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REGULAR ARTICLE

RISK OF LENTIL SEED CONTAMINATION BY RISK METALS FROM THE SOIL

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ABSTRACT

The aim of this study was to evaluate the influence of the grown locality on risky metal intake from the soil to the lentil seeds. The research was realised in four different localities of Iraq (Qushtopa, Shaklawa, Kalak and Koysinjaq) using the same lentil cultivar. In all soil samples the determined Co, Ni, Cr and Cd content in the soil extract by aqua regia exceeded the limit values (by 39% - 49%, 249% - 276%, 26% - 46% and 530% - 670% respectively). In two localities (Kalak, Koysinjaq) also the Cu content by 1% - 4% exceeded maximal allowed value given by the legislative. In all sample sites also the maximal available soil content of mobile Pb forms was by 55% - 150% exceeded. Despite of extremely high soil contents of Cu, Co, Ni, Cr, Pb and Cd the investigated lentil seeds are from the point of risky metal contamination safe. All determined values of heavy metal contents are lower than hygienic limits. Based on our results we could suppose that lentil can be grown also in the soil with enhanced amounts of risky metals without danger of lentil seeds contamination.

Keywords: soil, risky metals, lentil, safety

INTRODUCTION

Heavy metals are potential environmental contaminants with the capability of causing human health problems if present to excess in the food. They are given special attention throughout the world due to their toxic effects even at very low concentrations **(Das, 1990)**. Several cases of human disease, disorders, malfunction and malformation of organs due to metal toxicity have been reported **(Jarup, 2003)**. Many studies pointed out that legumes and cereals contaminated with different levels of heavy metals. The level of heavy metals in foodstuffs have been reported around the world; from East Asia **(Wu Leung and Butrum, 1972)**, Sweden **(Jorhem and Sundstroem, 1993)**, USA **(Pennington *et al*., 1995 a,b)**, China **(Zhang *et al*. 1998)**, Nigeria **(Onianwa *et al*., 1999)**, Italy **(Conti *et al*., 2000)**, and Turkey **(Saracoglu *et al*., 2004)**. Currently, contamination of soil in cultivated fields with toxic heavy metals such as cadmium, copper, nickel and zinc has emerged as a new threat to agriculture **(Singh *et al*., 2007)**. Cadmium is an unnecessary element for both plants and animals and has toxic effects when its concentration has exceeded a limit. Generally, it makes negative effect on their metabolisms by influencing the activity of cellular enzymes **(Yang *et al*., 1986)**. Many studies have been carried out on the effects of cadmium on plants. They showed that, cadmium in certain amounts inhibited the germination and development of the plants **(Aydinalp and Marinova, 2009)**. Trace heavy metals are significant in nutrition, either for their essential nature or their toxicity. Copper and zinc are known to be essential and may enter the food materials from soil through mineralization by crops or environmental contamination with metal-based pesticides. Excessive intake of either copper or zinc has been reported to be toxic **(Somer, 1974; Graham and Cordano, 1976; Prasad, 1976; Fairweather-Tait, 1988)**. Cadmium and lead are among the most abundant heavy metals and are particularly toxic. The excessive content of these metals in food is associated with etiology of a number of diseases **(WHO, 1992, 1995)**. Cadmium exposure may cause kidney damage and/or skeletal damage **(WHO, 1992; and Jarup *et al*., 1998)**. Lead is accumulated in the skeleton and cause renal tubular damage and may also give rise to kidney damage **(WHO, 1995)**. International Agency for Research on Cancer (IARC) classified cadmium and lead as human carcinogen **(IARC, 1993; Steenland and Boffetta, 2000)**. The physiology and biochemistry of the toxic effects of zinc in plants are likely to be similar to those reported for other heavy metals; however, zinc is not considered to be highly phytotoxic **(Kabata-Pendias and Pendias, 1973)**. Although, the effects of the individual heavy metals on plants have been evaluated by many studies **(Brown and Wilkins, 1986; Shafig *et al*., 2008; Shafiq and**

Iqbal, 2005; Kabir *et al*., 2008), limited information is available on the effects of heavy metal mixture on plant species. The aim of this study was to evaluate the influence of the grown locality on risky metal intake from the soil to the lentil seeds. The research was realised in four different localities of Iraq (Qushtopa, Shaklawa, Kalak and Koysinjaq) using the same lentil cultivar.

MATERIAL AND METHODS

The soil and lentils samples were collected in four localities of Iraq (Qushtopa, Shaklawa, Kalak and Koysinjaq) with different soil properties. The soil was sampled by valid methods from two horizons (A: 0-0.2 m; B: 0.3-0.45 m) with pedological probe GeoSampler fy. Fisher. In each soil sample the exchangeable reaction (pH/KCl), the contents of available nutrients (K, Mg, P) and mobile forms of Ca according Mehlich II., content of humus by Tjurin method and contents of $N\text{-}NH_4$ and $N\text{-}NO_3$ were determined. Pseudototal content of risk metals including all of the forms besides residual metal fraction was assessed in solution of *aqua regia* and content of mobile forms of selected heavy metals in soil extract of NH_4NO_3 ($c = 1$ mol.dm^{-3}). Gained results were evaluated according **Council Directive 86/278/EEC.** Risky element contents in legume seeds were determined after mineralization by wet way using the atomic absorption spectrometry, too. Analytical method was flame AAS (AAS Varian AA Spectr DUO 240 FS/240Z/UltrAA). The content od risky elements in lentil seeds were evaluated according to **Commission Regulation EC No. 1881/2006**.

RESULTS AND DISCUSSION

The soil as a starting place for input of risk substances into a human food chain is continually monitored. The necessity to monitor the soil contaminant contents is especially important in vicinity of industrial sources from the aspect of food safety and quality assurance.

The soil reaction in all investigated soil samples from four different localities was alkaline. Soil reaction has a major effect on the uptake of many risky elements; the most of them become more available to plants as pH decreases. The supply of humus is very small to small, content of Mg is very high, K content is high till very high, but in the soil samples there is very low till medium P content (Table 1).

Table 1 Agrochemical characteristics of soil

Soil	Locality	pH(KCl)	MELICH II. (mg.kg^{-1})				$C_{ox.}$ (%)	Humus (%)	N-NH_4	N-NO_3
			Ca	Mg	K	P				
1A	Qushtopa	7.43	8264.80	370.80	348.85	24.46	0.47	0.81	12.00	1.56
1B	Qushtopa	7.33	10524.00	381.20	278.10	16.57	0.58	1.00	8.77	1.44
2A	Shaklawa	7.54	8959.60	392.80	410.40	36.89	0.61	1.05	11.48	4.94
2B	Shaklawa	7.45	8881.20	388.40	351.35	26.08	0.65	1.12	9.80	1.81
3A	Kalak	7.48	9006.00	412.20	797.40	39.49	0.68	1.17	11.50	0.94
3B	Kalak	7.39	8499.40	406.20	305.65	40.57	0.51	0.88	9.09	0.92
4A	Koysinjaq	7.43	8233.80	387.00	314.15	27.81	0.47	0.81	8.77	0.53
4B	Koysinjaq	7.47	10022.00	396.40	275.30	11.82	0.65	1.12	6.27	0.90

In all soil samples the determined Co, Ni, Cr and Cd content in the soil extract by *aqua regia* exceeded the limit values (by 39% - 49%, 249% - 276%, 26% - 46% and 530% - 670% respectively). In two localities (Kalak, Koysinjaq) also the Cu content by 1-4% exceeded maximal allowed value given by the legislative (Table 2).

Movement of metals through soil profile is considered a slow process and the surface soil accumulate higher concentrations than lower horizon **(Kuhad *et al.* 1989; Salmasi & Tavassoli, 2006; Lamy *et al.*, 2006; Murtaza *et al.*, 2008).** Our results did not confirm these findings, because in some localities the higher metal content was determined in lower horizon.

Table 2 Content of risk metals in soil extract by *aqua regia*

Soil	Locality	Aqua regia (mg.kg^{-1})						
		Zn	Cu	Co	Ni	Cr	Pb	Cd
1A	Qushtopa	66.60	28.80	21.40	139.60	63.60	18.40	2.68
1B	Qushtopa	66.60	29.00	21.80	143.40	65.00	18.80	2.52
2A	Shaklawa	67.20	29.80	22.20	144.20	66.40	20.00	2.70
2B	Shaklawa	67.80	28.80	20.80	142.60	63.00	17.60	2.62
3A	Kalak	68.20	30.20	22.00	143.00	65.80	18.60	2.84
3B	Kalak	69.00	30.00	21.60	146.80	66.20	18.40	2.62
4A	Koysinjaq	68.20	29.80	21.40	147.80	64.00	19.60	2.96
4B	Koysinjaq	72.20	31.20	22.40	150.20	73.00	18.80	3.08
	Limit	**100.00**	**30.00**	**15.00**	**40.00**	**50.00**	**25.00**	**0.40**

In Table 3 contents of mobile forms of selected heavy metals in soil extract by NH_4NO_3 (c = 1 mol.dm^{-3}) are presented. Gained results were evaluated according to the valid legislative. The limit values of risk elements according this legislative norm are considered to be critical values of agricultural soil in relationship to the plant. In all sample sites only the maximal available soil content of mobile Pb forms was by 55-150% exceeded.

Table 3 Content of risk metals in soil extract by NH_4NO_3 (c = 1 mol.dm^{-3}).

Soil	Locality	1 mol.dm^{-3} NH_4NO_3 (mg.kg^{-1})						
		Zn	**Cu**	**Co**	**Ni**	**Cr**	**Pb**	**Cd**
1A	Qushtopa	0.050	0.050	0.115	0.170	0.020	0.155	0.067
1B	Qushtopa	0.055	0.065	0.155	0.250	0.020	0.225	0.054
2A	Shaklawa	0.050	0.080	0.135	0.195	0.020	0.180	0.059
2B	Shaklawa	0.045	0.075	0.140	0.220	0.015	0.190	0.064
3A	Kalak	0.045	0.065	0.135	0.230	0.020	0.200	0.065
3B	Kalak	0.055	0.070	0.150	0.225	0.015	0.200	0.077
4A	Koysinjaq	0.060	0.080	0.170	0.280	0.030	0.250	0.064
4B	Koysinjaq	0.060	0.065	0.155	0.225	0.015	0.195	0.044
	Limit	**2.00**	**1.00**	**-**	**1.50**	**-**	**0.10**	**0.10**

In Table 4 the determined contents of macronutrients are presented. Lentil is now considered as one of the most beneficial legumes for health **(Combe *et al.*, 2004)**. It is a valuable source of proteins, starch and non-starchy carbohydrates, minerals and micronutrients. The determined Na in our lentil samples was lower, but P, Ca and Fe contents were higher than those in work of authors **Zia-Ul-Haq *et al.* (2011)**. The contents of K and Mn were similar in both of works.

Table 4 Content of macronutrients in lentil seeds.

Seeds	Locality	Macroelement content (mg.kg^{-1})								%
		K	**Na**	**Ca**	**Mg**	**P**	**N**	**Fe**	**Mn**	**DM**
1	Qushtopa	7471	244	1820	1162	3433,4	35000	74	19	92,1
2	Shaklawa	7476,5	157	1704	1126	3721	33600	74,5	18,9	91,9
3	Kalak	7973	119,5	2162	1212	5286	33600	125,7	23,2	91,65
4	Koysinjaq	8089,5	98,5	1712	1124	4689,4	34300	102,5	20,4	91,85

Heavy metal accumulation in plants depends upon plant species, and the efficiency of different plants in absorbing metals is evaluated by either plant uptake or soil-toplant transfer factors of the metals **(Rattan *et al.*, 2005).**

Despite of extremely high soil contents of Cu, Co, Ni, Cr, Pb and Cd the investigated lentil seeds are from the point of risky metal contamination safe (Figure 1–7). All determined values of heavy metal contents are lower than hygienic limits. Based on our results we could suppose that lentil can be grown also in the soil with enhanced amounts of risky metals without danger of lentil seeds contamination.

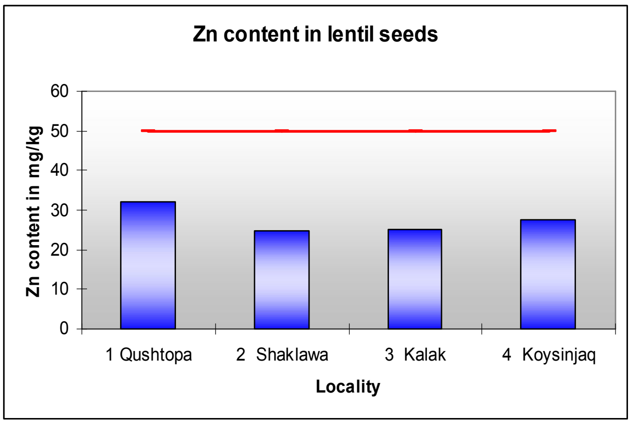

Figure 1 Content of Zn in lentil seeds in mg.kg^{-1}.

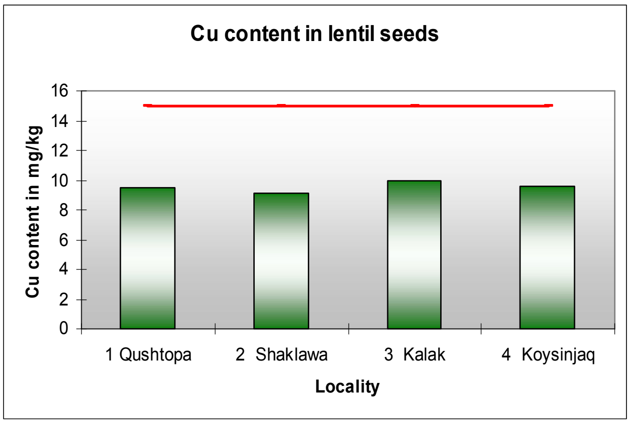

Figure 2 Content of Cu in lentil seeds in mg.kg^{-1}.

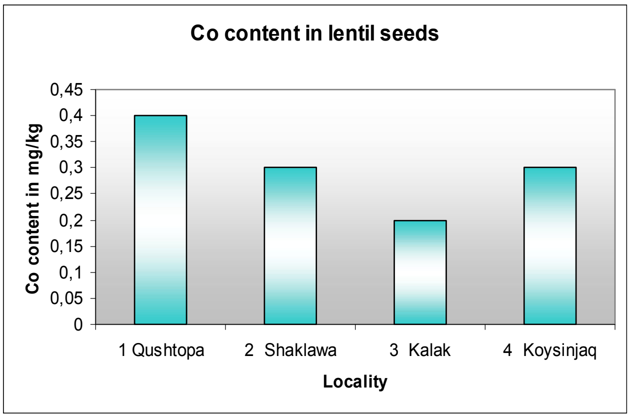

Figure 3 Content of Co in lentil seeds in mg.kg^{-1}.

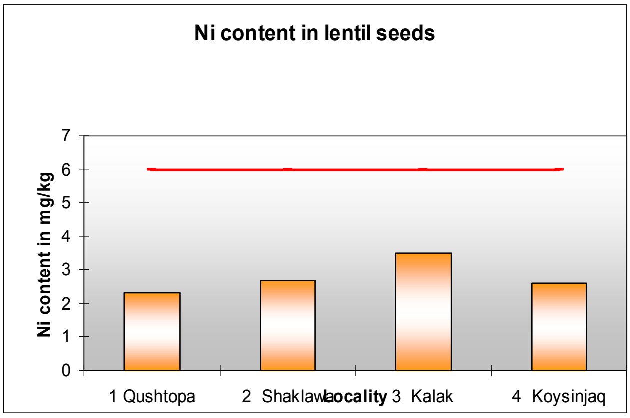

Figure 4 Content of Ni in lentil seeds in mg.kg^{-1}.

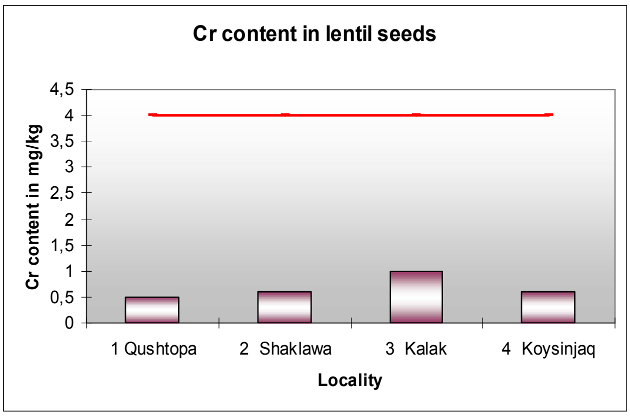

Figure 5 Content of Cr in lentil seeds in mg.kg^{-1}.

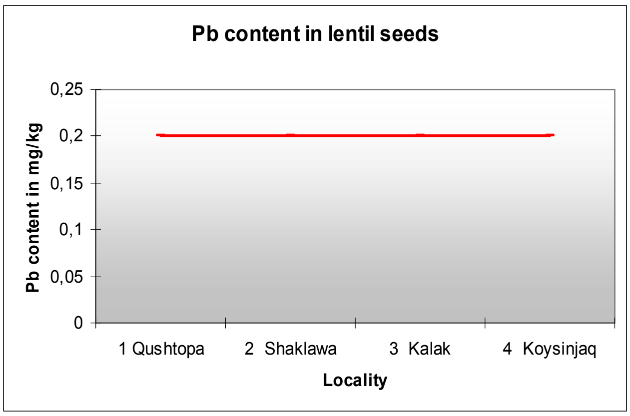

Figure 6 Content of Pb in lentil seeds in mg.kg^{-1}.

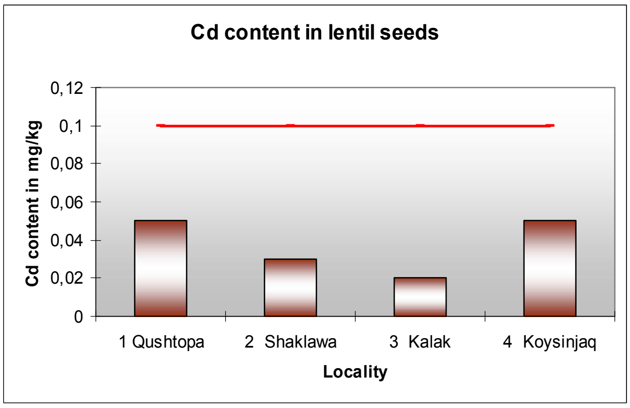

Figure 7 Content of Cd in lentil seeds in mg.kg^{-1}.

Lentil seeds are rich sources of proteins **(Iqbal *et al.*, 2006)** and bioactive peptides, including lecitins **(Cuadrado *et al.*, 2002)**, "defensin" protein **(Finkina *et al.*, 2008)**, and Bowman-Birk trypsin inhibitors **(Losso, 2008)**. The unsaponifiable lipid fraction of lentil is a potential source of bioactive components such as phytosterols, squalenen and tocopherols **(Ryan *et al.*, 2007)**. A number of researchers have confirmed the high antioxidant potential arising from tannin constituents present in plant extracts **(Amarowicz, 2007)**.

CONCLUSION

Despite of extremely high soil contents of Cu, Co, Ni, Cr, Pb and Cd all determined values of heavy metal contents in the investigated lentil seeds are lower than hygienic limits. Based on our results we could suppose that lentil belongs to plants with a high resistance to risky metal contamination. Lentil is an excellent source of nutrients, trace elements and also bioactive compounds and it plays the important role in the human nutrition.

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