Trace Metal Levels in Some Modern Cultivars and Turkish Landraces of Potato

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Five modern and ten traditional potato varieties grown in Black Sea coastal region of Turkey were studied for copper, cadmium, manganese, zinc and iron contents. Some traditional cultivars had quite low levels of cadmium. For other minerals, in general, there were not clear differences between traditional and modern varieties. However, there were relatively high levels of variation within both groups for these minerals. The potato samples were analyzed using flame (FAAS) and graphite furnace (GFAAS) atomic absorption spectrometry after microwave digestion.

Key Words: Potato, Trace metals, Microwave digestion, Atomic absorption spectrometry.

INTRODUCTION

Potatoes are a crop which originated from the Andes of South America and have been cultivated for about 8,000 years. Although about 2000 species are known within *Solanum* genus, only 160–180 of them can form tubers. Eight of these species can be used as food, but the major species cultivated and used throughout the world is *Solanum tuberosum* L.[1]. Today, potatoes are the fourth most important crop as human food after wheat, corn and rice. In 2002, about 307.4 million tons of potatoes were produced on 19 million ha[2].

Chemical composition of potatoes for human consumption is important and affected by cultivar, production area, soil and climate conditions, agricultural practices and storage of the product[3]. Among the agricultural practices, the most critical factor that affects the chemical composition including mineral composition of potatoes is fertilization. Maier *et al.*[4] reported that N, P and K applications considerably affect not only yield but also gravity, chip colour and chemical composition of tubers. Rivero *et al.*[3] noted that mineral contents of traditional cultivars are higher than those of modern cultivars. They found that Na and Mg

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contents are higher in modern cultivars while K, Fe, Cu and Zn contents are higher in traditional cultivars.

Mineral compositions are as important in physiological and biochemical functions as in nutrition. Trace elements such as Mo, Fe, Cu and Mn play an important role in nitrogen uptake and biotransformation of nitrogen compounds within the plant[5]. Sources of these elements are mainly plant nutrients, soil and water and to a lesser degree dust and precipitation. Studying Fe, Cu and Mn concentrations in tubers of 16 cultivars, these same researchers found statistically significant differences among cultivars. In the two-year experiment, Fe contents of tubers were between 0.30–2.20, Cu between 0.05–0.13 and Mn between 0.05–0.39 mg/100 g. There was a positive correlation between Fe and Cu contents.

There have been health concerns regarding high levels of heavy metals such as cadmium and lead. High levels of these metals could be a result of environmental pollution as well as of high levels of mineral contents in soils of production areas. These metals were reported to be higher in potato skin than flesh[6].

There is a danger of disappearing of traditional varieties in recent years because of their low yield potentials. Nevertheless, local varieties, as germplasm and biological diversity resources, are given great attention especially by CIP (International Potato Center)[7–9]. Therefore, local varieties have been studied for their useful properties, especially food properties. In this study, trace metal levels (Cu, Mn, Cd, Zn, Fe) of potato samples were determined by atomic absorption spectrometry.

EXPERIMENTAL

All reagents were of analytical reagent grade unless otherwise stated. Deionized water (18.2 MΩ cm) from a Milli-Q system (Millipore, Bedford, MA, USA) was used to prepare all aqueous solutions. All mineral acids and oxidants (HNO_3 and H_2O_2) used were of the highest quality grade (Suprapure, Merck, Darmstadt, Germany). Standard solutions were prepared from a 1000 mg L^{-1} Fe, Cu, Mn, Zn and Cd atomic absorption standards (Sigma & Aldrich). A Perkin-Elmer Analyst 700 AAS with deuterium background corrector was used in this study. Cadmium was determined by HGA graphite furnace using argon as inert gas. The other metals were measured using air/acetylene flame. The instrumental parameters and operating conditions were set as recommended by the manufacturer.

Sampling

The investigations was conducted in a Black Sea coastal region of Kabadüz in Ordu province of Turkey in 2002. Fifteen genotypes (five modern and ten traditional varieties) were grown in rows. Soil of experimental area had a clayed-loam texture. pH was 5.5, organic matter content was 4.5% and total salt content was 0.03%. Long term May–September period average temperature of the region is 20.2°C. Tubers were planted on 20 May and the harvest was realized on 22 September. Nitrogen was applied at the rate of 200 kg/ha N and phosphorus

at the rate of 100 kg/ha P_2O_5. Since the experimental area soil had enough level of K, no application was made. No irrigation was performed since the precipitation was enough.

Samples taken from plots were thoroughly washed and peeled using plastic knives. Inner parts of the tubers were thin-sliced and dried in an oven at 105°C for 12 h. For chemical analysis, dried samples were mechanically further broken into pieces without touching any metal tool.

Microwave Digestion

Milestone Ethos D microwave closed system (maximum pressure 1450 psi, maximum temperature 300°C) was used in this study. One gram of sample was digested with 4 mL of HNO_3 (65%) and 2 mL of H_2O_2 (30%) in microwave digestion system (2 min at 250 W, 2 min at 0 W, 6 min at 250 W, 5 min at 400 W, 8 min at 550 W) and diluted to 10 mL with deionized water. A blank digest was carried out in the same way.

RESULTS AND DISCUSSION

Dry matter and trace metal contents of tubers of ten traditional and five modern varieties are given in Table-1. Dry matter percentages of traditional varieties (23.3–27.5) were somewhat higher than those of modern varieties (18.7–24.3).

TABLE-1
CONCENTRATIONS OF TRACE METALS (mg/100 g) AND DRY MATTER CONTENT (%) IN DIFFERENT POTATO CULTIVARS

Cultivar No.	Cultivars	Dry matter content	Cu	Cd	Zn	Mn	Fe
1	Gürgentepe Sarisi	23.7±0.090	0.997±0.045	0.049±0.008	1.62±0.12	0.788±0.085	3.91±0.31
2	Gürgentepe Beyazi	27.2±1.094	0.378±0.040	0.052±0.008	1.31±0.17	0.503±0.045	2.08±0.19
3	Aleddiyan Sarisi	23.3±0.081	0.454±0.063	0.017±0.005	1.07±0.11	0.434±0.056	2.38±0.15
4	Aleddiyan Beyazi	26.8±1.014	0.266±0.037	0.045±0.010	1.59±0.10	0.622±0.072	2.05±0.21
5	Aybasti Sarisi	24.1±0.095	0.473±0.038	0.010±0.004	1.38±0.12	0.583±0.055	1.97±0.14
6	Aybasti Beyazi	27.5±1.120	0.442±0.028	0.011±0.004	1.02±0.10	0.562±0.048	1.79±0.15
7	Başçitlik Beyazi	25.7±1.089	0.456±0.073	0.018±0.005	1.56±0.18	0.720±0.060	2.19±0.14
8	Batum	25.2±0.098	0.437±0.032	0.026±0.005	1.66±0.07	0.473±0.050	2.86±0.22
9	Romanya Beyazi	25.4±1.004	0.486±0.052	0.032±0.005	1.17±0.15	0.473±0.053	2.04±0.23
10	Gölköy	24.8±1.012	0.509±0.055	0.041±0.005	1.57±0.16	0.687±0.059	2.37±0.22
11	Cosmos	21.8±0.080	0.574±0.050	0.047±0.011	1.81±0.15	0.862±0.091	3.67±0.25
12	Consul	18.7±0.071	0.220±0.028	0.025±0.009	1.35±0.12	0.818±0.071	2.76±0.28
13	Agria	23.9±0.088	0.643±0.062	0.050±0.006	2.66±0.03	0.898±0.076	3.62±0.29
14	Latona	19.6±0.073	0.466±0.041	0.040±0.006	2.02±0.19	0.734±0.061	2.64±0.24
15	Victoria	24.3±0.092	0.333±0.030	0.024±0.003	1.14±0.15	0.639±0.060	1.90±0.18

This could be due to the fact that most of the traditional varieties are white-fleshed cultivars while none of the modern varieties in our study is white-fleshed since dry matter content of white-fleshed tubers is higher. Similarly, traditional cultivars with white flesh (Nos. 2, 4, 6, 7 and 9) had higher dry matter content than the ones with yellow flesh (Fig. 1)

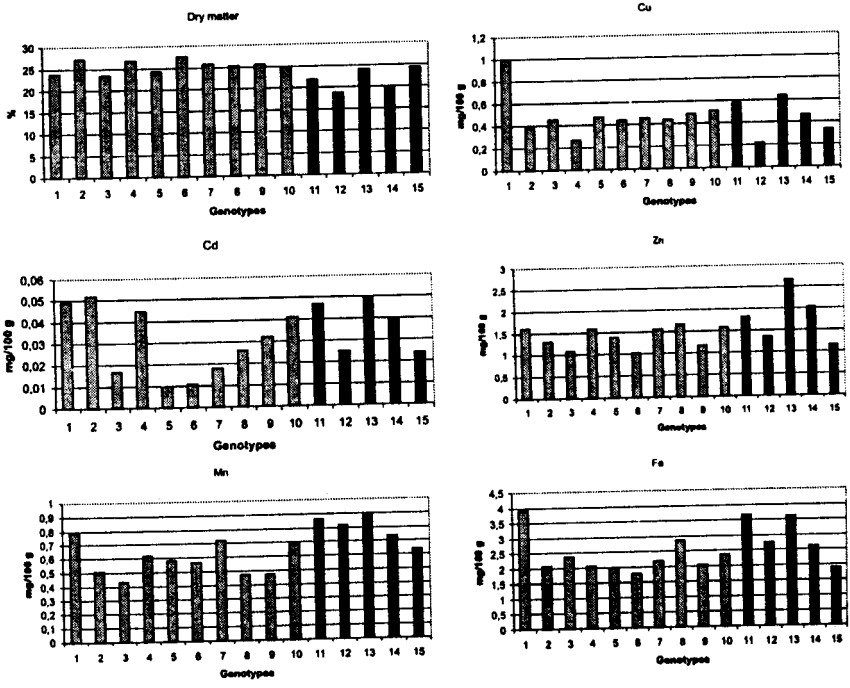

Fig. 1. Concentrations of some minerals and dry matter ratio in different potato cultivars

There were almost five times differences among cultivars for copper contents. Both traditional and modern cultivar group had high and low copper containing cultivars. A traditional variety (Gürgentepe sarisi, 0.997 mg/100 g) had the highest ratio followed by a modern variety (Agria, 0.643 mg/100 g) and a modern variety (Consul, 0.220 mg/100 g) had the lowest content followed by a traditional variety (Aleddiyan Beyazi, 0.266 mg/100 g). Based on fresh weight, our values correspond to about 0.04–0.25 mg/100 g. Sikora and Cieslik[5] studied 16 modern potato varieties and, based on two-year average, found a variation of 0.070–0.112 mg/100 g. Studying two traditional and two modern cultivars, Rivero *et al.*[3] found copper levels between 0.054 and 0.172 mg/100 g. So, variation in our material is much higher than those reported by these two groups of investigators.

Cadmium levels of tubers showed a similar amount of variation as that of copper. Cadmium is a trace metal for which there are serious health concerns. Some of the traditional cultivars (Aybasti sarisi, Aybasti Beyazi and Bacşçitlik Beyazi, 0.010, 0.011 and 0.018 mg/100 g) had considerably less amounts of

cadmium in their tubers. Another traditional variety (Gürgentepe Beyazi, 0.052 mg/100 g), on the other hand, had the highest cadmium content. On the whole, cadmium level in potato tubers in our study is much lower than what Queirolo *et al.*[6] reported (0.2–1.7 mg/100 g cadmium on fresh weight basis depending upon different locations). Variation by location could also be the reason for low levels of cadmium in our samples.

Zinc contents of the cultivars were between 1.02 and 2.66 mg/100 g. A modern variety (Agria) had considerably higher zinc content (2.66 mg/100 g) than others. The lowest zinc content was in Aybasti Beyazi (1.02 mg/100 g) followed by Victoria (1.14 mg/100 g). Five traditional varieties (Gürgentepe Sarisi, Aleddiyan Beyazi, Başçitlik Beyazi, Batum and Gölköy numbered 1, 4, 7, 8 and 10 had zinc levels comparable to modern cultivars. Rivero *et al.*[3] reported 0.218 and 0.352 mg/100 g zinc in two modern cultivars and 0.434 and 0.458 mg/100 g in two traditional cultivars. Zinc contents of modern cultivars are higher but traditional varieties are lower than these values.

Manganese contents of the modern varieties (0.639 to 0.898 mg/100 g) were considerably higher than traditional cultivars (0.434 to 0.788 mg/100 g). The highest three contents were in three modern cultivars, *i.e.*, Agria, Cosmos and Consul (0.898, 0.862 and 0.828 mg/100 g) while the lowest ones were in three traditional varieties, *i.e.*, Aleddiyan Sarisi, Batum and Romanya Beyazi (0.434, 0.473 and 0.473 mg/100 g). Three traditional varieties (Gürgentepe Sarisi, Başçitlik Beyazi and Gölköy), on the other hand, had manganese levels somewhat comparable to modern cultivars. Variation in our samples is 0.11-0.22 mg/100 g calculated on fresh basis (based on an average 25% dry matter). This variation is very similar to 0.06–0.228[5] and 0.143-0.177[3].

Iron contents varied from 1.79 (Aybasit Beyaiz) to 3.91 (Gürgentepe Sarisi) mg/100 g. There was not a clear distinction between traditional and modern groups. Sikora and Cieslik[5] found iron contents of 0.33–1.33 mg/100 g in fresh tissue. Rivero *et al.*[3] found iron contents of 7.8–1.0 mg/100 g. Considering that the dry matter content was 25% in our samples, 2–4 mg/100 g iron content is actually about 0.5–1 mg/100 g in fresh tissue which is very similar to the levels reported by the above mentioned studies.

All of the correlation coefficients between mineral contents were positive. Besides, iron levels had significant correlations with all other elements. In addition, cadmium-zinc and manganese zinc correlations were significant (Table-2).

TABLE-2
CORRELATION COEFFICIENT BETWEEN SOME TRACE METALS IN POTATO TUBER

	Cd	Zn	Mn	Fe
Cu	0.361	0.367	0.333	0.692†
Cd		0.585*	0.430	0.566*
Zn			0.679†	0.673*
Mn				0.674*

In general, traditional varieties showed considerable variations for all minerals studied, though lower on the average compared to modern varieties. Compared to a study by Rivero *et al.*[3], our traditional varieties have relatively lower mineral contents while modern cultivars have relatively higher mineral contents. These differences are due to specific varieties, both traditional and modern, included in our study. However, there are exceptions in both groups. A traditional variety, Gürgentepe Sarisi, is very interesting since it had very high percentages for all the minerals studied. Among the modern varieties, Agria had high percentages for all of the minerals as well. Başçitlik Beyaiz is prominent for its low cadmium level and high levels of other minerals. Besides, the traditional varieties Aybasti Sarisi and Aybasti Beyazi have very low levels of cadmium. These materials can be used for potato breeding for the areas in which potato tubers contain high level of cadmium (as a result of rich cadmium content in the soil of agricultural lands) and where there are health concerns for high cadmium levels in locally produced food.

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