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Mineral Composition of Some Turkish Durum Wheat Genotypes

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This study was conducted to determine mineral composition of some durum wheat genotypes. The research was carried out during 2001 and 2002 growing seasons in Sanliurfa, Turkey. Thirty one durum wheat genotypes were grown in the field and kernel samples analyzed by an atomic absorption spectrometry. Some minerals such as calcium, magnesium, iron, zinc, copper, manganese, molybdenum and boron were determined in kernel of wheat genotypes. Genotypes were statistically significant ($p < 0.01$) for all minerals in both years. In the wheat kernel, calcium ranged from 0.13 to 0.33 %, magnesium 0.16 to 0.28 %, iron 29.3 to 45.6 mg kg^{-1}, zinc 16.5 to 32.6 mg kg^{-1}, copper 4.03 to 9.79 mg kg^{-1}, manganese 37.3 to 47.5 mg kg^{-1}, molybdenum 3.34 to 5.71 mg kg^{-1} and boron 8.8 to 15.2 mg kg^{-1}. Some durum wheat genotypes such as Dicle-74, C.1252, Kiziltan-91, Kunduru-1149, Altar-84, Zenith and Gedifla had the richest mineral contents among other genotypes.

Key Words: Durum wheat, Metals, Minerals, Microwave digestion, Atomic absorption spectrometry.

INTRODUCTION

Wheat is one of the most important food crops in the world. According to worldwide scale, wheat contributes *ca.* 30 % of the total cereal production, making it a major source of minerals for majority of people[1]. Wheat flour products have an important role in human nutrition. The major use of durum wheat is for pasta products, bulgur and various types of breads. Turkish peoples show high prevalence of consumption of large quantities of wheat products. Generally, wheat products are considered to be a good source of energy and irreplaceable nutrients for the human body. But sometimes wheat flour and its products are nutritionally much poorer and do not adequately meet the requirements for many macro- or micro-nutrients[2]. An estimated 820 million people in developing countries are under nourished[3]. Some minerals such as Fe, Zn, Cu and Mn have an importance in living organism for healthy. Cu and Fe are required for the activity of enzymes. Zinc is an essential element for all living organisms. Many more suffer from specific deficiencies in certain micronutrients *e.g.*, 2 billion people are anemic, many due to iron deficiency[4]. Iron

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deficiency is a widespread nutrition and health problem in developing countries, causing impairments in physical activity and cognitive development, as well as maternal mortality. Billions people, especially in developing countries, are now affected by malnutrition such as zinc deficiencies[5]. Zinc deficiency has been shown to be the cause of dwarfism and hypogonadism among adolescents from low social classes[6].

Determination of mineral composition of wheat grains is necessary to obtain information for human health. Variety composition is one of the most important factors and it causes mineral content changes. Therefore, the present investigation was undertaken with 31 durum wheat genotypes to study the chemical composition including some macro elements essential microelements.

EXPERIMENTAL

This study was conducted during 2001 and 2002 in the Harran Plain, Sanliurfa, Turkey (altitude: 465 m; 37º08' N and 38º46' E). The texture of the soil of experimental field was clay. Field capacity, permanent wilting point and bulk density of the soil was 33.8 % (dry basis), 22.6 % and 1.41 Mg m^{-3}, respectively. Climate varies from arid to semi-arid. Total precipitation was 446 and 483 mm for 2001 and 2002 growing seasons, respectively.

Thirty one durum wheat genotypes (*Triticum turgidum* L. *var. durum*) were used in the study. The experiment was carried out in a randomized block design with four replications. Plot sizes were 6 m by 1.2 m (7.2 m^2) and each plot consisted 6 rows. The seeds were sown at 30-40 mm depth with a density of 500 plants m^2. At sowing, 80 kg ha^{-1} of pure P and 60 kg ha^{-1} of pure N was applied to each plot. This was followed by 60 kg ha^{-1} of N when the plants reached 25-30 cm in height.

For chemical analysis of the kernel, 20 spikes that contained distinctly developed kernels were chosen randomly from each plot and taken to the laboratory for analysis. Kernel samples washed with distilled water, put in paper bags and oven dried to constant weight at 65 °C for at least 4 days[7]. Dried samples were homogenized and stored in polyethylene bottles until analysis. Metal tools were not used in any stage of sample preparation. Double deionized water was used for all dilutions. HNO_3 and H_2O_2 were of suprapure quality (Merck). Samples (1.0 g) were digested with 6 mL of HNO_3 (65 %), 2 mL of H_2O_2 (30 %) in microwave digestion system for 0.5 h and diluted to 10 mL with deionized water. A blank digest was carried out in the same way. Due to higher accuracy with respect to both time and recovery values, this procedure preferred. The recovery values were nearly quantitative (> 95 %) for above mentioned digestion method. An atomic absorption spectrometer with deuterium background corrector was used for elemental analysis[8]. All measurements were carried out in an air/acetylene flame. An analysis of variance (ANOVA) was performed on chemical characteristics of wheat to evaluate statistically differences between genotypes.

RESULTS AND DISCUSSION

Genotypes were statistically significant for all minerals according to variance analyses in both years ($p < 0.01$). Calcium content of wheat genotypes ranged from 0.14 to 0.33 % in 2001 and from 0.13 to 0.31 % in 2002 (Table-1). The highest Ca content was obtained from Kiziltan-91, Kunduru-1149, Selçuklu-97, Altar-84 and Sariçanak-98 genotypes whereas the lowest values were seen at Massara, Waha, Salihli-92, Duraking and Altintoprak-98 genotypes. In wheat, lower kernel Ca content values than present findings were reported by Shtangeeva and Ayrault[9]. It is recognized that the mineral contents of crops are influenced by the mineral composition of the soil and environment in which plants grow[10].

TABLE-1
CALCIUM, MAGNESIUM, IRON AND ZINC CONTENT OF SOME DURUM WHEAT GENOTYPES GROWN IN TURKEY

Genotypes	*Ca (wt % ± σ)		Mg (wt % ± σ)		Fe (mg kg^{-1} ± σ)		Zn (mg kg^{-1} ± σ)	
	2001**	2002**	2001**	2002**	2001**	2002**	2001**	2002**
Aydin-93	0.19±0.05	0.22±0.02	0.18±0.04	0.19±0.03	38.4±2.41	33.5±1.98	31.4±1.86	28.3±1.85
Harran-95	0.25±0.04	0.27±0.03	0.19±0.03	0.18±0.05	39.3±1.81	32.7±1.51	23.8±3.34	22.6±2.85
Diyarbakir-81	0.20±0.03	0.19±0.03	0.19±0.05	0.17±0.03	44.8±2.65	40.6±1.12	25.3±2.59	24.8±4.42
Ceylan-95	0.23±0.03	0.25±0.04	0.21±0.03	0.23±0.02	45.2±3.13	43.1±1.23	20.9±1.63	22.4±3.10
Saricanak-98	0.30±0.04	0.28±0.04	0.20±0.03	0.21±0.05	34.3±3.93	36.7±2.08	21.8±2.33	23.7±1.75
Altintoprak-98	0.18±0.03	0.17±0.04	0.27±0.02	0.26±0.04	37.4±1.86	35.6±1.74	24.4±2.07	22.6±2.90
Dicle-74	0.19±0.04	0.18±0.05	0.18±0.04	0.16±0.04	40.7±0.42	38.8±2.06	32.6±3.61	29.3±4.14
C.1252	0.23±0.03	0.21±0.04	0.22±0.03	0.21±0.02	31.4±2.67	29.3±1.47	24.8±4.32	26.6±3.30
Kiziltan-91	0.33±0.04	0.31±0.02	0.26±0.04	0.26±0.03	35.3±2.63	37.7±1.02	21.7±1.53	22.9±3.84
Kunduru-1149	0.33±0.04	0.31±0.02	0.25±0.04	0.23±0.03	36.9±2.10	39.7±0.95	31.8±1.85	29.4±3.73
Selcuklu-97	0.31±0.03	0.32±0.04	0.28±0.02	0.27±0.02	38.6±0.42	34.2±3.28	22.5±1.58	20.5±2.63
Akcakale-1001	0.21±0.03	0.22±0.05	0.16±0.05	0.17±0.04	34.7±2.93	30.5±1.72	28.1±1.70	27.3±1.50
Akcakale-1005	0.20±0.07	0.21±0.03	0.18±0.06	0.18±0.05	31.5±3.17	33.6±3.26	20.7±2.06	22.8±1.46
Gediz-75	0.19±0.03	0.17±0.04	0.23±0.04	0.22±0.02	28.4±2.74	29.3±1.04	23.6±2.70	20.8±1.66
Salihli-92	0.17±0.03	0.15±0.03	0.25±0.06	0.24±0.03	35.2±1.66	36.6±1.67	22.9±1.04	19.2±2.41
Sham-I	0.29±0.03	0.27±0.03	0.18±0.06	0.19±0.03	30.8±0.64	32.9±2.47	25.4±1.53	26.4±1.30
Altar-84	0.30±0.04	0.30±0.02	0.27±0.03	0.25±0.03	42.6±2.02	39.5±0.98	23.6±1.64	25.7±3.48
Zenith	0.20±0.05	0.19±0.05	0.24±0.03	0.23±0.02	38.4±0.84	35.4±1.58	31.9±2.74	28.1±2.89
Havrani	0.21±0.04	0.23±0.02	0.22±0.04	0.21±0.03	33.5±2.76	35.9±2.13	18.7±1.86	19.1±1.39
Mesaphia	0.18±0.02	0.17±0.02	0.17±0.06	0.18±0.05	45.3±2.28	44.8±1.19	27.6±2.98	25.8±1.18
Waha	0.16±0.03	0.14±0.03	0.21±0.03	0.19±0.04	42.4±1.52	41.6±1.56	18.4±2.43	16.5±2.04
Korifla	0.21±0.04	0.20±0.05	0.23±0.05	0.22±0.03	36.3±3.97	34.7±1.92	20.2±5.03	20.3±1.58
Chambar-88	0.16±0.04	0.19±0.05	0.16±0.06	0.17±0.03	36.2±1.40	37.4±1.84	18.7±3.10	19.6±2.50
Massara	0.14±0.05	0.13±0.02	0.22±0.04	0.21±0.03	34.6±2.79	35.3±1.74	25.6±2.45	26.1±1.40
Aningavoll	0.22±0.02	0.20±0.02	0.18±0.02	0.16±0.02	37.8±3.48	34.7±1.45	20.6±4.87	19.5±1.50
Cosmodor	0.18±0.04	0.19±0.05	0.26±0.03	0.24±0.04	39.9±3.36	36.5±4.30	24.5±1.76	22.6±1.61
Gedifla	0.26±0.03	0.23±0.02	0.21±0.03	0.20±0.05	41.3±0.97	38.6±2.09	26.4±3.14	24.7±1.83
Firat-93	0.24±0.04	0.25±0.05	0.22±0.03	0.23±0.03	42.4±3.57	45.6±2.35	19.9±1.52	21.4±1.79
Duraking	0.17±0.05	0.16±0.03	0.19±0.06	0.18±0.04	37.8±4.19	34.9±0.65	22.4±3.06	20.9±1.32
Ege-88	0.21±0.05	0.19±0.06	0.23±0.05	0.22±0.05	37.9±4.71	38.4±1.23	23.6±3.01	21.2±1.66
Altintas-95	0.26±0.04	0.24±0.03	0.26±0.03	0.24±0.03	33.6±2.54	31.2±1.42	19.4±1.69	20.7±1.59

*All concentration measurements are the average of 4 samples and expressed to one standard deviation (± σ); **Denotes significant difference among genotypes $p < 0.01$.

Selçuklu-97 genotype shows the highest Mg values whereas the lowest Mg value was obtained from Akcakale-1001 and Chamber-88 genotypes. Magnesium contents ranged from 0.16 to 0.28 % in 2001, from 0.16 to 0.27 % in 2002. Mg content of some genotypes such as Selcuklu-97, Altintoprak-98, Kiziltan-9, Kunduru-1149, Salihli-92, Altar-84 and Altintas-95 were higher than others (Table-1). Quality and chemical composition of grain may be influenced by growing conditions, agricultural practices and cultivars[11].

Genotypes was different each other for Fe content. Iron contents of wheat genotypes were between 30.8 (Sham-I) and 45.3 mg kg^{-1} (Mesaphia) in 2001 whereas 29.3 (C.1252 and Gediz-75) and 45.6 mg kg^{-1} (Firat-93) in 2002 year. Higher Fe value in wheat as 119.1 mg kg^{-1} was reported by Liu *et al.*[12]. Iron contents was the highest at Ceylan-95, Mesaphia, Diyarbakir-81, Altar-84, Waha, Firat-93 and Gedifla genotypes.

Zinc contents of genotypes was ranged from 18.4 (Waha) to 32.6 mg kg^{-1} (Dicle-74) in 2001 and 16.5 (Waha) to 29.4 mg kg^{-1} (Kunduru-1149) in 2002. Similar findings in wheat were reported by Bose and Bhattacharyya[13]. In other studies, Zn contents of wheat was reported[12] as 47.1 mg kg^{-1} and varied[9] from 15.4 to 34.6 mg kg^{-1}. The highest Zn values were found at Dicle-74, Kunduru-1149, Aydin-93, Zenith, Akcakale-1001, Mesaphia and Gedifla genotypes. Oikeh *et al.*[14] stated genetic component accounted for 11 and 34 % of the total variation in kernel-Fe and kernel-Zn levels.

Soils low in available Zn are widespread in a number of the major wheat-growing regions of the world, including Turkey, India, Pakistan, China and Australia[15]. As reported by the Food and Agricultural Organization, United Nations and the World Health Organization, recommended dietary allowances (RDA) of iron for adult males and females are 10 and 15 mg, while those of zinc are 15 and 12 mg[5]. Then the required amount of iron in wheat flour should be 20 and 30 mg kg^{-1} for males and females, respectively and that of zinc should be 30 and 24 mg kg^{-1}. In the current study, all tested durum wheat genotypes of Fe contents were higher than amount of this reference. In the current study, average zinc contents of wheat flour calculated from mass balance of the 31 genotypes is 23.6 mg kg^{-1}. Andersson and Pettersson[16] stated that the zinc contents in grains should be < 34 mg kg^{-1} to be fit for human consumption. In some cases, zinc contents in grain exceeded that limit and harm effects can occur in the human body. But in present study, Zn content of wheat genotypes did not exceed this limit in both years. The iron content basically meets the RDA requirement, whereas zinc content is about 54.8 % of RDA. It is thus suggested that flour zinc content should be the major trait to be improved by wheat breeding or agronomic practices.

Copper contents was the lowest at Altintas-95 genotype (4.03 and 4.26 mg kg^{-1}) in both years while the highest values found at Zenith (9.79 mg kg^{-1}) in 2001 and Dicle-74 (9.65 mg kg^{-1}) in 2002 (Table-2). Cu content of Zenith, Kunduru-1149, Dicle-74, Aydin-93, C.1252 and Sham-I genotypes was higher than others. Copper

TABLE-2
COPPER, MANGANESE, MOLYBDENUM AND BORON CONTENT OF SOME DURUM WHEAT GENOTYPES GROWN IN TURKEY

Genotypes	*Cu (mg kg^{-1} ± σ)		Mn (mg kg^{-1} ± σ)		Mo (mg kg^{-1} ± σ)		B (mg kg^{-1} ± σ)	
	2001**	2002**	2001**	2002**	2001**	2002**	2001**	2002**
Aydin-93	9.21±1.01	8.95±0.39	44.9±1.33	41.7±1.05	4.68±0.24	4.41±0.31	11.5±0.39	12.6±0.45
Harran-95	6.45±0.45	6.28±0.84	43.5±0.99	42.4±1.59	5.71±0.38	5.27±0.39	14.4±0.60	13.3±0.93
Diyarbakir-81	6.81±1.77	5.65±0.42	41.8±1.45	43.7±1.86	3.84±0.49	3.61±0.24	13.2±1.19	11.9±0.49
Ceylan-95	5.34±0.66	5.16±0.69	46.3±2.44	42.9±2.14	4.93±0.17	4.81±0.52	14.1±1.08	12.8±0.48
Saricanak-98	6.65±1.41	6.89±0.64	44.6±1.12	46.3±2.49	4.71±0.52	4.63±0.26	14.2±0.57	13.4±0.55
Altintoprak-98	7.79±0.60	7.93±0.71	46.2±1.64	43.9±2.04	5.25±0.26	5.22±0.42	11.2±0.87	10.8±1.34
Dicle-74	9.45±0.78	9.65±0.64	44.6±1.76	47.1±1.04	4.71±0.18	4.65±0.52	13.2±0.70	11.4±1.11
C.1252	8.76±0.75	8.98±0.44	47.3±1.98	44.7±2.74	4.08±0.19	4.18±0.43	14.3±0.93	11.6±0.46
Kiziltan-91	6.33±0.43	6.12±0.95	46.5±1.74	43.8±0.99	4.31±0.55	4.56±0.48	8.8±0.64	9.7±1.01
Kunduru-1149	9.67±0.52	9.35±0.86	37.3±1.90	39.6±1.75	5.03±0.65	5.15±0.35	9.0±0.45	9.2±0.59
Selcuklu-97	6.27±0.26	6.48±0.55	39.6±2.25	42.7±2.24	3.72±0.22	3.58±0.17	9.7±1.15	9.4±0.54
Akcakale-1001	8.04±0.31	8.16±0.71	42.5±2.34	40.8±1.78	4.78±0.19	4.65±0.34	12.8±0.60	11.8±0.48
Akcakale-1005	7.89±0.23	8.21±0.63	40.7±1.88	41.6±2.79	4.61±0.22	4.86±0.18	12.2±0.88	11.8±0.89
Gediz-75	5.69±0.77	5.81±0.94	47.5±1.82	44.5±1.62	5.28±0.41	5.36±0.58	11.9±0.98	10.7±0.88
Salihli-92	6.79±0.51	6.50±0.48	39.4±1.72	42.8±1.43	4.41±0.25	4.65±0.19	10.8±0.85	12.9±1.04
Sham-I	8.64±0.76	8.80±0.83	41.3±1.55	43.9±1.16	4.46±0.16	4.15±0.17	14.9±0.48	13.6±0.97
Altar-84	7.84±0.52	7.75±1.00	38.7±2.53	40.1±2.19	3.34±0.39	3.86±0.18	10.7±0.79	9.1±0.93
Zenith	9.79±0.61	9.17±1.05	45.9±1.56	44.1±0.89	4.21±0.32	4.52±0.48	10.9±0.26	12.4±1.09
Havrani	8.06±0.89	7.96±0.57	40.6±1.98	42.8±1.56	5.64±0.49	5.42±0.35	12.8±1.35	10.9±0.47
Mesaphia	7.91±0.64	7.86±0.37	39.8±1.82	41.7±2.23	4.97±0.64	5.15±0.22	15.0±1.07	14.4±0.53
Waha	5.43±0.53	5.61±0.51	44.5±3.08	42.9±1.50	4.72±0.18	4.39±0.23	14.1±0.30	13.7±1.66
Korifla	7.10±0.91	6.83±0.69	46.1±2.55	43.7±2.91	4.42±0.28	4.21±0.26	14.6±0.38	12.4±0.49
Chambar-88	6.94±1.28	7.13±0.77	44.3±1.83	41.6±1.63	4.97±0.23	5.13±0.43	14.7±1.49	13.2±0.68
Massara	5.36±1.12	5.21±0.98	41.7±2.66	44.5±0.98	4.63±0.33	4.83±0.18	10.9±1.64	11.4±0.90
Aningavoll	6.84±0.39	6.75±0.48	45.3±3.31	43.9±1.33	3.46±0.15	3.91±0.54	9.9±0.55	11.0±0.46
Cosmodor	7.73±0.34	7.96±0.88	40.9±0.96	42.7±1.62	4.73±0.35	4.96±0.32	12.6±1.80	10.4±1.05
Gedifla	8.05±0.86	7.95±0.67	42.4±0.75	45.2±1.89	4.05±0.17	3.85±0.28	13.2±0.34	12.7±0.60
Firat-93	7.96±0.29	8.10±0.67	45.1±1.02	43.7±1.01	3.68±0.24	3.72±0.48	15.2±0.72	14.8±0.38
Duraking	6.34±0.17	6.51±0.63	39.9±2.09	42.8±2.06	3.98±0.24	4.35±0.25	14.2±1.67	13.5±1.01
Ege-88	7.29±0.39	7.35±0.54	41.7±1.64	44.8±1.23	5.39±0.20	5.61±0.19	12.6±1.78	12.9±0.94
Altintas-95	4.03±0.76	4.26±0.47	40.8±2.33	41.6±1.53	4.98±0.50	4.93±0.42	13.3±1.04	14.3±0.86

*All concentration measurements are the average of four samples and expressed to one standard deviation (± σ); **Denotes significant difference among genotypes $p < 0.01$.

contents was reported as 6.33 mg kg^{-1} in wheat grain by Frosta and Ketchum[17]. Mineral elements uptake by plants may influence by both soil and plant factors. These factors are quantity and mobility of elements in the soil solution and around the plant roots, source and chemical form of elements in soil, pH, organic material and plant species[18]. Environmental variation in quality traits can exceed genotypic variation[19]. Mineral nutrition also plays a major role in grain quality. The influence of micronutrients on grain quality was demonstrated by Flynn *et al.*[20] who showed that wheat flour derived from copper (Cu)-deficient wheat produced dough that was over-extensible and weak. Peck *et al.*[21] reported that a significant decrease was seen in the proportion of gluten under Cu deficiency.

The highest Mn content was found at Gediz-75 (47.5 mg kg^{-1}) genotype in 2001 and Dicle-74 (47.1 mg kg^{-1}) genotype in 2002 year (Table-2). Kunduru-1149 genotype gave the lowest Mn values (37.3 and 39.6 mg kg^{-1}) in both years. Kiziltan-91, C.1252, Ceylan-95, Altintoprak-95 and Korifla genotypes gave higher Mn content than others. Mineral elements uptake by plants may influence by both soil and genetic factors[22].

Molybdenum contents varied from 3.34 (Altar-84) to 5.71 mg kg^{-1} (Harran-95) in 2001, 3.58 (Selcuklu-97) to 5.61 (Ege-88) in 2002. The highest Mo value was seen at Harran-95, Havrani, Ege-88, Gediz-75, Altintoprak-98 and Kunduru-1149 genotypes. Boron content of wheat genotypes ranged between 8.8 and 15.2 mg kg^{-1} in 2001, 9.1 and 14.8 mg kg^{-1} in 2002. The highest B content was found at Firat-93, Mesaphia, Sham-I, Chambar-88, Korifla, Harran-95 and C.1252 genotypes. The nutritional value is affected by both variety and environment[23].

In light of the data obtained from present study indicate that mineral nutrient content of durum wheat genotypes were different each other. Dicle-74, C.1252, Kiziltan-91, Kunduru-1149, Altar-84, Zenith and Gedifla genotypes had the richest mineral composition among other genotypes. Differences in grain mineral element contents among varieties could be associated with differences in adaptation ability of genotypes, genotypic structure and reacted differently to soil and climate conditions.

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