Macro and Micro Element Contents of Several Oat (*Avena sativa* L.) Genotype and Variety Grains

Özcan, Mehmet Musa*+

Department of Food Engineering, Faculty of Agriculture, Selçuk University, 42031 Konya, TURKEY

Bağcı, Ahmet

High Vocational College, Selçuk University, Sarayönü-Konya, TURKEY

Dursun, Nesim; Gezgin, Sait; Hamurcu, Mehmet

Department of Soil Science and Plant Fertilization, Faculty of Agriculture, Selçuk University,42031 Konya, TURKEY

Dumlupınar, Ziya

Department of Field Crop, Faculty of Agriculture, Sütçü İmam University,Kahramanmaraş, TURKEY

Uslu, Nurhan

Department of Food Engineering, Faculty of Agriculture, Selçuk University, 42031 Konya, TURKEY

ABSTRACT: *In current study, macro and micro element contents of oat grains were determined by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES). P contents of grains were found between 2428.72 mg/kg (Arslanbey) and 4557.25 mg/kg (TL10). While K contents of oat samples change between 3055.99 mg/kg (TL63) and 5621.12 mg/kg (TL8), Ca contents of oats ranged from 568.50 mg/kg (TL63) to 1269.97 mg/kg (TL86). In addition, the highest and lowest Mg were determined in Kırklar (2024.88 mg/kg) and TL73 (1252.48 mg/kg) oat samples, respectively. Iron contents of oat changed between 29.98 mg/Kg (TL7) and 80.78 mg/Kg (Arslanbey). While Zn contents of oat samples change between 15.50 mg/kg (Arslanbey) and 37.68 mg/kg (TL/76), Mn contents ranged from 25.82 mg/kg (TL63) to 62.55 mg/kg (Kırklar). Also, the highest Zn and Cu contents of oat grains were found in TL76 (37.68 mg/kg) and TL67 (8.67 mg/kg). Locations had significant effect on all macro and micro nutrient concentrations of oat grains.The results presented here suggest that oat grains could serve as a good source of mineral elements.*

KEYWORDS: *Oat; Strains; Varieties; Elements; ICP-AES.*

INTRODUCTION

Oat (*Avena sativa* L.) is an important crop produced in various regions of Europe and North America [1]. Oats are largely used in cattle breeding and have occurred in human diet for a long time, mainly as oatmeal and

* *To whom correspondence should be addressed.*

+ E-mail: mozcan@selcuk.edu.tr

1021-9986/2017/3/73-79 7/$/5.70

rolled oats, but the positive physiological effects of oat products were recognised just rather recently [2]. Oats are arich source of soluble fiber, well-balanced proteins, several vitamins and minerals essential for the human health [3-5]. The consumption of oats is therefore an important component of diet for hypercholesterolemic patients [6]. In addition to their importance in the diet, oats antioxidants may also contribute to the stability and the taste of food products [7]. They are also widely used as a companion crop for under-seeding of forage legumes. Oats are mainly grown in temperate and cool sub-tropical environments[8,9]. sOats provide more protein, fiber, iron and zinc than other whole grains [10]. In comparison to other cereals, these are characterized constitute large amount of total protein, carbohydrate (primary starch content), crude fat, dietary fibre (non-starch), unique antioxidants and considerable vitamins and mineral content [7,11-13]. They have many uses as food cereal, feed grain, and green or conserved forage, and also in topical skincare products. Livestock grain feed is the primary use, accounting for about 74% of the world's total production. As a food cereal, oats are among most nutritious: high in protein, oil, and beta-glucan (a soluble dietary fiber) [14]. In folk medicine, an alcoholic extraction of oats has been reported to be a deterrent for smoking. Reports that oat extract helped correct the tobacco habit were disproven by *Bye et al.* [15]. The aim of present study was to determine mineral contents of several oat genotypes and varieties harvested from several provinces in Turkey.

EXPERIMENTAL SECTION

Materials

The grains of several oat genotype and varieties were obtained from several provinces in Turkey in 2015 (Table 1). Grains were transported to the laboratory in paper bags and held at room temperature. They were cleaned in an air screen cleaner to remove all foreign matter such as dust, dirt, stones and chaff, and immature and broken grains were discarded as well. Their moisture content was measured on arrival.

Method

Determination of mineral contents

Oat samples were dried at 70 ºC in a drying cabinet with air-circulation until they reached constant weight. Later, about 0.5 g dried and ground sample was digested by using 5ml of 65% HNO_3 and 2 mL of 35% H_2O_2 in a closed microwave system (Cem-MARS Xpress) at 200 °C. The volumes of the digested samples were completed to 20 mL with ultra-deionized water and mineral concentrations were determined by Inductively Coupled Plasma-optical Atomic Emission Spectroscopy (ICP-AES; (Varian-Vista, Australia). Measurement of mineral concentrations was checked using the certified values of the related minerals in the reference samples received from the National Institute of Standards and Technology (NIST; Gaithersburg, MD, USA). Distilled deionized water and ultrahigh-purity commercial acids were used to prepare all reagents, standards, and samples. After digestion treatment, samples were filtrated through whatman No 42. The filtrates were collected in 50 mL flasks and analysed by ICP-AES [16].

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 " (axial)
Auxilary gas flow rate (Ar) :1.5 "
Viewing height : 5-12 mm
Copy and reading time :1-5 s (max.60 s)
Copy time : 3 s (max. 100 s)

Results were analysed for statistical significance by analysis of variance [17]. The statistical evaluation was performed using the Minitab package program [18].

RESULTS AND DISCUSSION

Macro and micro element contents of grains of oat genotype and varieties are presented in Table 2. The major elements of oat grains had P, K, Ca, Mg and S. Element contents of oat grains were found to vary widely depending on genotype and varieties. P contents of grains were found between 2428.72 mg/kg (Arslanbey) and 4557.25 mg/kg (TL10). While K contents of oat samples change between 3055.99 mg/kg (TL63) and 5621.12 mg/kg (TL8), Ca contents of oats ranged from 568.50 mg/kg (TL63) to 1269.97 mg/kg (TL86). In addition, the highest and lowest Mg were determined in Kırklar (2024.88 mg/kg) and TL73 (1252.48 mg/kg) oat samples, respectively. Also, S contents of oat grains ranged from

Table 1: Genotype and varieties used in experiment.

No	Genotype	ACNO	PROVINCE	LOCATION	Latitude	Longitude
1	TL6	PI168122	Afyon	Emirdag	39,01667	31,15000
2	TL7	PI168123	Afyon	Ishakli	39,11667	31,21667
3	TL8	PI170936	Afyon	Ihsaniye	38,61667	29,95000
4	TL9	PI119477	Ankara	25 km southeast of Ankara on the slopes of Alma Dag	39,78333	33,01667
5	TL10	PI178483	Ankara	Polatli	39,58333	32,13333
6	TL11	PI203450	Ankara	40 km south of Ankara, along Route 1, in valley near Ahiboz	39,61667	32,85000
7	TL12	PI204406	Ankara	110 km southeast of Ankara	39,61667	33,61667
8	TL13	PI411399	Ankara	45 km west of Ankara	40,03333	32,38333
9	TL15	PI168068	Antalya	Elmali, Korkudeli	36,73333	29,91667
10	TL21	PI577978	Artvin	8 km north of Artvin-Yusufeli-Olur junction	41,05000	41,88333
11	TL26	PI119474	Balikesir	field 80 km west of Balikesir	39,56667	27,08333
12	TL28	PI168097	Balikesir	near Okcugol	40,05000	28,16667
13	TL37	PI168101	Bursa	near Apolyont lakeside	40,18333	29,05000
14	TL38	PI168102	Bursa	Bursa	40,41667	29,15000
15	TL42	PI177861	Bursa	Orhangazi	40,20000	28,35000
16	TL53	PI168094	Canakkale	Can	40,40000	27,30000
17	TL55	PI177852	Canakkale	Kocabey, Ayvacik	39,60000	26,40000
18	TL59	PI411416	Cankiri	Ilgaz	40,53333	34,98333
19	TL61	PI577901	Corum	27 km southeast of Tosya	40,33333	34,81667
20	TL62	PI577908	Corum	Between Corum and Alaca; 19 km south of junction to Alaca	41,66667	26,55000
21	TL63	PI119478	Edirne	Edirne	41,71667	26,58333
22	TL64	PI411408	Edirne	5 km northeast of Edirne	41,21667	26,81667
23	TL65	PI411409	Edirne	Copkoy	41,66667	26,51667
24	TL67	PI411411	Edirne	Lalapasa	40,85000	26,61667
25	TL69	PI411401	Elazig	15 km south of Basyurt	39,68333	42,13333
26	TL71	PI411414	Erzurum	Tortum	39,90000	40,85000
27	TL72	PI577946	Erzurum	18 km east of Askale	40,35000	41,83333
28	TL73	PI577980	Erzurum	1 km west of Narman	39,45000	31,53333
29	TL74	PI168108	Eskisehir	Sivrihisar	39,75000	30,95000
30	TL75	PI168124	Eskisehir	Alpu	39,68333	31,20000
31	TL76	PI170934	Eskisehir	Beylikahir	39,48333	30,98333
32	TL77	PI170937	Eskisehir	Mahmudiye	39,78333	31,03333
33	TL78	PI177860	Eskisehir	Hara, 52 km east of Eskisehir	39,36667	31,48333
34	TL79	PI577856	Eskisehir	11 km southwest of Sivrihisar	36,26667	36,56667
35	TL86	PI167378	Icel	school, Tarsus	36,71667	34,63333
36	TL89	PI178479	Istanbul	Baltaci Ciftligi, Yalova	41,08333	29,66667
37	TL90	PI411432	Istanbul	20 km east of Sile	41,01667	28,50000
38	TL92	PI168077	Izmir	Selcuk	39,11667	27,18333
39	TL95	PI182482	Kars	Melik	40,88333	43,26667
40	TL96	PI470278	Kars	9 km northwest of Arpacay	40,30000	42,65000
41	Faikbey	Variety		Winter		
42	Arslanbey	Variety		Facultative		
43	Chekota	Variety		Facultative		
44	Sebat	Variety		Facultative		
45	Kahraman	Variety		Facultative		
46	Fetih	Variety		Spring		
47	Yeniçeri	Variety		Facultative		
48	Sarı	Variety		Spring		
49	Kırklar	Variety		Facultative		
50	Seydişehir	Variety		Winter		

Table 2: Mineral contents of Oat grains (mg/kg).

Samples	Macro elements					Micro elements					
	P	K	Ca	Mg	S	Fe	Zn	Mn	B	Cu	Mo
TL6	3391.50±0.10*	5151.25±0.11	1232.28±0.25	1471.32±0.36	1457.49±0.20	40.22±0.97	24.31±0.90	38.62±0.20	6.99±0.47	1.77±0.69	1.73±0.20
TL7	3127.94±0.36	4574.96±0.11	1098.60±0.20	1344.78±0.40	1340.61±0.36	29.98±0.60	21.75±0.25	34.94±0.41	6.34±0.84	2.20±0.61	1.65±0.66
TL8	3435.59±0.14	5621.12±0.25	1190.39±0.36	1587.83±0.14	1656.62±0.01	79.93±0.36	25.59±0.14	42.24±0.25	1.68±0.39	5.87±0.98	1.99±0.65
TL9	3493.30±0.25	4776.17±0.21	1154.93±0.74	1725.94±0.45	1664.48±0.12	61.16±0.56	24.47±0.87	46.47±0.26	2.23±0.46	7.07±0.95	1.51±0.24
TL10	4557.25±0.84	5005.70±0.36	1141.53±0.28	1890.32±0.14	1878.31±0.90	52.10±0.94	27.80±0.10	43.20±0.11	1.45±0.25	5.99±0.36	1.88±0.20
TL11	3050.22±0.20	4190.03±0.36	895.79±0.11	1467.47±0.20	1441.73±0.65	44.10±0.30	20.02±0.97	33.71±0.90	3.12±0.20	5.87±0.47	1.30±0.69
TL12	2782.77±0.14	4594.13±0.36	1101.90±0.65	1319.89±0.14	1365.50±0.80	64.54±0.36	19.82±0.15	36.25±0.84	0.50±0.40	5.52±0.12	1.24±0.60
TL13	3881.54±0.90	4914.43±0.25	1202.75±0.33	1837.81±0.17	1426.06±0.70	59.97±0.97	23.96±0.12	47.08±0.21	0.79±0.09	5.92±0.87	1.41±0.69
TL15	3754.76±0.36	5363.72±0.11	1240.26±0.20	1753.72±0.47	1604.38±0.98	53.37±0.12	29.81±0.36	41.80±0.30	2.83±0.10	7.17±0.10	1.68±0.14
TL21	4207.67±0.84	5372.36±0.36	1236.53±0.28	1763.40±0.88	1662.20±0.21	55.85±0.21	26.18±0.47	45.56±0.97	0.00±0.00	4.97±0.21	2.72±0.90
TL26	3817.80±0.10	5295.55±0.11	1049.57±0.25	1687.34±0.98	1579.11±0.50	53.86±0.65	27.40±0.10	47.65±0.60	0.28±0.12	5.76±0.13	2.09±0.23
TL28	3458.28±0.99	4695.07±0.14	933.98±0.36	1572.48±0.11	1595.99±0.20	64.27±0.10	22.51±0.11	40.64±0.25	0.00±0.00	6.12±0.20	2.23±0.10
TL37	3855.22±0.36	5462.40±0.11	1194.59±0.20	1699.03±0.47	1594.52±0.98	45.52±0.10	25.32±0.54	56.62±0.15	0.15±0.24	5.73±0.36	2.10±0.25
TL38	3625.88±0.44	4750.17±0.10	1037.82±0.11	1867.02±0.25	1586.63±0.69	61.31±0.97	23.06±0.90	39.42±0.20	0.00±0.00	6.36±0.69	2.36±0.39
TL42	3748.47±0.98	5739.41±0.74	1193.99±0.84	1695.34±0.36	1580.50±0.28	61.02±0.36	20.97±0.14	46.19±0.25	0.00±0.00	6.36±0.98	1.77±0.65
TL53	3108.70±0.36	5166.89±0.11	1203.86±0.20	1545.15±0.21	1460.88±0.33	60.44±0.36	21.88±0.11	46.15±0.20	0.00±0.00	5.80±0.33	2.08±0.21
TL55	3186.84±0.54	4754.68±0.15	981.58±0.24	1453.54±0.36	1450.43±0.25	54.55±0.60	17.45±0.14	42.39±0.89	0.37±0.10	6.02±0.20	2.64±0.47
TL59	2968.69±0.10	4315.27±0.11	952.24±0.25	1327.18±0.15	1328.30±0.77	47.59±0.87	20.53±0.69	37.54±0.89	1.71±0.90	6.35±0.87	1.89±0.69
TL61	3780.90±0.60	4760.87±0.14	1116.26±0.89	1581.25±0.47	1581.49±0.20	54.58±0.30	31.80±0.12	45.83±0.97	0.00±0.00	7.39±0.21	1.59±0.90
TL62	3505.80±0.36	4727.71±0.11	1079.34±0.20	1555.80±0.47	1542.64±0.98	60.98±0.12	30.39±0.60	51.84±0.14	0.00±0.00	6.20±0.47	1.80±0.20
TL63	2333.66±0.52	3055.99±0.48	568.56±0.14	1155.59±0.65	1545.96±0.69	57.42±0.32	13.86±0.10	25.82±0.42	4.56±0.02	5.58±0.03	2.50±0.01
TL64	2940.54±0.32	3153.71±0.10	973.38±0.42	1476.10±0.02	2055.88±0.03	64.20±0.23	23.56±0.10	42.08±0.51	5.91±0.14	7.16±0.30	1.30±0.10
TL65	3282.09±0.60	3825.23±0.12	1008.89±0.25	1576.70±0.36	1876.44±0.74	61.52±0.32	29.84±0.10	33.68±0.42	5.43±0.02	8.67±0.03	2.28±0.01
TL67	3023.10±0.23	3511.03±0.10	984.64±0.51	1456.95±0.14	1726.78±0.30	52.92±0.32	25.41±0.10	35.50±0.42	4.61±0.02	6.45±0.03	1.74±0.01
TL69	2800.79±0.21	3397.27±0.40	1026.01±0.10	1371.35±0.30	2008.36±0.10	52.63±0.25	21.92±0.36	40.46±0.12	6.52±0.45	5.41±0.18	1.33±0.98
TL71	3286.13±0.52	3344.89±0.48	865.66±0.14	1571.42±0.65	1934.05±0.69	62.75±0.21	28.97±0.40	30.68±0.10	5.78±0.30	7.34±0.10	1.06±0.20
TL72	3124.20±0.52	3910.04±0.48	822.95±0.14	1425.59±0.65	1977.46±0.69	58.78±0.21	21.93±0.40	33.20±0.10	5.48±0.30	6.79±0.10	1.13±0.20
TL73	2709.78±0.21	3727.10±0.40	803.68±0.10	1252.48±0.30	2307.93±0.10	65.61±0.32	20.31±0.10	28.80±0.42	6.20±0.02	7.24±0.03	0.88±0.01
TL74	2878.94±0.25	3381.80±0.36	904.25±0.12	1407.63±0.45	1458.87±0.18	53.07±0.23	26.23±0.10	41.45±0.51	4.31±0.14	6.79±0.30	1.54±0.10
TL75	2829.64±0.32	3893.40±0.10	1154.31±0.42	1394.44±0.02	2333.89±0.03	58.96±0.25	24.70±0.36	32.61±0.12	6.71±0.45	7.77±0.18	1.27±0.98
TL76	3717.59±0.25	3990.40±0.36	980.78±0.12	1605.28±0.45	2150.24±0.18	60.07±0.21	37.68±0.40	39.60±0.10	6.10±0.30	7.70±0.10	1.88±0.20
TL77	3110.59±0.52	3864.65±0.48	1182.49±0.14	1563.60±0.65	2180.93±0.69	71.40±0.23	27.91±0.10	36.37±0.51	6.46±0.14	7.66±0.30	2.40±0.10
TL78	2807.84±0.23	3701.19±0.10	1141.79±0.51	1510.41±0.14	2229.44±0.30	70.17±0.21	24.64±0.40	35.33±0.10	6.54±0.30	7.36±0.10	2.09±0.20

Table 2: Mineral contents of Oat grains (mg/kg). (Continued)

TL79	3606.45±0.32	4833.36±0.10	1070.09±0.42	1635.19±0.02	2032.62±0.03	54.25±0.25	26.94±0.36	34.34±0.12	6.13±0.45	7.11±0.18	1.76±0.98
TL86	3467.26±0.52	5197.72±0.48	1269.97±0.14	1723.49±0.65	2268.28±0.69	71.33±0.32	23.51±0.10	36.74±0.42	7.08±0.02	6.50±0.03	3.23±0.01
TL89	3423.88±0.21	4062.29±0.4	1217.33±0.1	1499.32±0.3	2063.08±0.10	67.90±0.21	26.25±0.40	41.96±0.10	6.37±0.30	7.17±0.10	2.37±0.20
TL90	3461.28±0.32	4403.60±0.10	983.77±0.42	1555.27±0.02	2165.56±0.03	65.44±0.23	21.35±0.10	29.52±0.51	6.41±0.14	7.88±0.30	2.00±0.10
TL92	2973.86±0.21	4657.65±0.40	885.68±0.10	1401.79±0.30	1284.41±0.10	50.86±0.21	21.10±0.40	35.81±0.10	4.29±0.30	5.30±0.10	1.38±0.20
TL95	2995.00±0.25	4325.69±0.36	1089.15±0.12	1529.06±0.45	1493.46±0.18	67.30±0.25	19.92±0.36	43.78±0.12	4.97±0.45	5.49±0.18	1.59±0.98
TL96	3240.17±0.52	3817.50±0.48	869.87±0.44	1490.44±0.65	1594.37±0.69	67.29±0.10	24.87±0.10	35.51±0.10	5.05±0.20	5.80±0.20	1.36±0.10
Faikbey	2801.09±0.25	4485.92±0.36	933.06±0.12	1446.74±0.45	1676.28±0.18	62.25±0.10	25.07±0.10	39.14±0.10	5.82±0.20	5.94±0.20	2.75±0.10
Arslanbey	2428.72±0.23	3573.93±0.10	805.82±0.51	1294.60±0.14	2363.90±0.30	80.78±0.25	15.56±0.36	33.80±0.12	6.15±0.45	7.04±0.18	1.56±0.98
Chekota	2876.55±0.23	3952.37±0.10	803.68±0.51	1474.73±0.14	1683.60±0.30	63.16±0.23	19.29±0.10	33.86±0.51	5.00±0.14	6.81±0.30	2.41±0.10
Sebat	3483.27±0.90	5293.34±0.30	937.98±0.10	1664.86±0.11	1446.46±0.25	50.82±0.10	19.22±0.10	33.02±0.11	0.56±0.25	5.90±0.36	2.59±0.20
Kahraman	3114.52±0.36	4476.27±0.14	891.51±0.95	1430.15±0.25	1489.38±0.87	57.01±0.97	21.12±0.12	37.35±0.10	0.00±0.00	7.04±0.12	3.46±0.21
Fetih	3232.10±0.66	4313.89±0.15	777.95±0.36	1471.57±0.11	1556.89±0.20	61.79±0.39	18.70±0.98	47.67±0.10	0.15±0.36	6.40±0.14	2.23±0.25
Yeniçeri	3543.41±0.23	4060.78±0.10	786.99±0.51	1634.84±0.14	1464.34±0.30	59.42±0.10	23.55±0.10	38.56±0.10	4.73±0.20	6.59±0.20	2.61±0.10
Sarı	2970.12±0.25	4780.35±0.36	1010.83±0.12	1548.32±0.45	1589.97±0.18	64.86±0.25	20.53±0.36	46.76±0.12	5.19±0.45	4.82±0.18	2.63±0.98
Kırklar	4037.35±0.32	4810.40±0.10	1307.39±0.42	2024.88±0.02	1512.16±0.03	69.82±0.32	30.07±0.10	62.55±0.42	5.25±0.02	8.17±0.03	1.77±0.01
Seydişehir	3095.47±0.21	3709.05±0.40	864.47±0.10	1614.65±0.30	2127.62±0.10	69.84±0.25	19.01±0.36	34.63±0.12	5.82±0.45	6.55±0.18	2.20±0.98

1284.41 mg/kg (TL92) to 2363.90 mg/kg (Arslanbey). As microelement (Table 2), Fe contents of oat changed between 29.98 mg/kg (TL7) and 80.78 mg/kg (Arslanbey). While Zn contents of oat samples change between 15.50 mg/kg (Arslanbey) and 37.68 mg/kg (TL/76), Mn contents were determined between 25.82 mg/kg (TL63) to 62.55 mg/kg (Kırklar). Also, the highest Zn and Cu contents in oat samples were determined in TL76 (37.68 mg/kg) and TL67 (8.67 mg/kg). The lowest Zn content was found in Arslanbey (15.50 mg/kg) oat variety. Ca, Fe, Zn, K, P, Mn and Mg contents of oat grains are more abundant compared with mineral results of other cereals [19-21]. *Ciolek et al.* [22] reported that several oat strains and cultivars contained 0.326-0.423% K, 0.320-0.388% P, 0.0.83-0.117% Mg, 0.001-0.015% Ca, 32.0-58.2% Mn, 29.7-48.9% Fe, 23.6-41.7% Zn and 2.8-5.5% Cu. *Gambus et al.* [23] reported that the flour produced from black hull oat and the flour of yellow hull oat contained 0.292% K and 0.324% K, respectively. According to report of Souci et al. [24], K contents of oat grains changed between 0.338 and 0.387%. *Liu & Mahmood* [21] reported that oat grain contained 0.82 mg/g Ca, 1.65 mg/g Mg, 5.05 mg/g P, 4.90 mg/g K, 0.2 mg/g Na, 2.10 mg/g S, 2.0 µg/g Al, 1 µg/g Ba, 6 µg/g Cu, 10 µg/g Fe, 51 µg/g Mn, and 39 µg/g Zn. *Sangwan et al.* [10] reported that oat grain contained 84 mg/156 g Ca, 7.36 mg/156 g Fe, 276 mg/156 g Mg, 816 mg/156 g P, 668 mg/156 g K, 3 mg/156 g Na, 6.19 mg/156 g Zn, 0.977 mg/156 g Cu and 7.669 mg/156 g Mn. In previous study, the oat grain contained most potassium (5.26 g/kg), slightly less phosphorus (3.29 g/kg) and much less magnesium (1.37 g/kg), calcium (1.16 g/kg) and sodium (0.79 g/kg) [25]. In other study, the phosphorus content was high in most cases and ranged from 1375.20 ppm (BDMY- 6) to 4365.40 ppm (Y-2330). While the magnesium content of oat grain range from 1375.20 ppm (BDMY-6) to 1532.60 ppm (Che-Chois), the calcium content ranged from 318.30 ppm (Y-2330) to 427.10 ppm (Che-Chois) [20]. These values were close with results reported by *Skibniewska et al.* (2002), *Gambus et al.* (2006), *Souci et al.* [24] and *Liu & Mahmood* [21]. Also, the phosphorus, magnesium and potassium contents of all varieties determined in this study were found similar with respect to the results of *McKechnie* [26]. But some of our results of mineral contents of oat grains show minor differences when compared with the literature [26].

These differences might be due to growth conditions, genetic factors, geographical variations and analytical procedures [27,28]. Other differences may result from harvest conditions, storage, and post-harvest treatments or other processes that the crop is subject to before final use. The chemical composition of plants depends on the adequate mineral fertilisation, especially nitrogen fertilisation significantly [1,25].

The highest P contents were determined in Tl 10 (4557.25 mg/kg) and Tl 21(4207.67 mg/kg). While Tl 10 genotype grow in the central region of Turkey, Tl 21 oat genotype grow in Nourth-east region of Turkey. The P contents of oat genotypes in ther locations were lower than oats grown in the central and nourth-east regions of Turkey. The highest K contents of oat genotypes grown in Afyon, Ankara, Antalya, Artvin, Balıkesir, Bursa and Çanakkale provinces in Turkey. The most of these provinces are in North of Turkey (except Antalya and İçel). In addition, K contents of oat varieties were found low compared with results of genotypes. Genotypes were sign,f,cantly different for Ca, P, K Mn, Fe and Zn. Generally, Ca and K contents of oat varieties were found lower than those of results of genotypes. Locations had significant effect on all macro and micro nutrient concentrations of oat grains. Afyon (Tl 6 and Tl 8), Ankara (Tl 13), Antalya (Tl 15), Bursa (Tl 37 and Tl 42), Çanakkale (Tl 53), İçel (Tl 86) and İstanbul (Tl 89) genotypes had higher Ca contents than the other oat genotypes and varieties depending on locations. Depending on locations, the highest Fe contents were determined in Afyon (Tl 8), Eskişehir (Tl 77 and Tl 78) and İçel (Tl 86). Fe contents of oat varieties were found partly higher than those of genotype Fe results. In addition, the highest Zn contents were found in Tl 61 (31.80 mg/kg), Tl 62 (30.39 mg/kg), Tl 65 (29.84 mg/kg) and Tl 76 (37.68 mg/kg). All these situations may be probably due to soil, location and climatic facors of environment. Genotypes were significantly different for all micronutrient concentrations (except Cu and Mg). As a result, this work attempts to contribute to the knowledge of the nutritional properties of these seeds. In addition, knowledge of the mineral contents, as an ingredient of various baked and other products such as salad dressing, baby foods and snack foods is of great interest. The nutritive value of cereal grain depends on the content of minerals and their proportions.

Received : Jun. 5, 2016 ; Accepted : Oct. 17, 2016

REFERENCES

[1] Weiss E., Kislev M.E., Hartmann A., Autonomous Cultivation Before Domestication, *Sci*., **312**: 1608-1610 (2006).

[2] Pirjo M., Jarkko H., Pilhav J-M., The Content of Phenolic Acid in Some Grain Products. In: Abstract Books 1st International Conference on Polyphenols and Health, Institut National de la Recherche Agronomique, *Clermont-Ferraud*: 207 (2003).

[3] Charalampopoulos D., Wang R., Pandiella S.S., Webb C., Application of Cereals and Cereal Components in Functional Foods: A Review, *Int. J. Food Microbiol*, **79**:131-141 (2002).

[4] Demirbaş A., β-Glukan and Mineral Nutrient Contents of Cereals Grown in Turkey, *Food Chem.*, 773-777 (2005).

[5] Esposito F., Arlotti G., Bonifati A.M., Antioxidant Activity and Dietary Fibre in Durum Wheat Bran by-Products, *Food Res. Int*., **38**: 1167–1173 (2005).

[6] Czerwiński J., Bartnikowska E., Leontowicz H., Oat (*Avena sativa* L.) and Amaranth (*Amaranthushypochondriacus*) Meals Positively Affect Plasma Lipid Profile in Rats Fed Cholesterol-Containing Diets, *J. Nutr. Biochem.*, **15**: 622–629 (2004).

[7] Peterson D.M., Oat Antioxidants, *J. Cereal. Sci.*, **33**: 115–129 (2001).

[8] Dost M., "End of Assignment Report on Fodder Component", PAK/86/027. FAO/UNDP, Gilgit, Pakistan (1997).

[9] Bhatti M.B., Hussain A., Mohamamd D., Fodder Production Potential of Different Oat Cultivars Under Two Cut System, *Pak. J. Agric. Resh.*, 13(2):184-190 (1992)

[10] Sangwan S., Singh R., Tomar S.K., Nutritional and Functional Properties of Oats: An update, *J. Inn. Biol.*, **1**: 3-14 (2014).

[11] Brand T.S., Merwe J.P., Naked Oats (*Avena nuda*) as A Substitute for Maize in Diets for Weanling and Grower-Finisher Pigs, *Anim. Feed Sci. Technol.*, **57**: 139–147(1996).

[12] Lia A., Andersson H., Mekki N., Juhel C., Senft M., Lairon D., Postprandial Lipemia in Relation to Sterol and Fat Excretion in Ileostomy Subjects Given Oatbran and Wheat Test Meals, *Am. J. Clin. Nutri.*, 66: 357–365 (1997).

[13] Peltonen-Sainio P., Kontturi M., Rajala A., Impact Dehulling Oat Grain to Improve Quality of On-Farm Produced Feed. I. Hullability and Associated Changes in Nutritive Value and Energy Content, *Agric. Food Sci.*, **13**: 18–28 (2004)

[14] Webster F.H., Wood P.J. (Eds.), "Oats Chemistry and Technology" (2nd ed.). AACC Int. Press, St.Paul, MN (2011).

[15] Bye C., Fowle A.S.E, Letley E., Wilkenson S., Lack of Effect of Avena Sativa on Cigarette Smoking, *Nature*, **252**: 580-581 (1974).

[16] Skujins S., "Handbook for ICP-AES (Varian-Vista). A Short Guide to Vista Series ICP-AES Operation", Version 1.0. Switzerland: Varian International AG, ZUG (1998).

[17] Püskülcü H., İkiz F., "Introduction to Statistics", Bornova-Izmir: Bilgehan Press. p. 333.

[18] Minitab., "Minitab Reference Manual", Release 7.1. State College, PA: Minitab Inc (1991).

[19] Skibniewska K.A., Kozirok W., Fornal L., Markiewicz K, In Vitro Availability of Minerals from Oat Products, *J. Sci. Food Agric*., **82**: 1676-1681 (2002).

[20] Özcan M.M., Özkan G., Topal A., Characteristics of Grains and Oils of Four Different Oats (*Avena sativa* L.) Cultivars Growing in Turkey, *Int. J. Food. Sci. Nutr.*, 57: 345-352 (2006).

[21] Liu K., Mahmood K., Nutrient Composition and Protein Extractability of Oat Forage Harvested at Different Maturity Stages as Compared to Grain, *J. Agric. Sci.*, **17**: 50-58 (2015).

[22] Ciolek A., Makarski B., Makarska E., Zadura A., Content of Some Nutrients in New Black Oat Strains, *J. Lementol.*, **12**: 251-259 (2007).

[23] Gambus H., Gambus F., Pisulewska E., Catizarnowa Maqka Owsiana Jako Zrodto Sktadnikow Dietetycznych w Chlebach Pszennych, *Biul IHAR*, **239**:259-267 (2006).

[24] Souci S.W., Fachmann W., Kraut H., Food Composition and Nutrition Tables, Sci. Publ., Studgard (2002).

[25] Peterson D.M, Oat – A Multifunctional Grain, *Agri. food Res. Rep.*, **51**: 21-26 (2004)

[26] McKechnie R., Oat Products in Bakery Foods, *Cereal Foods World*, **28**(10): 635-637 (1983).

[27] Guil J.L., Martinez J.J.G., Isasa M.E., Mineral Nutrient Composition of Edible Wild Plants, *J. Food Comp. Anal.*, **11**: 322-328 (1998).

[28] Özcan M., Characteristic, of Fruit and Oil of Terebinth (*Pistacia terebinthus* L.) Growing Wild in Turkey, *J. Sci. Food Agric.*, **84**: 517-520 (2004).