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The Effectiveness and Advantages of Sapropel In Feeding Steers.

Ivan Fiodorovich Gorlov[1,2]*, Vasiliy Fiodorovich Radchikov[3], Viktor Petrovich Tsai[3], Marina Ivanovna Slozhenkina[1,2], Elena Yurievna Zlobina[1,4], and Ekaterina VladimirovnaKarpenko[1,2,4].

[1]Volga Region Research Institute of Manufacture and Processing of Meat-and-Milk Production, 6 Rokossovskogo Street, Volgograd, 400131, Russian Federation.
[2] Volgograd State Technical University, 28, Lenina Avenue, Volgograd, 400005, Russian Federation.
[3]Scientific Practical Centre of Belarus National Academy of Sciences on Animal Breeding», 11 Frunze Str., Zhodino, Minsk Region, 222163, the Republik of Belarus.
[4] Volgograd State University, 100, University Avenue, Volgograd, 400062, Russian Federation.

ABSTRACT

The article presents the results of studying the rationality of using sapropels in feeding young cattle. The positive effect of sapropels on the growth intensity of steers, their hematological indices and physico-chemical and organoleptic characteristics of meat have been revealed. Adding of sapropels (carbonate or siliceous) into the complete feed has contributed to optimization of ruminal digestion that has been followed by an increase in the nitrogen balance in the rumen2.0-2.4 times and an average daily growth by 11.0 % and 14.7% and made it possible to save up to 6-8% of concentrated feedstuff. Economic feasibility of using sapropels has been confirmed by a decrease in the cost of 1 kg of body weight gain by 0.1 EUR, which enabled to obtain more net profit than in the control by7.4 EUR and raise the level of profitability of beef production by 6.4% on the average. An average increase in the content of hemoglobin, erythrocytes, total protein, albumin, calcium and phosphorus in blood of animals in experimental groups was noted in comparison with the control, which positively influenced the meat production of the steers in experimental groups, as well as the physico-chemical and organoleptic characteristics of beef.

Keywords: bioassay, blood, cattle, gain, profitability level.

**Corresponding author*

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INTRODUCTION

Sapropel is a centuries-old bottom deposit infreshwater habitats that were formed from dead aquatic vegetation anddebris of living organisms, plankton and humus particles [1]. River and pond ooze sapropel has long been used as a fertilizer for increasing soil fertility [2,3]. The content of organic substances in sapropel exceeds 15% [4,5]. If the content of organic substances is lower, the bottom sediments are referred to mineral mud.

The sapropel production technique is environmentally safe and at the same time useful for a habitat becauseit allows the water bodies to rejuvenate, which contributes to the development of both the water body and its environment [6].

In terms of location, resources of sapropel are unequally deposited in the world. Especially intensive formation of sapropels occurs in lakes in the middle zone of Europe and Asia. In the American continent, sapropelic deposits are concentrated in Canada and the USA and are confined to the area of the Great Lakes. In Western Europe, sapropel resources are severely depleted. The reservoirs containing sapropels were in Germany, Poland, Scandinavian countries and to a lesser extent in France and Great Britain. A large number of sapropel deposits are in Lithuania, Latvia and Ukraine; the Russian Federation occupies one of the leading places in the world [7]. According to the State Research Institute for Nature Management of the National Academy of Sciences of Belarus, the reserves of lake sapropel in the Republic of Belarus make 3.73 billion cubic meters. Four types of sapropel are distinguished: organic, siliceous, carbonate and mixed. For organic sapropels, the upper ash limit is assumed equal to 30% [8].

Organic and mineral substances included in sapropel make it possible to consider sapropelic deposits as valuable minerals, suitable for use in various branches of the national economy: in agriculture as fertilizers and mineral-vitamin supplementary feeding for animals and poultry, in medicine as therapeutic mud and so on[9-13]. Currently, along with a deficiency of energy, protein, sugars and other nutritional elements in rations, there is an acute shortage of biologically active substances [14]. Feeds of vegetable and animal origin not always enable satisfying the need of animals in these elements. Therefore, the search for additional sources of mineral and vitamin raw materials and their involvement into the practice of feeding agricultural animals is of great scientific and practical interest [15,16].

Furthermore, as evidenced by international agricultural organizations, up to 40% of fodder used in animal husbandry are to some extent affected by mycotoxins (toxins produced by various kinds of mold fungi). Mycotoxins cause chronic poisoning of animal bodies, which leads to an increase in morbidity and decrease in productivity [17]. To address this problem, enterosorbents are used. The sapropelic feed additive contains about 16%protein, is rich in mineral salts, amino acids and enzymes that improve fuller assimilation of feed nutrients, stimulate functions of the digestive tract and increase assimilation of calcium and nitrogenous feed compounds.

Given the poorly understood use of sapropel as a feed additive in animal husbandry, the main purpose of this work was to study the effectiveness of sapropels from the PribylovichiLake (the Republic of Belarus) in rations of young cattle and determining their effect on the physicochemical and organoleptic characteristics of beef.

To achieve this purpose, the following tasks were formulated:

- To study the productivity of young cattle when using sapropel raw materials from the deposit of the PribylovichiLake in diets;
- Determine the physicochemical and organoleptic characteristics of experimental animals;
- Carry out an analysis of bacterial contamination of the test meat samples; and
- Evaluate the biological value and harmlessness of beef on the infusoriaTetrahymena pyriformis bioassay.

MATERIALS AND METHODS

To solve the tasks set, a scientific and economic experiment was organized under conditions of the "Zhodino Experimental Base" inSmolevichskyrayon, Minsk region of the Republic of Belarus, to study the effectiveness of sapropel in rations of young cattle of Black-and-white cowbreed (Table 1).

Table 1: Scheme of study

Groups	Number of animals	Live weight at the start of experiment, kg	Experiment time, days	Feeding habits
Control	15	241.6±2.6	92	Corn silage, mixed herbs haylage + feed compound (basic diet-BD)
I	15	236.0±2.7	92	BD + feed compound containing 6% carbonate sapropel
II	15	238.0±2.5	92	BD + feed compound containing 8% siliceous sapropel

For the scientific and economic experiment, according to the principle of analogy, three groups of steers with an average live weight of 236.0-241.6 kg, 15 heads each were selected. The experiment time was 92 days.

The conditions for the control and experimental groups were the same, i.e. twice a day feeding andwatering from autodrinkers. All studies were conducted in summer 2016.

In the scientific and economic experiment,the following parameters were studied: general livestock analysis of feed-stuff was carried out using the SpectraStar 2400 infrared analyzer (Unity Scientific, USA); analysis of fodder consumption was conducted by control feedings once every 10 days for two days; intensity of growth and average daily gain by individual weighing animals at the beginning and at the endof the experiment and also in courseof the experiment, monthly; and physiological states of the animals were monitored on the basis of a hematological analysis using the URIT-3000 Vet Plus and URIT-800 Vet devices (URIT Medical Electronic Co., Ltd., China).

The nutritional value (NV) was estimated accordance with following formula:

$$NV, MJ/1kg = (4 \cdot P + 9 \cdot F) \cdot 4.2 \cdot 10 \cdot 0.001$$

where P – is the percentage of protein, %;
F – is the percentage of fat, %;
C – is the percentage of carbohydrates, %;
4.2 – is the conversion factor of 1 kcal into 1 kJ;
10 – is the conversion factor of 100 g into 1 kg;
0.001 – is the conversion factor of 1 kJ into 1 MJ.

The protein quality indicator (PQI) was calculated using the following formula:

$$PQI = \frac{\text{Tryptophane}}{\text{Oxyproline}}$$

Organoleptic studies of meat fromsteers were carried out according to GOST 7269-79 "Meat. Methods of sampling and organoleptic methods of freshness test." The work was performed in a laboratory of ecology and veterinary science at the Institute of ExperimentalVeterinary n.a. S.N. Vyshelessky. The quality of beef was evaluated according to GOST 23392-78 "Meat. Methods of chemical and microscopic analysis of freshness" and "Rules for veterinary inspection of slaughtered animals and veterinary and sanitary examination of meat and meat products" (approved by the Ministry of Agriculture of the USSR on 27.12.1983 together with the "Methods of the physical andchemical examination of meat"). In beef, there weredetermined activity of peroxidase (benzidine test), content of polypeptides and other protein decay products (copper sulphate reaction), concentration of hydrogen ions (pH) by an ionomer and the amount of amino ammonia nitrogen and volatile fatty acids by titration.

Bacteriological studies of deep layers of muscles were carried out in accordance with GOST 21237-75 “Meat. Methods of bacteriological analysis.” Biological value and safety of meat from experimental steers were investigated according to the “Methodological instructive regulations for toxic and biological evaluation of meat, meat products and milk using infusoriaTetrahymena pyriformis (express method)” approved bythe Ministry of Agriculture and Food of the Republic of Belarus, 20.10.1997 (Vitebsk, 1997). In studyingsafety, changes in the morphological structure of protozoa, their motility and presence of dead forms were taken into account after 1, 2, 4, 8 and 24 hours of incubation. Chronic toxicity was determined by the same parameters, taking into account growth and development after 96 hours of cultivation of test organisms.

The cost-effectiveness of beef production was counted based on the annual actual and intrafarm economic effect and according to Minakov[18] (2014) using the following formulas:

$$\text{Prime cost of 1 kg of gain, €} = \frac{\text{Farm inputs, € per head}}{\text{Total gain, kg}}$$

$$\text{Beef sales proceeds, €} = \text{Total gain, kg} \times \text{Market value of beef, € per kg}$$

$$\text{Profit, €} = \text{Beef sales proceeds, € - Farm inputs, € per head}$$

$$\text{Profitability level, \%} = \frac{\text{Profit, €}}{\text{Farm inputs, € per head}} \times 100\%$$

The data on different variables, obtained from the experiment, were statistically analyzed by Statistica 10 package (StatSoft Inc.). The significance of differences between the indices was determined using the criteria of nonparametric statistics for the linked populations (differences with P<0.05 were considered significant: [a]P<0.001; [b]P<0.01; [c]P<0.05; ns = not significant at P>0.05). Student's t-test was applied for the statistical analysis[19]. The mean of a set of measurements was calculated according to the formula: $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$,

where $\bar{x}$ is a mean value; $\sum_{i=1}^{n} x_i$ is the sum of all x_i withi ranging from 1 to n, n is a number of measurements.

The residual variation is expressed as a root mean square error (r.m.s.e.): $\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$. The standard error of mean (s.e.m.) was calculated by the formula: $s.e.m.(\bar{x}) = \frac{\sigma}{\sqrt{n}}$.

The reliability of a sample difference (Student’s t-distribution) was estimated by the test of the difference validity, which is the ratio between the sample difference to the non-sampling error. The test of the difference validity was determined by the formula:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s.e._1{}^2 + s.e._2{}^2}} \geq t_{st}\,(d.f. = n_1 + n_2 - 2)$$,

where t is a Student’s t-distribution; ($\bar{x}_1 - \bar{x}_2$) is a difference of the sample mean measurements; $\sqrt{s.e.m._1{}^2 + s.e.m._2{}^2}$ is a sample difference error; $s.e.m._1$, $s.e.m._2$ is a non-sampling error of the sample statistics compared; t_{st} is a standard criterion according to the t-Table for the probability threshold preset depending on degrees of freedom; n_1, n_2 is a number of measurements in the samples compared; d.f. is a degrees of freedom for difference of two mean measurements.

RESULTS AND DISCUSSION

Fodder nutrition and productivity of experimental animals. From the physiological point of view, sufficient intake of nutrients and biologically active substances is an important point in maintaining high productivity and good health of animals. In the scientific and economic experiment, the ration of steers in control group contained corn silage, mixed herbs haylage and feed compound. Instead of grain, the feed compounds for animals in groups II and III contained 6 and 8% by weight of sapropel carbonate and siliceous, respectively (Table 2).

Table 2: Average daily ration of experimental steers (actually eaten fodder)

Feed	Groups		
	Control	I	II
Feed compound, kg	2.5	2.5	2.5
Mixed herbs haylage, kg	9.0	8.5	8.0
Corn silage, kg	10.0	9.0	11.0
The diet contains:			
feed units	7.49	7.41	7.5
metabolic energy, MJ	67.4	66.9	65.3
dry matter, kg	7.75	7.92	7.81
crude protein, g	972	975	979
digestible protein, g	631	634	633
degradable protein, g	710	741	724
non-degradable protein, g	262	234	255
RNB, g/kg of DM in ration	0.45	0.92	1.10
fat, g	290	293	275
cellulose, g	1623	1627	1630
sugar, g	570	568	571
calcium, g	40.5	40.0	41.3
phosphorus, g	22.5	23.0	22.2

Nutrition of rations of experimental steers corresponded to 7.41-7.50 feedunits. The concentration of metabolic energy in dry matter was 8.69 in control group and 8.44 and 8.36 in experimental groups (II and III), respectively. In the diet, per 1 feed unit there were 84.2 g of digestible protein in control group and 85.5 and 84.4 in experimental groups (II and III), respectively. With respect to the content of degradable and non-degradable proteins, the rations did not differ considerably. So, the rumen degradability of protein of control animals corresponded to 73%, butits highest value of 76% was registered in experimental group II, where animals consumed mixed compound with 6% carbonate sapropel. The concentration of metabolic energy in dry matter and difference in protein degradability had a substantial effect on the nitrogen balance in the rumen. In control group, this parameterwas 0.45 g per 1 kg of dry matter in the diet; in experimental group II, it was 2 times higher; and in experimental group III, it was 2.4 times higher than in control group. Sapropels can be assumed to havepositively affected on ruminal microflora and, in general, ruminal digestion.

The body weight is a complex parameter characterizing the growth, development and meat production of an animal. When setting the scientific and economic experiment, there were no significant differences between the animals. At the end of the experiment, the young cattlein experimental groups outperformed the ones in the control group by 5.8 kg, or 1.82% ($P<0.01$) and 4.9 kg, or 1.54% ($P<0.05$), respectively (Table 3). The gross live weight of steers inexperimental groups exceeded the control by 11.4 kg, or 14.75% ($P<0.001$) and 8.5 kg, or 10.99% ($P<0.01$), respectively. The high growth intensity of the animals was naturally caused higher average daily weight gain. So, the average live weight daily gain of the steers in experimental groups exceeded the control throughout the growing period and at the end of the experiment; the absolute values were 964.1 in the Test group I and 932.6 g in Test group II, which was more than in the control group by 123.9 ($P<0.001$) and 92.4 ($P<0.01$) g, respectively.

Table 3: Dynamics of live weight gain and productivity of experimental animals

Parameters	Groups		
	Control	I	II
Live weight, kg:			
at the beginning of experiment	241.6±2.6	236.0±2.7^{ns}	238.0±2.5^{ns}
at the end of experiment	318.9±1.3	324.7±1.1^{b}	323.8±1.6^{c}
Total gain, kg	77.3±1.8	88.7±1.3^{a}	85.8±1.7^{b}
Average daily gain, g	840.2±18.1	964.1±23.7^{a}	932.6±20.4^{b}
% to control	100.0	114.7	111.0
Notes. a = P<0.001; b = P<0.01; c = P<0.05 compared with data on the Control group; ns = not significant.			

Hematologic parameters

An important exposure indicator of environmental factors on the animal organism is changes in their blood composition. Being the main link between metabolic processes in the body, i.e. delivery of nutrients and oxygen to the cells of organs and tissues, removal of metabolic wastes, direction and intensity of metabolism and physiological state of an organism are most accurately determined on the basis of a biochemical and morphological analysis of blood, because while maintaining a constant composition, the blood, nevertheless, is a sufficiently mobile system that reflects the changes in the bodyunder normal and pathological conditions. Thus, the study of hematological parametersin addressing the impact of the level and quality of feeding animals is of great importance.

The study of the morphological and biochemical compositions of blood of experimental animals established all the parameters analyzed to correspond to the physiological norm. At the time the groups were formed at the beginning of the experiment, the differences in the content of erythrocytes, leukocytes and hemoglobin in blood of the steers were insignificant and unreliable. At the end of the experiment (Table 4), the steers in experimental groups I and II exceeded the ones in the control group with respect to the content of hemoglobin in blood by 3.10% (P<0.05) and 2.35% (ns); erythrocytes by 7.44% (P<0.05) and 3.48% (ns); and total protein by 0.99% (P<0.01) and 0.62% (P<0.05), respectively. An increase of these indices of blood serum of the steers in experimental groups indicated a better assimilation of nitrogen in feed as a result of an increase in the enzymes activity in their bodies. Being in close relationship with proteins of various tissues, protein fractions of blood serum subtly reacted to the changes in chemical and physicochemical processes in the organs of animals. The changes in the immunobiological reactivity of the body indicated the intensity and lability of metabolic processes, which affected the constituent protein fraction of blood serum. Higher productivity of animals is known to cause higher blood saturation with proteins and especially with albumins. Albumins play an important role in colloid osmotic pressure and carry out a transport function consisting in binding and transfer of fatty acids, cholesterol and a number of other substances. With age, the dynamics of albumin changes in blood serum of the steers in experimental groups was similar to that of the total protein. So, the young animals that received 6% carbonate (I) and 8% siliceous (II) sapropels in their diet had more albumin than the steers in the control by 3.44% (P<0.01) and 1.72% (P<0.05), respectively.

Table 4: Hematologic Parameters Of Experimental Steers

Parameters	Groups		
	Control	I	II
Hemoglobin, g/l	119.3±1.1	123.0±1.3^{c}	122.1±1.2^{ns}
Erythrocytes, 10^{12}/l	6.32±0.16	6.79±0.11^{c}	6.54±0.19^{ns}
Leucocytes, 10^{9}/l	9.92±0.75	10.00±0.93^{ns}	9.64±0.61^{ns}
Total protein, g/l	80.5±0.16	81.3±0.20^{b}	81.0±0.11^{c}
Globulins, g/l	45.6±0.5	45.2±0.6^{ns}	45.5±0.7^{ns}
Albumins, g/l	34.9±0.2	36.1±0.3^{b}	35.5±0.2^{c}
Calcium, mmol/l	2.71±0.07	2.95±0.06^{c}	3.04±0.09^{b}
Phosphorus, mmol/l	1.84±0.09	2.10±0.05^{c}	2.05±0.08^{ns}
Notes. a = P<0.001; b = P<0.01; c = P<0.05 compared with data on the Control group; ns = not significant.			

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Taking into account the active participation of the most mobile calcium and phosphorus ions in the cellular metabolism, the study of their dynamics under the conditions of this experiment was of great scientific and practical interest. In blood serum of the animals in Experimental groups I and II, the level of calcium was elevated by 8.86% (P<0.05) and 12.18% (P<0.01), compared to the control, and phosphorus by 14.13% (P<0.05) and 11.41% (ns), respectively.

The obtained results indicated that the carbonate and/or siliceous sapropels as a part of complete feed in the ration of steers ensured a more optimal course of physiological processes in the animals.

Chemical composition, organoleptic, physico-chemical and microbiological parameters of meat from experimental steers. In the course of studying the chemical composition of the rib eye and the average meat samples of control and experimental animals, a positive correlation between the use of sapropels and the level of meat production of the steers was established. The analysis results of the meat content of the carcasses (an average sample) of the examined animals showed that the meat from the steers in Groups I and II had the best physiological maturity and ripeness. So, the dry matter to moisture ratio in Experimental group I was 0.50, in Experimental group II it was 0.49, which was more than in the control group by 0.06 and 0.05, respectively (Table 5). The fat to moisture ratio in both experimental groups was 0.18, which was higher than in the control by 0.02. In the average meat sample from the steers in Experimental groups I and II, there was more dry matter than in the control group by 2.85 (P<0.001) and 2.34% (P<0.01), respectively. In terms of the amount of protein in the carcass flesh, the steers that received 6% carbonate sapropel exceeded the control ones by 1.86% (P<0.001). This parameter of meat from the animals fed with 8% siliceous sapropel was higher than the control by 1.68% (P<0.001). Similarly, Test groups I and II exceeded the control in terms of the fat content in the average flesh sample by 0.93 (P<0.001) and 0.64% (P<0.001), respectively. The protein quality indicator of meat from the steers in experimental groups was higher than the corresponding indicator in the control by 5.57 and 4.01%, respectively.

Table 5: Chemical composition of rib eyes and average samples of meat

Parameters	Groups		
	Control	I	II
Rib eye			
Dry matter, %	25.92±0.21	28.27±0.43[a]	27.23±0.35[b]
Protein, %	20.35±0.28	21.92±0.23[a]	21.46±0.19[b]
Fat, %	4.62±0.07	5.34±0.10[a]	4.79±0.09[ns]
Ash, %	0.95±0.01	1.01±0.02[c]	0.98±0.01[c]
Tryptophan, mg %	428.5±1.35	434.6±1.39[b]	432.9±1.27[c]
Oxiproline, mg %	66.90±0.68	63.52±0.84[b]	64.47±0.92[c]
Protein quality indicator	6.41	6.84	6.71
Nutritional value of 1 kg of meat, MJ	5.17	5.70	5.42
Average sample of meat			
Dry matter, %	30.44±0.41	33.29±0.54[a]	32.78±0.63[b]
Protein, %	18.27±0.23	20.13±0.19[a]	19.95±0.20[a]
Fat, %	11.16±0.08	12.09±0.11[a]	11.80±0.10[a]
Ash, %	1.01±0.02	1.07±0.02[c]	1.03±0.01[ns]
Tryptophan, mg %	390.5±0.95	395.9±0.92[a]	394.6±1.02[b]
Oxiproline, mg %	86.9±0.36	83.5±0.38[a]	84.5±0.29[a]
Protein quality indicator	4.49	4.74	4.67
Nutritional value of 1 kg of meat, MJ	7.29	7.95	7.81
Notes. a = P<0.001; b = P<0.01; c = P<0.05 compared with data on the Control group; ns = not significant.			

One of the most significant parameters that indicate the meat appeal of the carcass is the chemical composition of the rib eye. According to the examination results in the rib eyes from the steers in Test groups I and II, there was more dry matter than in the control by 2.35 (P<0.001) and 1.31% (P<0.01), protein by 1.57 (P<0.001) and 1.11% (P<0.01) and fat by 0.72 (P<0.001) and 0.17% (ns). The protein quality indicator of meat from the steers in experimental groups was higher than in Control group by 6.71 and 4.68%, respectively.

An important criterion for assessing consumer appeal is the study of the nutritional value of meat. The meat from the steers in experimental groups was established to be notable for a higher nutritional value in comparison with the meat from the steers in Control group (Table 5). The nutritional value of the average meat sample from the steers in experimental groups exceeded the control indicator by 9.05 and 7.13%; nutritional value of the rib eye by 10.25 and 4.84%.

The test samples on the cut were slightly moist, not sticky; on pressing,the meat quickly became even, which indicated its elastic consistency. The smell of the surface layers of the meat samples from experimental and control groups was specific for this species of animals (cattle), characteristic of fresh meat, light red.

The boiling test showed that the broth, both in experimental and control groups, was transparent and aromatic; the fat aggregated on the surface of the broth as large droplets.

Microscopical investigation of tissue smears found single cocci in field of vision; rod forms of microorganisms and traces of decomposition of muscle tissue were not detected.

The bacteriological analysis of the muscles of all steer groups didnot registered their pathogenic or opportunistic pathogenic microflora. Physicochemical parameters of meat are shown in Table6.

As is clear from the data inTable 6, no reliable differences from both experimental and control groups were found. The concentration of hydrogen ions was within the permissible limits for ripe fresh meat. During storage for 10 days, meat of both control and experimental groups was well preserved, a pronounced crust of drying out was observed.

Table 6: Microbiological and physicochemical parameters of meat

Parameters	Time at 2^0C, h	Groups		
		Control	I	II
Aminoammonia nitrogen, mg KOH	24	1.15±0.02	1.08±0.04 ^{ns}	1.12±0.02^{ns}
	240	1.20±0.02	1.14±0.03^{ns}	1.19±0.05^{ns}
Bacterioscopy of tissue smears	24	In meat from animals of all groups, single cocci		
pH	24	5.63±0.06	5.53±0.04^{ns}	5.55±0.08^{ns}
	240	6.10±0.04	6.02±0.02^{ns}	6.09±0.02^{ns}
Reaction with 5% copper sulphate solution in broth	24	3-	3-	3-
	240	3-	3-	3-
Peroxidase reaction	24	3+	3+	3+
	240	3+	3+	3+
Volatile fatty acids, mg KOH	24	3.69±0.12	3.54±0.12^{ns}	3.58±0.28^{ns}
Notes. (-) means that the reaction is negative; (+) means positive reaction. a = P<0.001; b = P<0.01; c = P<0.05 compared with data on the Control group; ns = not significant.				

The safety of beef. When studying safety of the meat samples from steers of experimental and control groups on test organismsof infusoriasTetrahymenapyriformis,any deviations in the morphological structure, motility, growth and development of protozoa were not observed (Table 7).

Table 7: Relative biological value of meat

Sample type	Groups	Average of two experiments	
		Average number of test organisms	% to control
meat	Control	233	100.0
	I	248	106.5
	II	250	107.3

The average data on the relative biological value of the test meat samples exceeded those of the control samples by 6.5% in test group II andby 7.3% in test group III. The relative biological value of meat from the test animals was in the range of reliable fluctuations with respect to the control; the products were safe to the test organisms of infusoriaTetrahymena pyriformis. Deviations in the morphological structure, motility, growth and development of protozoa have been not revealed.

Having stated that, it may be concluded that the meat from steers under study corresponded to high quality products.

Economic efficiency of beef production. Monitoring the economic efficiency of the application of various feed additives is of decisive importance and determines the expediency of their use and profitability of production (Table 8).

Table 8: Cost-effectiveness of beef production. The average values calculated as economic indicators up to autumn 2017, the RUR/EUR exchange rate was 68.0.

Parameters	Groups		
	Control	I	II
Total gain, kg	77.3	88.7	85.8
Farm inputs, € per head	91.9	101.3	95.6
Prime cost of 1 kg of gain, €	1.2	1.1	1.1
Market value of beef, € per kg	1.4	1.4	1.4
Beef sales proceeds, €	108.2	124.2	120.1
Profit, €	16.3	22.9	24.5
Profitability level, %	17.7	22.6	25.6

Taking into account the effectiveness of growing young cattle in experimental groups, which contributed to the increase in body weight gain in comparison with Control group by 11.4 (14.75%, $P<0.001$) and 8.5 kg (10.99%, $P<0.01$), the prime cost of 1 kg of live weight gain was reduced by 0.1 EUR in these groups.

In comparison with the control, the sales proceeds from the steers fed with sapropels amounted to 124.2 and 120.1 EUR, which was more by 16.0 and 11.9 EUR. The amount of profit was more than in Control group by 6.6 and 8.2 EUR, respectively.

The advantage of the received profit contributed to the fact that the profitability of beef production exceeded the same parameter in Control group by 4.9 and 7.9%. The average values were calculated as economic indicators up to autumn 2017, when the RUR/EUR exchange rate was 68.0.

CONCLUSIONS

- The sapropels from the PribylovichiLake in the composition of compound feed for fattening steers have contributed to the optimization of ruminal digestion, which causedan increase in the rumen nitrogen balance 2-2.4 times and average daily gains by 11.0% and 14.7%, and made it possible to save 6-8% of concentrates.
- Sapropels consumption positively affected the physiological states of the animals.
- Feeding with sapropels positively affected the physicochemical, organoleptic and microbiological characteristics of beef.
- The samples of meatweresafe for protozoa of infusoriaTetrahymena pyriformis.
- The use of sapropels in rations made it possible to reduce the prime cost of 1 kg of live weight gain, receive additional profit and raise the level of profitability of beef manufacture, which proved the economic efficiency of their application.

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