

## Changes of Vitamin C Content in Relation to the Range of Accumulation of Cd, Pb and Zn in Potato Tubers

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**Abstract:** The changes of vitamin C content in relation to Cd, Pb and Zn accumulation in 6 potatoes varieties: very early (Junior, Impala), early (Livera), middle early (Agria), medium-late (Asterix, Desirée) were surveyed in this work. The soil used in pot trial had pseudototal (in soil extract of *aqua regia*) contents of Cd 0.54–0.9, Pb 14.0–107.2, Zn 47.9–55.8 mg/kg. Experiment was conducted in 4 variants: A – control, B–D with the gradual treatment of Cd, Pb, and Zn in form on their salts solutions. The metals content in potatoes was assessed by AAS, vitamin C by HPLC method. The accumulation Cd, Pb, Zn varied in dependence on variety, the highest one was in varieties Junior, Impala; the lowest one in Asterix, Desirée. The vitamin C content (mg/kg f.m.) was highest after Cd treatment in all varieties in variant D: 491.46 (Junior) – 566.27 (Asterix); after Pb in variant B: Impala (101.51) – Desirée (157.31), after Zn in variant C: Impala (78.80) – Desirée (143.41).

**Keywords:** potatoes; heavy metals; vitamin C

### INTRODUCTION

The term vitamin C is used for the whole reversible redox system, including L-ascorbic acid and L-dehydroascorbic acid. About 90–95% of vitamin C comprises the form of ascorbic acid in foodstuffs of plant origin, remaining is the dehydroascorbic acid (VELÍŠEK 2002).

Vitamin C is the main vitamin in potatoes. Its nutritious contribution from potatoes forms about 40% of daily recommended intake (VREUGDENHIL *et al.* 2007). The content of vitamin C in freshly harvested tubers is in range 10–25 mg/100 g fresh matter, whereas according to BROWN (2005) the average content 20 mg/100 g can represent up to 13% of total antioxidant capacity of tuber. The effectiveness of vitamin C in plants is often influenced also by presence of other compounds. Some bioflavonoids belong among them, reported in literature as vitamin P. The flavone rutin and flavonol quercetin are the main effective ones.

### MATERIAL AND METHODS

The experiment was carried out under model conditions of vegetative pot trial. The values of active and changeable form of soil reaction pH,  $C_{ox}$  and humus content in tested soil taken from locality of Výčapy-Opatovce were assessed.

The content of available nutrients (P, K, Ca, Mg) in soil was determined by the method of Mehlich II and the N content by the method of Kjeldahl.

Pseudototal content of Cd, Pb and Zn which includes all of their forms besides residual fraction of metals was assessed in *aqua regia* extract, the potentially mobilisable forms of selected heavy metals were assessed in soil extract by  $HNO_3$  ( $c = 2 \text{ mol/dm}^3$ ) with ending by flame AAS (AAS Varian AA Spectr DUO 240FS/240Z/UltrAA) and the contents of mobile forms of Cd, Pb and Zn in soil extract by  $NH_4NO_3$  ( $c = 1 \text{ mol/dm}^3$ ).

The contents of Cd, Pb, and Zn in peeled potato tubers harvested in consumer mature quality, were

determined after samples mineralisation by wet way method of flame AAS (AAS Varian AA Spectr DUO 240FS/240Z/UltrAA).

The content of vitamin C in potato tubers was assessed by HPLC method (HAN *et al.* 2004).

The changes of vitamin C content in potato tubers were compared in dependence on variety and on the range of Cd, Pb, and Zn accumulation. The doses of heavy metals treatment in variants 1–4 were applied as following: Cd 0; 3; 5; 10 mg/kg soil in form of  $\text{CdCl}_2 \cdot 2.5\text{H}_2\text{O}$  (varieties Junior, Livera, Agria, Asterix); Pb 0; 70; 105; 140 mg/kg in the form of  $\text{Pb}(\text{NO}_3)_2$  and Zn 0; 100; 200; 300 mg/kg in the form of  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  (varieties Impala, Livera, Agria, Desirée).

## RESULTS AND DISCUSSION

Soil used in trail experiment was strong to weakly acid (pH/KCl 4.63–5.89), with medium supply of humus (2.55–2.65%) and low content of P (9.654 to 51.88 mg/kg), good content of K (215.5–297.0 mg/kg) and high content of Mg (252.0–340.0 mg/kg). N content was in range 2100.0–2975.0 mg/kg of soil and Ca content was in range 1356.0–2532.5 mg/kg of soil.

The contents of Cd, Pb, Zn in soil determined in mentioned agents are reported in Table 1.

Variety Junior most significantly reacted on increased contents of Cd in soil, where the highest contents of Cd in tubers and the lowest contents

Table 1. Contents of heavy metals in mg/kg of soil

	Cd			Pb			Zn		
	2006	2007	2008	2006	2007	2008	2006	2007	2008
<i>Aqua regia</i>	0.9	0.56	0.54	22.8	107.2	14.0	52.4	55.8	47.9
$\text{HNO}_3$	0.22	0.208	0.148	8.88	11.0	7.12	5.34	6.26	5.24
$\text{NH}_4\text{NO}_3$	0.027	0.023	0.022	0.22	0.21	0.195	0.24	–	0.09

Table 2. Heavy metals contents in mg/kg of dry matter (1) and vitamin C in mg/kg of fresh matter (2) in potato tubers

Varieties		Variants							
		A		B		C		D	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Cd	Junior	1.089	182.20	2.327	234.73	2.898	196.16	3.464	491.46
	Livera	0.520	425.76	2.107	368.54	2.609	515.16	3.381	540.05
	Agria	0.556	238.28	2.102	292.84	2.267	247.75	3.313	517.12
	Asterix	0.483	406.29	1.743	496.88	2.192	542.76	2.842	566.27
Pb	Impala	1.527	85.30	2.287	101.51	2.743	97.21	3.562	64.61
	Livera	1.395	101.82	1.821	112.56	2.439	106.20	3.032	83.63
	Agria	1.031	90.06	1.592	123.72	2.211	138.62	2.688	96.79
	Desirée	0.813	112.34	1.458	157.31	1.913	142.07	2.624	107.19
Zn	Impala	16.002	60.49	29.453	71.94	45.536	78.80	60.925	75.25
	Livera	12.643	76.17	28.909	80.72	44.500	91.52	48.749	86.68
	Agria	14.072	69.31	23.848	89.48	42.695	95.27	47.270	91.25
	Desirée	10.848	126.50	23.370	138.71	40.443	143.41	44.795	135.13

of vitamin C were assessed (Table 2). The lowest contents of Cd and the highest contents of vitamin C (except for variant A) were determined in potatoes of variety Asterix. The sensitive reaction on enhanced concentration of Cd in the environment is referred by HLUŠEK *et al.* (1996), when the doubled concentration of Cd in soil copies the doubled concentration of Cd in plants and in contrary, the potatoes are much less sensitive on enhanced content of Pb in soil, what is in correspondence with our results.

With the increasing of Pb content in soil also its content has increased in potato tubers, whereas the highest content of Pb was in potatoes by variety Impala and the lowest one by variety Desirée.

The content of vitamin C was increasing in comparison with control variant gradually in variants B and C, but in variant D was declining more when compared to variant A. The variety Agria was the exception, with its content of vitamin C lower in variant D than in variants B and C, but higher than in variant A.

Similarly, the increasing doses of Zn were reflected by zinc accumulation in tubers as following: Desirée > Agria > Livera > Impala (Table 2).

The content of ascorbic acid is affected by various external and internal factors, such as variety, year and the cultivation and its conditions (GUZIUR *et al.* 2000; LACHMAN *et al.* 2000; HAMOUZ *et al.* 2007), but the influence of the environment on the vitamin C content in different genotypes is low (LOVE *et al.* 2004).

The highest contents of heavy metals and the lowest content of vitamin C were assessed in very early potato varieties through all three years of survey and in contrary in medium late and late varieties of potatoes were the lowest contents of Cd, Pb and Zn and the highest contents of vitamin C.

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