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The concentration of lead in muscle tissue of wild boars (*Sus scrofa*) in selected voivodeships in Poland

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The aim of the study was to assess the degree of bioaccumulation of lead in the muscle tissue of wild boars harvested in Poland in six selected voivodeships. The presence of chemical contaminants is one of the criteria for assessing the safety of food products for human consumption. The material consisted of samples taken from wild boars in peak condition during the 2013/2014 season. The animals were shot down in six voivodeships: Lower Silesian, Lubusz, Kuyavian-Pomeranian, Warmian-Masurian, Greater Poland and West Pomeranian. The analysis showed that the acceptable concentration of lead was exceeded in only five cases, which was about 4.5% of the samples. Excessive concentrations occurred in the Greater Poland (1 sample), West Pomeranian (2 samples) and Kuyavian-Pomeranian (2 samples) voivodeships.

KEY WORDS: *Sus scrofa* / lead/ meat/ concentration

Harmful substances which enter the environment due to human activity include pesticide residues, heavy metals, and their compounds. Due to lead accumulating in the tissues of successive links in the food chain, carcass parts become unsuitable for direct consumption by humans and animals. The most important activities generating accumulation of lead and its toxic compounds are the metallurgical, energy, and mining industries, transport, and agriculture [13]. Heavy metals, including lead, enter living organisms via the air, soil or water [4]. A significant source of accumulation of heavy metals, including lead, is transport. Some toxic substances containing heavy metals, accumulating near roads, may be carried over short distances by the air, but the vast majority are carried together with precipitation washing over and permeating the road surface [3]. Another highly significant source of heavy metal contamination is municipal waste, as landfills release gases and leachate into the environment [11].

Regular consumption of fodder and food containing elevated levels of lead and other heavy metals may be manifested after many years, as these elements accumulate in the

body and can persist in the organs for an entire lifetime [4, 14, 16]. Lead has the highest coefficient of accumulation, ranging from 10% to even 600% [1]. The most important organs acting as filters for heavy metals are the kidneys, liver and bones. Lead is deposited in the muscles to a much lesser extent, but this depends on the intensity of exposure to the source of metals [16]. In animals consuming contaminated fodder, lead is deposited mainly in the skeleton (ribs), liver, kidneys and hair. The concentration of lead may be 5 times higher in the liver than in the muscles, and even 8 times higher in the kidneys [13, 16].

Increasing industrialization, the dynamic growth of automobile transport and the continual increase in the number of automobiles have become an enormous threat to wild animals, not only due to collisions and limitations on migration caused by infrastructure development, but also because of the pollutants emitted by automobiles. Therefore the tissues of wild animals may have a considerably higher concentration of heavy metals, including lead, than animals raised for slaughter. This mainly pertains to animals living in regions with high emissions of heavy metals. A high lead concentration is also linked to the use of lead ammunition. The concentration of lead in muscles taken from the vicinity of a gunshot wound may reach even hundreds of milligrams per kg, whereas parts of the carcass located further from the wound have shown much lower concentrations—tenths of a milligram per kg [2, 12].

The last decade has seen an increase in game harvesting in Poland, mainly of wild boar. The difference in the annual harvest is clearly evident; 106,800 individuals were harvested in the 2003/2004 hunting season, and over twice this number in the 2012/2013 season—218,900 individuals (Fig.).

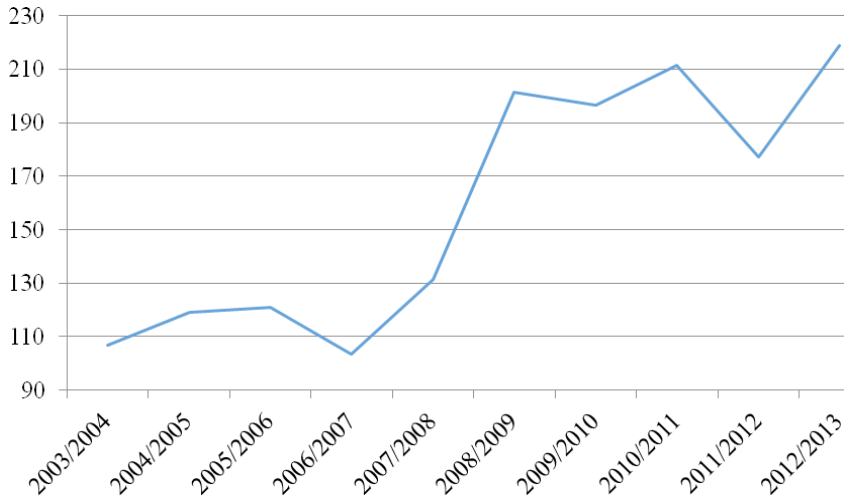

Fig. Harvesting of boars (in thousands of individuals) based on data from annual hunting plans [15]

The objective of the study was to evaluate the degree of bioaccumulation of lead in the muscle tissue of wild boars harvested in Poland in six selected voivodeships, taking into account the sex and carcass weight of the animals. Game in forests may serve as a bioindicator of the degree of contamination of the environment, and the presence of heavy metals in the meat of wild animals is one of the criteria used to evaluate its suitability for consumption.

Material and methods

The experimental material consisted of samples taken from wild boars in peak condition during the 2013/2014 season. The animals were shot down in six voivodeships: Lower Silesian (16 boars), Lubusz (14), Kuyavian-Pomeranian (21), Warmian-Masurian (20), Greater Poland (20) and West Pomeranian (20). Samples were collected from carcasses received at a game processing plant. The samples were taken at a minimum 30 cm distance from gunshot wounds. The meat was frozen at –18°C for about 4 weeks. All samples (111 in total) were collected from the shin muscle of the boars. They were grouped according to the following criteria:

– origin (six voivodeships)
– carcass weight (up to 20 kg, 20-40 kg, 40-60 kg, over 60 kg)
– sex/age (young individuals—piglets, adults—female and male)

Lead content was determined by atomic absorption spectrometry. Samples were mineralized under high pressure in a MARS 5 Xpress microwave digester by CEM. Lead content was determined in a graphite furnace with Zeeman background correction (in an argon atmosphere) with an AA 240Z Varian spectrometer. A certified reference material and blank samples were analysed in parallel with the experimental samples. The analysis was performed according to PN-EN 14084 [5].

The lead concentrations obtained were compared with the maximum acceptable levels of certain contaminants in foodstuffs. For meats, except for offal, the highest acceptable level of lead is 0.10 mg/kg, according to Commission Regulation (EC) no. 1881/2006 [6]. Computer software (SAS Institute Inc. 2012. SAS/STAT 9.3 Users Guide. Cary; NC: SAS Institute Inc.) was used to calculate arithmetic means, standard deviations, and minimum and maximum values. Significance of differences between means was verified by Duncan's test.

Results and discussion

The study found the highest mean lead concentrations in the muscles of boars from the West Pomeranian Voivodeship (0.072 mg/kg), and the lowest in the Lubusz Voivodeship (0.015 mg/kg). The analysis showed that the acceptable concentration of lead was exceeded in only five cases, which was about 4.5% of the samples. This occurred in the Greater Poland, West Pomeranian and Kuyavian-Pomeranian voivodeships (1, 2 and 2 samples, respectively). The lead concentration in the remaining samples fluctuated at a low level and did not raise hygienic or toxicological concerns (Tab. 1).

Table 1
Lead content in the muscle tissue of wild boars (mg/kg wet weight)

Voivodeship	Number of samples	Mean	Range	Standard deviation
Lower Silesian	16	0.0168[b]	0.0029-0.0623	0.0154
Lubusz	14	0.0152[b]	0.0035-0.0393	0.0093
Kuyavian-Pomeranian	21	0.0316	0.0022-0.1346	0.0342
Warmian-Masurian	20	0.0296	0.0042-0.0730	0.0212
Greater Poland	20	0.0413	0.0105-0.1523	0.0323
West Pomeranian	20	0.0722[a]	0.0133-0.6009	0.1292
Total	111	0.0361	0.0022-0.6009	0.0613

Values marked with the letters a and b significantly different at $p<0.05$

Analysis of the lead content in the muscles of boars with different carcass weights showed a certain correlation. The greater the carcass weight, the lower the concentration of lead in the muscle tissue. The highest concentration of this element was noted in the boars with a carcass weight of up to 20 kg (0.0735 mg/kg), and the lowest in the boars with a carcass weight above 60 kg (0.0267 mg/kg) – Table 2.

Differences in lead concentration were also noted in the muscles of boars of different carcass weights harvested in particular voivodeships. The highest mean concentration of this element in animals whose carcass weight did not exceed 20 kg was noted in the West

Table 2
Mean lead content in the muscle tissue of wild boars with different carcass weight (mg/kg)

Carcass weight	Number of samples	Mean	Standard deviation	Minimum	Maximum
< 20 kg	16	0.0735[a]	0.1421	0.0082	0.6009
20-40 kg	25	0.0369[b]	0.0283	0.0022	0.1605
40-60 kg	25	0.0280[b]	0.0314	0.0035	0.1346
> 60 kg	45	0.0267[b]	0.0310	0.0029	0.1346
Total	111	0.0613	0.0613	0.0022	0.6009

Means marked with the letter b are not significantly different at $p<0.05$

Pomeranian Voivodeship (0.158 mg/kg), and the lowest in the Lubusz Voivodeship (0.014 mg/kg). In the 20-40 kg weight range the boars most contaminated with lead were from the West Pomeranian Voivodeship (0.063 mg/kg), and the least contaminated were from the Lower Silesian Voivodeship (0.014 mg/kg). Among boars with carcass weight in the 40-60 kg range, the highest lead concentration was noted for the muscle samples of boars shot down in the Kuyavian-Pomeranian Voivodeship (0.073 mg/kg), and the lowest in boars from the Lubusz Voivodeship (0.0080 mg/kg). In the weight category above 60 kg, the highest lead concentration was found in samples from the carcasses of boars harvested in the Greater Poland Voivodeship (0.061 mg/kg).

Comparison of the lead concentration in the muscle tissue of boars of different sexes revealed the highest mean concentration in the piglets (0.061 mg/kg), and the lowest in the adult males (0.028 mg/kg) – Table 3. Among young individuals the highest lead concentration was noted in the samples collected from the carcasses of boars harvested in the West Pomeranian Voivodeship (0.158 mg/kg). It should be noted that the high result, exceeding the maximum acceptable lead concentration (0.10 mg/kg), may be due to the low carcass weight of the young animals, and thus a shorter distance between the site where the sample was collected and the gunshot wounds. The lead concentration at these sites increases dramatically. This occurs when lead bullets are used and has no connection with contamination of the environment. The most lead was observed in the muscle tissue of boars harvested in the West Pomeranian Voivodeship (0.060 mg/kg), and the least in the Lubusz Voivodeship (0.011 mg/kg). Adult males from the Greater Poland Voivodeship had the highest lead concentration (0.059 mg/kg), while the lowest concentration was noted in adult males of the Lower Silesian Voivodeship (0.011 mg/kg).

The analysis showed that the meat of boars in the voivodeships studied can be considered safe. According to regulations establishing the maximum acceptable levels of contaminants in foodstuffs, the content of lead in muscle tissue may not exceed 0.10 mg/kg [6, 7, 8]. Acceptable norms were exceeded in only five samples. The lead concentration in the remaining samples was at a low level and did not raise hygienic or toxicological concerns.

Table 3
Mean lead content in the muscle tissue of boars of different sexes and of piglets

Age/sex	Number of samples	Mean	Standard deviation	Minimum	Maximum
Piglets	20	0.0614[a]	0.1288	0.0082	0.6009
Adult females	49	0.0335	0.0270	0.0022	0.1605
Adult males	42	0.0278[b]	0.0339	0.0029	0.1523
Total	111	0.0613	0.06132	0.0022	0.6009

Values marked with the letters a and b are significantly different at $p<0.05$

Comparison of the results obtained for lead concentration in the muscle tissue of the boars with the results of screening tests for toxic elements in foods of animal origin conducted by Szkoda et al. [9] indicates that the mean lead concentration in the muscle tissue of the boars was over seven times lower than the mean concentration of this element in the muscle tissue of boars in the screening tests (on average 0.273 mg/kg). Interestingly, a study by Szkoda and Żmudzki [10] published 10 years earlier showed a far higher lead concentration in the muscle tissue of boars—4.342 mg/kg, and the maximum limit for lead in meat was exceeded in 25% of samples tested. The researchers stated that such a high concentration of toxic elements was more likely linked to contamination of the carcasses from gunshot wounds than to contamination of the environment [10].

The results of our study show that meat obtained from harvested boars is safe in terms of contamination with heavy metals. This is important for consumers, as boar meat is currently offered in supermarkets.

Due to the scarcity of current scientific literature dealing with heavy metals in the muscle tissue of boars and other wild animals, further comparison of the results of the study with other research is not possible. The analyses showed that the concentration of lead in the muscle tissue of boars does not dangerously exceed norms defining the highest acceptable lead concentration in meat. These concentrations were exceeded in only 4.5% of cases, while the remaining results did not raise hygienic or toxicological concerns. Comparison of the results with the scientific literature concerning lead concentrations in the muscles and organs of boars revealed that the degree of environmental contamination and the quality of game carcasses have improved in the last few years [9, 10].

REFERENCES

1. DUMA P., PAWŁOS M., RUDY M., 2012 – Zawartość metali ciężkich w wybranych produktach spożywczych województwa podkarpackiego. ***Bromatologia i Chemia Toksykologiczna*** XLV, 1, 94-100.
2. DZIERŻYŃSKA-CYBULKO B., FRUZIŃSKI B., 1997 – Dziczyzna jako źródło żywności. Wartość żywieniowa i przetwórcza. PWRiL, Warszawa.
3. FORMAN R.T.T., SPERLING D., BISSONETTE J., CLEVENGER A.P., CUTSHALL C., DALE V., FAHRIG L., FRANCE R., GOLDMAN C., HEANUE K., JONES J., SWANSON F., TURRENTINE T., WINTER T., 2003 – Road ecology: Science and Solutions. Island Press, Washington, USA.
4. OCIEPA-KUBICKA A., OCIEPA E., 2012 – Toksyczne oddziaływanie metali ciężkich na rośliny, zwierzęta i ludzi. ***Inżynieria i Ochrona Środowiska*** 15, 2:169-180.
5. PN-EN 14084, 2004 – Artykuły żywnościowe. Oznaczenie pierwiastków śladowych. Oznaczenie ołowiu metodą atomowej spektrometrii absorpcyjnej po mineralizacji mikrofalowej.
6. Rozporządzenie Komisji (WE) NR 1881/2006 z dnia 19 grudnia 2006 r. ustalające najwyższe dopuszczalne poziomy niektórych zanieczyszczeń w środkach spożywczych (Dz.U. UE, L 364/5 z dnia 20.12.2006 r.).
7. Rozporządzenie Komisji (WE) NR 629/2008 z dnia 2 lipca 2008 r. ustalające najwyższe dopuszczalne poziomy niektórych zanieczyszczeń w środkach spożywczych (Dz.U. UE, L 173/6 z dnia 30.07.2008 r.).

8. Rozporządzenie Komisji (UE) NR 420/2011 z dnia 29 kwietnia 2011 r. zmieniające rozporządzenie (WE) NR 1881/2006 ustalające najwyższe dopuszczalne poziomy niektórych zanieczyszczeń w środkach spożywczych (Dz.U. UE, L 111 z dnia 30.04.2011 r.).
9. SZKODA J., NAWROCKA A., KMIECIK M., ŻMUDZKI J., 2011 – Badania kontrolne pierwiastków toksycznych w żywności pochodzenia zwierzęcego. ***Ochrona Środowiska i Zasobów Naturalnych*** 48, 475-484.
10. SZKODA J., ŻMUDZKI J., 2001 – Pierwiastki toksyczne w tkankach zwierząt łownych (Toxic elements in tissues of game animals). ***Medycyna Weterynaryjna*** 57, 12, 883-886.
11. SZYMAŃSKI K., 2009 – Związki ołowiu i chromu w środowisku naturalnym i odpadach. ***Roczniki Środkowo-Pomorskiego Towarzystwa Naukowego Ochrony Środowiska*** 11, 173-182.
12. TROPIŁO J., KISZCZAK L., 2008 – Badanie i ocena sanitarno-weterynaryjna zwierząt łownych i dziczyzny. Wyd. Wieś Jutra, Warszawa.
13. WĘGLARZY K., 2007 – Metale ciężkie – źródła zanieczyszczeń i wpływ na środowisko. ***Wiadomości Zootechniczne*** 3, 31-38.
14. ZAWADZKI M., PORĘBA R., GAĆ P., 2006 – Mechanizmy i skutki toksycznego oddziaływania ołowiu na układ krążenia. ***Medycyna Pracy*** 57, 6, 543-549.
15. ZESTAWIENIA DANYCH SPRAWOZDAWCZOŚCI ŁOWIECKIEJ, 2013 – Polski Związek Łowiecki, Warszawa.
16. ŻEBROWSKA-RASZ H., 1992 – Chemiczne skażenia zwierząt i żywności pochodzenia zwierzęcego. Kancelaria Sejmu Biuro Studiów i Ekspertyz. Wydział Analiz Ekonomicznych i społecznych. Informacja nr 47.