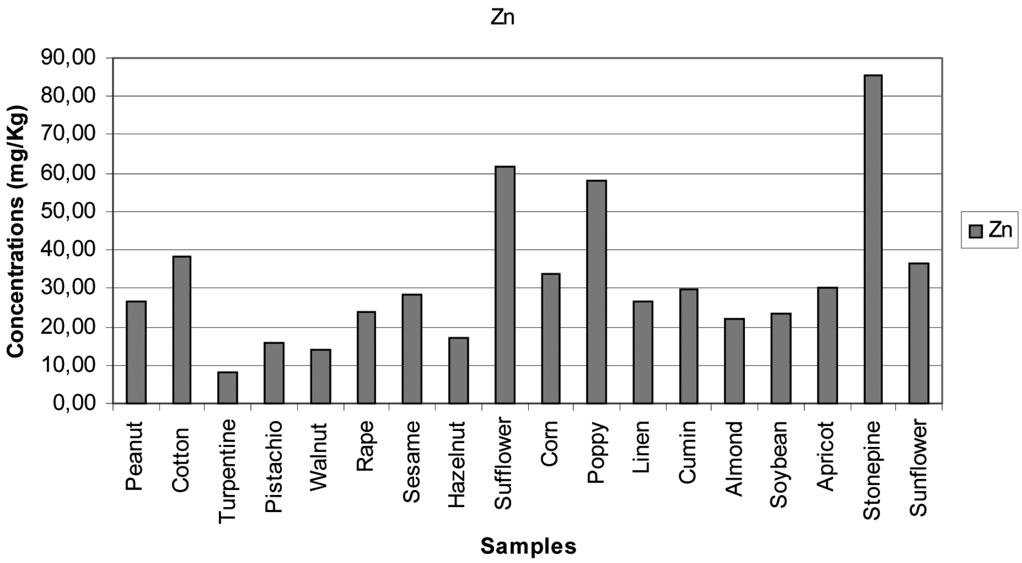



K
25000,00
20000,00
15000,00
10000,00
5000,00
0,00
Concentrations (mg/Kg)
K
Peanut
Cotton
Turpentine
Pistachio
Walnut
Rape
Sesame
Hazelnut
Sufflower
Corn
Poppy
Linen
Cumin
Almond
Soybean
Apricot
Stonepine
Sunflower
Samples


Mg
3000,00
2500,00
2000,00
1500,00
1000,00
500,00
0,00
Concentrations (mg/Kg)
Mg
Peanut
Cotton
Turpentine
Pistachio
Walnut
Rape
Sesame
Hazelnut
Sufflower
Corn
Poppy
Linen
Cumin
Almond
Soybean
Apricot
Stonepine
Sunflower
Samples


Na
1200,00
1000,00
800,00
600,00
400,00
200,00
0,00
Concentrations (mg/Kg)
Na
Peanut
Cotton
Turpentine
Pistachio
Walnut
Rape
Sesame
Hazelnut
Sufflower
Corn
Poppy
Linen
Cumin
Almond
Soybean
Apricot
Stonepine
Sunflower
Samples





In a previous study, Enujiugha (2003) reported the mineral contents (Ca, Mg, P, Cu, Fe, Zn, Ni, Co, Cb) of a conophor nut called as the African walnut, and determined it as (mg/100 g) 42.06, 57.37, 465.95, 1.56, 1.55, 6.84, 0.38, 0.05 and 0.01, respectively. Özcan (2000) reported that some apricot kernels contained Na (2.75-3.68 %), K (0.35-0.64%), Ca (0.08-0.11%), Mg (0.23-0.26%) and Fe (10.7-74.9%) minerals. Özcan and Akgül (1995) determined the mineral contents (0.07- 0.16 % Na; 0.47- 0.60 % K; 1.01-1.85% P; 15.58-20.45 ppm Cu; 65.20-85.95 ppm Fe; 16.61-22.66 ppm Mn and 70.10- 121.41 ppm Zn) of sesame seeds provided from several different regions. In another study, Na, K, Ca, P, Fe, Zn, Cu, Mg, Mn, Al, As,B,Cs,Cr,Li,Pb,Se and V values of two different peanuts have been established by using Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES). Both seeds of Çom and NC-7 peanut cultivars were found rich in Na, K,Ca,P,Fe,Zn,Cu,Mg,Mn,Al,B and Sr (Özcan and Seven,2003). Potassium and Calcium were the predominant elements in the poppy seeds followed by sodium, magnesium and phosphorus (Nergiz and Ötleş,1994). Cu, Fe and Zn are essential minerals for human nutrition, and their daily doses for adults, respectively, are 2-3 mg, 18 mg and 15 mg (Clydesdale and Francis,1985).

Oil-bearing seeds and kernels were high in phosphorus and calcium, which are essential for bone and teeth development (Brody,1994). The high phosphorus content agrees with the observation of Nwokolo (1987) that phosphorus was high in some tropical grains and oil seeds. Nickel was detected in very low concentrations below the minimum permissible levels for the human body. The results of the present study compare favorably with those obtained by Özcan and Akgül(1995), Özcan (2000) and Özcan (2004).

These differences might be due to growth conditions, genetic factors, geographical variations and analytical procedures (Guil et.al.,1998; Özcan,2004; Özcan and Akgül,1998; Özcan et al.,1998).

The Mg, Fe, K, Ca and P levels are adequate. Inorganic elements which may contribute to biological processes, but which have not been established as essential, are B and Li (Macrae et al.,1993a). Lithium is another element with beneficial pharmacological properties; it has been used effectively in the treatment of manic depressive disorders. There is evidence to suggest that lithium is also an essential element (Macrae et al.1993b).

ACKNOWLEDGEMENT

Author thanks to Dr Kadir Sabancı for him help. Also, this study was supported by Selçuk University Scientific Research Project (S.Ü.-BAP).

REFERENCES

Anonymous. 2004a. Availaoble:http:// www. Indiangyan. Com / book/ healthbooks/ food-that-heal /sunflower –seeds. Shtml. (21.03,2004).

Anonymous. 2004b. Available:http://www.projectgroep biotechnologie.nl/actueel/download/SubstantialEquivalence-OilseedRape.pdf (7.4.2004)

Açkurt, F., Özdemir, M., Biringen, G., Löker, M. 1999. Effect of geographical origin and variety on vitamin and mineral composition of hazelnuts (*Corylus avellena* L.) varieties cultivadet in Turkey. *Food Chemistry* **65**,309-313

Al-Khaliffa, A.S. 1996. Physicochemical characteristics, fatty acid compasition and lipoxygenase activity of crude pumpkin and melon seed oils. *Jouurral of Agricultural and Food Chemistry* **44**. 964-966.

Anke, M., Groppel, B., Kronemann, H. 1984. Significance of newer essential trace elements (like Si, Ni, As, Li, V,...) for the nutrition of man and animals P. Bratter &P. Schramel (eds.) In: Trace elements-analytical chemistry in medicine and biology. Vol. 3, pp 424-464, Berlin.

Ayfer,M., Uzun, A., Bal, F. 1986. Türk Fındık Çeşitleri (Turkish Hazelnut varieties). Ankara: Black Sea Hazelnut Exporters Union,Turkey.

Baş, F., Ömeroğlu, S., Türdü and Aktoz, S. 1986. Composition of the main hazelnut varieties cultivated in Turkey (Önemli Türk Fındık sentlerinin bileşim özelliklerinin saplanması). *Gıda* **11**,195-203. (in Turkish)

Botta., R., Giovonni, M. 1996. Kernel guality in hazelnut cultivars and selections analysed for sugars, lipids, and fatty acid composition. *Acta Harticulturae* **445**,319-326.

Alphan, E., Pala, M., Açkurt, F., Yılmaz, T. 1996. Nutritional composition of hazelnuts and its effects on glucose and lipid metabolism. *Acta Harticulturae* **445**, 305-310.

Bouis, H. 1996. Enrichment of food staples through plant breeding: A new strategy for tighting micronutrient malnutrion. *Nutr. Rev* **54**,131-137.

Brody, T. 1994. *Nutritional Biochemistry*, Son Diego, CA: Arademic Pass.

Clydesdale, F. M., Francis, F. J. 1985. Food Nutrition and Health. The AVI Pubishing Company Inc, Westport, Connecticut, pp 225-226.

Dugo, G., pera L. L., La Torre, G. L., Giuffrida, D. 2004. Determination of Cd (II), Cd (II), Pb (11), and Zn (11) content in commercial vegetable oils using derivative potentiometric stripping analysis. *Food Ctermitiy* (in press)

Erujiugha, V. N. 2003. Chemical and funetional characteristic, of conophor nut. *Pakistan Journal of Nutrition* **2**(6), 335-338

El-Adawy, T. A., Taha, K. M. 2001. Characteristic, and compasition of different seed oils and Flours. *Food Chermistry* **74**, 47-54.

Glew, R. H., Vanderjagl, D. J., Lockell, C., Grivetti, L. E., Smith G. C., Pastuszyn, A., Millson, Millson,M. 1997. Amino acid, fatty acid, and mineral composition of 24 Indigenous plants of Burkina Faso. *J. Food Composition and Analysis* **10**,205-217.

Guil, J. I., Martinez, J. J. 6., Isasa, M.E. 1998. Mineral nutrient compasition of edible wild plants. *J. Food Composition and Analysis* **11**,322-328

Macrae, R., Robinson, R. K. Sadler, M. J. (eds.) 1993a. Encyclopaedia of Food Science, *Food Technology and Nutrition, Vol. 5*, 3126-3131, Academic Press INC., San Diego,CA.

Macrae, R., Robinson, R. K. Sadler, M. J. (eds.). 1993b. Encyclopaedia of Food Science*, Food Technology and Nutrition, Vol. 7*, 4593-4600, Academic Press INC., San Diego,CA.

Mertz, W. 1982. Trace minerals and atherosclerosis. Food Processing **41**(11), 2807-2812.

Nergiz, C., Ötleş, S. 1994. The proximate composition and some minor constituents of poppy seeds. *Journal of the Science of Food and Agricultur* **66**, 117-120.

Nielsen,F.H. 1984. Ultratrace elements in nutrition. *Annual Review of Nutrition* **4**, 21-41.

Nwokolo, E. 1987. Composition and availability of nutrients in some tropical grains and oilseeds. *Nutr. Rep. Int.,* **36**, 631-640.

Özcan M. and Akgül, A. 1995. Some compositional characteristic of sesame seed and oil. *Tr. J. Agricultura and Forestry* **19**: 59-65

Özcan, M., Akgül, A. (1998). Influence of species, harvest date and size on composition of capers (*Capparis* spp.) flowers buds. *Nahrung* **42**,102-105

Özcan, M., Akgül, A., Bagci, Y., Dural, H. 1998. Chemical composition and mineral content of edible wild plants consuned. *Annual Review of Nutrition Journal* **15**,72-77

Özcan, M. 2000. Composition of some apricot (*Prunus armeniaca* L) kerrels grown in Turkey. *Acta Alinentaria* **29**(3), 289-293

Özcan, M., Seven, S. 2003. Physical and chemical analysis and fatty acid composition of peanut, peanut oil and peanut butter from com and N C –7 cultivars. *Grasas y Aceites* **54** (1), 12-18.

Özcan, M. 2004. Mineral content, of some plants used as condimennts in Turkey. *Food Chemistry* **84**, 437-440

Özcan. 2004. Characteristics of fruit and oil of terebinth (*Pistacia terebinthus* L.) growing wild in Turkey. *Journal of the Science of Food and Agriculture* 84(6):517-520.

Özdemir, M. 1985. Elemental analysis of hazelnut kernels and shells by spark source mass spectromentry. *Z. Lebensmittel Untersuchung. und Forschun* **180**, 289-292.

Özdemir, M., Açkurt, F., Kaplan, M., Yıldız, M., Löker, M., Gürcan,T., Biringen, G., Okay, A., Seyhan, F.G. 2001. Evaluation of new Turkish hybrid hazelnut (*Corylus avellana* L.) varieties: fatty acid compasition, α-tocopherol content, mineral composition and stability. *Food Chemistry* **73**,411-415

Pala, M., Açkurt, F., Löker, M., Yıldız, M., Ömeroğlu, J. 1996. Fındık çeşitlerinin bileşimi ve beslenme fizyolojisi açısından değerlendirilmesi. *Turkish Jourral of Agriculture & Forestry* **20**, 43-48

Parcesio, J., Rafeces, M., Castellote, A. I., Codony, R., Farran, A., Garcia, J., Lopez, A., Romena, A., Boatella, J. 1995. Influence of variety and geographical origin on the lipid fraction of hazelnuts (*Corylus avellena* L.) from Spain: II.Triglyceride composition. *Food Chemistry* **30**, 245-249

Pershern, A. S., Breene, W. M., Lulai, E.C. 1995. Analysis of Factors influencing lipid oxidation in hazelnuts (*Corylus* sp.). *Jourral of Food Processing and Preservation* **19**, 9-25

Sanchez- Castillo, C.P., Dewey, P.J.S., Aguirre, A. Lara, J. J, Vaca, R., Leon de la Barra, P., Ortiz, M., Escamilla, I., James, W-P.T. 1998. The mineral content of mexican fruits and vegetables. *Journal of Food Compasstion and Analysis* **11**,340-356.

Skujins, S. 1998. *Handbook for ICP-AES (Varian-Vista). A short Guide To Vista Series ICP-AES Operation. Varian Int.* AG, Zug, Version 1.0, Switzerland

Smith, K. T. 1988. *Trace minerals in foods*. New York: Marcel Dekker.

Smith. G. C., Clegg, M.S., Keen, C.L., and Griventi, L. E. 1996. Mineral values of selected plant foods common to sounthern Burkina Faso and to Niamey, Niper,West Afrika, Int. *J. Food Sci Nutr.* **47**, 41-33

Şimşek,A., Aslantaş,R. 1999. Composition of hazelnut and role in human nutrition (Fındığın bileşimi ve insan beslenmesi açısından önemi). *Gıda* **24**(3), 209-216. (in Turkish)

Wiseman, J. (Ed.). 1987. *Feeding of Non-ruminant Livestock*. (Collective edited work by the research staff of the Département de l'Élevage des Monogastriques, INRA, under the responsibility of Jean-Claude Blum. Butterworth. 214 pp.

Recibido: Noviembre 2005
Aceptado: Enero 2006