Contents of Heavy Metals in Different Saccharides Fractions of Potato Tubers

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Abstract: In this work the Cd, Cu and Zn accumulation in potatoes, their influence on starch, water-soluble (WSS) and water-insoluble saccharide (WIS) contents and content of heavy metals in various saccharide fractions of potatoes were determined. The fraction of WSS was isolated by Somogyi method, the WIS fraction was obtained from delipided portion of potatoes. Enhanced pseudototal Cd contents in relationship to limit value 0.7 mg/kg of soil were determined in 13 soil samples (0.72–1.06 mg/kg). Contents of Zn and Cu were lower than their limit values in all observed soil samples. Observed heavy metals have not influence on their accumulation in potatoes, the Cd content in potatoes (0.0015–0.0042 mg/kg f.m.), Cu (0.0590–0.1780 mg/kg f.m.) and Zn contents (0.1887–0.3517 mg/kg f.m.) were also lower than their limit values. The proportion of observed heavy metals in selected saccharide fractions: Cd (mg/kg): 0.017–0.140 (starch), 0.0133–0.2293 (WIS), 0.8711–109.7713 (WSS); Cu (mg/kg): 0.067–1.433 (starch), 0.2844–6.9877 (WIS), 18.0134–1070.5216 (WSS); Zn (mg/kg): 6.667–66.300 (starch), 0.7869–23.3673 (WIS), 101.4842–4020.790 (WSS)

Keywords: potatoes; heavy metals; saccharides; starch

INTRODUCTION

The quality of potatoes including also their safety has been influenced by many factors. It is not only determined by nutritious components important in human nutrition, but it could be affected also by other ineligible substances. Heavy metals belong to this mentioned group.

Soil is the starting place of enter of heavy metals into the plants and afterwards to food chain. Regular long-term monitoring surveys of heavy metals by various international projects have revealed significant enhancement in their concentration in soil, especially in urban and industrial areas (Vollmannová *et al*. 2008). Contamination of Slovak soils is allocated mainly to area of industrial centres, to surroundings of urbanised sites, but also to areas with high geochemical background of contaminating elements (Tomáš *et al*. 2008). The heavy metals input from soil into the plants depends on the quality of soil and on the species and genotype of plant (Jomová *et al.* 2004).

Cadmium from the health standpoint belongs to those metals, whose toxic traits can be manifested by relatively low contents. Contamination of food chain with cadmium is associated mainly with soil contamination (Dobríková *et al.* 2004).

Copper and zinc belong to elements that fill important roles in plants, but in higher concentrations can exert toxic effects (Velíšek 2002).

Heavy metals can accumulate in various components of foodstuffs with nutritive value. Saccharides are stable compounds of all cells. In animal tissues could be present only in traces, in plant tissues where they fill structural, as well as metabolic role, they usually from 85–90% of dry matter (Murray 1998; Velíšek 2002).

Starch is the most important component of potato tuber dry mater, not only from economic standpoint, but also from the standpoint of potato quality. The qualitative properties of starch have great importance for various applications of starch and its derivatives, whereas Gebhardt *et al.* (2005) reported that the starch content and the yield of tubers are real quantitative and polygenic traits.

MATERIAL AND METHODS

Sampling of soil and plant material was carried out from the key site Stará zem in cadastre Komárno. This site with acreage 62.5 km, on which 29 sampling points were identified on the basis of 6 seconds raster, soil and plants samples after localisation of sampling point were taken. Five potato varieties: 2 very early ones – Adora, Vivaldi, 2 early ones – Livera, Courage, 1 middle early one – Victoria were cultivated on key site.

Agrochemical analysis of soil (pH/H_2O, pH/KCl, C_{ox} (%) and % humus), nutrients contents and contents of heavy metals (Cd, Cu, Zn) were carried out after taking of soil. Nutrients contents (P, K, Ca, Mg) were assessed by Mehlich II method, nitrogen content by Kjeldahl method, pseudototal contents of Cd, Cu, Zn in *aqua regia* solution, contents of potential mobilisable forms Cd, Cu, Zn in solution of HNO_3 (c = 2 mol/dm^3) and contents of mobile forms Cd, Cu, Zn in soil solution NH_4NO_3 (c = 1 mol/dm^3).

Contents of Cd, Cu and Zn were assessed in the whole tuber of potato, in starch, in soluble saccharides (WSS) and in insoluble saccharides (WIS). The total contents of heavy metals in tubers were assessed after mineralisation of the sample by wet method. Starch was isolated by classical way (hand-washing) after its mineralisation by dry way method and then surveyed heavy metals were assessed. WIS were isolated by sequential analyses from lyophilised and defatted sample by gradual extraction and coagulation. WIS and ash were mineralised by concentrated HNO_3 and the contents of Cd, Cu and Zn were assessed in mineralisate. Supernatants containing WSS were put into 50 cm^3 and used directly for Cd, Cu, Zn determination in WSS. The content of WSS was assessed by Somogyi method.

Analytical ending for all determinations was AAS (AAS Varian AA SpectrDUO 240FS/240Z/UltrAA).

RESULTS AND DISCUSSION

The tested soil had low to very low content of phosphorus (45.1–636.4 mg/kg), middle to very high content of potassium (146.5–647.5 mg/kg), very low to high content of magnesium (19.5 to 198.0 mg/kg). Determined content of calcium was in range 800–25 400 mg/kg and content of nitrogen 1050–5250 mg/kg. The values of active form of pH were in range 6.44–8.70 and changeable form of pH in range 5.26–7.92, thus considering acid to strongly alkali reaction. The most suitable pH values for potatoes cultivation are in range 5.5–6.5 and with the humus content above 2%.

Only cadmium appeared to be the risk metal from the standpoint of soil contents, its pseudototal content exceeded hygienic limit in 13 sampling sites (i.e. 45%) and content of potential mobilisable forms in 15 sampling sites (i.e. 52%). It could be stated that the soil is not contaminated, because mentioned forms of cadmium are actually not available. Although, their bioavailability can be affected by soil properties changes (Vollmannová *et al.* 2002).

The influence of starch content and its quality is in close relation not only to variety and nutrition, but also depends on ecological conditions, as well as on soil quality, in which potatoes are cultivated. Starch content in potato tubers is in range 8–29.5% and comprises about 80% of the total solids of tuber (Vreugdenhil *et al.* 2007), whereas early potatoes have the lowest content, what is confirmed also by our results: in Vivaldi variety the average content of starch was 13.37%, in Adora variety 12.96%, in Victoria variety 14.31, in Livera variety 19.23% and in Courage variety 16.6% . Limit value given in Foodstuffs Codex SR for heavy metals in foodstuffs defines only the highest acceptable amount for copper in starch (10 mg/kg), the highest acceptable amounts for other heavy metals are defined for potatoes, or for potatoes products. The highest acceptable amounts of Cd for other foodstuffs (0.1 mg/kg) were exceeded in five samples (by 10–67%). These values were not exceeded when compared to the highest acceptable amount of Cd in dehydrated and instant foodstuffs (0.5 mg/kg) and with the highest acceptable amount of copper.

As it have been already reported, limit content values of Cd in soil were enhanced on 52% of sampling sites and values of Zn were enhanced only on 3% of sampling sites. The content of copper was below limit values given by legislative norm on all monitored sites. Enhanced contents of Cd, Cu and Zn in potato tuber were not recorded in any case.

The results of assessments, as well as determined contents of Cd, Cu, and Zn in saccharides fractions WSS and WIS are reported in Table 1.

The method of regression and correlation analyses was used for statistical evaluations of gained results.

Table 1. Contents of heavy metals in potatoes (A), WIS and WSS in mg/kg f.m.

s. s.	A			WIS				WSS			
	Cd	Cu	Zn	%	Cd	Cu	Zn	%	Cd	Cu	Zn
1	0.0021	0.065	0.216	12.50	0.053	1.940	11.020	0.94	3.951	55.507	256.365
2	0.0020	0.118	0.314	12.42	0.164	1.468	23.230	0.91	1.957	53.290	481.260
3	0.0027	0.104	0.302	13.12	0.098	1.962	9.563	0.89	1.566	42.642	105.762
4	0.0021	0.090	0.277	11.62	0.195	0.738	7.842	0.55	2.068	89.345	248.137
5	0.0026	0.095	0.347	12.44	0.026	1.638	23.367	0.62	1.590	50.471	156.943
6	0.0028	0.064	0.189	13.11	0.082	0.573	1.473	2.71	1.266	25.944	124.024
7	0.0024	0.073	0.250	9.95	0.216	2.372	13.800	1.38	0.871	18.200	183.402
8	0.0019	0.085	0.215	11.83	0.181	1.269	7.431	1.69	1.573	18.013	101.484
9	0.0035	0.059	0.189	12.96	0.132	1.159	8.360	0.69	3.775	53.032	208.696
10	0.0036	0.086	0.279	10.17	0.229	1.058	9.085	0.77	3.162	62.536	248.286
11	0.0029	0.111	0.304	16.51	0.111	1.567	8.227	0.89	5.310	61.586	183.544
12	0.0034	0.078	0.284	15.50	0.166	2.007	9.411	0.52	11.784	90.647	209.724
13	0.0024	0.142	0.352	15.86	0.135	2.366	6.829	0.19	28.591	358.846	867.810
14	0.0026	0.084	0.255	13.96	0.200	6.989	8.141	0.25	21.632	261.107	643.049
15	0.0029	0.118	0.322	14.51	0.177	4.656	9.682	0.22	19.281	301.199	898.801
16	0.0028	0.102	0.246	14.79	0.225	1.885	10.587	0.19	28.549	325.784	805.825
17	0.0030	0.117	0.274	12.89	0.135	3.077	10.130	0.13	39.631	538.983	854.590
18	0.0020	0.114	0.308	16.35	0.216	2.667	8.864	0.39	11.166	241.234	437.684
19	0.0027	0.095	0.298	13.59	0.028	2.831	10.899	0.05	109.77	1006.237	4020.790
20	0.0015	0.121	0.323	16.18	0.013	0.795	2.187	0.10	28.171	915.540	1242.815
21	0.0021	0.105	0.321	15.77	0.082	1.156	8.297	0.20	16.783	386.868	1160.605
22	0.0038	0.178	0.352	15.08	0.114	0.284	6.612	0.20	16.519	427.166	960.598
23	0.0029	0.099	0.235	14.82	0.043	0.579	6.874	0.24	13.758	277.865	703.205
24	0.0024	0.148	0.260	15.36	0.126	0.667	2.744	0.30	12.230	197.389	820.521
25	0.0028	0.078	0.234	12.35	0.191	0.782	2.953	0.31	8.569	136.970	455.863
26	0.0016	0.063	0.203	14.23	0.151	0.754	7.761	0.05	49.228	1070.52	3113.889
27	0.0018	0.112	0.301	13.63	0.118	0.551	0.787	0.13	14.506	494.142	1040.886
28	0.0042	0.095	0.326	15.13	0.149	0.913	7.138	0.31	6.443	197.362	561.910
29	0.0036	0.090	0.289	13.12	0.131	0.409	2.860	0.28	6.116	218.300	682.768

s. s. – sampling site

Statistical dependence (R = 0.038) between % WIS and Cu content was not confirmed. There was middle strongly negative statistical dependence between % WIS and Zn content (R = –0.303) and weak and negative statistical dependence between % WIS and Cd content (R = –0.27). The dependence between % WSS and contents of Cu, Zn and Cd in samples was also found out by the method of regression ad correlation analyses. There was very strong statistical dependence among all combinations (% WSS and Cu content: R = 0.97; % WSS and Zn content: R = 0.939; % WSS and Cd content: R = 0.922).

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