PROBLEM OF RISK ELEMENTS ACCUMULATION IN CEREAL RAW MATERIALS AND FOODSTUFFS

PROBLÉM AKUMULÁCIE RIZIKOVÝCH PRVKOV V CEREÁLNYCH SUROVINÁCH A POTRAVINÁCH

MIKUŠKA RASTISLAV, MUCHOVÁ ZDENKA, FIKSELOVÁ MARTINA

Department of Plant Storage and Processing, Faculty of Biotechnology and Food Sciences, Tr. A. Hlinku 2, Slovak University of Agriculture, 949 01 Nitra, Slovakia, Tel. +421376414379
Corresponding author: Martina.Fikselova@gmail.com

Manuscript received: June 30, 2008; Reviewed: September 30, 2008; Accepted for publication: November 5, 2008

ABSTRACT

Four kinds of cereals- wheat (Triticum aestivum L.), barley (Hordeum sativum L.), triticosecale (Triticosecale sativum L.) and oat (Avena sativa L) were taken from risk region of Slovakia in order to determine risk elements content in individual parts of grain. The results indicate significant differences in the content of the risk elements in four mill streams. Among observed cereals the highest content of risk metals decreased in order: oat>barley>triticosecale>spring wheat>winter wheat. Significant high contents of Pb and Cd were confirmed especially in some mill streams (MF III and MF IV) during all period of research. Results of baking trial confirmed there excess content of the same risk elements which were detected in mill products used for baking.

Key words: cereal crops, mill streams, content of risk elements

ABSTRAKT

Vzorky pšenice, jačmeňa, tritikale a ovsa boli odoberané zo zaťaženého regiónu Slovenska s cieľom stanoviť obsah rizikových prvkov (Fe, Mn, Zn, Cu, Co, Ni, Cr, Pb and Cd) v jednotlivých častiach zrna. Výsledky indikujú preukazne rozdiely v obsahu rizikových prvkov v jednotlivých mlynských frakciách. Zo sledovaných cerálií najvyšší obsah rizikových prvkov akumulovali: ovos>jačmeň>tritikale>jarná pšenica>ozimná pšenica. Preukazne vysoké obsahy olova a kadmia sa potvrdili špeciálne v mlynských frakciách MF III a MF IV počas celej doby výskumu. Pekársky pokus potvrdil vysoký obsah tých istých rizikových prvkov vo výrobkoch, ktoré boli stanovené v múkach použitých na pečenie.

Kľúčové slová: cereálie, mlynské frakcie, obsah rizikových prvkov

DETAILED ABSTRACT

Príspevok sa zaoberá kumuláciou vybraných rizikových prvkov (Fe, Mn, Zn, Cu, Co, Ni, Cr, Pb a Cd), vo vzorkách pšenice (Triticum aestivum L.), jačmeňa (Hordeum sativum L.), tritikale (Triticosecale sativum L.) a ovsa (Avena sativa L). Zrno jednotlivých druhov cereálií bolo odobraté z rizikových regiónov Slovenska (Spiš). Počas prvého roku sledovania (2001) sa vzorky odoberali z poľnohospodárskych družstiev -Gemerská Poloma, Kluknava a Spišská Nová Ves. V ďalších rokoch (2002, 2003) výskum pokračoval v najkontaminovanejšej oblasti – Kluknava. Analýza obsahu rizikových prvkov sa uskutočňovala v mlynských frakciách, charakterizujúcich anatomické časti zrna- endosperm (vonkajší a vnútorný), otruby a klíčky. Výsledky indikujú preukazne rozdiely v obsahu rizikových prvkov v mlynských frakciách, obsah narastal od vnútra endospermu k obalom (MF I< MF II <MF III< MF IV). Preukazne vysoký obsah Pb a Cd sa potvrdil najmä vo frakciách MF III a MF IV, charakterizujúcich vonkajší endosperm a obalové vrstvy (tab.2-7) počas celej doby výskumu. Výsledky pekárskej skúšky potvrdili vysoký obsah tých istých rizikových prvkov, ktoré boli detekované v mlynských frakciách použitých na pečenie aj vo výrobkoch (striedka chleba).

INTRODUCTION

The existence of heavy metals in soil, air, water is serious global problem. Their negative influence on environment is very high because heavy metals are non-biodegradable. Slovak Republic belongs to countries whose environment is under environmental stress in some regions. Extensive industrial and agricultural production caused a lot of damages on environment, especially during past years [4, 5, 19]. Many regions of Slovakia (9 risk regions) are characterized by geo-chemical anomalies and consequently by polluted environment. These regions are characterized by anthropogenic activities into the environment, especially mining [2]. The distribution of metals is very different in plants [17]. High content of risk elements in polluted areas can be reflected in whole-grain products, that is serious problem. This information has an important significance for the choice of appropriate milling technnology. Use and application of suitable plant technologies [12] and mill technologies [10, 13-16] can be a reason for the decline of excess contents of risk elements in final cereal products.

In this article obtained results of some risk elements presence are shown in individual parts of grain of four sorts of cereals from high contaminated region of Slovakia- Stredný Spiš (3 regions). We used obtained flours from observed cereals (MF I and MF II) for baking and the same risk elements were determined in final products (crumb of loaf) as well.

MATERIAL AND METHODS

Grains of Triticum aestivum, L. (winter and spring), barley Hordeum sativum, L.(winter and spring), triticosecale Triticosecale sativum, L. (crossbread of rey and wheat), oat (Avena sativa L)., were used. Cereals were cultivated in contaminated soil regions: Gemerska Poloma, Spišska Nova Ves and Kluknava. Samples of soil were taken within each region from 4 different places. Observed soils of these regions were rich sources of P-phosphorus, satisfy in K and Mg, medially with Fe, Mn and B contents. High content of Hg, As, Zn, Cu, Cr, Pb and Cd was found especially in region Kluknava (Tab. 1). Analyses of soils were performed by Soil Science and Conservation Research Institute in Slovakia, monitoring of Ni and Co contents was not performed.

Grain was milled by a laboratory mill (Brabender Quadrumat Senior) and four mill streams were gained: two flours (MF I and MF II), shorts (MF III) and bran (MF IV).

Methods

The analysis of Cd, Pb, Cr, Ni, Co, Cu, Zn, Mn, Fe presence was preformed by the flame atomic absorption spectrophometry (AAS PYE UNICAM SP-3) after mineralization of burned samples by diluted HNO_3 . Ash content was determined by ISO 2171 [8] after combustion of samples (temperature 900+/- 25°C). All important characteristics of flours were determined needed for experimental baking: protein content - % N by Kjeldahl method (KJELTEC AUTO 1030 Analyzer fy Tecator) the protein content was calculated with coefficients for wheat and triticale 5.7 and for barley 6.25. The determination of gluten content and its properties, Zeleny – index by ISO 5529 [9], Falling number by ICC- standard 107 [6], water-binding capacity of flour with use of farinograf by ICC standard 115/1 [7] were another parameters determined.

Trial baking was performed: from mixture 300 g of wheat and triticale flour (MF I + MF II), 4 % yeast 1.8 % NaCl, 1 % sugar was added, fermentation 45 min (temperature 26°C), baking 45 min (at starting temperature 230° C in casts 127 x 127 mm at automatic regulated stove with rise room TP 270). In crumb of loaf content of all 9 risk elements was determined by the same methods as in raw material.

Statistical processing

Statistical processing was performed with use of non-parametric methods (scatterplot) for testing of hypothesis and summary of distribution (Kendall´s and

Spearman´s correlation analysis, measures of central tendency and analysis of variance) and cluster analysis of multidimensional datas (hierarchical aglomerative methods, dendograms). Datas were computed in R language with use of R software environment for statistical computing and graphics.

RESULTS

The different contamination of soil by risk elements in observed regions is significantly demonstrated by contamination or intake of these substances into different parts of grain. (Tab.2). During the first year of our study (2001), excess limit contents of Cd (more than 0.2 mg.kg^{-1}) were found at oat in periphery parts of grain - MF III and MF IV (Tab. 2-4). The highest amount of Cd was accumulated by oat, less barley and wheat cultivated in Kluknava > Spišska Nová Ves > Gemerska Poloma. At Pb (max. 0.2 mg.kg^{-1}) limits were overstepped also in central part of grain (endosperm – MF I, MF II). Pb was the most accumulated by oat > barley > wheat in soils of Kluknava and Spišská Nová Ves > Gemerská Poloma. Cu levels (5 mg. kg^{-1}) were not overstepped only in endosperm of wheat (MF I and MF II). In other fractions of wheat and all fractions of barley and oat showed higher Cu content. This element was the most accumulated at barley > oat > wheat, in regions Spišská Nová Ves > Kluknava > Gemerská Poloma.

Content of Cr (3 mg.kg^{-1}) was not exceeded in all researched plant species and regions. At wheat higher accumulation of Cr in bran parts of grain was confirmed.

Ni limit (3 mg.kg^{-1}) for cereal products was overstepped only at oat (bran parts MF III and MF IV) and in regions Spišská Nová Ves and Kluknava. Food codex of Slovakia [3] does not determine maximal acceptable level for Zn, Mn, Co and Fe. Our results are supposed to be high, especially at bran. This claim results from the comparison of our datas with datas of Food Research Institute in Bratislava [20], that monitores results of grain analysis, mill products and different baking products. We can conclude that the contents of Zn 50 mg.kg^{-1}, Mn 49 mg.kg^{-1}, Fe more than 25 mg.kg^{-1} and Co more than 0.09 mg.kg^{-1} are considered to be very high.

Next years our research continued about accumulation of risk elements in capital parts of grain of cereals, cultivated in the highest contaminated area Kluknava. In contribution we present the results from the years 2002 (Tab. 5) and 2003 (Tab.7).Tendency of high excess accumulation of Cd and Cu in all bran parts of grain and in all cereals was confirmed during the year 2002. At some cultivating areas higher accumulation of Cd was found in endosperm of wheat (MF I, MF II) and barley (MF II) as well. Pb was accumulated more at MF II – MF IV, in these parts were found Pb excess limit values (more than 0.2 mg.kg^{-1}) at all researched sorts of cereals. Obtained results are statistically significant. Because of wide variation of samples file we present statistical results in the Figure 1.

Higher accumulation of Cr and Zn content was confirmed in bran (MF III and MF IV) than in endosperm (MF I, MF II). Higher values of Fe, Mn, Zn, Co were evident in bran parts (MF III and MF IV), especially in wheat and triticale.

Tab. 1 Mean content of risk elements in soils of individual places of observed regions

Regions	Places	Hg	As	Zn	Cu	Cr	Pb	Cd
		(mg.kg^{-1})						
Gemerska Poloma	1	0.4	16.3	77.5	30.4	42.7	57.2	1.22
	2	0.18	29.9	4.74	5.29	2.15	16.3	0.21
	3	0.42	17	8.25	7.85	3.95	22.47	0.25
	4	1.64	22.1	6.15	10.52	3.41	21.03	0.24
Spišská Nová Ves	1	0.4	12	10.25	9.3	2.3	34.7	0.19
	2	18.41	26.4	14	81.5	2.3	23.15	0.26
	3	1.5	12	17	19.3	3.4	24.55	0.38
	4	1.2	21	11.51	11.51	2.5	16.25	0.25
Kluknava	1	4.9	85.8	181.8	63.89	67.7	71.3	2.03
	2	2.9	31.5	164.6	12.42	129.9	74.4	1.12
	3	1.8	56.5	292.5	18.6	452.8	84.2	1.88
	4	1.8	56.5	292.5	23.95	454.3	86.2	1.32
Norm[1]	**limit**	**0.5**	**25**	**150**	**60**	**70**	**70**	**0.7**

Norm[1] - legislation n. 220/2004

Tab 2. Content of risk elements (mg.kg^{-1}) in mill fractions in region Gemerska Poloma (mean values)

	mg.kg^{-1}								
Samples	**Cd**	**Pb**	**Cu**	**Cr**	**Zn**	**Mn**	**Fe**	**Ni**	**Co**
wheat									
MF I.	0.02	0.56	4.15	0.22	7.15	6.08	20.76	0.07	0.09
MF II.	0.02	0.48	4.44	0.24	14.09	14.39	12.67	0.09	0.22
MF III.	0.07	0.64	10.23	0.42	59.90	72.61	62.43	0.24	0.20
MF IV.	0.10	0.66	11.26	0.68	56.91	69.71	88.22	0.50	0.28
barley									
MF I.	0.04	1.30	7.49	0.40	17.98	18.91	51.83	0.37	0.33
MF II.	0.04	0.99	8.58	0.42	26.96	24.53	42.88	0.33	0.15
MF III.	0.04	0.86	13.91	0.39	33.28	20.90	48.01	0.38	0.15
MF IV.	0.04	0.69	7.59	0.42	32.25	18.54	62.56	0.24	0.18
oat									
MF I.	0.04	1.17	5.02	0.35	18.80	40.59	124.80	0.77	0.22
MF II.	0.06	0.95	6.92	0.71	35.26	69.04	63.64	1.55	0.09
MF III.	0.07	1.05	11.36	0.39	53.35	93.10	72.38	1.76	0.14
MF IV.	0.06	0.86	5.85	0.55	36.79	73.35	60.32	1.66	0.18

Tab. 3 Contents of risk elements (mg.kg^{-1}) in mill streams in region Kluknava (mean values)

	mg.kg^{-1}								
Samples	**Cd**	**Pb**	**Cu**	**Cr**	**Zn**	**Mn**	**Fe**	**Ni**	**Co**
wheat									
MF I.	0.05	0.33	2.02	0.48	10.83	9.92	21.25	0.33	0.09
MF II.	0.07	0.56	3.27	0.51	22.32	25.63	20.04	1.18	0.09
MF III.	0.19	0.91	18.33	0.84	85.25	99.23	76.07	2.00	0.40
MF IV.	0.17	1.54	10.44	0.55	65.50	67.91	68.47	1.57	0.40
barley									
MF I.	0.06	1.40	8.16	0.63	31.57	32.38	68.21	1.51	0.13
MF II.	0.08	1.44	7.59	0.55	48.36	34.03	49.31	1.44	0.36
MF III.	0.17	1.40	9.20	0.74	61.35	30.11	49.75	1.13	0.33
MF IV.	0.63	1.18	21.78	0.81	60.72	14.06	50.31	0.52	0.25
oat									
MF I.	0.13	1.05	8.09	0.39	30.98	35.47	75.47	2.29	0.35
MF II.	0.13	2.46	10.15	0.92	73.20	97.08	82.05	2.58	0.42
MF III.	0.22	2.19	15.50	0.92	82.60	93.11	133.20	3.69	0.35
MF IV.	0.13	1.24	6.38	0.52	32.63	56.99	52.38	3.76	0.14

Trial baking was made with use of experimental grinded wheat and triticale flours. Results of crumb analysis confirmed high relationship of all selected risk element contents with their contents in used flours (Tab.6). Excess limit values of Cd were determined only at crumb from wheat number 4 (spring form), but at Pb and Zn values were high at all products.

Contents of risk elements intake in the year 2003 (Tab. 7) were different compared to 2002 (Tab.5). Changes were caused by rotation of crops. Contents of risk elements in cereals related to the content of these metals in cultivated regions and their bioavailability during researched period (different influence of weather). Contamination gradually increased from low-milled products (MF I, MF II) to high milled products (MF III, MF IV). Among mill streams was found statistically significant difference. Maximal

Tab 4 Content of risk elements (mg.kg^{-1}) in mill streams in region Spišská Nová Ves (mean values)

	mg.kg^{-1}								
Samples	**Cd**	**Pb**	**Cu**	**Cr**	**Zn**	**Mn**	**Fe**	**Ni**	**Co**
wheat									
MF I.	0.05	0.37	2.51	0.48	9.56	13.40	26.32	0.14	0.19
MF II.	0.06	0.47	3.78	0.55	26.27	45.09	33.52	0.44	0.36
MF III.	0.18	1.93	19.00	0.84	86.82	145.27	98.88	1.39	0.44
MF IV.	0.14	1.65	8.80	0.77	58.64	94.42	82.21	0.99	0.52
barley									
MF I.	0.06	1.62	14.74	0.52	37.52	23.37	58.84	0.66	0.19
MF II.	0.06	1.77	12.16	0.85	44.14	23.39	40.62	0.48	0.22
MF III.	0.10	1.95	18.21	0.66	48.90	24.69	59.56	0.66	0.44
MF IV.	0.09	1.25	5.17	0.52	47.03	22.63	51.13	0.55	0.22
oat									
MF I.	0.13	1.19	7.36	0.33	29.67	34.74	86.62	2.40	0.24
MF II.	0.15	2.37	8.32	0.40	49.35	100.92	64.33	2.94	0.29
MF III.	0.19	2.16	17.04	1.14	74.58	102.13	89.32	4.15	0.46
MF IV.	0.22	1.05	5.55	0.77	57.46	43.10	72.32	4.25	0.45

limits were overstepped mostly at bran parts (MF III, MF IV), but in case of Pb were overstepped limits for spring wheat and triticale in flour (MF II), in consequence high content was observed at results of experimental baking during this year 2003 (Tab. 8). Content of observed risk elements was increasing in order: Gemerská Poloma (Gemer) < Spišská Nová Ves< (Spiš) <Kluknava (Spiš). Among cereals, content of risk metals decreased: oat> barley>triticosecale>spring wheat>winter wheat; that is shown in the Table 5.

DISCUSSION

Limits (maximal acceptable contents) of risk elements are present by Food Codex SR either for grain (Cd, Pb) or for flours (Cu) and nondefined cereal products (Cu, Ni). Limits for Cr, Cd, Cu, Ni and Pb are defined for others (not specified) foods. Similarly it is solved within foreign countries. Our standards are conformable with the standards of EU countries. Geo-chemical anomalies especially in surrounding of Rudňany, Zavadka and Markušovce significantly contaminate the soil of Spiš region. Soils of Stredný Spiš are typical for bigger contents of Fe and Mn, these contents relate to Mn electrolysis plant [18].

Lots of researched works confirm, that in moister environment, by increased microbiological activity, higher decomposition of organic matter and acid soil reaction get increased e.g. levels of mobile and lightly accessible forms of Cd in soil [1, 11], therefore is Cd better acceptable for plants. Obtained results from three years (2001, 2002, 2003) in one area (Kluknava) confirm this information. Acid soil reaction is typical for Kluknava area. Cd is low bounded in this soil and is more acceptable for plants. Differences found in places of this region regarding to accumulation of Cd in grain of cereals were statistically significant compared to year 2002 (P-value is less than 0.01 there is a statistically significant difference among years at the 99.0 % confidence level), higher levels were found than in 2001 and 2003. The similar tendencies are found at Cu and Cr, Ni and Pb with some exceptions.

CONCLUSION

Content of observed risk metals in selected cereals and areas increased in order: Gemerská Poloma (Gemer) < Spišská Nová Ves< (Spiš) <Kluknava (Spiš). Among cereals, content of risk metals decreased: oat>barley>triticosecale>spring wheat>winter wheat; and within the grain risk metals increased from the middle of endosperm to bran (MF I< MF II <MF III< MF IV). These results are high statistically significant. Results of baking trial (crumb of loaf) confirmed excess content of the same risk elements detected at mill products (MF I and MF II) used for baking.

It is generally declared that plant production obtained from risk regions shall not be used for food production, but it is not real to think that these regions are covered by individual methods (bioremidation, phytoremidation).

Tab. 5 Content of risk elements in individual mill streams in region Kluknava (2002)

Samples	Fractions	Cd	Pb	Cu	Cr	Zn	Mn	Fe	Ni	Co
						(mg.kg^{-1})				
winter	I.	0.13	0.1	1.2	0.13	4.9	2.4	6.7	0.1	0.1
wheat	II.	0.19	0.33	1.5	0.1	7.3	3.7	3.3	0.13	0.06
1	III.	0.33	0.8	10.2	0.23	76.3	44.7	115.2	0.7	0.27
	IV.	0.33	0.9	10.8	0.33	90.4	65.4	64.7	0.83	0.3
winter	I.	0.12	0.1	1.4	0.17	4.5	1.4	10.4	0.17	0.05
wheat	II.	0.17	0.5	1.4	0.1	4.9	2.5	6.3	0.1	0.07
2	III.	0.24	0.6	5.9	0.2	42.2	28.7	34.3	0.43	0.07
	IV.	0.41	1.03	8.3	0.37	82.8	58.2	63	0.73	0.3
winter	I.	0.23	0.3	1.8	0.03	8	2.7	13.7	0.27	0.07
wheat	II.	0.29	0.3	2	0.03	9.9	3.7	8.2	0.23	0.07
3	III.	0.51	0.9	9.8	0.07	108.6	38.7	41.3	0.9	0.33
	IV.	0.73	1.2	13.2	0.37	172.1	69.2	85.5	1.77	0.33
spring	I.	0.32	0.3	1.7	0.13	7.2	1.6	8.4	0.03	0.07
wheat	II.	0.34	0.43	1.8	0.13	7.3	2.2	7.4	0.07	0.17
4	III.	0.54	0.6	7.4	0.27	82.8	24	42	0.4	0.17
	IV.	0.8	1	10.4	0.33	164.3	51.4	64.4	0.77	0.4
Triticale	I.	0.1	0.13	1.6	0.03	5.8	2.5	9.5	0.17	0.03
5	II.	0.08	0.37	2	0.13	9.3	4	9.4	0.17	0.1
	III.	0.32	1.33	9.7	0.2	119.1	39.9	51.3	0.83	0.3
	IV.	0.2	1.03	11.2	0.4	137.8	60.8	67.2	1.23	0.4
spring	I.	0.16	0.13	2.8	0.13	9.7	5.5	48.7	0.1	0.03
barley	II.	0.2	0.4	3.7	0.2	23.2	9.1	26.2	0.1	0.2
6	III.	0.29	1	8.4	0.33	56.7	21.8	44.7	0.33	0.33
	IV.	0.29	0.73	6.2	0.4	43.5	15.2	46.9	0.27	0.23
spring	I.	0.21	0.37	3.4	0.27	11.9	5.8	52.7	0.3	0.2
barley	II.	0.26	0.47	4.4	0.27	20.6	7.8	28.4	0.13	0.13
7	III.	0.3	0.73	6.9	0.27	31	10.4	35.3	0.27	0.2
	IV.	0.42	1.03	5.9	0.37	38.9	12.9	44.1	0.43	0.2
winter	I.	0.15	0.3	3.4	0.2	13.3	5.1	43.6	0.2	0.13
barley	II.	0.34	0.85	4.8	0.3	19.9	7.4	29.9	0.1	0.17
8	III.	0.49	0.9	9.9	0.37	31.3	9.3	45.8	0.33	0.2
	IV.	0.33	1.03	5.6	0.3	33.7	9.2	47.6	0.33	0.27

Tab. 6 Baking trial - contents of risk elements in crumb of loaf (2002)

Samples	Cd	Pb	Cu	Cr	Zn	Mn	Fe	Ni	Co
w.wheat 1	0.11	0.28	1.40	0.12	6.05	2.85	5.80	0.10	0.08
w.wheat 2	0.11	0.30	1.35	0.16	4.60	2.00	8.45	0.13	0.06
w.wheat 3	0.20	0.30	1.90	0.03	8.80	3.25	10.15	0.25	0.07
s.wheat 4	0.30	0.38	1.75	0.12	7.25	2.00	7.85	0.06	0.13
Triticale 5	0.10	0.25	1.90	0.09	7.50	3.15	9.35	0.15	0.06

Tab. 7 Contents of risk elements in individual mill streams from region Kluknava (2003)

	Fractions	Cd	Pb	Cu	Cr	Zn	Mn	Fe	Ni	Co
Samples						(mg.kg^{-1})				
winter	**MF I.**	0.05	0.10	1.40	0.10	6.30	3.70	20.40	0.15	0.05
wheat	**MF II.**	0.18	0.20	1.70	0.10	7.10	5.20	15.40	0.10	0.10
1	**MF III.**	0.24	1.80	11.00	0.15	66.80	67.90	96.00	0.80	0.35
	MF IV.	0.27	1.80	10.20	0.20	63.60	67.10	108.90	1.10	0.35
spring	**MF I.**	0.07	0.20	1.70	0.00	7.00	3.80	17.00	0.05	0.10
wheat	**MF II.**	0.10	0.35	2.00	0.05	7.90	4.70	13.30	0.10	0.10
2	**MF III.**	0.23	1.45	10.40	0.15	65.50	47.60	70.50	0.85	0.15
	MF IV.	0.32	1.70	10.20	0.20	102.40	89.30	113.80	1.65	0.25
Triticale	**MF I.**	0.05	0.10	1.60	0.05	4.50	2.10	14.90	0.07	0.15
3	**MF II.**	0.06	0.30	2.20	0.10	8.00	3.70	9.20	0.10	0.10
	MF III.	0.18	1.45	14.90	0.20	77.10	37.70	63.10	0.60	0.35
	MF IV.	0.17	1.70	12.70	0.20	92.20	47.80	89.30	0.75	0.35
spring	**MF I.**	0.06	0.65	4.60	0.10	17.20	8.10	93.40	0.25	0.15
barley	**MF II.**	0.08	0.90	7.20	0.15	31.60	14.90	119.80	0.25	0.40
4	**MF III.**	0.08	0.85	9.30	0.25	40.30	14.60	48.90	0.25	0.10
	MF IV.	0.08	0.95	6.40	0.35	46.30	13.80	61.30	0.35	0.20
spring	**MF I.**	0.05	0.51	3.50	0.14	15.00	7.50	76.30	0.20	0.15
barley	**MF II.**	0.06	0.51	5.20	0.16	26.90	12.90	29.70	0.20	0.15
5	**MF III.**	0.09	0.90	9.20	0.30	41.70	15.70	51.70	0.35	0.15
	MF IV.	0.10	1.00	6.50	0.30	48.00	14.60	68.60	0.45	0.15

Tab. 8 Baking trial - risk elements in the crumb of loaf (2003)

Samples	Cd	Pb	Cu	Cr	Zn	Mn	Fe	Ni	Co
w.wheat 1	0.07	0.17	1.45	0.10	6.20	3.73	12.50	0.12	0.07
s.wheat 2	0.09	0.27	1.70	0.05	7.63	2.87	10.87	0.07	0.08
triticale 3	0.10	0.20	1.80	0.07	5.80	2.43	12.07	0.08	0.11

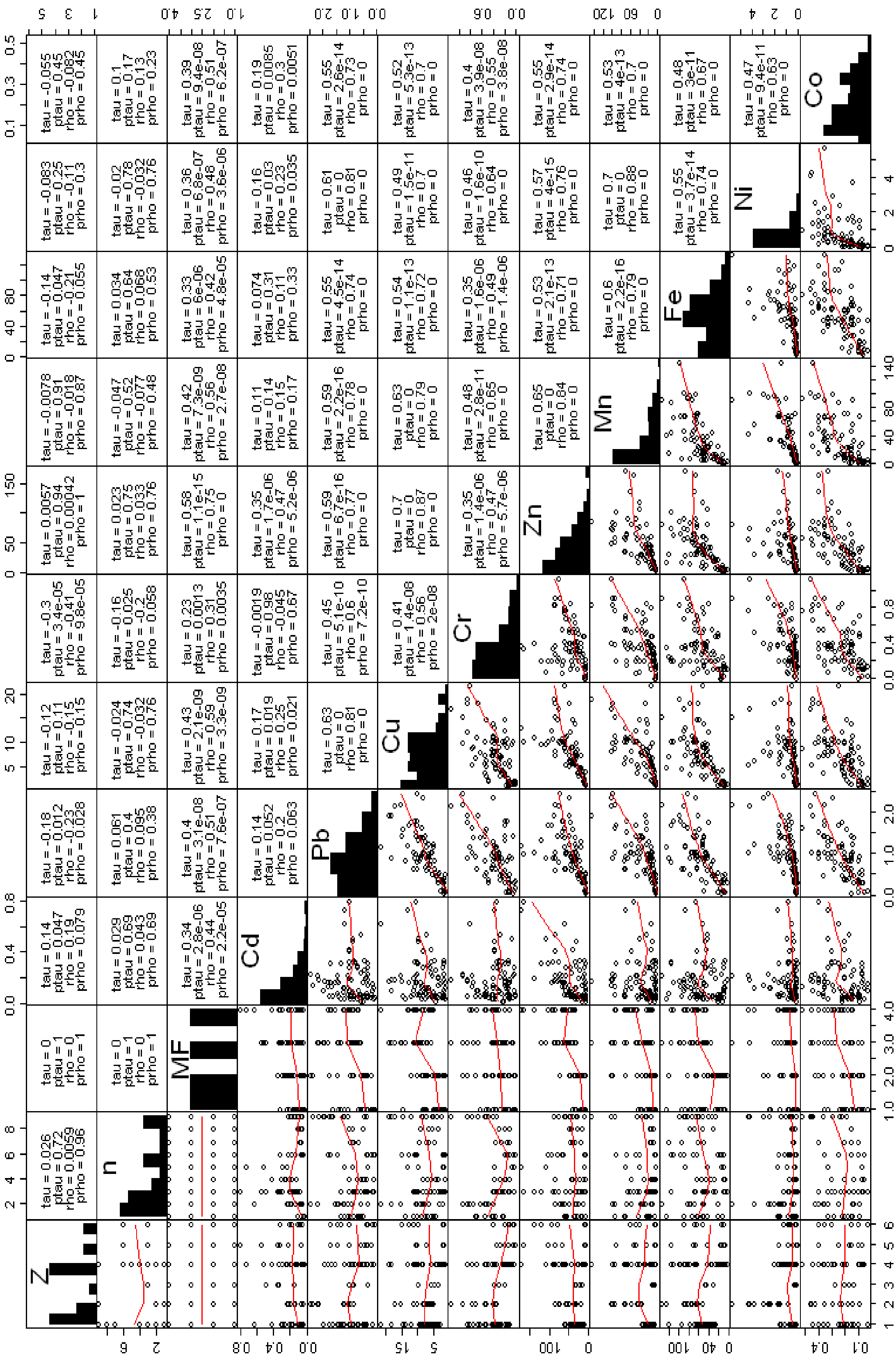

Fig.1 Scatterplot of individual elements

This production is for technical purpose, for feeding of animals and one part is for mill processing. Our results showed some possibilities to use obtained production as a small part in mixtures preparation, but mixture must have higher contents of non-contaminated grain (confirmed by analysis).

REFERENCES

[1] Barančíková G., Makovníková J., The influence of humic acid quality on the sorption and mobility of heavy metals. Plant Soil Environ (2003) 49: 565-571.

[2] Brechtl et al., Životné prostredie Slovenskej republiky, Ministerstvo životného prostredia SR, Bratislava, 1998.

[3] Food Codex SR. (2003). Available on internet: http://www.svssr.sk/sk/legislativa/kodex/kodex.asp

[4] Halásová M., Vollmanová A., Decrease of contamination of cereals in surroudings of OFZ Istebné after implementing corrective measures, Pestovanie a využitie obilnín na prelome milénia, Zborník z vedeckej konferencie s medzinárodnou účasťou, SPU, Nitra, 2000, pp. 205.

[5] Hecl J., Transfer of zinc in Soil-Plant system, Foreign substances in the environment, SPU, Nitra , 2003, pp. 372-374.

[6] ICC Standard 107/1, Determination of the Falling Number according to Hagberg-Perten as a measure of the degree of alpha-amylase activity in grain and flour, ICC, 1995.

[7] ICC Standard 115/1, Method for using the Brabender Farinograph, ICC, 1992.

[8] ISO 2171, Cereals and milled cereal products . Determination of total ash, 1993.

[9] ISO 5529, Wheat .Determination of sedimentation index - Zeleny test, 2007.

[10] Kučerová J., Holánková M., Kadmium v zrne pšenice a mlynských výrobkoch, Výživa a potraviny pre tretie tisícročie, Nitra , 2001, pp. 233-235.

[11] Miklovič, D., Cd, Zn and Pb in soil and plants oats, rye and silage maize, Agrochime (2001) 41 :4-7.

[12] Muchová Z., Jaška P., Vplyv podmienok pestovania na akumuláciu kadmia a olova v potravinárskej pšenici, Rostlinná výroba (1996) 42: 59- 63.

[13] Muchová Z., Slamka P., Gorny M., Kumulácia ťažkých kovov v hlavných mlynských frakciách potravinárskych obilnín, Cudzorodé látky v životnom prostredí, III medzinárodná konferencia , SPU, Nitra, 2000, pp.168- 172.

[14] Muchová Z., Prienik rizikových kovov do pekárskych surovín a potravín, Rizikové faktory potravového reťazca III, SPU, 2003, pp. 105-106.

[15] Muchová Z., Mikuška R., Kvalita mlynských produktov z pohľadu kontaminácie ťažkými kovmi, Rizikové faktory potravového reťazca, Nitra, SPU, 2004, pp. 173-175.

[16] Oberlander H. E., Roth K., Uptake and distribution of lapelled soil applied heavy metals in cereal plants and their milling products, Bodenkultur (1987) 78: 287-298.

[17] Prugar J., Jakost cereálií z ekologického zemědelství, Výživa, (1994) 49: 107-108.

[18] Tomáš J., Ťažké kovy v pôdach a rastlinných produktoch v podmienkach regionálneho a lokálneho znečistenia ovzdušia, Habilitačná práca, Nitra, SPU, 2003.

[19] Tóth J., The evolution of content of heavy metals in selected soil types and in cultivated plants in High Tatras region, Foreign substances in the environment, SPU, Nitra, 2002, pp. 210-214

[20] Vojtaššáková A., Kováčiková E., Simonová E., Holčíková, K., Obilniny a strukoviny – Potravinové tabuľky, ÚVTIP, Bratislava, 1999.