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THE HEAVY METAL CONTENT IN COMMERCIAL DOG FOODS

ZAWARTOŚĆ WYBRANYCH METALI CIĘŻKICH W KARMACH DLA PSÓW

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Streszczenie. Rosnące zainteresowanie zwierzętami domowymi, szczególnie psami, każe zwrócić szczególną uwagę na ich żywienie. Do badań wytypowano 12 rodzajów karm z podziałem na karmy dla psów młodych („junior") oraz dla psów dojrzałych („adult"). Do badań wybrano metale ciężkie, które są szkodliwe dla organizmu (kadm, rtęć, ołów) oraz te, które w odpowiednich ilościach są niezbędne do jego prawidłowego funkcjonowania (miedź, żelazo, cynk). Stężenia metali, takich jak: kadm, rtęć i ołów, porównywano z wartościami granicznymi, podanymi w Rozporządzeniu Ministra Rolnictwa i Rozwoju Wsi z dnia 6 lutego 2012 r. w sprawie zawartości substancji niepożądanych w paszach. Badania wykazały, że metalem, który przekracza dopuszczalne normy w pożywieniu dla psów, jest kadm, którego stężenie wyniosło 2,499 mg · kg^{-1} (wartość graniczna wynosi 2 mg · kg^{-1}). Karmy dla psów dojrzałych miały wyższe średnie stężenia metali ciężkich (kadmu, ołowiu, żelaza, miedzi, cynku), niż karmy „junior", z wyjątkiem rtęci i żelaza, których wyższe stężenia odnotowano w karmach „junior". Badania wykazały przekroczenie dopuszczalnej wartości granicznej w pożywieniu jedynie w przypadku kadmu (karma „adult"), którego stężenie wynosiło 2,499 mg · kg^{-1} (wartość graniczna wynosi 2 mg · kg^{-1}).

Key words: heavy metal, pollution, feeds for dogs.
Słowa kluczowe: metale ciężkie, zanieczyszczenia, karma dla zwierząt.

INTRODUCTION

In Poland, the number of dogs in households is growing every year and following the forecasts of 2015 they number over 8 million individuals, thus the issue of controlling the heavy metal content in foods is of paramount importance. Heavy metals pose the greatest threat to animals and humans (Kijowski 2014). Heavy metals constitute very important elements of the earth's crust. Along with the development of technology, they are found in increasing concentrations in the biotic (humans, animals, plants) and abiotic environment. Heavy metals belong to the most dangerous environmental contaminants. Certain concentrations of some heavy metals are indispensable for the proper functioning of organism (zinc, iron, copper). However, there are other heavy metals, for which no biological role has been determined so far and thus they are assumed as completely foreign to the organism: they are harmful already in low concentrations (mercury, cadmium, lead).

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Elements such as mercury, cadmium and lead belong to the group of elements with the highest accumulation coefficient of 10–600. Mercury, lead and cadmium are easily absorbed from atmospheric air. Heavy metals such as cadmium are also absorbed from drinking water and food. Long-lasting exposure of the system to low doses of heavy metals may cause irreversible disease lesions, which may appear after many years (Kujawa and Traczewska 2012). Heavy metals penetrate to human and animal organisms by ingestion. The presence of heavy metals in commercial foods intended for dogs and cats constitutes the subject of scientific study since 1970s (Mirowski 2013) It has been determined, that heavy metal concentrations in canned foods were several times higher than the doses considered potentially harmful to children (Hankin et al.1975). In animal organisms, heavy metals primarily cause changes in protein synthesis and contribute to ATP production disorders. The scale of the disorders depends on the amount of an element introduced to the organism.

Toxic effect toward animals are very extensive, and lead, mercury and cadmium are particularly harmful. These metals are easily accumulated in certain organs. The carcinogenic influence occurs, when the level of a given metal in the organism attains or exceeds the threshold. Heavy metals attack mainly the liver and kidneys. The accumulation of metals is often determined for the muscles, bones or the brain (Ociepa-Kubicka and Ociepa 2012). It should be assumed, that the dogs with lower weight are threatened by heavy metals contained in the food to a greater extent, because they consume more food in conversion to 1 kg of body weight than the dogs with higher weight. It should be borne in mind that the food does not constitute the only source of heavy metals. Their higher concentration in the organisms of smaller individuals is also influenced by environmental contamination. (Mirowski 2013). The potential threat related to the occurrence of heavy metals in the diet of pet animals should not be ignored, particularly when considering their possible cooperation with other, potentially harmful substances. In Poland the heavy metal concentration in food intended for pet animals is regulated by the Ordinance of the Minister of Agriculture and Rural Development of February 6, 2012, on the undesirable substance content in foods (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 6 lutego 2012 r.).

The objective of the study was to demonstrate the differences of the content of selected heavy metals in foods for young dogs (junior) and mature dogs (adult).

MATERIAL AND METHODS

Twelve types of foods with use depending on the age of the dog (both „junior" foods as well as „adult" foods) were selected from the dry foods available on the market. The study material was dried, then the total zinc, iron, copper, cadmium and lead content were determined using atomic absorption ASA with a spectrophotometer ICE 3000 Thermo Scientific, with a prior mineralization in a mixture of concentrated nitric and perchloricacids in 5 : 1 ratio in a MILESTONE microwave oven. Evaluation of the precision of used methods and analytical procedures was performed using a certified reference material: CRM036-050 Loamy Sand 4. Total mercury concentration in the studied samples was performed using AMA 254 analyzer. For the analyzed parameters, basic statistical parameters were calculated, i.e. mean, standard deviation, median and coefficients of variation. The foods were divided into two groups: „junior" foods (1–6) and „adult" foods (7–12). Cadmium, mercury and lead analysis results were compared with the Ordinance of the Minister of Agriculture and Rural Development of February 6, 2012 on the undesirable substance content in feeds (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 6 lutego 2012 r.).

RESULTS AND DISCUSSION

The laboratory studies allowed to determine, that heavy metal concentrations varied, both within the established groups as well as between these groups (Tables 1 and 2). It was also observed, that mean heavy metal concentrations were higher in the food intended for adult dogs than in „junior" foods (Table 3). Firstly, the results of cadmium, mercury and lead concentrations will be discussed thanks to the highest accumulation coefficient and due to the fact, that so far no biological role of these elements has been determined. Cadmium will be discussed first, since its toxic effect is primarily linked to disorders of different metabolic cycles (Ociepa-Kubicka and Ociepa 2012). The highest cadmium concentration was recorded for the food no. 12 („adult") 2.499 mg · kg^{-1} and it was four-fold higher than the highest cadmium concentration in a „junior" food (no. 2 – 0.567 mg · kg^{-1}). Also the lowest cadmium concentration was found in an „adult" food no. 11, amounting to 0.205 mg · kg^{-1}. Mean cadmium concentration in „adult" foods was 0.670 mg · kg^{-1} and it was approximately two times higher than the mean concentration of the „junior" foods (0.350 mg · kg^{-1}) – Table 3. In reference to the Ordinance of the Minister of Agriculture and Rural Development of February 6 2012 on the undesirable substance content in foods, the allowable concentration was exceeded only in the food no. 12 („adult"), where it was 2.499 mg · kg^{-1} (limit 2 mg · kg^{-1}). The remaining foods were within the established threshold. The levels of cadmium in examined dog foods was somewhat lower, than those studied by Duran et al. (2010) in pet foods commercially available in Turkey, which ranged from 0.94 to 2.14 mg · kg^{-1} and are comparable with contents of cadmium of cattle feed, as examined by Nicholson et al. (1999).

Table 1. Concentration of heavy metals in „junior" foods
Tabela 1. Stężenie metali ciężkich w karmach „junior" [mg · kg^{-1}]

Var. of food Odmiana karmy	Cd	Hg	Pb	Fe	Zn	Cu
1	0.32	0.006	0.17	650.42	311.42	14.55
2	0.57	0.002	0.16	1034.61	267.97	22.32
3	0.36	0.003	0.42	484.43	358.28	30.33
4	0.23	0.002	0.15	553.94	420.53	25.17
5	0.31	0.008	0.19	364.92	125.11	16.61
6	0.30	0.001	0.13	976.84	399.24	28.70

Table 2. Concentration of heavy metals in „adult" foods
Tabela 2. Stężenie metali ciężkich w karmach „adult" [mg · kg^{-1}]

Var. of food Odmiana karmy	Cd	Hg	Pb	Fe	Zn	Cu
7	0.26	0.002	0.45	533.20	338.43	32.06
8	0.40	0.004	2.09	246.07	279.84	49.78
9	0.39	0.004	1.39	439.43	324.88	39.62
10	0.26	0.004	0.83	414.33	321.82	34.07
11	0.20	0.003	2.18	495.41	439.77	49.84
12	2.50	0.004	2.25	228.45	285.87	51.86

Table 3.Main characteristics of statistical data for „junior" and „adult" foods
Tabela 3. Ogólna charakterystyka podstawowych parametrów statystycznych karm „junior" i „adult"

Statistical parameter Parametry statystyczne	Junior foods Karmy „junior"					
	Cd	Hg	Pb	Zn	Fe	Cu
Mean – Średnia [mg · kg⁻¹]	0.35	0.004	0.20	313.76	677.53	22.95
Standard deviation Odchylenie standardowe [mg · kg⁻¹]	0.11	0.003	0.11	108.05	271.33	6.38
Coefficient of variation Współczynnik wariancji [%]	32.57	75.00	52.45	34.44	40.05	27.82
Median – Mediana [mg · kg⁻¹]	0.32	0.001	0.16	334.86	602.18	23.75
	Adult foods Karmy „adult"					
Mean – Średnia [mg · kg⁻¹]	0.67	0.003	1.53	331.77	392.82	42.87
Standard deviation Odchylenie standardowe [mg · kg⁻¹]	0.90	0.001	0.77	57.72	127.61	8.74
Coefficient of variation Współczynnik wariancji [%]	134.18	33.33	50.00	17.40	32.47	20.38
Median – Mediana [mg · kg⁻¹]	0.33	0.004	1.74	323.35	426.88	44.70

Mercury is another very important element, because mercury compounds belong to the most toxic chemicals. Inorganic as well as organic mercury compounds are intensively cumulated in the kidneys, liver, and methylmercury compounds are cumulated in nervous system, causing severe poisoning and even death (Ociepa-Kubicka and Ociepa 2012). The highest mercury concentration was reported from the food no. 5 („junior"), where it amounted to 0.008 mg · kg^{-1}, and this concentration was two times higher than the highest concentration of „adult" foods, where it amounted to 0.004 mg · kg^{-1} (8, 9, 10, 12). The lowest mercury concentration occurred also in a junior feed, and it amounted to 0.001 mg · kg^{-1}. Higher mean mercury concentration occurred in „junior" feed (0.004 mg · kg^{-1}) than in „adult" feed (0.003 mg · kg^{-1}). Mean levels of mercury in animal feeds, exmined by Wang et al. (2013) ranged from 1.1 µg · kg^{-1} to 7.2 µg · kg^{-1}.

Following the Ordinance of the Minister of Agriculture and Rural Development of February 6, 2012 on the undesirable substance content in feeds (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 6 lutego 2012 r.), none of the analyzed samples exceeded the allowable mercury content for the feeding stuffs for dogs, cats and fur animals, which is 0.3 mg · kg^{-1}. The elevated concentrations as compared to the remaining samples were observed for the feed 1 and 5 (junior), which amounted to 0.006 and 0.008 mg · kg^{-1}, respectively.

Lead is another heavy metal characterized by an elevated accumulation coefficient. The metal is absorbed to the organism through the respiratory tract and skin, and less frequently through the digestive tract. All known lead compounds are poisonous. In animals, it causes benign and malignant kidney tumors, endocrine gland tumors, lung adenomas (Ociepa--Kubicka and Ociepa 2012). Higher lead concentrations were reported in the samples of „adult" dog foods, remaining in the range from 0.448–2.250 mg · kg^{-1}. Despite this fact, these values did not exceed the allowable limit value of lead in feeding stuffs for animals, which amounts to 10 mg · kg^{-1} (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 6 lutego 2012 r.). However, the elevated values were reported for the food no. 8, 9, 11 and 12, and amounted to 2.095; 1.393; 2.185; 2.250 mg · kg^{-1} respectively, and these values were approximately seven times lower than the threshold value. Mean lead concentration for „adult" foods was 1.534 mg · kg^{-1} and it was seven times higher than the mean concentration for „junior" foods (0.204 mg · kg^{-1}). The highest value of lead in „junior" food (0.417 mg · kg^{-1}) was approximately five times lower than the highest concentration of lead in „adult" food (no. 12–2.250 mg · kg^{-1}). The study enabled determination, that the highest lead and cadmium concentrations occurred in the food no. 12 (adult). Mercury concentrations in the studied „junior" foods oscillated between 0.001–0.008 mg · kg^{-1}, whereas for the „adult" foods the concentrations had a narrower range from 0.002 to 0.004 mg · kg^{-1}.

The elaboration of the basic statistical parameters allowed to observe, that in the analyzed samples higher standard deviation (0.899 mg · kg^{-1}) occurred in „adult" foods, than in „junior" foods (0.114 mg · kg^{-1}), thus it can be determined, that cadmium concentrations for junior foods are more similar, than in the samples of the second type. Similar situation was observed for lead, for which standard deviation for „junior" food samples was 0.204 mg · kg^{-1} and for „adult" foods it amounted to 0.767 mg · kg^{-1}, which also shows that the concentrations for „junior" foods are more homogeneous (Table 3). Coefficients of variation was also calculated for the studied values. Cadmium was characterized by a very high variability („adult" foods), as its coefficients of variation was 134.18%, and for „junior" foods 32.57% and was only averagely variable. High variability was also reported for the mercury concentrations in „junior" food samples (75.0%) (Fig. 1). In both food types, lead was also characterized by high concentration variability („junior" food – 52.4%, „adult" food – 50.0%).

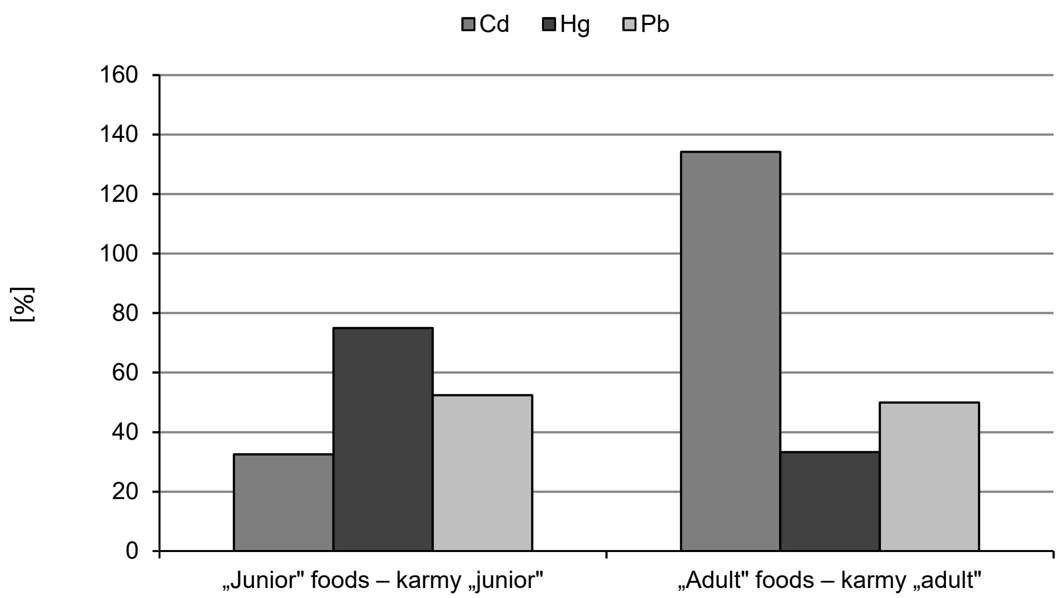

Fig. 1. Coefficient of variation for cadmium, mercury and lead in „junior" and „adult" foods
Ryc. 1. Współczynnik zmienności kadmu, rtęci i ołowiu dla karm „junior" oraz „adult"

The present study also focused on the iron, zinc and copper content, as these metals in the proper concentrations are necessary for the proper functioning of organism. The study demonstrated higher mean concentrations of zinc and copper in „adult" foods than in „junior" foods, which were as follows: 331.766–313.762 mg · kg^{-1}; 42.871–22.947 mg · kg^{-1} (Table 3). However, a reversed situation was observed for iron: higher mean iron concentration was observed in „junior" foods (677.526 mg · kg^{-1}) than in „adult" foods (392.817 mg · kg^{-1}).The highest iron concentration occurred in a „junior" food, and amounted to 1034.614 mg · kg^{-1}, being two-fold higher than in „adult" foods: 533.204 mg · kg^{-1}. Highest concentrations in „adult" foods occurred also for zinc and copper (439.773; 51.862 mg · kg^{-1}). Mean concentration of zinc was nearly as twice as high, than one examined by Alomar et al. (2006) in commercial dry dog foods, amounting 180.2 mg · kg^{-1}, while mean contents of copper was somewhat higer than in examined „junior" dog foods, amounting 29.5 mg · kg^{-1}. Comparing to Alomar et al. (2006), mean contens of iron were nearly twice lower in commercial dog foods available in trade in Chile (353.8 mg · kg^{-1}), than in examined „junior" dog foods, whereas concerning „adult" foods, they were comparable. Analyzed heavy metals were characterized by a variable coefficient of variation for both groups, as well as individual foods. Average variability characterized zinc values („junior" food) and copper concentrations, both in „junior" as well as „adult" foods. On the other hand, in adult food, zinc was characterized by low variability (17.40%). Iron concentration values had average variability in „adult" foods, whereas for „junior" foods the variability was high (40.048%). Summing up, it has to be emphasized, that heavy metal (Cd, Hg, Pb) concentrations in the examined foods did not exceed allowable, according to state regulations. This was except for the food no. 12 („adult"), for which allowable threshold was exceeded.

CONCLUSIONS

1. Cadmium was the metal, for which the threshold was exceeded in dog foods („adult" food) and its concentration was 2.499 mg · kg^{-1} (limit 2 mg · kg^{-1}).
2. Higher mean concentrations of cadmium, lead, zinc and copper occurred in „adult" foods than in „junior" foods.
3. The highest coefficient of variability characterized cadmium in foods for adult dogs.

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Abstract. Increasing interest in pet animals, particularly dogs, enforces paying special attention to their nutrition. Twelve food types were selected for the study, divided into food for young dogs („junior") and mature dogs („adult"). Heavy metals that are harmful for organism (cadmium, mercury, lead) were selected for the study, as well as these, which in certain amounts are necessary for its proper functioning (copper, iron, zinc). Concentrations of heavy metals such as: cadmium, mercury and lead were compared with the Ordinance of the Minister of Agriculture and Rural Development of February 6, 2012 on the undesirable substance content in feeds, demonstrating the limits of the analyzed metals (cadmium, mercury, lead). The study has demonstrated, that cadmium is the metal that exceeds acceptable standards and its concentration was 2.499 mg · kg^{-1} (limit 2 mg · kg^{-1}). Foods for adult dogs contained higher mean heavy metal concentrations (cadmium, lead, iron, copper, zinc) than „junior" foods, excepts for mercury and iron, for which higher concentrations were observed for „junior" foods. The study has demonstrated exceeding of allowable concentration limit only for cadmium (adult food), the concentration of which was 2.499 mg · kg^{-1} (limit 2 mg · kg^{-1}).