

Effect of feeding sorbent and enzymes on heavy metal toxicity in young steers

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Abstract

It seemed to us a topical issue of achieving the goal of research to study the effect of the adsorbent preparations toxfin and MEC celloviridin G20x on the state of ruminal metabolism in fattening gobies, whose diets had an excess content of lead, zinc and cadmium salts. The objects of research were the animals of the Swiss breed. The duration of their fattening was 12 months before they reached the age of 18 months. To intensify growth and activate the processes of digestive metabolism due to better elimination of salts of heavy metals, it is advisable to jointly introduce adsorbent preparations toxfin in the amount of 1 kg/t of feed and the multienzyme complex celloviridin G20x in the amount of 70 g/t in the composition of the diets of fattening young cattle compound feed. Due to the combined feeding of the multienzyme complex and the toxfin adsorbent under the conditions of detoxification of HM salts in young fattening cattle of the 4-experimental group, it was possible to achieve superiority over the analogs of the control group in terms of average daily body weight gain by 11.10%. The consequence of this relative to the control analogs in them was the activation of growth in the rumen of the number of representatives of ciliates (producers of cellulases and amylases) by 54.26% and bacteria of the Flavobacterium vitarumen group (producers of proteinases) – by 29.36%. Due to this, the animals of the 4-test group had a significant ($P<0.05$) superiority over the control analogs in the contents of the rumen in terms of proteinase activity by 4.00%, cellulases – by 1.77% and amylases – by 1.77%. The combined feeding of the tested feed additives provided an increase in the rumen fluid of the bulls of the 4th test group relative to the control analogs of the propionic acid level by 3.00% with a parallel drop in the concentration of oil acids – by 4.7%.

Key words: fattening steers; heavy metals; enzyme preparation; sorbent; growth; digestive metabolism

Introduction

In recent years, domestic consumers' requirements for the environmental safety of the produced beef have sharply increased, taking into account the natural and climatic conditions of each region. One of the most important factors directly affecting the sanitary and hygienic properties of the meat of fattened gobies is the level of soil and forage crops contamination with various toxicants in the region. In a number of constituent entities of Russia, with a well-developed infrastructure of metallurgical enterprises (including on the territory of the Republic of North Ossetia - Alania), one of the key environmental factors negatively affecting the quality characteristics of meat products is the excessive accumulation of heavy metal salts (HM) in feed components of the diets of fattened animals (Temiraev et al., 2012; Osikina et al., 2012; Dubrovin et al., 2012; Kokaeva et al., 2020).

According to a number of researchers (Dzodziewa et al., 2015; Tedtova et al., 2013; Temiraev et al., 2008), excessive intake of HM salts with feed contributes to a decrease in the body weight gain of young ruminants for fattening, deterioration of the environmental safety of the resulting meat products. All these negative environmental consequences are due to the manifestation of a depressing effect on the state of the digestive metabolism of heavy metal ions in fattening animals. This problem is aggravated by the ability of HMs to gradually accumulate in the organs and tissues of gobies, to poison their body, helping to inhibit metabolic processes, reducing meat productivity and the quality of beef produced.

Under these conditions, one of the most effective ways of detoxification of HM salts is the introduction of feed preparations into their diets, adsorbents that bind them firmly on their surface in the gastrointestinal tract (GIT) and remove them from the animal's body, thereby increasing the ecological purity of meat gobies. Moreover, in the practice of feeding young ruminants on fattening, feed preparations of adsorbents of a new generation are being introduced more and more often. They often exhibit synergistic effects on metabolic processes with a wide range of biologically active additives (BAA), including multienzyme complexes (MEC) (Chabaev et al., 2018; Temiraev et al., 2020; Hamikoeva et al., 2021).

In this regard, it seemed to us a topical issue of achieving the goal of research to study the effect of the adsorbent preparations toxfin and MEC celloviridin G20x on the state of rumen metabolism in fattening gobies, whose diets had an excess content of lead, zinc and cadmium salts.

Material and methods

To solve this goal on the principle of analogous pairs in the conditions of the feeding farm SPK «Vesna» (RNO – Alania, Russia)(Longitude: 44° 40'04 " East, Latitude: 43° 02'12 "North. Altitude: 671 m), 4 groups of fattening bulls at the age of 6 months, 10 heads in each, were formed. The objects of research were the animals of the Swiss breed. The duration of their fattening was 12 months before they reached the age of 18 months. In the course of the research and production experience, the adsorbent preparations toxfin and MEC celloviridin G20x were consumed by young animals of the compared groups in the composition of mixed fodders by stepwise mixing with other ingredients in accordance with the nutritional standards of the Russian Agricultural Academy (2003) according to the scheme shown in Table 1. The content of HM ions (Zn, Pb, and Cd) in the rations (summer) for experimental animals (Table 2) was determined using an atomic adsorption spectrometer.

Celloviridin G20x - the drug is obtained by drying the filtrate obtained by submerged cultivation of the fungus *Trichoderma reesei* (viride) in a spray dryer. Fine, hygroscopic, amorphous powder from light yellow to dark brown, containing a complex of enzymes capable of hydrolyzing plant polysaccharides - cellulases, glucanases, xylanases, hemicellulases and others. Produced with cellulolytic activity of 200 units/ g, 1000 units/ g and 2000 units/ g. The manufacturer of the drug is the Berdsk plant (Novosibirsk region, Russia). The rate of input into compound feed is 50-100 g / t of compound feed.

Dry Toxfin is a feed additive designed to absorb aflatoxin from feed for farm animals and poultry. The company is the manufacturer of the drug Kemin Industries Inc.(USA). As the main components, Toxfin contains sepiolite and bentonite-montmorillonite. The sorption capacity of the drug is at least 95%. Externally, it is a beige powder with a greenish tint. Practically insoluble in water. The input rate is 1-5 kg / ton.

In the selected feed samples, the content of HM salts was studied and their content was determined in the composition of the winter and summer rations for feeding the bulls of the compared groups. So, in the composition of the winter diet of the experimental animals, an excess of the maximum permissible concentrations (MPC) for zinc concentration was observed by 67.6-67.9%, lead– by 63.0-64.2%, and cadmium– by 59.4-60.5%, in the composition of the summer diet this excess of the MPC values for the indicated elements was 65.1-66.2 %, 61.0-62.4 % and 63.1-65.2 %.

Scar fluid samples were collected through the esophagus using a medical probe. The amount of volatile fatty acids (VFA) was determined by steam distillation in a Markgam apparatus. The content of heavy metal ions (HM) was determined by the atomic adsorption method on an AAZ-115-M1 spectrophotometer. Taking into account the difficulty of obtaining the contents of the rumen, the effect of the tested preparations on the state of ruminal metabolism in fattening young animals was studied according to generally accepted methods for only 3 animals from the 1-control group and the 4-experimental group with the best productivity.

The obtained digital material was subjected to mathematical processing with the calculation of the Student's criterion.

Table 1 – Scheme of scientific and economic experience (n=10)

Group	Feeding features
I-Control	Basic ration (BR), in which an excess content of Zn, Pb and Cd salts was wound
II	BR + MEC celloviridin G20x in the amount of 70 g / t of compound feed
III	BR + adsorbent toxfin in the amount of 1 kg / t of compound feed
I	BR + MEC celloviridin G20x in the amount of 70 g / t of compound feed + adsorbent toxfin in the amount of 1 kg / t of compound feed

Table 2 - Daily ration for experimental bulls at the age of 6-9 months

Index	Required by the norm	Contained
Green mass oats + vetch, kg	-	22
Cereal-grain mixture, kg	-	1.7
Era-3 concentrate, kg	-	0.3
Table salt, g	30	30
Complex of salts of microelements, g	-	2.41
Disodium phosphate, g	-	31
The diet contains:		
exchange energy, MJ	43.0	49
dry matter, kg	5.4	5.86
digestible protein, g	565	566
crude fiber, g	1135	1234.2
starch, g	735	785.4
calcium, g	41	47.5
phosphorus, g	26	25.8
zinc, mg	245	524.3
lead, mg	-	124.26
cadmium, mg	-	10.27

Results and Discussion

The dynamics of the growth of the experimental bulls was observed following the results of the control individual weighing once a month. The weighing data at the beginning and at the end of the experiment for fattening young ruminants are shown in Table 3.

According to the results of the studies, it was found that by the end of fattening at the age of 18 months, the animals of the 4-experimental group had the highest body weight, which, according to this indicator, outstripped the bulls of the control group by 29.20 kg ($P < 0.05$) or 6.86% ($P < 0.05$). Based on these data, in terms of gross growth, young animals from the 4-test group also outstripped the control analogues by 28.30 kg ($P < 0.05$).

Due to the combined feeding of the multienzyme complex and the toxfin adsorbent under the conditions of detoxification of HM salts in young fattening cattle of the 4-experimental group, it was possible to achieve superiority over the analogs of the control group in terms of average daily body weight gain by 11.10%. Moreover, the difference between the animals of the compared groups was statistically significant ($P < 0.05$).

In the course of the experiment, the researchers found that when feeding the fattening gobies with the phytase enzyme with the adsorbent chelaton, an increase in live weight and an improvement in their slaughter indicators occurred (Osikina et al., 2012).

Taking into account the complexity of taking samples of ruminal fluid and conducting studies of their chemical composition, as mentioned above, we studied the effect of the tested dietary supplements on the indicators of the state of digestive metabolism in bulls from the 1-control and 4-experimentagroups. Table 4 shows data characterizing changes in the number of a number of microflora representatives, the pH value of the medium and the concentration of ammonia in the contents of the rumen of the animals of these groups, under the influence of the conditions of their feeding.

Under the conditions of using an adsorbent and an enzyme preparation for the removal of HM salts from the body, the pH value of the rumen fluid medium and the ammonia content in it in animals of the two compared groups were practically the same. This is justified by the fact that there were no significant ($P > 0.05$) differences according to these parameters characterizing the intensity of digestive metabolism in young animals of the indicated groups.

At the same time, under the influence of the synergistic action between the tested preparations, the elimination of HM ions (Zn, Pb and Cd) from the body in the fattening bulls of the 4-test group was more effective. The consequence of this relative to the control analogs in them was the activation of growth in the contents of the rumen of the number of representatives of ciliates (producers of cellulases and amylases) by 54.26% ($P < 0.05$) and bacteria of the *Flavobacterium vitarumen* group (producers of proteinases) – by 29.36% ($P < 0.05$).

Table 3 – Changes in live weight in experimental animals(n = 10)

Index	Group of bulls			
	I-control	II	III	IV
Live weight/ head, kg:				
at the age of 6 months	160.90±0.42	160.80±0.26	160.70±0.43	160.80±0.58
at the age of 18 months	425.60±1.67	446.30±2.22	445.50±1.46	454.80±2.13
Live weight gain, kg	264.70±1.52	285.50±1.88	284.80±1.37	293.00±1.92

Table 4 – Changes in the number of a number of microflora representatives, the pH value of the medium and the concentration of ammonia in the contents of the rumen of animals (n=3)

Index	Group of bulls	
	I-control	IV
Number of ciliates, thousand/ ml	457.0±4.22	705.0±4.11
Flavobacterium vitarumen, thousand/ ml	125.0±0.34	163.0±0.45
Ammonia level, mg %	18.84±0.17	18.92±0.30
pH of the medium	7.22±0.09	7.24±0.13

Table 5 – Changes in the activity of enzymes in the rumen fluid of experimental animals (n=3)

Name indicator	Group of bulls	
	I-control	IV
Activity analysis: amylase, mg starch	23.78±0.42	25.49±0.42
cellulase,%	16.30±0.31	18.07±0.46
proteinase,%	42.68±0.30	46.68±0.45

Table 6 – Changes in VFA concentration in the contents of the proventriculus experimental animals (n=3)

Index	Group of bulls	
	I-control	IV
amount of VFA, mmol/ 100 ml	8.11±0.35	9.79±0.43
Molar ratio of VFA,%:		
acetic	63.50±0.78	63.30±0.71
valerian	1.60±0.49	1.70±0.52
nylon	1.20±0.41	1.00±0.33

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These types of protozoa and microorganisms inhabiting the rumen of ruminants, as mentioned above, actively produce enzymes of the hydrolase class, which contribute to the intensification of the destruction of protein, fiber and starchy feed compounds in the contents of the rumen of fattened young cattle. This position is confirmed by the results of changes in the activity of the analyzed enzymes in the rumen fluid of the animals of the compared groups under the influence of the tested drugs, shown in Table 5.

As shown in Table 5, the combined use of HM in diets with an excess content of HM salts due to an increase in the number of these representatives of beneficial microflora made it possible to activate the processes of digestive metabolism in gobies. Due to this, the animals of the 4-test group had a significant ($P<0.05$) superiority over the control analogs in the contents of the rumen in terms of proteinase activity by 4.00%, cellulases – by 1.77% and amylases – by 1.77%. This contributed to a better level of digestion and assimilation of protein, fiber and nitrogen-free extractives (NFE) of rations by young animals of the 4-test group versus control analogues.

It has been experimentally proven that when the enzyme preparation pectofetidin P10x in combination with bentonite was introduced into the feed of fattening gobies, the number of ciliates, the activity of proteinases and cellulases increased in the rumen of animals of the experimental group, which contributed to the optimization of the amount of volatile fatty acids (VFA) (Chabaev et al., 2018; Temiraev et al., 2020). The results of our studies are consistent with the indicated experimental data.

With an increase in the breakdown of poorly and readily soluble polysaccharides of feed under the action of enzymes secreted by the microflora of the gastrointestinal tract, their metabolites in the rumen of ruminants are actively fermented to form volatile fatty acids (VFA). By participating directly in the metabolic processes of VFA,

they can influence the growth rate of young cattle for fattening while reducing the risk of intoxication with HM salts. The data of the influence of the tested feed additives on changes in the concentration of VFA in the contents of the rumen of the experimental animals are shown in Table 6.

It was found that due to the combined feeding of MEC preparations celloviridin G20x and toxfin, the processes of detoxification of HM salts were more efficient, therefore, fattening bulls of the 4-experimental group in the rumen fluid accumulated VFA more actively, reliably ($P<0.05$) outstripping the animals of the control group in this indicator by 1.68 mmol/100 ml or 20.71%. There were practically no significant differences in the concentration of acetic, valeric and caproic acids in the rumen liquid between the bulls of the compared groups.

Propionic acid is of more importance among the representatives of VFA for intensifying the growth of fattened young ruminants. Moreover, often its concentration in the rumen has an inverse biological relationship with the content of an undesirable representative of VFA - butyric acid.

As shown empirically, when optimizing the processes of digestive metabolism due to the rational use of cellulolytic enzymes in diets in young cattle, the amount of propionic acid in the rumen increases with a decrease in the mass fraction of propionic acid (Kokaeva et al., 2020).

As can be seen from the data obtained, shown in Fig. 3, the combined feeding of the tested feed additives provided an increase in the rumen fluid of the bulls of the 4th test group relative to the control analogs of the propionic acid level by 3.00% ($P<0.05$) with a parallel drop in the concentration of oil. acids – by 4.7% ($P<0.05$). The obtained research results are consistent with the changes in the average daily body weight gain of the fattening young animals of the compared groups with the effective use of an adsorbent and a multienzyme complex for removing HM salts from the body.

Conclusion

Consequently, to intensify growth and activate the processes of digestive metabolism due to better elimination of salts of heavy metals, it is advisable to jointly introduce adsorbent preparations toxfin in the amount of 1 kg/t of feed and the multienzyme complex celloviridin G20x in the amount of 70 g/t in the composition of the diets of fattening young cattle compound feed.

References

- 1) Chabaev M.G., Tedtova V.V., Baeva Z.T., Kononenko S.I., Tarchokov T.T., Chopikashvili L.V. 2018. Effect of different adsorbent doses on the morphological and biochemical composition of blood of bull calves in detoxification of heavy metals. *Journal of Pharmaceutical Sciences and Research*. 5: 1122-1124.
- 2) Dubrovin A.I., Baeva Z.T., Dzodzieva E.S., Biboeva Z.Ya. 2012. Ecological and nutritional evaluation of different beef breed bulls fattening on diets with excess heavy metals content. *Animal Science*. 4: 14.
- 3) Dzodzieva E.S., Kokaeva M.G., Temiraev R.B., Abramova G.A., Gurtsieva D.O. 2015. Comparative Assessment of the Quality of Meat of Gobies Fattened in the Technogenic Zone. *Meat Industry*. 2: 46-48.
- 4) Hamikoeva, S.R. Temiraev R.B., Chabaev M.G., Tsis E.Yu., Gappoeva V.S., Khabaeva Z.G., Gagloeva A.R. 2021. Effect of adsorbent and enzyme preparations on productivity of fattening steers with diets containing heavy metals. *Journal of Livestock Science* 12: 60-64. doi. 10.33259/JLivestSci.2021.60-64.
- 5) Kokaeva M.G., Temiraev R.B., Dzhaboeva A.S., Osikina R.V., Gazzaeva M.S., Shugusheva L.H., Sattsaeva I.K., Nerovnykh L.P., Arutyunova G.Y., Efendiev B.S. 2020. Method for increasing the ecological and food values of milk and dairy products. *Journal of Livestock Science* 11: 14-19.
- 6) Osikina R.V., Baeva Z.T., Dzodzieva E.S., Tsopanov Z. Ya. 2012. Assessment of the meat qualities of gobies of different breeds fed in the technogenic zone of North Ossetia – Alania. *Bulletin of the Mountain State Agrarian University. –Vladikavkaz. – V. 49. – № 1-2: 95-98.*
- 7) Tedtova V.V., Baeva Z.T., Dzodzieva E.S., Smelkov Z.A., Tsopanov Z. Ya. 2013. Morphological and biochemical parameters of the blood of Hereford gobies during the detoxification of heavy metals in feed. *Bulletin of the Mountain State Agrarian University. – V. 50. – № 3: 127-130.*
- 8) Temiraev R.B., Kairov V.R., Khamitsaeva E.S., Tuaeveva T.K. 2008. Heavy metal contamination: how to keep pork safe. *Compound feed*.4:34-35.
- 9) Temiraev R.B., Sukhanova S.F., Tarchokov T.T., Osepchuk D.V., Baeva Z.T., Kubatieva Z.A., Kozhokov M.K., Kaloeva Z.Yu., Khmelevskaya A.V. 2020. Effect of adsorbents in diets on production efficiency of broiler with high nutritional and ecological characteristics. *Journal of Livestock Science* 11: 26-32. doi. 10.33259/JLivestSci.2020.26-32.
- 10) Temiraev R.B., Kokaeva F.F., Tedtova V.V., Baeva A.A., Khadikova M.A., Abaev A.V. 2012. A method of increasing the dietary qualities of meat and improving metabolism in broiler chickens in the technogenic zone of the Republic of North Ossetia-Alania. *News of the Mountain State Agrarian University. – Vladikavkaz. –V. 49. –№. 4:130-133.*