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Abstract. The article presents the results of study on the effect of zeolite-sapropel feed additives on the metabolism of mares in Central Yakutia. Three groups of horses were formed to conduct scientific experiments. These groups were selected based on the principle of analogues, which took into account age, body weight and fatness. The control group got a basic ration. The experimental groups got a zeolite-sapropel feed additives to the basic ration in doses of 0.5 g of zeolite per kg of body weight with 200 and 300 g of sapropel. The study of the absorption of nutrients determined the effect of zeolite-sapropel feed additives on the intensity of nutrient uptake. Animals of the I and II experimental groups digest better: dry matter by 0.89% and 1.10%, organic matter by 0.90% and 1.17%, crude protein by 1.07% and 1.48%, crude fat by 2.16% and 5.08%, crude fiber by 1.70% and 2.43%, nitrogen-free extractives by 0.63% and 0.77%. Thus, the studies have shown that mares of the experimental groups fed with zeolite-sapropel additives, better use nitrogen, calcium and phosphorus. The studies have proved the effectiveness of using zeolite-sapropel feed additives when feeding mares in Yakutia.

1. Introduction

Natural and climatic conditions of the Republic of Sakha (Yakutia) along with low nutritional value of plant feeds reduce the efficiency of livestock production [1]. Lack of macro-and micronutrients and nutrients leads to a shortage of products. The use of feed additives with the missing micronutrients is one of the solutions for a balanced nutrition [2]. The influence on the processes of digestion and absorption of nutrients makes feed additives tools for regulating animal productivity [3]. Therefore, the inclusion of various feed additives for optimizing rations is of great scientific and practical interest for agriculture development [4]. Currently, many feed additives have been developed to improve the efficiency of feeding agricultural animals [5]. Among them, zeolites, sapropels, mineral salts, as well as various premixes are well-proven. The inclusion of feed additives of natural origin in the ration of farm animals shows high efficiency in practical experience.

Natural zeolites have catalytic, adsorption, and ion exchange properties due to their crystal structure. Zeolites improve the absorption of macro- and micronutrients contained in feed. In Russia, zeolites have also been used in livestock as a feed additive [6]. Zeolite also stimulates digestibility and increases the absorption of nutrients. The composition of zeolite includes up to 40 macro- and micronutrients. This already makes it a valuable feed additive in the conditions of Yakutia, where there is a shortage of

macro- and micronutrients in soils and plants. On the territory of the Republic of Sakha (Yakutia), there is a Suntar zeolite deposit, which reserve is estimated at 11.4 million tons. The chemical composition of the Suntar zeolite is shown in the diagram (figure 1) [7].

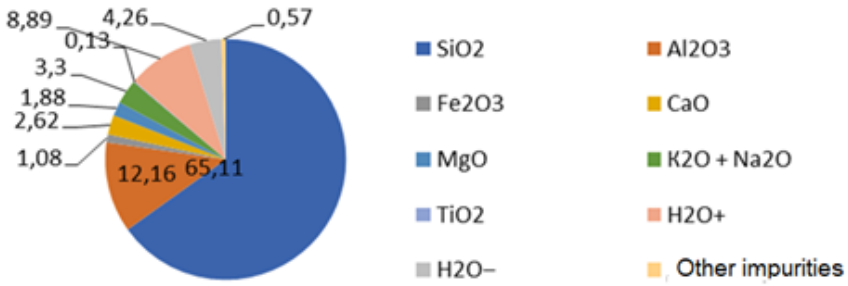

Figure 1. The chemical composition of zeolite from the Suntar deposit, %.

There is information about the effectiveness of feed additives containing zeolite and sapropels in horse breeding. The research conducted by R. V. Ivanov found that the addition of sapropel to the daily ration of mares with grain fodder ensures the safety of their fatness and contributes to the birth of more viable foals [8].

The sapropel feed is a valuable feed additive for animals and birds, containing a set of special biologically active substances that increase the productivity of farm animals, as well as increasing resistance to various diseases [9]. It was found that sapropel contains macronutrients (calcium, phosphorus, magnesium, etc.), micronutrients (iron, copper, zinc, manganese, cobalt, iodine) and other biologically active substances. The sapropel feed is non-toxic and harmless as an environmentally friendly product [10]. The use of zeolite and sapropel as additives to the ration of farm animals increases the use of nutrients, normalizes metabolism and reduces feed costs [1]. In this regard, this research work is aimed at studying the influence of non-traditional feed additives (zeolite and sapropel) when feeding the mares in Yakutia.

The research purpose is to study the digestibility of feed and metabolism of mares when including zeolite-sapropel feed additives in their ration.

2. Materials and research methods.

The research was conducted on the mares of the Megezhek breed, on the basis of the collective farm "Eige" of the municipality of the city of Yakutsk. For experiment conducting, the experimental groups of mares were formed by the method of analogues, which took into account the indicators of age, body weight and physiological condition of animals. The mares selected for the experiments were clinically healthy. The duration of the experiment was three months. The average body weight of mares was 450 kg, average fatness. The scheme of scientific experience is shown in table 1.

Table 1. The scientific experience scheme.

group name	number of horses	experimental conditions
control	12	basic ration
experimental I	12	basic ration + 0,5 zeolite g/kg of body weight + 200 g of sapropel
experimental II	12	basic ration + 0,5 zeolite ** g/кg of body weight + 300 g of sapropel

Analysis of sapropel did not reveal pathogens in the experimental samples. The chemical composition of sapropel used in the scientific experiment is represented by the following composition (table 2).

Table 2. The chemical composition of sapropel used in the scientific experiment.

composition	measure unit	indicators
Original moisture	%	23,06
Nitrogen nitrate	mg/100 g	traces
Humic	%	7,50
Alkalinity	mg/100 g	0,57
Chlorides	mg/100 g	0,59
Phosphorus	mg/kg	116,46
Potassium	mg/kg	614,65
General nitrogen	%	0,45
Manganese	g/kg	6,61
Medallists	mg/kg	194,30
Zinc	mg/kg	435,60
Iron	g/kg	370,50
Cobalt	mg/100 g	78,12
Iodine	mg/100 g	1,60
Selenium	mg/kg	67,77
Molybdenum	mg/kg	31,80

Thus, the analysis of sapropel showed that it contains minerals that are deficient in plant feeds.

Setting mares on experience, as well as the study of the biochemical composition of feed and metabolic products was carried out according to generally accepted research methods. When analyzing feed rations, there was studied the content of crude protein, crude fat, crude fiber, carotene, ash, as well as calcium and phosphorus. Metabolic products, as well as average samples of feed and sapropel were studied in the laboratories of the Federal state budgetary educational institution of higher education "Yakut State Agricultural Academy", the Federal state budget scientific Institution "Yakut Research Institute of Agriculture", the State budgetary institution of the Republic of Sakha (Yakutia) "Yakut Republican Veterinary Testing Laboratory", the Republican Agrochemical Design and Survey Station, using the following methods: analysis of hay according to GOST 4808-87; of meadow grass according to GOST 27978-88; of crude fiber according to GOST 13496.2-91; of crude fat according to GOST 13496.15-97; of carotene according to GOST 13496.17-95; of crude ash according to GOST 26226-95; the content of nitrogen and crude protein according to GOST P 50466-93 and their mass fraction according to GOST P 51417-99; calcium according to GOST 26570-95; phosphorus according to GOST 26657-97; moisture according to GOST 27548-97. Mathematical calculations were performed according to the methods of V. N. Bakanov and V. K. Menkin [11]. Method for determining the digestibility of feed and rations according to M. F. Tomme [12]. According to the research program, the study of the digestibility of rationary nutrients was conducted in the middle of a scientific experiment on three mares from each group. Feed studies were conducted in accordance with the method of P. T. Lebedeva and A. T. Usovich [13]. Research data were processed biometrically using the method of N. A. Plakhinsky with the definition of reliability [14]. The reliability of the difference was evaluated by the Student criterion.

3. Research results and discussion

The experiment was conducted on the basis of the collective farm "Eige" of the Yakutsk city municipality on the Megezhek breed mares, which were kept at the horse farm during the research. The daily rations of mares in winter and summer are shown in table 3.

Table 3. The winter and summer rations of experimental mares in the collective farm "Eige".

indicators	measure unit	norm	nutrients, actually
Meadow hay	kg	11,0	13,0
Oat	kg	5,0	5,0

Salt	g	31,0	31,0
Dry matter	kg	13,0	14,6
Exchange energy	MJ	107,5	122,0
Crude protein	g	1612,5	1718,0
Digestible protein	g	1122,3	1115,0
Crude fiber	g	2322,0	2335,0
Calcium	g	64,5	57,9
Phosphorus	g	45,2	42,1
Magnesium	mg	17,0	16,5
Iron	mg	1032,0	985,0
Copper	mg	116,0	113,0
Zinc	mg	387,0	372,0
Cobalt	mg	5,4	5,0
Manganese	mg	516,0	487,0
Iodine	mg	5,2	5,0
Carotene	mg	290	265
Feed availability	%		113,4

The analysis of the ration showed that there is a lack of micro-and macronutrients. The balance experiment was conducted in the middle of the experiment. The experiment was conducted according to the generally accepted zootechnical method. The digestibility of nutrients, the balances of nitrogen, calcium and phosphorus were studied by feeding three mares from each experimental group to a physiological experiment. The nutritional digestibility coefficients of the ration are calculated on the basis of data from physiological experience, the data of which are presented in table 4.

Table 4. The nutritional digestibility coefficient of the ration % (M ± m, n = 3).

group name	dry matter	organic matter	protein	fat	crude fiber	nitrogen-free extractive substances
control	73,10±0,87	74,24±0,92	67,41±3,27	71,35±2,08	70,54±1,25	76,14±0,85
experimental I	73,99±2,43	75,14±2,87	68,48±3,87	73,51±2,02	72,24±0,90	76,77±4,39
experimental II	74,20±0,45	75,41±0,38	68,89±1,25	76,43±1,82	72,97±1,55	76,91±0,67

During the experiment, it was found that when feeding zeolite-sapropel feed additives, the experimental mares had a different coefficient of ration nutrients digestibility. A high coefficient of the components of ration nutrients digestibility was observed in the mares of the I and II experimental groups. They used better the following: dry matter by 0.89% and 1.10%, organic matter by 0.90% and 1.17%, crude protein by 1.07% and 1.48%, crude fat by 2.16% and 5.08%, crude fiber by 1.70% and 2.43%, nitrogen-free extractives by 0.63% and 0.77%. Analysis of the coefficient of substances digestibility found that there are differences between the experimental groups. The mares of the II experimental group used nutrients better than the I experimental group: dry matter by 0.21%, organic matter by 0.27%, crude protein by 0.41%, crude fat by 2.92%, crude fiber by 0.73%, nitrogen-free extractives by 0.14%, respectively.

Nitrogen, calcium and phosphorus balances are determined based on the results of the balance experiment of the chemical composition of feed and their residues. Nitrogen balance is necessary to assess changes in the animal body at different levels of feeding as well as to assess the deposition and breakdown of proteins. The data on nitrogen balance of the mares are presented in table 5. The balance of all experimental mares was positive.

Table 5. The nitrogen balance (M ± m, n = 3).

indicator	mares' groups		
	control	experimental I	experimental II
taken with food, g	159,87±0,26	161,48±0,19**	162,61±0,23**
excreted with feces, g	52,10±5,25	51,32±6,24	52,21±2,07
digested, g	107,77±5,26	110,16±6,42	110,40±1,99
excreted in the urine, g	73,36±3,99	73,18±4,33	72,97±1,10
balance, (+, -)	+34,41±9,13	+36,99±2,62	+37,43±1,86
used from taken, %	21,52±5,70	22,90±1,59	23,02±1,14
used from the digested, %	31,25±6,99	33,57±1,18	33,88±1,22

Note: **P>0.99

The nitrogen intake from feed in all groups was almost the same and varied within the range of 159.87-162.61 g, while the deposition in the body was different. In the mares' bodies of the control group, 107.77 g was digested, in the I and the II experimental groups were 110.16 and 110.40 g, respectively. The nitrogen balance in all groups of mares was positive and amounted separately for groups: in the control group to 34.41 g, in the I experimental group to 36.99 g and in the II experimental group to 37.43 g. The degree of nitrogen use in the mares' bodies was also different. The control group was inferior to the experimental groups in the use of nitrogen from the taken by 1.38% and 1.50%, respectively. The coefficient of nitrogen utilization from the digested nitrogen in the control group was 31.25%, which is less than in the I and II experimental groups by 2.32% and 2.63%, respectively. The nitrogen use by the mares of the experimental groups that additionally were fed with zeolite-sapropel feed additives was relatively higher compared to the mares of the control group. This indicates a higher digestibility of nutrients due to the effect of feed additives on the metabolism of horses' bodies.

The use rate of calcium and phosphorus and other minerals is an important indicator characterizing the metabolism in the body. One of the most common elements in the horse body is calcium. It is a part of the bone tissue, is also an activator of the enzyme system and blood coagulation. The balance of calcium and phosphorus and their use by mares is presented in table 6.

Table 6. The balance of calcium and phosphorus (M ± m, n = 3).

indicator	mares' groups		
	control	experimental I	experimental II
calcium balance			
taken with food, g	58,64±0,27	59,37±0,42	59,81±0,12[a]
excreted with feces, g	34,83±1,35	35,09±0,46	35,42±0,49
excreted in the urine, g	1,38±0,16	1,33±0,16	1,36±0,08
total excreted, g	36,22±1,51	36,43±0,37	36,79±0,56
balance (+), (-)	+22,41±1,51	+22,94±0,72	+23,02±0,45
used, % from taken	38,23±2,56	38,63±0,96	38,50±0,83
phosphorus balance			
taken with food, g	31,85±0,18	32,29±0,06	32,79±0,28
excreted with feces, g	12,81±0,63	12,34±0,65	12,27±0,37
excreted in the urine, g	4,19±0,30	3,88±0,35	4,16±0,25
total excreted, g	17,01±0,35	16,23±0,52	16,43±0,45
balance (+), (-)	+14,84±0,35	+16,06±0,46	+16,35±0,22[a]
used, % from taken	46,58±1,06	49,75±1,53	49,89±0,99

Note: [a] P>0.95

4. Conclusion

The balance of calcium in the mares' body was positive in all groups and amounted to 22.41 g, 22.94 g and 23.02 g. The coefficient of calcium use from the taken one was 38.23% in the control group, which is less than the indicators of the I and II experimental groups by 0.40% and 0.27%, respectively.

The phosphorus balance in all experimental groups of mares was positive. But the coefficient of phosphorus use in the groups was different, this is due to the influence of zeolite-sapropel feed additives on the intensity of metabolism in the mares' bodies. The use of phosphorus from the taken one was 46.58% in the control group, which is less than in the I experimental group by 3.17% and in the II experimental group by 3.31%. Studies have shown that mares of the experimental groups fed with the zeolite-sapropel feed additives used nitrogen, calcium and phosphorus better.

When feeding with the zeolite-sapropel feed additives, an increase in the digestibility of dietary nutrients, as well as the absorption of nitrogen, calcium and phosphorus, was found. So, the I and II experimental groups of mares digested better dry matter by 0.89% and 1.10%, organic matter by 0.90% and 1.17%, crude protein by 1.07% and 1.48%, crude fat by 2.16% and 5.08%, crude fiber by 1.70% and 2.43%, nitrogen-free extractives by 0.63% and 0.77%. The difference between the experimental groups was in favor of the II experimental group: dry matter by 0.21%, organic matter by 0.27%, crude protein by 0.41%, crude fat by 2.92%, crude fiber by 0.73%, nitrogen-free extractives by 0.14%, respectively.

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