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THE CONCENTRATION OF HEAVY METALS IN BEEF PRODUCED WITH THE USE OF TRITICALE IN THE DIET OF ANIMALS WITHIN THE MAN-INDUCED IMPACT ZONE

КОНЦЕНТРАЦІЯ ВАЖКИХ МЕТАЛІВ У ЯЛОВИЧИНІ, ВИРОБЛЕНІЙ У ЗОНІ ТЕХНОГЕННОГО НАВАНТАЖЕННЯ, ПРИ ВИКОРИСТАННІ В РАЦІОНАХ ТРИТИКАЛЕ / Ю.І. Савченко, І.М. Савчук, М.Г. Савченко, К.В. Гончарова, Л.І. Чорна.

Мета. **Вивчити накопичення важких металів (Pb, Cd, Cu, Zn) в організмі бугайців при використанні різних доз тритикале в складі кормової зерносуміші в умовах зони Полісся (III зони радіоактивного забруднення).** ***Методи.*** **Сформовано 3 групи піддослідних бугайців: I група (контрольна) — зерносуміш № 1 (без тритикале); II група (дослідна) — зерносуміш № 2 (20% тритикале замість пшениці); III група (дослідна) — зерносуміш № 3 (40% тритикале замість пшениці). Зразки кормів, сечі і калу для визначення важких металів відбирали під час проведення фізіологічного досліду по перетравності поживних речовин раціонів та вивчення балансів азоту, кальцію, фосфору і важких металів. Визначення Pb, Cd, Cu, Zn проводили на атомно-абсорбційному спектрометрі "Квант-2А". Зразки найдовшого м'яза спини та печінки відбирали від 3-х бугайців із кожної групи під час їх контрольного забою.** ***Результати.*** **Концентрація свинцю, міді та цинку в продуктах забою бугайців була нижче ГДК, в той час як рівень забруднення яловичини і печінки кадмієм значно перевищував гранично допустиму концентрацію у тварин усіх піддослідних груп. Найменшим умістом Cd в м'ясі характеризується молодняк ВРХ контрольної групи (зерносуміш: пшениця — 40, люпин — 35, овес — 25% за масою).** ***Висновки.*** **Заміна в складі зерносуміші 20% (за масою) дерті пшениці на аналогічну кількість дерті тритикале при відгодівлі бугайців у III зоні радіоактивного забруднення сприяє значно меншому нагромадженню і переходу свинцю та кадмію в яловичину.**

Ключові слова: тритикале, бугайці, цезій -137, важкі метали, свинець, кадмій, мідь, цинк, баланс.

The range of feed materials for feeding farm animals in Ukraine expands as the years go by. In particular, the enterprizes of Polissya area started the large scale cultivating the grain of fall and spring triticale, which is a wheat and rye hybrid combining the positive features of both varieties. Being less demanding of soils like wheat it provides high yields on fertilized sand clay (35–60 centner/ha), and is well eaten by animals and poultry [1].

The world leader in triticale cultivation is Poland with 840000 ha, or 9,6% of all cereal crops area. The average yield of triticale (grain) in Poland makes up 30 centner/ha. Poland developed a special technology of triticale grain processing, allowing its use up to 80% in the

diet when battening pigs and broiler chickens. In general this country uses 63% of the Triticale croppage in cattle breeding, 22% — in the bakery and confectionery industries. Belarus leads in triticale areas among the CIS countries (more than 350000 hectares, or 15–17% of the cultivated land). About 50% of Belarus triticale grain is used in cattle breeding and 50% — in fermentation industry (beer, alcohol) [2].

Triticale is distinguished by the high yielding potential, the high content of protein and key amino acids. All the above determines its biological and nutritional value as well as the feed quality. The content of protein in triticale is 1,0–1,5% more than that in wheat and by 3–4% in rye respectively. The digestion of wheat and triticale protein is almost the same — 89,3 and 90,3%, respectively. The triticale grain is as good as the wheat in respect of micro- and macroelements [3].

The expansion of triticale cropped land and its use for feeding animals in the Polissya area (radioactively contaminated zone), triggered the necessity for studying the effectiveness of its use in the composition of various grain mixture for feeding bulls as well as the produce quality.

The aim of the research. To investigate the concentration of heavy metals in the bulls beef and liver using different doses of triticale in grain mixtures in the diets in the context of zone III radioactive contamination.

Methodology. The research was carried out in the laboratory conditions of the Polissya Institute of Agricultural Sciences of National Academy of Agriculture in tying conditions. To carry out the scientific-industrial experiment the researchers selected the bulls of Ukrainian black-speckled dairy breed, formed three groups by the method of pair-analogues with regard to origin, age and live weight, the growth intensity of during the period of comparison. The research design is given in table 1.

According to the research design, fattening young stock of (control) group I received a basic diet which consisting of silage corn, maize silage, cereal hay, salt + grain mixture # 1. The animals of group II and III were fed with grain mixtures # 2 and # 3 respectively, instead of grain mixtures # 1 in addition to basic diet. The composition of grain mixtures for feeding bulls in all the experimental groups was different (by weight, %) — group I (grain mixture # 1): fall wheat — 40, sweet lupin — 35, oats — 25; group II (grain mixtures # 2): fall wheat — 20, triticale — 20, sweet lupin — 35, oats — 25; group III (grain mixtures # 3): triticale — 40, sweet lupin — 35, oats — 25. All the feed used for feeding young stock of experimental group were grown in zone III of radioactive contamination due to the Chernobyl accident (v. Grozyno, Korosten district, Zhytomyr oblast).

The diets for feeding experimental bulls during the experiment were were similar in the energy feeding value, metabolic energy concentration and provided with protein and mineral substances aimed at gaining 900–1000 g of daily increase in live weight. The type of feeding animals is silage-concentrated. The nutrient density of the feed diets composition for young stock made up: concentrated feed (grain mixtures) — 34,34–34,40% rough feed — 9,78–9,79 and succulent feed (corn silage) — 55,82–55,87%.

The concentration of metabolizable energy in 1 kg of ration dry matter for fattening bulls made up 9,40–9,58 mJ during the experimental period. Each feeding unit contains 91–94 grams of digestible protein.

The preparation of the plant and animal samples to specify heavy metals was carried by dry mineralization according to national standard 26929–94 [4] and the analysis — according to national standard 30178–96 [5] at the atomic absorption spectrometer “Kvant-2A”.

The digestible trial was carried out on three animals from every group under the action of the factor under analysis, on the background of the Institute laboratory conditions during the experiment on the bulls according to the methodology suggested by O.I. Ovsyannikov to study the nutrients digestibility, the balance of nitrogen, calcium, phosphorus and heavy metals (Pb, Cd, Cu, Zn).

1. The research design

Groups	The number of animals in the group, unit	Experimental periods	
		comparative (21 days)	investigative (153 days)
I — control	7	BD (basic diet) — maize silage, cereal hay, salt + grain mixture # 1	BD + grain mixture # 1
II — experimental	7	BD + grain mixture # 1	BD + grain mixture # 2
III — experimental	7	BD + grain mixture # 1	BD + grain mixture # 3

After the experiment completion, three typical animals from each group were selected by for control slaughter according to national standard 1213–74. The slaughter was carried out in the workshop of Korosten manufacturing trading marketing enterprise. The samples of liver and the longest dorsi muscle (300–400 g by weight) between 9th and 12th ribs from the right semi-carcass after 48-hour refrigeration at 4°C were taken to carry out the heavy metals analysis of meat.

The research materials were processed according to the method of variation statistics (N.A. Plokhynskyy, 1969) [7].

The findings of the investigation. To solve the problem of providing the population with ecologically clean production it is necessary to carry out the research aimed at studying the ways of heavy metals migration (cadmium, lead, copper and zinc) in the succession feed → animal body → production (milk and meat) as well as their clearance.

The analysis of heavy metals content showed that almost the same amount of lead and copper while the amount of zinc and cadmium was different in the body of the young cattle of all experimental groups, kept in zone III of radioactive contamination due to the Chernobyl accident (table 2).

Thus, the concentration of lead and copper in average daily diet has fluctuated around the experimental groups of bulls in minor limits and amounted 18,896–19,036 mg and 26,52–27,14 mg, respectively. However, due to the greater content of Cd and Zn in grain mixtures #2 and #3, the concentration of these elements in the average daily diets of young livestock of II and III experimental groups was the largest — 0,240–0,254 mg and 92,14–95,94 mg, respectively. The difference for cadmium in respect to I group made up 0,019–0,033 mg (8,6–14,9%), while the amount of zinc was 2,51–6,31 mg (2,8–7,0%).

The content of heavy metals in meat is one of the important indicators of quality in conditions of anthropogenic pollution of farmland and feed with toxic elements. The investigation of the heavy metals level in the longest dorsi muscle and liver of experimental animals proved that the amount of lead, copper and zinc was significantly less than the maximum allowable concentration and met the requirements of ecologically clean production animal products (table 3).

2. The concentration of heavy metals in the average daily diet, mg

Feed		Heavy metals			
		Pb	Cd	Cu	Zn
Maize silage		15,228	0,131	15,73	41,15
Cereal hay		2,988	0,027	3,27	10,90
Grain mixture:	# 1	0,820	0,063	7,52	37,58
	# 2	0,762	0,096	8,14	40,09
	# 3	0,680	0,082	7,84	43,89
Total, mg:	group I	19,036	0,221	26,52	89,63
	group II	18,978	0,254	27,14	92,14
	group III	18,896	0,240	26,84	95,94

3. The contamination level of products of bulls slaughter with heavy metals, mg/kg of natural substance

Groups	Heavy metals			
	Pb	Cd	Cu	Zn
The longest dorsi muscle				
I — control	0,181±0,082	0,645±0,322	0,29±0,03	13,56±0,73
II — experimental	0,123±0,047	0,488±0,249	0,26±0,02	13,83±0,74
III — experimental	0,177±0,078	0,731±0,349	0,28±0,01	16,16±0,38
MAC	0,50	0,05	5,0	70,0
Liver				
I — control	0,305±0,037	0,923±0,082	11,52±0,43	19,71±0,48
II — experimental	0,265±0,008	0,689±0,410	7,15±1,54	22,14±2,69
III — experimental	0,269±0,025	0,877±0,044	6,90±0,59	17,73±0,46
MAC	0,60	0,30	20,0	100,0

The concentration of lead, referring to the cumulative toxins, in the bulls longest dorsi muscle of the control group as compared to experimental groups II and III appeared to be greater by 0,058 mg/kg or 47,1%, and 0,004 mg/kg, or 2,3%, respectively. A similar trend is observed in respect to the accumulation of lead in the liver of young livestock. The lead content in this organ was also greater in animals of group I regarding the analogues from the experimental groups by 13,4–15,1%.

The contamination level of bulls slaughter products with cadmium exceeded the maximum allowable concentration. Thus, this parameter in the longest dorsi muscle and liver of experimental animals was 9–9 and 2,3–3,1 times more, respectively, than the existing regulatory requirements. The beef and liver of young livestock of the II (experimental) group contained less concentration of cadmium by 24,3–33,2 and 21,4–25,4%, respectively, than in group I and III analogues.

The concentration of copper in the products was low (0,26–0,29 mg/kg in beef and 6,90–11,52 mg/kg in the liver) and did not exceeded MAC (5,0 and 20,0 mg/kg, respectively). However, the highest content of copper was observed in the products from the control group animals fed with the diets containing grain mixture #1. According to this indicator they dominated over the analogues experimental groups by 3,6–11,5% in the longest dorsi muscle and by 61,6–67,0% in the liver.

The concentration of zinc was greater in the bulls longest dorsi muscle of group II in respect to the analogues of I and II groups by 2,60 and 2,33 mg/kg, respectively, whereas this parameter being the highest in the young livestock liver of group II (22,14 mg/kg).

The parameter characterizing the contamination of animal products with heavy metals according to their admission into the animal body along with the feed diets is the transition coefficient. The lead transition coefficients from the diet into the bull longest dorsi muscle were low and fluctuated within minor limits — 0,65–0,95% (table 4). However, this parameter proved to be the lowest in the young livestock fed with the grain mixture with 20% ground triticale (experimental group II), as compared with the analogues of group I and III with the intergroup difference amounting to 0,29–0,30% of the absolute.

The data from table 2 show that the concentration of cadmium in the bull average daily diet was low and amounted to 0,221–0,254 mg. At the same time, its content in both the longest dorsi muscle and the liver of the experimental animals turned out to be considerable and fluctuated within 0,488–0,731 mg/kg and 0,689–0,923 mg/kg, respectively. Therefore, the Cd transition coefficients into the beef and liver were high and made up 192,1–304,6%; 271,3–365,4%, respectively. However, this parameter proved to be the lowest in the bulls of group II (192,1 and 271,3%, respectively) being below the analogues from the other groups by 99,7–112,5 and 57,2–94,1% of the absolute.

A similar pattern is observed in respect to the accumulation of Cu and Zn in the young livestock products. Therefore, the transition coefficients of copper and zinc into into the longest dorsi muscle were the least in animals of group II (0,96 and 15,01% respectively), being less than in the bulls of and group I and III by 0,08–0,13% and 0,12–1,83% of the absolutes, respectively. The lowest transition coefficient of copper and zinc was observed in the liver of the bulls fed with the diets containing grain mixture # 3 with the maximum amount of ground triticale (40% by weight) — 25,71 and 18,48%, respectively.

Thus, the results of the research proved that the heavy metals are accumulated in the slaugh-

4. The transition coefficients of heavy metals into the bulls products, %

Groups	Heavy metals			
	Pb	Cd	Cu	Zn
The longest dorsi muscle				
I — control	0,95	291,8	1,09	15,13
II — experimental	0,65	192,1	0,96	15,01
III — experimental	0,94	304,6	1,04	16,84
Liver				
I — control	1,60	328,5	43,44	21,99
II — experimental	1,39	271,3	26,34	24,03
III — experimental	1,42	365,4	25,71	18,48

5. The average daily balance of Pb and Cd in the body of fattening bulls, units

Groups	Consumed with feed	Got out of the organism				Remained in the organism	
		with feces		by urinary way			
		g	%	g	%	g	%
Pb balance							
I	18,865	0,176±0,108	0,93	0,364±0,172	1,93	18,325	97,14
II	18,839	0,331±0,082	1,75	0,344±0,012	1,82	18,164	96,43
III	19,213	0,169±0,140	0,88	0,356±0,009	1,85	18,688	97,27
Cd balance							
I	0,249	0,122±0,009	49,00	0,017±0,008	6,83	0,110	44,1
II	0,275	0,112±0,032	40,73	0,018±0,003	6,54	0,145	52,7
III	0,257	0,129±0,024	50,19	0,015±0,001	5,84	0,113	43,9

ter products in different amounts depending on the feed consumed by the animals. They are accumulated in the body of the young cattle in concentrations much lower (except for cadmium) than in case of their migration through the diet. The replacing 20–40% of ground wheat (by weight) with a similar number of ground triticale in grain mixture while feeding the bulls within zone III of radioactive contamination contributes to much less accumulation and migration of lead and cadmium into the beef.

We investigated the peculiarities of heavy metals exchange in the organisms of fattening bulls (table 5). The object under study were the results of the balance experiment on digestibility and the use of feed.

Feeding the fattening animals the grain mixtures different amounts of ground triticale did not have meaningful positive impact on the lead excretion by urinary way — this parameter fluctuated across the experimental groups within 1,82–1,93% of the consumed.

The inclusion of ground triticale to the grain mixture in the amount of 20% by weight (experimental group) contributed to greater Pb removal with feces: by 0,82% of the absolutes in comparison with the control and by 0,87% of the absolutes as compared to (experimental) group III. Therefore, the body of group II bulls held the lead back by 0,71% less of the absolutes than their analogues from the I group and by 0,84% of the absolutes as compared to group III (96,43% against 97,14 and 97,27).

The balance of the cadmium in the body fattening young livestock was positive as well. The animals of group II excreted Cd with feces less by 8,27–9, 46% of the absolutes as compared to the counterparts from the other experimental groups. With the same amount of cadmium being excreted by urinary way (5,84–6,83%), the body of the bulls of the held it back by 8,56–8,76% of the absolutes more as compared to the group I and III.

The young livestock of the experimental groups consumed approximately the same amount of copper per day — 27,72–28,63 mg. The animals of group III excreted more Cu with feces in comparison with the analogues of group I and II by 13,27 6,36% of the absolutes, respectively (table 6). Thus, the body of the bulls within this group held back less copper by 1,44–3,75 gr as compared to their analogues from the other groups.

6. The average daily balance of Cu and Zn in the body of fattening bulls (n=3; M±m)

Groups	Consumed with feed, mg	Got out of the organism:				Remained in the organism:	
		with feces		by urinary way			
		g	%	g	%	g	%
Cu balance							
I	27,72	15,37±0,02	55,45	0,72±0,10	2,60	11,63	41,95
II	28,53	12,98±1,03	45,50	1,61±0,35	5,64	13,94	48,86
III	28,63	16,19±0,75	56,55	2,25±0,68	7,86	10,19	35,59
Zn balance							
I	96,65	73,63±4,36	76,18	0,85±0,23	0,88	22,17	22,94
II	99,84	81,55±9,01	81,68	1,45±0,12	1,45	16,84	16,87
III	105,69	77,77±7,19	73,59	1,42±0,16	1,34	26,50	25,07

The body of young cattle trace lost both Zn and Cu and with feces (73,59–81,68%) and only a small amount by urinary way (0,88–1,45%). The most amount of zinc excretion with the feces was detected in animals of the II group — 83,13%, whereas this parameter in the analogues of group I and III made up 74,93–77,06%. Therefore, the body of the bulls in this group retained the least amount of Zn — 16,87% and was lower by 6,07–8,20% of the absolutes as compared with the young livestock of the other experimental groups.

Thus, when using 20% of ground triticale in mixture grain (experimental group II), the body of the fattening animals accumulated the least amount of lead and zinc, whereas the body of animals fed with the mixture grain with 40% of ground triticale by weight (experimental group III) the least amount of cadmium and copper.

CONCLUSION

The study proved that the concentration of lead, copper and zinc in the products was considerably less than the MAC, whereas the level of beef and liver contamination with cadmium exceeded regulatory requirements 9,8–14,6 and 2,3–3,1 times, respectively. The replacing 20% of ground wheat (by weight) with a similar number of ground triticale in grain mixture while feeding the bulls within zone III of radioactive contamination contributes to much less accumulation and migration of lead and cadmium into the beef.

The matter of cadmium requires additional studying during the further experiments by means of bulls control slaughtering before their experimental analysis. As much as the young livestock of 130–150 kg by live weight is delivered from another region, it is entirely possible that the considerable Cd accumulation in the body of the animals occurs during the experiments.

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