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CONTENT OF CHEMICAL ELEMENTS IN MUSCULAR TISSUE AND LIVER OF MALE KIDS AND RAM LAMBS IN CENTRAL-EASTERN POLAND

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Abstract

The aim of the study was to estimate the content of Pb, Cd, Zn, Mn, Cu, Fe, Ca in meat and liver of male kids and ram lambs fed mixtures containing 10% of flax seeds. Castrated male kids ($n = 7$) of White Upgraded breed and castrated ram lambs ($n = 7$) of Polish Lowland sheep fattened up to about 35 kg of body weight were used as experimental material. The animals were fed mixture CJ *ad libitum*, supplemented with 10% of flax seeds and meadow hay as a structural supplement. Contents of the chemical elements were analysed in samples of *longissimus dorsi* muscle.

The content of Cd (0.01 mg kg^{-1}) in male kid meat was lower than in ram lamb meat ($p \leq 0.05$). Similarly, Pb content was lower ($p \leq 0.05$) in male kids (0.04±0.003 mg kg^{-1}) than in ram lambs (0.07±0.002 mg kg^{-1}). Slightly lower content of Pb (by 0.01 mg kg^{-1}) and Cd (by 0.01 mg kg^{-1}) in male kid liver was determined, and the differences were statistically insignificant. Significantly larger ($p \leq 0.01$) Cu content (1.14±0.07 mg kg^{-1}) in muscular tissue of ram lambs was also stated. Male kid meat, however, was richer in Mn, Fe, Zn and Ca, with the differences tested at $p \leq 0.05$ and $p \leq 0.01$. The liver was an organ which accumulated not only Pb and Cd but also Cu, Mn and Zn both in ram lambs and male kids. Especially high level of Cu and Mn in liver was found, which could be the result of a high content of the chemical elements in mixtures. Moreover, significantly larger content of Ca (15.24±1.68 mg kg^{-1}) in ram lamb liver compared to male kid liver was stated. On the other hand, muscular tissue of male kids contained more Ca (21.94±1.74 mg kg^{-1}) than that of ram lambs.

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The content of chemical elements (especially heavy metals) in muscular tissue and liver was lower than the norms established by the Minister for Health and the European Committee, which prove that the tested food products were fully safe for consumption.

Key words: goat kids, ram lambs, flax seeds, muscular tissue, liver, chemical elements, heavy metals.

POZIOM METALI W TKANCE MIĘŚNIOWEJ I WĄTROBIE KOZIOŁKÓW I TRYCZKÓW Z REGIONU ŚRODKOWO-WSCHODNIEJ POLSKI

Abstrakt

Celem badań było określenie zawartości Pb, Cd, Zn, Mn, Cu, Fe, Ca w mięsie i wątrobie koziołków i tryczków żywionych mieszanką pełnoporcjową z 10% udziałem nasion lnu. Materiał doświadczalny stanowiły wykastrowane koziołki ($n = 7$) rasy białej uszlachetnionej i wykastrowane tryczki ($n = 7$) polskiej owcy nizinnej, tuczone do masy ciała ok. 35 kg. Zwierzęta doświadczalne otrzymywały do woli przemysłową mieszankę treściwą CJ, dodatek 10% nasion lnu oraz siano łąkowe jako dodatek strukturalny. Próby do analizy pobrano z mięśnia najdłuższego grzbietu (*m. longissimus dorsi*), w którym oznaczono zawartość pierwiastków.

W mięsie koziołków stwierdzono niższą zawartość Cd (0.01 mg kg^{-1}) niż u tryczków – $p \leq 0.05$. Podobnie poziom Pb był niższy ($p \leq 0.05$) w grupie koźląt (0.04±0.003 mg kg^{-1}) w porównaniu z tryczkami (0.07±0.002 mg kg^{-1}). W wątrobie koźląt stwierdzono nieznacznie niższy poziom Pb oraz Cd (0.01 mg kg^{-1}) – różnice nieistotne statystycznie. Istotnie wyższą ($p \leq 0.01$) zawartość Cu (1.14±0.07 mg kg^{-1}) w tkance mięśniowej stwierdzono u tryczków. Natomiast mięso koziołków było bogatsze w Mn, Fe, Zn i Ca – różnice $p \leq 0.05$ i $p \leq 0.01$. Wątroba była narządem koncentracji nie tylko Pb i Cd, ale Cu, Mn i Zn zarówno u tryczków, jak i koziołków. Zaobserwowano szczególnie wysoki poziom Cu i Mn w wątrobie, czego przyczyną mógł być wysoki poziom tych pierwiastków w paszy. Ponadto w wątrobie tryczków stwierdzono istotnie ($p \leq 0.01$) wyższy poziom Ca (15.24±1.68 mg kg^{-1}) niż u koziołków. Natomiast tkanka mięśniowa koziołków zawierała więcej Ca – 21.94±1.74 mg ≤ kg^{-1}.

Stężenie pierwiastków, szczególnie metali ciężkich, w tkance mięśniowej i wątrobie było poniżej dopuszczalnych norm podanych przez Ministra Zdrowia i WE, co kwalifikuje je jako surowce żywnościowe w pełni bezpieczne do spożycia.

Słowa kluczowe: koziołki, tryczki, nasiona lnu, tkanka mięśniowa, wątroba, pierwiastki, metale ciężkie.

INTRODUCTION

Environmental pollution has worsened the health quality of food, which is one of the main sources of exposure of people to harmful trace minerals. Young kid meat is praised for its excellent quality and delicate taste. It is also a source of phosphorus, sulphur, copper, iron and calcium. This meat competes with veal and lamb in nutritive value (HUMANN-ZIEHANK et al. 2008, KRUPA, KOGUT 2000, LIDWIN-KA•MIERKIWICZ et al. 2006, NIEDZIÓŁKA et al. 2008). Addition of oil plant seeds to mixtures influenced the fatty acid content,

which is of great importance in cholesterol regulation, and also affected heavy metal content (Krełowska-Kułas 1998, Morawiec 1991, Niedziółka et al. 2007, Pieniak-Lendzion 2006). Studies that have been conducted recently showed an altered content of chemical elements in tissues and edible organs, from trace values to levels which exceeded physiological values.

The aim of this study was to test the content of Pb, Cd, Zn, Mn, Cu, Fe, Ca in meat and liver of male kids and ram lambs fed mixtures containing 10% of flax seeds.

MATERIAL AND METHODS

Castrated male kids (n = 7) of White Upgraded breed and castrated ram lambs (n = 7) of Polish Lowland sheep fattened up to 35 kg of body weight were used as experimental material. Kids and rams were kept together with their dams until the 60th day of life. At the age of 1 month all kids and ram lambs were castrated using a surgical method. The experimental animals were fed *ad libitum* on mixture CJ supplemented with 10% of flax seeds and meadow hay as a structural supplement. The mixtures were produced from components originating from Podlasie. The slaughter was conducted according to methodology presented by the Zootechnic Institute. Samples were taken from *longissimus dorsi* muscles. The content of chemical elements such as Zn, Cu, Mn, Fe was tested in an atomic absorption spectrophotometer AAS. The content of Pb and Cd was analysed using the extraction method. An Atomic absorption spectrophotometer AAS-30 manufactured Carl Zeiss Jena was used to conduct the analyses. Each time, 10 g of the material was dried at 150°C for 24 hours. Then, each sample was combusted in a muffle stove (temp. 420°C). The ash was moistened with nitric acid and, after distilling nitrogen oxide, the ash was placed in a muffle stove at 420°C for 30 minutes. The white rest was dissolved in muriatic acid (1 mol dm^{-3}) and was analysed directly from an aqueous solution – aspirating to flame of the atomic absorption spectrophotometer. The content of heavy metals in meat was tested in a laboratory of the Institute of Chemistry at the University of Podlasie.

The results were statistically presented in tables, showing mean values (x) and standard deviation (SD) for each tested value. Significance of differences between means for both species was analyzed by Tukey test. Statistical calculations were done using Statistica 6.0PL.

RESULTS AND DISCUSSION

The content of chemical elements in muscular tissue was low and did not exceed the norms accepted by the Minister for Health and the European Committee, which indicated that kid and lamb meat are healthy products suitable for consumption (*Minister for Health* 2003, EC 2006). Lead and cadmium (Table 1) are toxic elements and their accumulation in ram lamb tissues was larger than in kid tissues by 0.03 and 0.01 mg kg^{-1}, respectively

Table 1

Content of lead and cadmium in meat and liver (mg kg^{-1} fresh tissue)

Chemical elements	Analyzed tissue	Statistical parameters	Species	
			goat kids	ram lambs
Pb	meat	$\overline{x}$	0.04*	0.07*
		SD	0.003	0.00
	liver		0.25	0.26
		SD	0.03	0.03
Cd	meat	$\overline{x}$	0.02*	0.03*
		SD	0.003	0.008
	liver	$\overline{x}$	0.03	0.04
		SD	0.006	0.01

*value significant at $p \leq 0.05$. **value significant at $p \leq 0.01$

– $p = 0.05$. Two-fold more Cd was found in liver, from 0.03 mg kg^{-1} (kids) to 0.04 mg kg^{-1} (ram lambs) and a four-fold higher level of Pb (0.25 and 0.26 mg kg^{-1}) was also demonstrated. The addition of flax seeds to mixtures lowered the Pb and Cd content, which was confirmed by a larger content of Pb and similar content of Cd in muscular tissue and liver found in our earlier studies on lambs and kids (KRUPA, KOGUT 2000, NIEDZIÓŁKA et al. 2007). The aim of the study performed by LIDWIN-KA•MIERKIEWICZ et al. (2006) was to examine cadmium, lead, copper, mercury and zinc in raw beef, beef boiled in water without NaCl and in water with NaCl. The lowest concentration of Pb was in brisket boiled in water without salt and the highest in raw entrecote. The Cd content in raw beef as well as in beef boiled in water without salt was low.

The source of lead and, possibly cadmium, for animals is mainly green forage, silage, whole plants from roots and, to a lesser degree, cereal grain. Consequently, the risk of contamination with Pb and Cd is the highest for sheep, cattle and wild boar game. Skilful indoor nourishment with the cereals and oilplant parts combined with beneficial influence of spicy plants can

limit the content of heavy metals in animal bodies (Bayçu et al. 2003, Krupa, Kogut 2000, Pieniak-Lendzion et al. 2008)

Significantly larger ($p = 0.01$) content of Cu (1.14 mg kg^{-1}) in muscular tissue of ram lambs was found (Table 2). Noteworthy is the fact that both kid and ram lamb livers contained high level of copper. However, the level of copper was 14.37 mg kg^{-1} higher in ram lamb liver. The content of copper in male kid muscular tissue (0.88-0.96 mg kg^{-1}) was similar, while that in kid liver (73.78-92.58 mg kg^{-1}) was larger than in a study by Pieniak-Lendzion et al. (2008). The content of copper depended on the gender and male kids accumulated less Cu in muscular tissue but more Cu in liver. In other studies (Johnson et al. 1995), the average content of Ca in muscular

Table 2

Content of manganese iron, zinc, copper and the calcium in meat and the liver (mg kg^{-1} fresh tissue)

Chemical elements	Analyzed tissue	Statistical parameters	Species	
			goat kids	ram lambs
Mn	meat	$\overline{x}$	0.46**	0.32**
		SD	0.05	0.03
	liver	$\overline{x}$	5.00*	5.77*
		SD	0.33	0.72
Fe	meat	$\overline{x}$	28.27*	21.70*
		SD	5.58	1.34
	liver	$\overline{x}$	53.11	48.55
		SD	4.13	7.41
Zn	meat	$\overline{x}$	59.90**	52.99**
		SD	1.47	4.14
	liver	$\overline{x}$	69.42	69.04
		SD	3.96	6.72
Cu	meat	$\overline{x}$	0.97**	1.14**
		SD	0.08	0.07
	liver		109.58	123.95
		SD	17.02	21.48
Ca	meat	$\overline{x}$	21.94**	18.32**
		SD	1.74	0.75
	liver		6.66**	15.24**
		SD	0.38	1.68

*value significant at $p \leq 0.05$. **value significant at $p \leq 0.01$

tissue of young kids was 28.1 mg 100 g^{-1}, the content of Zn – 92.3 mg 100 g^{-1} and Cu – 4.4 mg 100 g^{-1}. Male kid meat was richer in Mn, Fe, Zn and Ca, with the significant differences appearing at $p = 0.05$ and $p = 0.01$. The iron content in muscular tissue of male kids was larger by about 6.57 mg kg^{-1} than that of ram lambs ($p = 0.05$). Hoffman et al. (2003) demonstrated a lower content of iron (16.29-18.83 mg kg^{-1}) in muscular tissue of lambs slaughtered at 40 kg of body weight. The aim of a study completed by Pięta, Patkowski (2009) was to determine the content of elements in the *longissimus dorsi* muscle of lambs, dependent on the system of maintenance**.** It was noted that in lambs kept with their mothers in an outdoor system it was higher compared to lambs kept indoors (16.29 vs 10.47 mmol kg^{-1}). The content of iron was 447.3 µmol kg^{-1} (indoor) and 486.6 µmol kg^{-1} (outdoor), being similar to the levels determined in our own investigations. The liver was an organ which not only accumulated Pb and Cd, but also Cu, Mn and Zn both in ram lambs and male kids. It was proved that the Cu content in the liver exceeded 100 mg kg^{-1}, and the Mn content was over 5 mg kg^{-1}, which resulted from a higher level of the chemical elements in the mixtures. However, a statistically significantly larger Ca content in muscular tissue than that in the liver both in ram lambs and male kids was found. Elevated amounts of calcium in muscular tissue of male kids (by 3.62 mg kg^{-1}, $p \leq 0.01$) and in the liver of ram lambs (by 8.58 mg kg^{-1}, $p \leq 0.01$) were stated. The correlations regarding increased levels of iron, manganese, copper and calcium in the liver than in muscular tissue were confirmed by other researchers (Humann-Ziehank et al. 2008, Morawiec 1991, Niedziółka et al. 2008, Pieniak-Lendzion et al. 2007).

CONCLUSIONS

1. It was found that the species differentiated the content of chemical elements in meat and the liver of male kids and ram lambs fed mixtures supplemented with flax seeds, but the levels of the elements did not exceed the accepted norms.

2. The content of Cd and Pb was significantly lower in muscular tissue and slightly lower in the liver of male kids than those of ram lambs.

3. The liver was an organ which accumulated not only Pb and Cd, but also Cu, Mn and Zn both in ram lambs and male kids. The effect of a species on the accumulation of Cu and Ca was proved.

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Rozporządzenie Komisji (WE) nr 1881/2006 z dnia 19.12.2006 (DzU UE z 20. 12. 2006) ustalające najwyższe dopuszczalne poziomy niektórych zanieczyszczeń w środkach spożywczych. [Establishing the highest admissible levels of some foreign bodies in food].

Rozporządzenie Ministra Zdrowia z dnia 31.01.2003 r. (Dz.U. z 2003 r. nr 37, poz. 326) w sprawie maksymalnych poziomów zanieczyszczeń chemicznych i biologicznych które mogą znajdować się w żywności, składnikach żywności, dozwolonych substancjach dodatkowych, substancjach pomagających w przetwarzaniu albo na powierzchni żywności. [Ordinance of the Minister for Health of 31 January 2003, Jouranl of Law of 2003, no 37, item 326, on the maximum levels of chemical and biological contaminants which can be found in food, food components, permissible additives, food processing and substances on the surface of food products]. (in Polish)