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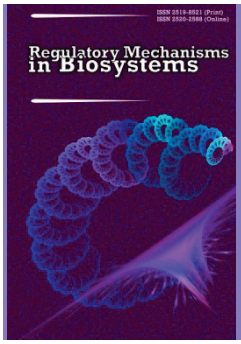

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Effects of mineral supplementation on qualitative beef parameters

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Correct nutrition with sufficient amount of optimal doses of microelements efficiently supports high levels of beef production and health of the animals throughout the feeding period. In the sphere of beef production, microelements are needed as additional supplements to play an important role in the productivity of cattle and the quality of the products made from them. Providing cattle with a more bioavailable source of deficient microelements could increase the metabolic process of the main nutrients, which would affect the intensity of bull growth and slaughter meat parameters. It has been revealed that organic complexes of deficient microelements have greater bioavailability. Throughout the experiment, Ukrainian Black Spotted bulls of 175–200 kg live weight were fed with diets enriched by chelate compounds of microelements with lysine and methionine. Animals of the second group were fed a diet with methionates of microelements in the following doses, mg/kg of live weight: iron – 0.05, cobalt – 0.04, iodine – 0.05 and selenium – 0.02; the third group received lysinates in the same doses of microelements; and the fourth group was given lysinates and methionates in a complex with half-doses of microelements. The studies were carried out using the following methods: zootechnical (productivity), biochemical (chemical blood composition), morphological (weight and sizes of certain tissues and internal organs), physical-chemical and sanitary meat parameters and statistical (mean arithmetic value and its error, significance level of difference between parameters). We found evidence and confirmed the benefits of using microelement supplemention with essential aminoacids in the bulls' diet. Feeding chelate supplement to animals during the second feeding period improved hematological parameters, the productivity and nutrition value of beef. We determined that the best outcomes resulted from feeding bulls with lysinates and methionates in complex with microelements (Fe, Co, Se and I) during the second feeding period. The animals had 26.0% higher mean daily increments and 11.1% greater growth rates, and they grew 25.8% more intensively than the others that consumed only the main diet. The animals of this group had 5.2% higher slaughter yield and 4.8% higher carcass yield. The experimental groups were observed to have lower number of microorganisms in the longissimus layer in one field of view when analyzing impression smears. After 14 days of beef storage, qualitative reactions in the control group were positive with formaldehyde, sulphuric-acid copper, Nessler's reagent and negative with benzidine. The reactions in the samples from experimental groups were doubtful. Less deterioration of beef stored at low positive temperatures (0…+2 ℃) was observed for the samples of experimental groups.

Keywords: bulls; microelements; chelate elements; nutrition; diet; slaughter parameters; meat quality; productivity.

Introduction

Beef plays a significant role in the global nutrition of people and is third most popular source of meat in Ukraine after poultry and pork according to nutrition per person (The statistical collection, 2022). Beef consumption has continued to increase over the recent years. Most of the livestock of fed young cattle in Ukraine are grown in dairy cattle herds (Dovgal, 2020). Increase in beef production is an important task of the agroindustrial complex in supporting the country's food safety. Increases in produced meat per amount of fodder used would improve economic efficiency of livestock farming (Bartoň et al., 2003; Holubenko, 2018). In the complex of measures oriented at increasing meat productivity of young cattle, special attention is paid to complete and balanced diet (Mikhur, 2015; Tsup et al., 2015; Skoromna et al., 2019).

Microelements are significant components of the main nutrition needs of cattle. They take part in physiological, structural, catalytic and regulatory functions, and therefore their inclusion in animals' diet is necessary. Diets can be balanced according to necessary amounts of certain minerals for satisfying animals' needs, whereas low bioavailability of minerals decreases the total share of nutrients in feedstuffs (Kincaid, 1999; Zakharenko et al., 2004). Furthermore, the needs of animals for mineral compounds changes throughout their life cycle. Therefore, the data on mineral needs for support of the organism and growth of young cattle are important for realizing the productive genetic potential. Almost every region of Ukraine has some specifics associated with micromineral nutrition of cattle. Nutrition value of feedstuffs according to mineral elements varies depending on geographic location, type and soil fertility, and also quality of food itself (Kravtsiv & Paska, 2003). The mineral component of any feedstuff depends on species of plants, agrochemical practices during their cultivation, phases of plant vegetation, technologies of storage and feedstuff use.

The positive mechanism through which microelements influence animals was revealed by a number of studies we have carried out. The results suggest that microelements promote increase in activity of enzymes of the digestive system, improvement of availability of nutrients and biologically active compounds, their better use by animal organisms. This results in better coefficient of feedstuff benefits, promoting increase in productive parameters of animals (Niedermayer et al., 2018).

The main source of microelements for animals is feedstuffs and highly-productive animals have increased need of them, and therefore require supplementation with salts of deficient mineral elements (Brandão et al., 2016). In the organism, mineral compounds perform most functions in parallel or in groups, while some of them are antagonists (Kozlowski et al., 2009). The needs for microelements in young cattle are often hard to

fulfill because of various environmental factors such as absence of certain elements or presence of their antagonists in feedstuffs (Arthington & Ranches, 2021). Some elements can replace one another in the formation of organic-mineral compounds.

To realize the genetic potential of animals and poultry and support their health, microelements should be ingested in optimal amounts and proportions (Budde et al., 2019; Prilipko et al., 2019). Perfect balance of mineral elements in feeding agricultural animals and poultry has significant advantage over uncontrolled mineral support (Razanova et al., 2022). Regulation of microelements in diet should take into account the certain role each plays in vital functions of animals and the fact that there is a close relationship between them, and therefore this factor is taken into account when developing new mineral feedstuff supplements.

The importance of microelement supplements to animal feedstuffs is undeniable. Deficiency of microelements is common when attempts are made to satisfy the requirements of cattle using only feedstuff. Introduction of microelements to the animals' diet can be done in the form of protein-energy supplements and minerals based on salt (Feduchka et al., 2010; Marques et al., 2016; Caramalac et al., 2017). Supplements enriched by salt-based microelements are the commonest. In the recent years, there have been discussions on new concepts of mineral bioavalability and inclusion of new additives to animal diets. Differences between inorganic and organic microelements in animal feeding are evident. Inorganic salts of microelements have low biological availability, and therefore are worse metabolized by the animal organism (Costa e Silva et al., 2015). Higher biological availability is characteristic of organic forms of microelements, especially chelate microelements with essential aminoacids.

An important physiological aspect of metabolism of microelements is the degree of stability and dissolvability of the formed compounds which could lead to improvement of growth and decrease in duration of feeding period of bulls (Farionik, 2015; Muegge et al., 2017). Chelate compounds of microelements in feedstuff supplements have better metal-assimilating properties compared with its inorganic form. Genther & Hansen (2014) studied the effects of micromineral condition on growth productivity and characteristics of carcass of meat cattle and the results they obtained indicate that respective microelement nutrition is significant for the development of marbling during raising, as well as during the final phase. Deficiency of mineral compounds is also caused by the duration of feeding with diets lacking minerals, trace mineral status and physiological condition of animals (Moriel & Arthington, 2013; Caramalac et al., 2017). Increasing mineral supplements in diets in order to increase their availability when ingested in organic rather inorganic form maximizes growth potential (Wellmann et al., 2020).

The objective of this study was determining the effect of chelate microelements with methionine and lysine on the intensity of feeding, quantitative parameters of carcasses, physical-chemical and sanitary parameters of beef.

Materials and methods

During the experiments on Ukrainian Black-Spotted Dairy bulls, we followed the principles of the European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific Purposes (ETS No. 123, Strasbourg, 1986) and the Law of Ukraine "On the Protection of Animals against Abuse" (No. 3447-IV as of 06/21/2006 as amended on 08/04/2017).

To conduct the study, we selected 60 Ukrainian Black-Spotted Dairy bulls during their second feeding period. Based on body weight (175–200 kg), prior to the experiment, the bulls were divided into four groups according to paired analogue principle: the control and three experimental, 15 individuals in each (Ibatullin et al., 2017). According to the preliminary results of the study, we determined the optimal doses of microelement chelates that had been used with the diet for young cattle. For a detailed analysis of the influence of chelate microelement supplements with lysine and methionine on the physiological processes and productive parameters of bulls, we carried out studies according to the scheme given in Table 1. At the beginning of the experiment, the bulls were weighed and identified.

Table 1
Scheme of bulls' diet with chelate microelement supplements containing lysine and methionine

Group of animals	Feeding scheme	Doses of introduced mineral supplement, mg/kg of live weight
1 control	MD (main diet)	–
2 experimental	MD + methionate Fe,	0.05
	Co,	0.04
	Se,	0.02
	I	0.05
3 experimental	MD + lysinate Fe,	0.05
	Co,	0.04
	Se,	0.02
	I	0.05
4 experimental	MD + methionate Fe,	0.025
	Co,	0.020
	Se,	0.010
	I	0.025
	+ lysinate Fe,	0.025
	Co,	0.020
	Se,	0.010
	I	0.025

According to the results of the slaughter, we studied pre-slaughter live weight, weight of paired carcasses, weight of tallow, slaughter weight, carcass yield and slaughter yield (Vlizlo et al., 2012). Weight of fresh carcasses was determined 45 min after the slaughter on the industrial scales of accuracy class III.

The results were analyzed using ANOVA. The data in tables are presented as x ± SD (mean value ± standard deviation). Differences between the groups were considered statistically significant at $P < 0.05$ (taking into account the Bonferroni's correction).

Results

Feeding bulls with diets containing methionates and lysines of microelements in deficit (Fe, Co, Se and I) stimulated intense development of the animals during the second feeding period. Parameters higher than the control group were observed in all the experimental animals. The highest growth parameters were seen in animals of the second group that had been fed with the diet with methionate microelements in the following doses (mg/kg of live weight): iron – 0.05, cobalt – 0.04, iodine – 0.05 and selenium – 0.02.

Table 2
Development intensity of bulls fed with methionates and lysinates of deficient microelements (x ± SD, n = 15)

Group of animals	Live weight, kg		Increment		Growth rates, %	Growth intensity, g/kg/day
	at the beginning of experiment	at the end of experiment	total, kg	mean daily, g		
1 control	230.0 ± 3.7	488.8 ± 3.8	258.8 ± 3.5	719.6 ± 5.5	72.04 ± 1.23	3.15 ± 0.07
2 experimental	218.5 ± 3.7	528.8 ± 3.7***	310.3 ± 3.5***	861.7 ± 5.8***	83.08 ± 1.05***	3.88 ± 0.08***
3 experimental	242.4 ± 3.9*	547.7 ± 3.9***	305.3 ± 3.6***	847.8 ± 5.7***	77.25 ± 1.16**	3.52 ± 0.09**
4 experimental	252.5 ± 3.8***	578.7 ± 3.8***	326.2 ± 3.8***	906.1 ± 6.1***	78.46 ± 1.32***	3.56 ± 0.07***

Note: * – $P < 0.05$, ** – $P < 0.01$, *** – $P < 0.001$ differences between the control and experimental groups; MD – the main diet, PVMS – protein-vitamin-mineral supplement.

Compared with the control group, bulls of the second group had 19.9% increase in overall and mean daily increments, 11.1% in growth rates, and 25.8% in growth intensity. Feeding the second-group animals with methionates in the abovementioned doses caused 51.5 kg increase in their live weight, compared with the control group. Those increases in all the mentioned parameters were statistically significant ($P < 0.001$). Mean

daily increment in animals was on average 848-906 g in the experimental groups, and 719 g in the control. The growth rates of experimental-group bulls during the second feeding period increased, equaling 77.3–83.1% against 72.0% in the control, and the growth intensity was 3.5–3.9 against 3.1 g/kg/day in the control group.

Intake of the studied microelements positively influenced the hematological parameters of bulls. We determined increases in the activity of transamination enzymes: 6.7% in the activity of aspartate aminotransferase in the second group, 2.4% in the third group and 10.2% in the fourth experimental group, compared with the control. The increase in the activity of alanine aminotransferase was confirmed to be significant, accounting for 12.1% in the second group, 11.3% in the third, and 14.9% in the fourth (Table 3). We determined increase in the activity of cytochrome oxidase in blood: 4.2% in the second group, 4.0 in the third and 5.4% in the fourth ($P < 0.01$), compared with the control. Introduction of chelate microelements with lysine and methionine aminoacids promoted increase in the activity of succinate dehydrogenase: 9.5% in the second group ($P < 0.05$), 8.8 in the third ($P < 0.05$), and 14.8% in the fourth ($P < 0.01$). There occurred insignificant increases in the glucose concentration in blood of bulls of the experimental groups, by 2.3%, 3.2% and 3.4%, compared with the control. Only in the fourth experimental group,were the results were statistically significant ($P < 0.05$).

Table 3

Hematological parameters of bulls fed with methionates and lysinates of deficient microelements ($x \pm SD$, $n = 10$)

Parameter		Group of animals			
		1 control	2 experimental	3 experimental	4 experimental
Erythrocytes, 10^{12}/L		6.45 ± 0.06	6.89 ± 0.05***	6.72 ± 0.05**	7.10 ± 0.04***
Hemoglobin, g/L		105.2 ± 1.1	108.6 ± 1.2	108.2 ± 1.2	110.4 ± 0.9***
Total protein, g/L		75.3 ± 1.7	80.8 ± 1.6*	81.9 ± 1.6*	83.5 ± 1.6***
Protein fractions, %	albumins	38.84 ± 0.67	41.71 ± 0.66**	41.98 ± 0.65**	42.15 ± 0.66**
	α - globulins	19.38 ± 0.36	18.72 ± 0.43	18.45 ± 0.41	18.24 ± 0.35
	β- globulins	15.07 ± 0.26	14.63 ± 0.30	14.26 ± 0.25	14.02 ± 0.30*
	γ- globulins	26.65 ± 0.51	25.01 ± 0.53*	25.27 ± 0.51	25.56 ± 0.49
Aspartate aminotransferase (AST), mmol/h/L		2.54 ± 0.86	2.71 ± 0.27	2.60 ± 0.86	2.80 ± 0.94
Alanine aminotransferase (ALT), mmol/h/L		1.41 ± 0.75	1.58 ± 0.35	1.57 ± 0.53	1.62 ± 0.65
Cytochrome oxidase (COX), mmol/h/L		9.70 ± 0.15	10.11 ± 0.13	10.09 ± 0.10*	10.22 ± 0.08**
Succinate dehydrogenase (SDH), mmol/h/L		21.09 ± 0.53	23.1 ± 0.52*	22.94 ± 0.54*	24.22 ± 0.59***
Glucose, mmol/L		3.40 ± 0.03	3.48 ± 0.04	3.52 ± 0.04	3.52 ± 0.04**

Note: see Table 2.

Intake of the diets containing chelate compounds of deficient microelements in certain proportions with aminoacids allowed for improvement of the meat productivity parameters of bulls (Table 4). Therefore, feeding animals of the second group with methionates in the following doses (mg/kg of live weight: iron – 0.05, cobalt – 0.04, selenium – 0.02 and iodine – 0.05) caused 3.78% increase in slaughter yield ($P < 0.001$), 3.50% in carcass yield ($P < 0.001$) and 0.28% in visceral fat yield ($P < 0.01$), compared with the control group.

Table 4

Slaughter parameters of the bulls fed with diets containing methionates and lysinates of deficient microelements ($x \pm SD$, $n = 15$)

Parameter	Group of animals			
	1 control	2 experimental	3 experimental	4 experimental
Pre-slaughter live weight, kg	482.3 ± 2.4	521.7 ± 2.5***	540.6 ± 2.6***	569.5 ± 2.8***
Slaughter weight, kg	233.3 ± 3.3	272.5 ± 3.7***	278.2 ± 3.8***	305.6 ± 3.9***
Slaughter yield, %	48.41 ± 0.60	52.19 ± 0.51***	51.42 ± 0.62***	53.61 ± 0.57***
Weight of paired carcass, kg	224.6 ± 3.3	261.6 ± 3.4***	267.3 ± 3.4***	292.9 ± 3.3***
Carcass yield, %	46.64 ± 0.59	50.11 ± 0.56***	49.37 ± 0.56***	51.35 ± 0.59***
Weight of visceral fat, kg	8.72 ± 0.36	10.92 ± 0.41***	10.93 ± 0.43***	12.65 ± 0.40***
Yield of visceral fat, %	1.81 ± 0.04	2.09 ± 0.06***	2.02 ± 0.05***	2.21 ± 0.05***

Note: see Table 2.

The third experimental group was observed to have 3.01%, 2.80% and 0.21% increases in the slaughter yield, carcass yield and yield of visceral fat, respectively, following the intake of diet containing lysinates in the doses of 0.05 mg/kg of live weight, cobalt – 0.04, selenium – 0.02 and iodine – 0.05 mg/kg. The data we obtained were statistically significant ($P < 0.01$). The diet containing methionates and lysinates of microelements in the same doses, particularly iron – 0.025 mg/kg of live weight, cobalt – 0.02, iodine – 0.025 and selenium – 0.01 mg/kg of live weight, which was consumed by bulls of the fourth group, promoted 5.2% increase in slaughter yield ($P < 0.001$), 4.8% in carcass yield ($P < 0.001$) and 0.4% in yield of visceral fat ($P < 0.001$), compared with the control. Therefore, summarizing the data on how feeding bulls with chelate compounds of deficient microelements affects their slaughter parameters, the best results were seen in the fourth group of animals that had been receiving both methionates and lysinates.

During the veterinary-sanitary expertise of carcasses and the internal organs, no visible pathological-anatomical changes were observed. We saw no deviations in the organoleptic parameters of meat of animals of all the groups. Meat had specific smell, characteristic of this particular species, the cut surface of meat was slightly moist, dense, elastic (the meat quickly returned its shape after being slightly pressed with a finger), animal carcasses were light-red or dark-red. The physical-chemical parameters and sanitary properties of meat of animals of the control (first) group and three experimental groups right after the slaughter (paired) and after 48 h storage (cooled) indicate that the meat was of good quality and suitable for maintenance. The data in Table 5 suggest that qualitative reactions with sulfuric-acid copper, formaldehyde, Nessler's reagent in meat of animals after 48 h storage were negative, and the reaction with benzidine (for peroxidase) was positive.

Colour of meat significantly changed after introduction of the studied supplements to the bulls' diet. The colour (colour parameter) of meat was 10.3% ($P < 0.01$) significantly more intensive in animals of the second group, 9.7% ($P < 0.01$) in the third, and 12.8% in the fourth ($P < 0.001$), compared with the first, control, group. In meat of all three experimental groups, pH was somewhat lower than in meat of the control animals at ($P < 0.01$).

The water content of meat in those groups was also lower, though no sanitary confirmation was found. In impression smears from the layer of the longissimus 48 h after the slaughter, we observed singular microorganisms, mostly cocci (1–3 cells) in samples of the experimental groups and 2–3 microorganisms in the control group. After 14-day meat storage, we conducted examinations revealing that the number of microorganisms during the storage increased in all experimental groups. In the samples of meat of bulls of the control group, we found 25–35 microorganisms, 24–31 in the second and third groups, and 22–25 microorganisms in the fourth group. That is, in all the experimental groups, the number of microorganisms in one field of view of the impression smears of longissimus layer was lower than in the control.

Table 5
Physical-chemical and sanitary parameters of beef from bulls consuming the diets with chelate compounds of microelements (x ± SD, n = 15)

Parameter	Group of animals			
	1 control	2 experimental	3 experimental	4 experimental
Examination after 48 h storage				
Number of microorganisms in one view field	2–3	1–3	1–3	1–3
pH	5.84 ± 0.03	5.66 ± 0.03***	5.71 ± 0.03**	5.60 ± 0.04***
Reaction with $CuSO_4$	–	–	–	–
Reaction for peroxidase	+	+	+	+
Reaction for ammonia	–	–	–	–
Formol reaction	–	–	–	–
Colour parameter, E*1000	390 ± 7	430 ± 7***	428 ± 7***	440 ± 7***
Water content	63.0	61.12	60.17	59.62
Examination after 14-day storage				
Number of microorganisms in one view field	25–35	24–31	24–31	22–25
pH	6.34 ± 0.04	6.21 ± 0.03	6.25 ± 0.03	6.10 ± 0.04***
Reaction with $CuSO_4$	+	+ /–	+ /–	+ /–
Reaction for peroxidase	–	+ /–	+ /–	+ /–
Reaction for ammonia	+	+ /–	+ /–	+ /–
Formol reaction	+	+ /–	+ /–	+ /–

Note: see Table 2.

Discussion

An optimal task of feeding is use of feedstuff mineral supplements that have positive effects on the animal organisms and improve growth (Pal et al., 2021; Szacawa et al., 2022) and also slaughter parameters (Ward & Spears, 1997). Da Silva Zornitta et al. (2021) do not recommend using injected microelements on animals under stress during the weaning phase, because it did not improve meat productivity and biochemical variables. Usachenko et al. (2008) provided evidences of benefits of feeding bulls with diets that include microelement supplements. At the same time, the hematological parameters improved, the growth intensity increased by 5.5–11.4%, and the meat coefficient increased by 5.7–22.6%. In the studies by Gryban & Mylostiva (2014), diet correction for bulls of Ukrainian meat breed using microelements in the form of inorganic salts was confirmed to increase the productivity of bulls, slaughter yield (by 6.4–13.2%), and morphological composition of carcasses, improve quailtative meat parameters, and increase its calorie value. The studies by a number of scientists (Edenburn et al., 2016; Wilson et al., 2016; McCarthy et al., 2020) found no effects of minerals included in diets on the intensity of growth of fed bulls, characteristics of carcass and meat quality. Against the background of mineral deficiency of microelements in diet feedstuffs of fed bulls, the results of the studies of feeding bulls with the diet containing methionates and lysinates of deficient microelements (Fe, Co, Se and I) are coherent with the results of a number of studies. After supplementing the diet of Ukrainian Black-Spotted bulls with chelate microelement compounds in different proportions with essential aminoacids during the second period of feeding, the mean daily increment increased by 17.9–26.0%, growth rates by 1.3–11.1%, growth intensity by 12.9–25.8%. Enrichment of the bulls' diet by lysinates of deficient microelements and in complex with methionate and lysinates of microelements stimulated the animals to grow more intensively. Greater increments in live weight were observed in the animals that had been consuming the complex of methionates and lysinates with half-doses of deficient microelements, but the highest growth rates and growth intensity were seen in the bulls that had consumed lysinates with respective microelement doses: iron – 0.05 mg/kg of live weight, cobalt – 0.04, iodine – 0.05 and selenium – 0.02 mg/kg of live weight.

Addition of microelements to the diet of calves of various breeds had no effect on the concentrations of microelements in blood serum, which were within respective ranges and did not differ between those breeds (Pereira et al., 2018). Liu et al. (2022) confirmed improvement of growth productivity of and nutrient metabolism in calves the diet of which had been supplemented with Co. Such a diet also increased the level of glucose in blood and vitamin B_{12}. In the bulls that consumed diets with chelate microelements, there was found no significant effect on hematological parameters, which were within the norm. The studies revealed increases in the activity of transamination enzymes: 10.2% in the activity of aspartate aminotransferase and 14.9% in the activity of alanine aminotransferase. Introduction of chelate microelements with aminoacids caused 5.4% increase in the activity of cytochrome oxidase in blood of the animals and 14.8% increase in the activity of succinate dehydrogenase.

Kitagawa et al. (2018) determined an interrelation between concentration of minerals and relationship of concentration of minerals and physical-chemical characteristics of bull muscles. According to Senechin (2002), the correction of bulls' diets with methionates and lysinates of microelements led to positive changes in physical-chemical and sanitary parameters of beef, which manifested in up to 5.2% increase in slaughter yield, 9.5% increase in the content of dry matter, increase in calorie content of meat, decrease in meat pH, decrease in water content and increase in colour parameter. Möllerberg et al. (1975) determined that introduction of ferrum to calves' diet had no effect on the amount of hemoglobin. On the contrary, it insignificantly decreased, whereas daily increment increased, and expenses for food per kg of increment decreased, the carcass weight was higher, colour and structure of carcasses were 2.5 units higher. The results obtained by the researchers correlate with our study with feeding bulls with methionates and lysinates of deficient microelements, in which the slaughter yield increased by 3.8–5.2%, carcass yield by 2.8–4.8%, depending on dose of microelements introduced to the diet. Higher parameters were produced by supplementing the diet with the complex of methionates and lysinates with half-doses of microelements. There were also improvements in physical-chemical and sanitary parameters of meat, particularly pH level accounted for 5.60–5.71 against 5.84 in the control group after two-day storage. Fourteen days after the slaughter, the meat pH level decreased in the experimental group on average to 6.11–6.25, and to 6.34 in the control. Lower number of microorganisms in one field of view in the longissimus was seen in the samples from experimental groups after 2 days of storage, as well as after 14 days. The greatest difference between the experimental and control samples was after 14 days: 25–35 in the control, 22–31 in the experimental groups. The difference in meat colour and pH can occur because of storage time and composition of animals' diet (Murray, 1989; Page et al., 2001; Nian et al., 2018). Meat colour significantly changed when supplementing the bulls' diet with chelate microelements with aminoacids, 428–440 E*1000 in the experiment and 390 E*1000 in the control.

Conclusions

Intake of chelate compounds of deficient microelements with essential aminoacids (lysine and methionine) improved the hematological parameters and growth intensity of bulls during the second period of feeding. Intake of the diet containing the complex of methionates and lysinates of microelements in half-doses resulted in 5.2% higher slaughter yield, compared with the control. In meat of animals of the control group after 14 days of storage, qualitative reactions were positive with sulfuric-acid copper, formaldehyde, Nessler's reagent, negative with benzidine. The reactions were and doubtful for the samples of experimental groups.

Less deterioration when stored at low positive temperatures (0 to +2 ºC) was observed for meat of the animals of experimental groups. The best parameters were seen in the meat of animals of the fourth experimental group.

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