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INFLUENCE OF DIFFERENT LEVELS OF CADMIUM IN RATION WITH NATURAL DETOXICANT ON PERFORMANCE, DIGESTIBILITY OF SUBSTANCES AND METABOLISM OF NITROGEN IN YOUNG FATTENING PIGS

Наведено результати досліджень щодо використання кормових буряків і яблучних вичавок у ролі детоксикантів важких металів, зокрема Кадмію, в організмі молодняку свиней на відгодівлі. При цьому встановлено, що вміст Кадмію в раціоні на рівні ГДК спричинює погіршення перетравності поживних речовин і засвоєння азоту, унаслідок чого зменшується середньодобовий приріст свиней на 14,43 % та водночас підвищуються затрати корму на приріст на 16,8 %. За уведення в раціон сухих яблучних вичавок (1,5 г/кг маси тіла) чи кормових буряків (7 % від загальної поживності раціону) за підвищеного рівня Кадмію продуктивність і оплата корму у молодняку свиней наближається до рівня контролю.

Ключові слова: кормові детоксиканти, Кадмій, молодняк свиней, продуктивність.

Statement of the problem. Given the dramatic environmental situation, along with various pesticides, herbicides, special danger to human and animal health make heavy metals, in particular, Cadmium, Mercury, Lead, Chromium, and as a result of the accident at the Chernobyl nuclear power plant to the above mentioned heavy metals in the Kiev region and neighboring regions, there were added radioactive elements – Cesium and Strontium. That situation needs a relevant research for the prevention or decrease of their negative impact on animals and humans [1].

Analysis of recent research and publications. Under the influence of anthropogenic factors the chemical composition of air and water is changing, the processes of transformation and degradation (salinity, loss of humus, water and wind erosion, etc.) are more intensive, the structural composition of phytomass changes significantly, there is a functional decomposition of natural ecosystems, which lose the ability for self-cleaning and regeneration [2, 3].

Heavy metals in high concentrations, particularly Cadmium, Mercury, Lead, Chromium, act as the most dangerous poison [4]. They are well absorbed by the soil, especially with high content of humus in it. Their compounds during long time retain high mobility and toxicity, widely migrate from soil to plants, which are a source of food for humans and forages for animals. Getting into the animal body with food, heavy metals accumulate in it and penetrate into production, thus creating the problem for production of organic livestock products. All this leads to the search and development of effective methods of preventing or decrease of penetration of heavy metals, including Cadmium, into animal production, including pigs [5, 6].

Today there are known different methods of removing heavy metals, including Cadmium, from the blood using pectin additives, glutathione, citrate, 2,3-dimercaptosuccinic acid and complexon, that effectively mobilize Cadmium from the internal organs, especially kidneys, which are the first aim for toxic effect of Cadmium [7, 8].

However, the opinion of many researchers tells [9, 10], for prevention as more effective methods of removing heavy metals from the body and reduce their impact on the body of input and output using natural detoxicants, rather than curative, although this cannot reject. Therefore, research on the possibilities and the most efficient use of available feed as natural detoxicants – fodder beet and apple pomace is important.

The purpose and objectives of the study. The purpose of the research was to study the influence of different levels of Cadmium in the diet with natural detoxicants (fodder beet and dry apple pomace) on performance, digestibility of substances and Nitrogen metabolism in young fattening pigs. To achieve this purpose it is necessary to determine the actual content of Cadmium in feed rations of young pigs in growing and fattening, to establish the nature of impact of elevated levels of Cadmium in the ration with natural detoxicants on the dynamics of body weight, feed conversion, nutrient digestibility and Nitrogen balance.

Material and methods of research. The first stage of the research was to study Cadmium content in feed of rations of experimental young pigs. In this case, mixed fodder and its components were analyzed.

For the scientific and economic experiment at APC "Musiyky" 40 heads of young pigs, analog of large white rocks, were selected, which were divided into four groups of 10 goals each, based on date of birth, live weight and origin: I-st group – control group, II-nd, III-d and IV-th groups – experimental ones (Table 1).

Table 1 – Scheme of scientific and economic experiment in young pigs

Group	Terms of feeding	
	preparatory period	main period
I – control	basic ration (BR)	OP
II – experimental	BR	BR + Cd (CH ₃ COOH) ₂ ·2H ₂ O (1 mg/kg DM*)
III – experimental	BR	BR + Cd + apple pomace (1,5 g/kg of live weight)
IV – experimental	BR	BR + Cd + fodder beet (7–8 % of the total nutritiousness of ration)

Note: * – Dry matter (DM).

During the preparatory period, within 14 days, young pigs of all groups were fed the basic ration (BR), which included a complete mixed fodder with mineral additives. At the end of the preparatory period the groups of experimental animals were aligned according to the growth energy (average daily increments) and placed on the main period.

During the main period of the experiment the pigs of the I-st control group received BR – complete mixed fodder while to the basic ration of animals of the II-d, III-d and IV-th research groups was added Cadmium acetate was added to bring the total content of Cadmium in the ration to the maximum permissible level (MPL) – 1 mg / kg of dry matter. In addition to this, to the ration of animals of III-d and IV-th research groups dried apple pomace (1.5 g/kg of body weight) and fodder beet (7–8 % of the total nutritiousness of ration) were included respectively. They fed experimental pigs twice a day with a daily accounting of feed eaten. Pigs of the III-d experimental group ate mixed fodder mixed with apple pomace and animals of the IV-th experimental group ate mixed with chopped fodder beet. Access of animals to water was free.

On the background of scientific and economic experiment physiological (balance) experiment was conducted to study digestibility of nutrients and Nitrogen balance in three animals from each group.

Chemical analysis of biological objects were conducted in accordance with the current methods.

Statistical analysis of the results was performed with the help of the Microsoft Excel program. Probability of difference between the performance was estimated according with the Student's test [1].

Results of research and their discussion. Due to the study of Cadmium content in the feed, which was part of mixed fodder, it was set that among the components natural grain of barley contained the least quantity of Cadmium – 0.068 mg/kg or 0.079 mg/kg of dry matter (DM).

Corn, unlike barley, differed having increased content of Cadmium. While corn of natural moisture contained 0.088 mg/kg of Cadmium, grain barley contained 0.068 mg/kg, which is 29.4 % less. In terms of dry matter of grain difference in Cadmium content in corn compared to barley is even higher – 35.4 %.

In wheat bran Cadmium content was 0.098 mg/kg DM or 0.084 mg/kg of natural feed.

Regarding soybean meal, the dry matter contained 0.081 mg/kg DM of Cadmium or 0.073 mg/kg of natural feed.

Fodder yeast differed increased Cadmium content – 0.114 mg/kg of dry matter and 0.102 mg/kg of natural feed.

As for fodder beet, the content of Cadmium in their dry matter was low and was 0.002 mg/kg of natural feed and 0.018 mg/kg of dry matter.

Overall mixed fodder contained 0.079 mg/kg of Cadmium for natural moisture or 0.088 mg/kg on dry matter basis.

As a result of scientific and economic experiment it was noticed that young pigs of control and experimental groups consumed almost the same amount of food (Table 2).

Table 2 – The actual feed intake experimental animals and their nutritional value, for 1 head per day

Feed	I group (control)	Experimental group		
		II	III	IV
Mixed fodder, kg	2.06	2.06	1.99	1.92
Fodder beet, kg	–	–	–	1.41
Apple pomace, g	–	–	93	–

Cadmium acetate, mg	–	7.382	7.425	7.393
Ration contained:				
feed units	2.26	2.26	2.27	2.28
metabolizable energy, MJ/kg	25.2	25.2	25.1	25.8
dry matter, kg	1.77	1.77	1.78	1.82
digestible protein, g	250	250	251	246
lysine, g	17.72	17.72	17.75	17.07
methionine + cystine, g	9.89	9.89	9.91	9.50
Cadmium, mg	0.163	1.770	1.780	1.820
Calcium, g	18.3	18.3	17.9	17.6
Phosphorus, g	15.2	15.2	14.8	14.8
Iron, mg	268	268	263	261
Copper, mg	23	23	22	24
Zink, mg	165	165	168	159
Manganese, mg	101	101	102	109
Cobalt, mg	2.37	2.37	2.33	2.22
Iodine, mg	0.74	0.74	0.75	0.73
carotene, mg	3.83	3.83	3.83	3.75
vitamin A, thousand IU	9.30	9.30	9.31	9.34

For example, the pigs of I-st control and II-d research groups in average ate 2.06 kg mixed fodder per day during the whole period of the experiment.

As for pigs of the III-d experimental group, the result of adding to their ration of apple pomace, the average daily consumption of mixed fodder was lower than in the control and II-d experimental groups and was 1.99 kg. Amount of apple pomace consumed per day was by 93 g. With regard to of pigs of IV-th experimental group, they ate 1.4 kg of fodder beet and 1.92 kg of mixed fodder a day. Nutritionally, the mass fraction of beets in the ration was 7.5 %.

Except the main feed, the pigs of the II-d, III-d and IV-th research groups received daily 3.751–3.857 mg of Cadmium acetate, or 1.770–1.820 mg of Cadmium element in the composition of mixed fodder.

As the analysis of the dynamics of body weight of experimental animals showed, it was influenced by different levels of Cadmium in the diet and detoxicants – apple pomace and fodder beet (Table 3).

Thus, a body weight of a pig of II-d research group at the end of the experiment was on average 100.4 kg, which is, compared with the control group, 10.8 kg, or 9.71 % less. In connection with this the absolute increase of live weight per head in this group was 64.9 kg, which is 11.0 kg or 14.49 % less than in the control group. As for the average daily live weight gain, in the pigs of II-d group it was 433 g. This is 73 g, or 14.43 % less than in the control animals.

Table 3 – Dynamics of live weight of experimental pig (n=10, M±m)

Indicator	Control group	Experimental group		
	I	II	III	IV
Life weight, kg: at the beginning	35.3±1.04	35.5±1.12	35.2±1.06	35.1±1.10
at the end	111.2±3.00	100.4±2.32	109.7±1.94	108.4±8.5
± before control: kg	–	–10.8	–1.5	–2.8
%	–	9.71	–1.35	2.52
Absolute increase, mg	75.9±3.6	64.9±4.5	74.5±5.1	73.3±4.6
± before control: mg	–	–11	–1.4	–2.6
%	–	–14.49	–1.84	–3.43
Average daily gain, g	506±15.3	433±14.7	497±12.9	489±13.8
± before control: g	–	–73	–9	–17
%	–	–14.43	–1.78	–3.36
The conversion of feed per 1 kg growth, feed units	4.47	5.22	4.57	4.66
In % before control	100	116.8	102.2	104.3

The addition of apple pomace to the ration significantly improved growth rate of pigs of the III-d experimental group compared with animals of the II-d experimental group. Live weight of one pig of

III-d experimental group at the end of the experiment was 109.7 kg, and of the II-d experimental group – 100.4 kg, which is 9.26 % less.

The average daily of live weight gain of pigs of the III-d experimental group exceeded analogues of the II-d experimental group at 64 g or 14.78 %. Given the fact that the level of Cadmium in rations of animal of II and III research groups was the same, increasing growth in pigs of III-d experimental group can be explained by the presence the dry apple pomace in their diet, which, in our opinion, reduced the negative impact of Cadmium on the growth of animals. This, in terms of live weight at the end of the experiment, young pigs of III experimental group ceded to the pigs of the control group only 1.5 kg or 1.35 %.

Regarding the performance of pigs of IV-th research group which ration contained 7.5 % nutritionally of fodder beet, their average daily were lower compared with the animals of the III-d experimental group, only 8 grams or 1.6 %, and compared with control analogues – 17 g or 3.36 %.

Intergroup differences in the intensity of growth of the experimental young pigs caused differences in performance payment of their feed. In particular, the expenses of feed units per 1 kg increase was the smallest in pigs of the I-st control group (4.47 f.u.) and the highest (5.22 f.u.) in animals of the II-d experimental group, which ration did not contain feed detoxicants and the level of Cadmium was the same as in rations of animals of III and IV research groups. Feed fees for pigs of III-d and IV-th research groups which consumed the rations with, respectively, apple pomace and fodder beet, was almost equal to control group – 4.57 and 4.66 to 4.47 f.u.

So, presented data of productivity and feed fees of experimental pigs indicate deterioration of the high content of Cadmium in the ration (II-d experimental group) and a marked improvement for the introduction in the ration of apple pomace (III-d experimental group) and fodder beet (IV-th experimental group) ($P < 0.05-0.01$).

Study of digestibility coefficients of nutrients in 3 pigs from each group showed their dependence on factors studied (Table 4).

Table 4 – Coefficients of digestibility of nutrients in pigs, % (n=3, M±m)

Indicator	Control group	Experimental group		
	I	II	III	IV
Dry matter	77.1±1.29	70.5±1.45*	75.2±2.16	75.4±2.90
Organic matter	82.2±1.35	75.4±1.32*	79.7±1.94	76.3±2.51
“Crude” protein	78.4±1.62	69.8±2.11*	75.5±1.95	76.1±2.02
“Crude” fat	67.8±1.59	59.7±1.77*	66.95±2.04	67.82±1.67
“Crude” cellulose	35.9±1.12	30.9±1.07*	36.5±1.08	36.6±1.46
BER (nitrogen-free extract matters)	90.6±2.31	80.4±2.13*	88.4±1.97	89.5±2.45

Note: hereinafter * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$ as compared with the control group.

If in the animals of the II-nd experimental group digestibility coefficients of dry and organic matter, crude protein, fat and crude cellulose and nitrogen-free extract matters, compared with the control group, were, respectively, 6.6 %; 6.8; 8.6; 8.1; 5.0 and 10.2 % ($P < 0.05$) lower, in the pigs of the III-d and IV-th research groups because of the adding in the ration of natural forage detoxicants they are almost the same as in the control group.

An important indicator of the efficiency of use of forages in feeding young animals that grows is Nitrogen balance. In our research, increased levels of Cadmium in the ration of pigs of the II-d experimental group had a negative impact not only on the digestibility of nutrients, but also on the sediments and assimilation of Nitrogen in the body (Table 5).

Despite the nearly identical Nitrogen consumption, excreting of it with the feces and urine of pigs of II-d experimental group was higher than in the control analogues at 3.22 g or 9.6 %. At the same time, more Nitrogen was excreted with the feces, which, obviously, can be explained by depressing effect of Cadmium on digestive enzyme system of pigs of II-d experimental group. In this connection, deposition of Nitrogen in the body of these animals, compared with the control group, was lower at 3.99 g or 21.3 %, which also led to reducing the intensity of their growth.

Table 5 – Average daily Nitrogen balance in pigs, g (n=3, M±m)

Indicator	Control group		Experimental group	
	I	II	III	IV
Nitrogen consumed with food	56.09	55.32	56.10	56.04
Discharge from feces	12.12	16.71	12.75	13.39
Digested	43.97	38.61	43.35	42.65
Discharge from urine	21.27	19.90	21.20	20.60
Total allocated	33.39	36.61	33.95	33.99
Postponed in the body	22.70±0.31	18.71±0.23*	22.15±0.27	22.05±0.35
In % of consumption	40.47	33.82	39.48	39.35
In % of digested	51.63	48.46	51.90	51.70

If we compare the relative indexes of efficiency of using of Nitrogen, we can see that in the body of pigs of II-d experimental group there is 6.65 % less Nitrogen regarding consumer number in comparison with the control group, and there is 3.17 % less Nitrogen regarding digested number.

Concerning common emission and accumulation of feed Nitrogen in the body of young pigs of III-d and IV-th research groups, they were approaching the maximum to the control animals. This gives the reason to assert the favorable impact of apple pomace and fodder beet as detoxicants on the negative effect of elevated levels of Cadmium in the ration.

Thus, the use in rations of young pigs in growing and fattening dried apple pomace or fodder beet can significantly reduce the toxic effects of heavy metals, including cadmium, the digestion and absorption of nutrients. So, productivity performance of the animals with elevated level of Cadmium in the ration are almost the same as in their control analogues.

Conclusions and prospects for further research. 1. Increase of Cadmium in the ration to the maximum permissible level (1 mg / kg CP) causes deterioration digestibility of nutrients and Nitrogen balance, resulting in decreased average daily gain of young pigs during growing and fattening compared to control, to 14.43 %, and feed conversion increased by 16.8 %.

2. Introduction to the ration of the maximum permissible level of Cadmium dried apple pomace (1.5 g/kg of body weight) or fodder beet (7–8 % of the total nutritiousness of ration) ensures that the average daily gain of young pigs in growing and fattening maximum is close to control level – 497 g and 489 g to 506 g.

In the future study of the effect of feed detoxicants in the ration with elevated levels of cadmium in rates of protein, carbohydrate, fat and mineral metabolism in young pigs in growing and fattening is topical.

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Влияние различных уровней Кадмия в рационе с природными детоксикантами на продуктивность, переваримость веществ и обмен Азота у молодняка свиней при откорме

Л.С. Дяченко, Т.Л. Сызык, Е.М. Косяненко

Приведены результаты исследований по использованию кормовой свеклы и яблочных выжимок в роли детоксикантов тяжелых металлов, в частности Кадмия, в организме молодняка свиней на откорме. При этом установлено, что содержание Кадмия в рационе на уровне ПДК вызывает ухудшение переваривания питательных веществ и усвоения Азота, вследствие чего уменьшается среднесуточный прирост свиней на 14,43 % и одновременно повышаются затраты корма на прирост на 16,8 %. При включении в рацион сухих яблочных выжимок (1,5 г/кг массы тела) или кормовой свеклы (7 % от общей питательности рациона) на фоне повышенного уровня Кадмия продуктивность и оплата корма у молодняка свиней приближается к уровню контроля.

Ключевые слова: кормовые детоксиканты, Кадмий, молодняк свиней, продуктивность.

Influence of different levels of Cadmium in ration with natural detoxicant on performance, digestibility of substances and metabolism of nitrogen in young fattening pigs

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The results of researches on the use of fodder beet and apple pomace as detoxicants of heavy metals, in particular Cadmium, in the body of young fattening pigs. In this case established that the content of Cadmium in the diet at MPC leads to deterioration of digestibility of nutrients and Nitrogen assimilation, resulting in decreases the average daily live weight gain of pigs on 14.43 % and at the same time rising forage costs for increase at 16.8 %. The inclusion in the diet of dried apple pomace (1.5 g / kg of body weight) or fodder beet (7 % of the total dietary ration) with elevated levels of Cadmium leads that performance and feed conversion in young pigs approaching the level of control.

Key words: feed detoxicants, Cadmium, young pigs, performance, apple pomace, fodder beet, digestibility.

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