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DETERMINATION OF HEAVY METALS IN VISCERA AND MUSCLES OF CATTLE

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Summary

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The objective of the present study was to determine the concentration of heavy metals – chromium, cadmium, lead, nickel, copper, zinc, manganese in internal organs and various muscles of Lithuanian Black and White cows and steers of the same breed. Concentration of heavy metals was different in lungs, liver and kidneys. The highest concentrations of chromium and copper were those in lungs, of cadmium – in kidneys and those of zinc and manganese – in liver. The concentrationa of lead were similar in lungs, liver and kidneys.

The concentrations of studied metals in the organs and muscles of cows and those of steers was different. In cows, statistically significant higher concentrations of cadmium than those in steers were determined in kidneys. The tendency of increased concentrations of nickel and chromium were detected in lungs and liver, respectively. Compared to cows, steers had higher concentration of copper in lungs and liver, of manganese – in liver and muscle, and of zinc – in muscle. The concentrations of heavy metals in the various muscles of cattle were different. The lowest concentrations were found in longissimus lumborum et thoracis muscle, higher – in diaphragm and the highest – in the intercostal muscles. Seeking not to decrease the value of the carcass and the longissimus lumborum et thoracis muscle with regard to heavy metals determination, it is advisable to collect samples from the diaphragm or the longissimus lumborum et thoracis muscle at the most distant rib.

Key words: cattle, heavy metals, muscle, viscera

INTRODUCTION

In order to improve public health in most countries of the world, as well as in the countries of the European Union, great attention is paid to the production of ecologically pure and safe meat for human consumption. Effort have been made to control all stages of meat production starting with the forage and going to the final product. It is considered that such control helps to avoid or reasonably decrease meat contamination with various pollutants (Sabir *et al*., 2003; Staniskiene & Garaleviciene, 2004). In case of highly developed transport, industry, energetics and other branches of economy, insufficiently developed technologies cause environmental pollution with various pollutants: radio nuclides, heavy metals, various sulphur and nitrogen compounds, and others (Mazvila *et al*., 2001).

The heavy metals such as mercury, cadmium, lead are rather toxic for both human beings and animals. Feeding animals with forage produced in contaminated areas, results in increased concentration of heavy metals in the organism. Consequently, milk and meat production is reduced and the contamination of the production is higher (Maracek *et al*., 1998; Massanyi *et al*., 2001; Tairova, 2001; Jarup, 2003).

In order to produce products ecologically pure and safe for public health, the improvement of the methods for the control of contamination becomes primarily important (Vaizenen & Vaizenen, 2002). The results of experiments have demonstrated that the ration containing flour from the stems of cucumbers helps to decrease the concentration of cadmium, titanium and aluminum in the organism; the flour from the stems of sunflowers facilitates the decrease of the lead concentration (Vaizenen *et al*., 1998).

In this study, we examined the characteristic features of heavy metals distribution in viscera and separate muscles of adult animals and offspring.

MATERIALS AND METHODS

Three series of trials have been performed:

I. A field trail was conducted to estimate the concentrations of heavy metals – chromium, cadmium, lead, nickel, copper, zinc, manganese in internal organs and muscles of Lithuanian Black and White cows and Lithuanian Black and White steers. To estimate concentration of heavy metals in internal organs, 25 cows 4- to 6-years old and 20 steers were used. Cows grazed on pastures and were fed concentrate supplements composed of ground grain reared in the farm – 50 %, barley – 40 % and forage peas 10 %. They had no access to other mineral supplements, and veterinary medicinal products. Milk yield ranged between 3800 and 5000 kg milk per lactation. Cows were slaughtered at the age of 5 to 7 years, weighing 575 kg on the average. Steers for the trial were from the same farm and fed the same feed as the cows. They were slaughtered at the age of 15 to 18 months weighing between 430 to 475 kg. Samples of lungs, liver, kidneys (50 g) for heavy metals determinations in cows and steers were collected at slaughterhouse from lung apex, the middle of the left lateral lobule of the liver, and as an average organ sample of kidneys.

II. Trials to determine distribution of heavy metals in different muscles were conducted with 15 Lithuanian Black and White cows and 15 Lithuanian Black and White steers reared at the farm in the seaside area, at a good distance from an industrial center. Cows used in the trial were from 510–583 kg. Milk yield was between 4300 and 6000 kg. The kind of sampled muscles is shown in Table 2. The samples were collected from the middle of the muscle (with respect to its length).

III. Trials to compare the concentration of heavy metals in the longissimus lumborum et thoracis muscle, intercostal and diaphragm muscles were conducted with carcasses in 10 Lithuanian Black and White cows and 10 Black and White steers. Cows used in the trial were from 4 to 6 year of age, weighing between 510 and 570 kg. Their milk yield ranged from 4000 to 5450 kg per lactation. In summer, cows were grazing and were provided with salt lick and concentrate supplement. Steers included in the trial were between 18 and 20 month of age, with weight ranging from 410 to 450 kg. Both cows and steers were reared at the same farm in the middle of Lithuania. Trial samples were collected from the longissimus lumborum et thoracis muscle at the last rib site, from intercostal muscles at the site of the last rib, at the distance of 15 cm from thoracic spinous processes and diaphragm.

The amount of heavy metals was measured by of atomic absorption spectrophotometry - AAS (Monisov, 1992).

Statistical analyses were performed by the Student method using Microsoft Excel software. Significance was set at P< 0.01.

RESULTS AND DISCUSSION

The results of heavy metals determinations in viscera organs are shown in Table 1. The concentration of chromium in lungs and liver of cows was the same. In kidneys, it was 2.2 times lower than that in liver and lungs. The differences in concentrations were not statistically significant. The concentration of cadmium in kidneys was 5.7 times higher than that in lungs and 3.4 times higher than that in liver (P<0.001). The concentration of lead was similar in all the investigated organs. The lowest concentration of lead was found in lungs, the highest – in kidneys. The highest concentration of nickel was found in lungs. It was 2 times and 2.7 times higher than those in liver and kidneys, respectively. A rather high copper concentration was observed in liver: 14.2 times higher than that in lungs and 1.8 times – higher than in kidneys (P<0.001 and P<0.05, respectively). The highest concentration of zinc was determined in liver. It was 1.8 times higher than in lungs, and 1.7 times – higher than in kidneys (P<0.05 and P>0.05, respectively). The liver content of manganese was 170 times higher than that in lungs and 81 times – than in kidneys (P<0.001).

The investigations of steers' viscera demonstrated different peculiarities of the of heavy metals distribution in viscera compared to that of the cows (Table 1). The content of chromium in lungs ex-

Table 1. Concentration of heavy metals in cows and steers' viscera, mg/kg

Heavy metals	Organs		
	Lungs	Liver	Kidneys
Cows (n=25)			
Chromium	0.11±0.03	0.11±0.01	0.05±0.01
Cadmium	0.03±0.01 [b]	0.05±0.01 [b]	0.17±0.01
Lead	0.23±0.04	0.25±0.05	0.26±0.02
Nickel	0.38±0.17	0.18±0.05	0.14±0.00
Copper	0.48±0.23 [c]	6.91±1.09	3.81±0.70 [a]
Zinc	15.76±2.14 [a]	29.05±4.41	16.82±2.69 [a]
Manganese	0.30±0.15 [c]	51.20±0.87	0.63±0.17 [c]
Steers (n=20)			
Chromium	0.14±0.05	0.06±0.04	0.07±0.00
Cadmium	0.04±0.00	0.07±0.01	0.09±0.01
Lead	0.25±0.02	0.30±0.02	0.22±0.02
Nickel	0.14±0.00	0.17±0.04	0.14±0.04
Copper	0.82±0.12	11.36±3.02	1.29±0.28
Zinc	16.30±2.02	22.86±2.97	10.18±4.22
Manganese	0.26±0.05	0.97±0.42	0.38±0.04

[a] P<0.05 vs liver; [b] P<0.01 vs kidneys; [c] P<0.001 vs liver.

Table 2. Concentration of heavy metals in different parts of cows and steers' musculature, mg/kg

Heavy metals	Muscles			
	Pars scapularis of deltoideus muscle	Longissimus lumborum et thoracis muscle	Psoas minor muscle	Vastus lateralis muscle
Cows (n=15)				
Chromium	0.08±0.05	0.08±0.00	0.07±0.00	0.10±0.03
Cadmium	0.02±0.01	0.02±0.00	0.05±0.01	0.02±0.01
Lead	0.14±0.06	0.14±0.07	0.22±0.02	0.21±0.01
Nickel	0.10±0.03	0.10±0.03	0.14±0.04	0.11±0.02
Copper	0.21±0.08	0.27±0.12	1.29±0.71	0.42±0.17
Zinc	15.27±4.22	13.49±6.50	10.18±1.22	19.97±6.59
Manganese	0.05±0.03	0.09±0.01	0.38±0.04 [d]	0.08±0.02
Steers (n=15)				
Chromium	0.08±0.01	0.09±0.00	0.08±0.00	0.08±0.00
Cadmium	0.02±0.00	0.03±0.00	0.03±0.01	0.03±0.00
Lead	0.14±0.01	0.21±0.01 [b]	0.19±0.04	0.21±0.01 [b]
Nickel	0.08±0.00 [c]	0.15±0.04	0.14±0.04	0.16±0.00
Copper	0.04±0.01 [a]	0.52±0.16	0.46±0.25	0.42±0.06
Zinc	27.12±11.26	29.55±5.14	18.89±6.26	29.81±1.59
Manganese	0.16±0.01	0.17±0.01	0.18±0.05	0.18±0.04

[a] P<0.01 vs longissimus lumborum et thoracis muscle; [b] P<0.001 vs pars scapularis of deltoideus muscle; [c] P<0.001 vs vastus lateralis muscle; [d] P<0.001 vs pars scapularis of deltoideus muscle.

ceeded that of kidneys about twice. The data were not statistically significant. The concentration of chromium in liver and kidneys was the same. As cows and steers were reared in the same area, the higher concentration of chromium in steers' lungs was evidently caused by the peculiarities of the growing organism.

The highest concentration of cadmium in steers' viscera, similarly to cows, was determined in kidneys. It was 2.2 times higher than that in lungs and 1.3 times – than in liver. The cadmium concentration in steers' liver was about 1.5 times higher than that in cows. The difference was not statistically significant. The concentrations of lead in all organs of steers were very similar and differed insignificantly from this parameter in the corresponding organs of cows.

The tendency of manganese accumulation in calves' viscera was similar to that in cows. The highest concentration was in liver, less – in kidneys, and the least – in lungs. The differences in the concentration of manganese accumulated in calves' viscera were less evident compared to that of cows and were statistically insignificant.

In our experiment, a tendency of higher distribution of copper and zinc in the liver of calves was also noticed.

The investigations of the muscles taken from different parts of the carcass of cows (Table 2) demonstrated that the concentrations of chromium in all the muscles were similar. The concentration of cadmium, with the exception of the psoas minor muscle, was similar in all studied muscles. The concentrations of lead in the pars scapularis of deltoideus muscle and longissimus lumborum et thoracis muscle were similar and lower by 36% and 34% respectively vs that in psoas minor muscle and the vastus lateralis muscle. The psoas minor muscle contained the highest concentration of nickel. The concentration of copper in the psoas minor muscle exceeded its concentration in the pars scapularis of deltoideus muscle by 6.1 times. The highest concentration of zinc was found in the vastus lateralis muscle and the lowest – in the psoas minor muscle. The highest concentration of manganese was typical for the psoas minor muscle, whereas it was the lowest in the pars scapularis of deltoideus muscle ($P<0.001$). The concentration of this element was almost the same in the longissimus lumborum et thoracis muscle and vastus lateralis muscle.

The content of chromium in the analogous muscles of steers was very similar to that in cows (Table 2). Cadmium concentration was nearly the same in the four studied muscles. The highest concentration of lead was discovered in the vastus lateralis and the longissimus lumborum et thoracis muscles, whereas the lowest was that in the pars scapularis of deltoideus muscle ($P<0.001$). The pars scapularis of deltoideus muscle contained the lowest concentration of nickel as well. The highest concentration of this element was defined in the vastus lateralis muscle ($P<0.001$). The highest copper level was determined in the longissimus lumborum et thoracis muscle and the lowest – in the pars scapularis of deltoideus muscle ($P<0.01$). A rather high zinc content was found in the vastus lateralis muscle, whereas the lowest amount of this component was in the psoas minor muscle. The accumulation of manganese in the various muscles showed small differences.

The comparative analysis of concentrations of heavy metals in the muscles of cows and steers demonstrated that the pattern of chromium, cadmium and lead accumulation in separate muscles tended to be quite similar. The concentrations of copper in the studied muscles of cows and steers, with the exception of the psoas minor muscle in cows and pars scapularis of deltoideus muscle in steers were also comparable. The copper content in the psoas minor muscle in cows exceeded considerably that in other muscles studied. A general tendency of lowest concentration of zinc in the psoas minor muscles in both cows and steers was observed. The concentration of manganese in cows' muscles, with the exception of that in psoas minor muscle, was lower than that in analogous muscles of steers. It seems necessary to emphasize that the tendency towards lower concentration of heavy metals in the pars scapularis of deltoideus muscle and higher concentration in the psoas minor muscle and vastus lateralis muscle for the majority of cases was common for both groups of animals studied.

The results of comparative evaluation of the accumulation of heavy metals in the area of thorax are presented in Table 3.

It can be concluded from the data obtained that higher chromium concentration was found in the muscles of diaphragm and the intercostal muscles ($P>0.05$). The amount of chromium in the longissimus lumborum et thoracis muscle was 3.7 times less than in the intercostal muscle, and it was almost the same in the intercostal and diaphragm muscles.

Table 3. Concentration of heavy metals in the muscles of the thorax, mg/kg (n=20)

Heavy metals	Muscles		
	Longissimus lumborum et thoracis muscle	Diaphragm	Intercostal muscles
Chromium	0.04±0.01	0.14±0.01[a]	0.15±0.05 [a]
Cadmium	0.01±0.00	0.01±0.00	0.02±0.00
Lead	0.06±0.01 [b]	0.06±0.01[b]	0.16±0.01
Nickel	0.02±0.00	0.03±0.00	0.10±0.02
Copper	0.22±0.01 [b]	0.23±0.15	0.54±0.05
Zinc	8.10±0.19 [b]	12.27±0.66[b]	36.70±2.45
Manganese	0.04±0.00	0.06±0.01	0.29±0.20

[a] $P<0.05$ vs longissimus lumborum et thoracis muscle; [b] $P<0.001$ vs intercostal muscles.

The concentration of cadmium in the longissimus lumborum et thoracis muscle and the diaphragm was the same, and inconsiderably higher in the intercostal muscles. The pattern of lead accumulation in the thoracic muscles was the same as that of cadmium. The same concentration of this element was found in the longissimus lumborum et thoracis muscle and the diaphragm muscles, whereas in the intercostal muscles it was 2.7 times higher ($P<0.001$).

The difference in the concentrations of nickel between longissimus lumborum et thoracis and muscles of diaphragm was inconsiderable whereas the amounts in intercostal muscles were higher. The longissimus thoracis et lumborum muscle and the muscle part of diaphragm contained nearly the same concentration of copper, whereas its content in the intercostal muscles was 2.3 times higher ($P<0.001$).

The highest concentration of zinc was determined in the intercostal muscles. It was 4.5 times higher than that in the longissimus lumborum et thoracis muscle ($P<0.001$), and 3 times higher than that in the muscle part of diaphragm ($P<0.001$).

The differences between manganese concentrations in the longissimus lumborum et thoracis muscle and the muscles of the diaphragm was less considerable compared to that vs intercostal muscles levels. The concentration of manganese in the intercostal muscles was 4.8 and 7.2 times higher than that in the diaphragm and the longissimus thoracis muscle, respectively, although because of the big variations in the concentration of manganese in the intercostal muscles, the differences were statistically not significant.

In conclusion, these studies have shown that concentrations of heavy metals chromium, cadmium, leads, nickel, copper, zinc, manganese – were different in viscera and muscles. The concentrations of some of them was different in viscera and muscles of cows vs those in steers.

With the exception of nickel, the highests concentration of all heavy metals studied were found in the intercostal muscles, lower – in the diaphragm, and the lowest - in the longissimus lumborum et thoracis muscle. Naturally, with the regard to the ecological value of the carcass (taking into account heavy metals), the best trade quality could be ensured collecting samples from the diaphragm and the intercostal muscles. Our data correlated with those in existing literature, that the concentrations of heavy metals were different in separate muscles of adult animals and their offspring (Massanyi *et al*., 2001).

REFERENCES

Monisov, A. A., 1992. Evaluation of the Toxic Elements by Atomic Absorption Methods in the Food Products and Food Material. Kolos, Moscow, 22 (RU).

Jarup, L., 2003. Hazards of heavy metal contamination. *British Medical Bulletin*, **68**, 167–182.

Maracek, I., L. Lazar & I. Dietzova, 1998. Residues of heavy metals in cow reproductive organs and morbidity of cattle in the fallout region of metallurgical plant. *Veterinárni Medicina,* **42,** 283–287.

Massanyi, P., P. Nad, R.Toman & J. Kovacik, 2001. Concentrations of cadmium, lead, nickel, copper and zinc in various muscles of sheep. *Austrian Journal of Agricultural Research*, **52**, 56–62.

Mazvila, J., T. Adomaitis, L. Eitminavichius, J. Lubyte, A. Antanaitis & K. Matusevicius, 2001. Heavy metals in Lithuania's soils and plants. *Journal of Agriculture*, **73**, 64–90 (LT).

Sabir, S. M., S. W. Khan & I. Hayat, 2003. Effect of environmental pollution on quality of meat in district Bagh, Azad Kashmir. *Pakistan Journal of Nutrition*, **2**, 98–101.

Staniskienė, B. & D. Garalevicienė, 2004. Heavy metals in fish meat. *Veterinary Medicine and Zootechnics*, **26,** No 48, 46–52 (LT).

Tairova, A. R., 2001. The use of chitozan for adjusting heavy metals in products of cattle slaughter. *Zootechnics*, **9**, 27–29 (RU).

Vaizenen, G. N., A. I. Tokar & V. A. Guliaev, 1998. The use of calcium carbonates for to get ecologically clear beef. *Zootechnics*, **2**, 30–32. (RU).

Vaizenen, G. N. & G. A. Vaizenen, 2002. The use of easer technology in beef producing. *Zootechnics*, **6**, 28–30 (RU).

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