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Obtaining Organically Pure Milk Using Natural Highly Activated Zeolites from Deposits in the European Zone of Russia

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Abstract

This research tried to obtain organic products in animal husbandry, including environmentally friendly milk of high-quality valuable composition. Our long–term research shows that using zeolites as mineral additives - natural enterosorbents by processing enrichment of silicon-containing minerals, in particular components (amino acids, probiotics, etc.). The work studied the feasibility of using feed additives based on natural and technologically activated (modified) zeolite feeding black-and-white dairy cows, based on the chemical composition of the mineral, conducting scientific and production tests in the conditions of farms in Russia in the Ulyanovsk region. The first is to establish the effect of additives on the physiological status of the cows' organism, their level of productivity and the qualitative composition of milk. The first group was a control, and the second was experimental, with the introduction of a zeolite additive into the diet at a dose of 2% of the dry diet matter, which is 250g/head/day, the control animals received only a household diet. The substantiation of the main properties, composition and mechanism of biological action on dairy cows' bodies of zeolite of different degrees of technological processing: quarry and activated, enriched with amino acids is given. It is proved that zeolite additives help to increase the intensity of metabolism and improve the morpho-biochemical status of the animal body. An increase in milk productivity and milk quality has been established. The greatest effect was obtained when using an activated form of zeolite enriched with amino acids.

Discipline: Animal Science (Dairy Science).

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1 Introduction

The leading scientific achievement of the XX century was the discovery and development of zeolites of both volcanic and sedimentary origin. The development began in 1960, and up to 20 large deposits were discovered in many countries of the world, including the USA, Japan and Russia. The European part of Russia has a poor sedimentary type of zeolite ores (up to 18 ... 40 % of zeolite in the rock). Zeolite deposits have been discovered, but little studied: in the Ulyanovsk region: Yushansk, Kadyshevsk, Bely Klyuch, Gulyushevsk; in the Republic of Tatarstan - Tatarsko-Shatrashansk; in the Republic of Bashkortostan - South Uralsk; in the Chuvash Republic - three large sites: Pervomaisky, Northern and Southern zeolite-containing rotten stones of the Alatyr deposit; in the Samara region - Vodnitsk deposit, etc. Basically, the reserves of zeolites of sedimentary origin are concentrated here, which differ in composition from volcanic ones but are not inferior to them in useful properties and effectiveness of action (Zyalalov et al. 2020; Dezhatkina et al. 2021; Vorotnikova & Dezhatkina 2019). Natural zeolites are aluminosilicates of alkaline and alkaline earth metals. Due to their crystal structure, they contain channels and voids occupied by large ions and water molecules, capable of ion exchange and reversible hydration. Zeolites are used in biology, medicine, veterinary medicine, agronomy, national economy and agriculture. The reason for much attention to them is their useful properties: ion exchange, adsorption, the function of a molecular sieve, and catalyst function (Shlenkina et al. 2019; Sharonina et al. 2018; Akhmetova et al. 2020). Thanks to this, zeolites are able to:

- supply and enrich the body with macro-and microelements, including vital silicon, calcium, copper, manganese, etc.;
- bind and neutralize harmful gases, poisons and toxins during poisoning; remove heavy metals and radionuclides from the body;
- demonstrate the properties of catalyst for redox reactions in the body and increase the activity of enzyme systems;
- activate the activity of beneficial microflora in the gastrointestinal tract;
- show anti-inflammatory and medicinal properties, etc..

The use of zeolite as a mineral additive in animal feed is due to the fact that it is a good natural antioxidant and as a detoxifying agent is able to neutralize and remove toxins, radionuclides, heavy metals from the body. Zeolites have a high ion-exchange capacity for potassium, sodium, magnesium and other ions, and are able to remove excess amounts of them from the body. They provide regulation of the composition of electrolytes, mineral homeostasis and acid-base balance. Optimize the metabolic processes of proteins, minerals, carbohydrates and fats. They activate and immobilize gastrointestinal enzymes, increase the digestibility of feed nutrients, and assimilate nitrogen and vitamins. By slowing down the progress of food coma, they favorably affect the state of the intestinal mucosa and improve the activity of the digestive tract. They bind many pathogenic strains and their toxins. The binding of gases during putrefactive fermentation eliminates flatulence and improves blood supply to the intestines. They stimulate productive

qualities, growth of young animals, and reproductive abilities in adult animals (Dezhatkina et al. 2021b; Akhmetova et al. 2020; Ziruk et al. 2020; Lyubin et al. 2020; Ushakova et al. 2020; Dezhatkina et al. 2019).

The new technology of activation, structuring, dehydration and enrichment of natural zeolite that we have developed allows us to open more pores in its structural lattice and strengthen its useful properties.

2 Materials and Methods

The scientific interest of scientists and experts is caused by the issues of comparative evaluation of the effectiveness of biological action of quarry zeolite and zeolite that has undergone technological activation and the process of enrichment with useful components. This was the purpose of this work (Zyalalov et al. 2020; Dezhatkina et al. 2021a).

The experiments were carried out in Russia in the Ulyanovsk region in the conditions of LLC "Agrofirm Tetyushskoe" on black-and-white dairy cows. The animals were fed with the rations adopted on the farm, which met the necessary requirements of the norm for nutrients but had a deficiency in mineral elements and vitamins. 50 animals were selected for each group. For physiological experiments, 5 cows were selected according to the principle of analogues, taking into account the breed, age, physiological condition and productivity (Dezhatkina et al. 2019; Lyubin et al. 2020). The first group was a control, and the second was experimental, with the introduction of a zeolite additive into the diet (Table 1) at a dose of 2 % of the dry diet matter, which is 250 g / head/day, the control animals received only a household diet.

Table 1: The experiment scheme.

Animal group	I control	II – experiment
Cow quality, head	50	50
Experiment 1	main diet (OR)	OR+250 quarry zeolite g / head/day (OR+Zк)
Experiment 2	main diet (OR)	OR+250 activated zeolite enriched with amino acids g / head/day (OR+Za+Am)

Blood sampling was performed before morning feeding. Milk productivity was recorded according to control milking once a month.

We did the research in the laboratory at the department “Morphology, physiology, and pathology of animals” and the Interdepartmental Center of the Faculty of Veterinary Medicine of the Ulyanovsk State Agrarian University named after P.A. Stolypin.

The study of morpho-biochemical parameters was carried out in laboratory conditions of the interdepartmental center of the faculty of veterinary medicine and biotechnology of FSBEI HE Ulyanovsk SAU, using analyzers: "Erma pce-90", "Stat Fax 1904 Plus", "Lactan 1-4", for measuring of the indicator we were using: PCE-90Vet», «АКБа-01-БИОМ», all data processed by the program " Statistika".

Radiology research studies were carried out by the №126/210(0100250-2000-2011 based on OGBU "Simbirsk Veterinary Reference Center" city Ulyanovsk, spectro-radiometry MKGB-01 "РАДЭК», gamma spectrometer MKSP-01 "РАДЭК".

We used local raw materials – natural zeolite, deposited in Yushanskoye, Ulyanovsk region for preparation of feeding supplement.

Zeolite belongs to the group of water-based frame silicates and consists of an anionic part of silicon (Si) and tetrahedral aluminum (Al) and a cationic part (Ca++, Na+, K+, Mn++, Cu++, Zn++, and others.).

The zeolite granule is riddled with tubules of the crystal lattice and absorbing like sponge ions (proteins and hormones macromolecules can't go through the tubules.

Zeolite is a good source of macro-and–Micro-Elements it is used for mineral metabolism correction and as an enterosorbet of toxins, poison gases, and substances.

Zeolite is not toxic to all animal, bird, and fish species as a supplement since 2013. It is not broken down in the gastrointestinal tract and is not let into an animal's body or human's organism. In general, it does not pose any danger to a person who eats poultry meat or an animal that has been fed zeolite.

The average grain size for animals and birds is 0.1...4.0 mm extra unused zeolite grains don't build up but are excreted naturally from the body. Overdose excluded.

According to the resolution of the European Commission in the European Union, Zeolite is registered as a feeding supplement E 567 and E568, and later 19 598.

Technological processing of raw minerals using modification tech with different levels of zeolite activation carried out in the OOO 'Keramzit" Ulyanovsk city.

Then modified zeolite was enriched with amino acids. The complex of amino acids "VitAmin" formed after enzymatic hydrolysis and includes up to 17 amino acids (34.74±5.21 g/100g), and is characterized by high biological activity (proportional of protein is 35.5±0.20 %) (Table 2).

Table 2: The chemical composition of VitAmin.

Indicator, g/100 g product	Content		Indicator, g/100 g product	Content
Aspartic acid	3.31±0,50		Phenylalanine	1.76±0.26
Glutamic acid	2.88±0,43		Isoleucine	3.18±0.48
Serine	0.70±0.11		Leucine	4.46±0.67
Histidine	0.52±0.08		Lysine	7.41±1.11
Glycerin	0.95±0.14		Proline	3.10±0.46
Threonine	0.60±0.09		Vitamin A (retinol), МЕ/л	8300±2000
Arginine	0.89±0.13		Vitamin D_3 (cholecalciferol), МЕ/л	510 000±120 000
Alanine	1.30±0.19		Vitamin B_1 (thiamine), g/l	4.31±0.26
Tyrosine	1.15±0.17		Vitamin B_2 (riboflavin), g/l	3.2±0.26
Cystine	0.32±0.05		Vitamin B_6 (pyridoxine), g/l	2.38±0.19
Valine	1.82±0.27		Copper, mg/kg	7.6±1.8
Methionine	0.42±0.06		Zinc, mg/kg	45.3±9.5

Content of feeding supplement based on modified zeolite enriched with amino acids "VitAmin": carrier – zeolite modified– 97.09 %, filler – amino acids "VitAmin" concentrate - 2.91%.

The complex is rich in vitamins A, and D, and group B contains trace elements – copper and zinc.

The manufacturer is Russia, Moscow the company OOO "Semiramida" (ТУ 20.14.42-001-27361838-2019, ROSS certificate of conformity RU.HB56.H01245

3 Results

According to the results of chemical analysis (Table 2) of the mineral rock of the Yushansky site of the Ulyanovsk region, it was found that it consists of active phases: opal-cristobalite, montmorillonite, hydrosluda, calcite. The total cation exchange capacity is 93...106 mg-eq/100 g. A significant role in the exchange belongs to silicon up to 40 % and calcium up to 88 %, then potassium up to 8 %, sodium up to 3 %, and magnesium up to 3 %.

The composition of natural zeolite is quite rich in mineral elements, it includes up to 40 macro-and microelements.

Table 3: Chemical composition of the zeolite of the Yushansky site in the Ulyanovsk region, %.

Oxide	Content	Error	Element	Content	Error
SiO2	64.48	0.23	**Si**	32.48	0.11
CaO	13.42	0.19	**Ca**	9.74	0.13
Al2O3	6.59	0.13	**Al**	4.02	0.07
Fe2O3	2.20	0.08	**Fe**	1.46	0.06
K2O	1.50	0.06	**K**	1.24	0.05
MgO	1.27	0.044	**Mg**	0.538	0.027
TiO2	0.323	0.016	**Ti**	0.193	0.010
Na2O	0.270	0.016	**Na**	0.200	0.012
P2O5	0.247	0.012	**Px**	0.108	0.005
Au	0.0838	0.0042	**Au**	0.0838	0.0042
SO3	0.0702	0.0052	**Sx**	0.0281	0.0021
PtO2	0.0540	0.0034	**Pt**	0.0464	0.0029
SrO	0.0485	0.0024	**Sr**	0.0410	0.0020
PdO	0.041	0.014	**Pd**	0.035	0.013
Re2O7	0.0279	0.0099	**Re**	0.0215	0.0076
WO3	0.0267	0.0037	**W**	0.0212	0.0029
BaO	0.0249	0.0061	**Ba**	0.0223	0.0055
HgO	0.0214	0.0039	**Hg**	0.0198	0.0036
MnO	0.0159	0.0011	**Mn**	0.0123	0.0009
GeO2	0.0135	0.0017	**Ge**	0.0094	0.0012
Cr2O3	0.0114	0.0014	**Cr**	0.0078	0.0010
V2O5	0.0106	0.0018	**V**	0.0059	0.0010
NiO	0.0079	0.0009	**Ni**	0.0062	0.0007
MoO3	0.0071	0.0024	**Mo**	0.0047	0.0016
ZrO2	0.0056	0.0028	**Zr**	0.0041	0.0021

The rock of the Yushansky site in the Ulyanovsk region of Russia has a low aluminum content of 4.02 0.07%, the concentration of amorphous silicon is 32.48 0.11% and amorphous calcium is 9.74 0.13 %. According to toxicity, it belongs to class 4.

We have experimentally proved that the addition of quarry zeolite from the Ulyanovsk region deposit to the diet of dairy cows contributed to an increase in the average daily milk yield by 5.5...12.9% compared to analogues. When converted to a basic fat content of 3.6 %, the average monthly milk yield per 1 dairy cow was 564.47 kg, which is 64.30 kg more than in the group of analogues.

The milk gain in the group using quarry zeolite was 2.15 kg, the feed costs for obtaining 1 kg of milk of basic fat content decreased by 11.3 % compared to the control. All indicators were within the physiological norms for animals of this species and the physiological state. The inclusion of quarry zeolite in the diet of cows of the 2nd group contributed to an increase in their blood red blood cells by 17.43 % ($P<0.05$), hemoglobin - by 19.01 % ($P<0.05$), hematocrit - by 3.33% and leukocytes by 21.5 % ($P<0.02$) compared to the data in the control group (Table 4).

Table 4: Morpho-biochemical parameters of the blood of dairy cows when adding quarry zeolite to their diet.

Indicators, unit.	1 group (control - OR)	2 group (OR+Zк)
	in blood	
Red blood cells, *1012/l	4,59 ± 0,09	5,39 ± 0,27*
% from control	100	117,43
Hemoglobin, g/l	101,67 ± 4,41	121,00 ± 4,58*
% from control	100	119,01
Hematocrit, %	30,00 ± 1,53	31,00 ± 0,58
% from control	100	103,33
Leukocytes, *109/l	5,35 ± 0,22	6,50 ± 0,23*
% from control	100	121,50
Total protein, g/l	74,77 ± 2,39	81,83 ± 0,13*
% from control	100	109,44
	in liver	
Crude protein, g/l	134,00 ± 1,53	141,00 ± 3,79
% from control	100	105,22

Note: * - ($p<0,05$, $p<0,02$) compared to the indicator in control

The intensity of protein metabolism increased, the level of total protein increased by 9.4 % ($P<0.05$), and the activity of enzyme systems increased: AST and ALT- aminotransferases, HE-cholinesterases, LDH-lactate dehydrogenase, ALP-alkaline phosphatase.

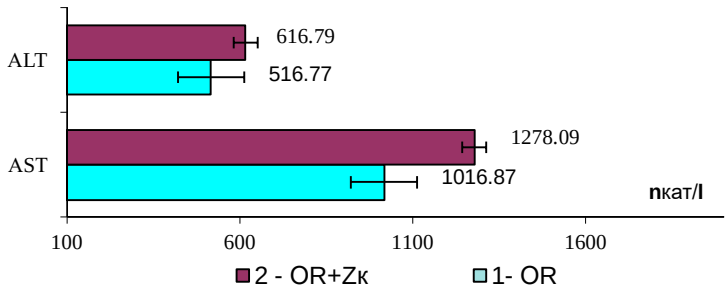

Figure 1: The activity of aminotransferases in the blood of cows when feeding with quarry zeolite.

This indicates an increase in nitrogen metabolism in the body of dairy cows of the experimental group.

The intake of quarry zeolite into the body of cows normalizes mineral metabolism, and a reserve of mineral elements is created in the depot organs of dairy cows (Figure 2).

The concentration of calcium (P<0.01), phosphorus and magnesium increases in the blood, the level of iron increases in the liver (P<0.01), and the content of iron (P<0.02), copper and zinc (P<0.05) increases in the spleen. The addition of quarry zeolite to the diet of cows of the 2nd group contributed to an increase in the activity of transamination enzymes: AST by 25.7% and ALT - by 19.35% in the blood serum of cows compared with the control (Figure 1).

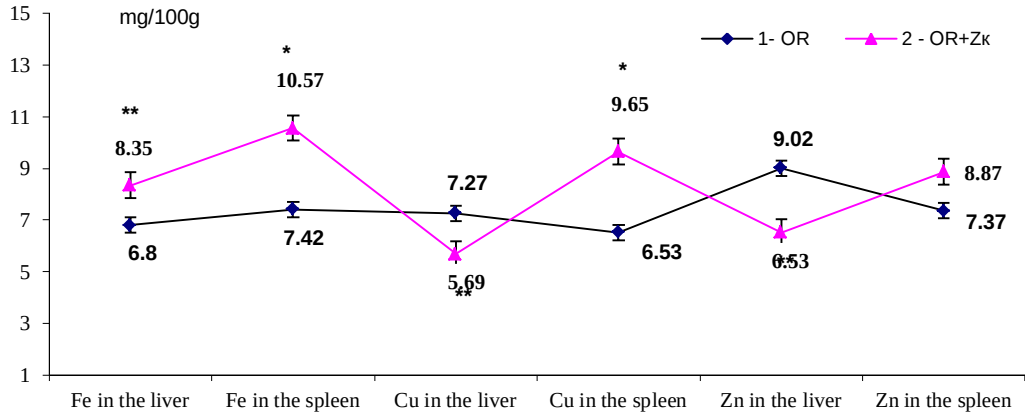

Figure 2: The content of mineral elements in the depot organs in cows when feeding with quarry zeolite

Feeding an additive of activated zeolite enriched with amino acids to dairy cows also contributed to a favorable effect on the indicators of the physiological and biochemical status of their body and nitrogen metabolism (Table 5).

Table 5: Indicators of the physiological and biochemical status of the cows ' bodies when using activated zeolite enriched with amino acids.

Indicators, ед.	1 group (control - OR)	2 group (OR+Za+Am)
Red blood cells, *10 12 /l	6.40±0.45	7.32±0.05
% to control	100,00	114.38
Hemoglobin, g/l	115.00±2.89	129.00±3.79*
% to control	100.00	112.17
Leukocytes, *109/l	9.05±0.26	10.90±0.31**
% to control	100.00	120.44
Crude protein, g/l	76.00±2.08	85.00±5.29
% to control	100.00	111.84
Albumine, g/l	27.00±0.58	30.00±1.15
% to control	100.00	111.11
Globuline, g/l	49.00±1.73	55.00±5.77
% to control	100.00	112.24
ALT, нкат/l	477.93±66.35	439.92±40.00
% to control	100.00	92.05
Urea, mmol/l	1.71±0.31	1.33±0.10
% to control	100.00	77.78
ALP, нкат/l	788.99±18.12	627.96±56.34
% to control	100.00	79.59
Glukoze, mmol/l	3.01±0.27	2.90±0.14
% to control	100.00	96.35

In the blood of cows of the 2nd group, an increase in the number of red blood cells by 14.38%, and hemoglobin by 12.17 % (p<0.05) was found, which indicates an increase in the

respiratory function of their blood. A significant increase in the blood of cows of the experimental group within the norms of white blood cells by 20.44 ($p<0.01$) % compared to the control indicates an increase in protective forces of the body of lactating animals.

The inclusion of activated zeolite enriched with amino acids in the diet of cows of the experimental group enhances the synthesis of proteins in their body: the concentration of total protein in blood serum increases by 11.84 %, albumins by 11.11 %, globulins by 12.24% compared to the control.

Against this background, a decrease in the concentration of urea in the blood of cows group 2 was found by 22.22 %, which indicates a positive nitrogen balance, that is, the use of feed nitrogen for anabolic processes that are associated with the formation of new tissue proteins.

With an increase in the content of total protein, albumins and globulins and a decrease in the level of urea, a positive dynamics of enzyme activity in the blood of cows of the experimental group was noted. ALT activity decreased by 8.0 %, which characterizes the productive use of amino acids in the metabolism of nitrogenous substances and the strengthening of amino acid transamination reactions along the catabolic pathway of medium amino acid metabolism.

Consequently, those amino acids that were not involved in the synthesis of proteins are involved in the processes of catabolism, reducing the oxidation and use of amino acids in the process of gluconeogenesis and the formation of urea. The activity of alkaline phosphatase (AP) in the blood of cows of the experimental group decreased by 20.41% compared to the control. This indicates a reduction in the load on the liver of cows.

The use of activated zeolite enriched with amino acids as an additive also normalizes mineral homeostasis in the body of cows (table 5). In the blood serum of cows of the 2nd group, the concentration of calcium (Ca) increased by 42.15 % ($P<0.01$), phosphorus (P)-by 9.16 %, magnesium (Md) - by 29.41 % and the content of iron (Fe) decreased by 13.75 %, copper (Cu) and zinc (Zn) by 23.94 and 21.53 % compared to analogues, which indicates their effective use in metabolic processes, in enzyme synthesis reactions and hematopoiesis (Figure 3).

The enrichment of dairy cows' diets with zeolites of various degrees of processing contributed to an increase in productivity and an increase in the quality of milk composition.

When activated zeolite enriched with amino acids is added to the diet of the 2nd cow group, the content of mineral elements in milk increases. At the same time, the calcium concentration increased by 7.3 %, and the Ca : P ratio increased by 11.1 % compared to the indicators in control.

The concentration of calcium in the experimental group was 69.1±3.60 mg%, versus 64.4± 1.70 mg% in the control group, and phosphorus, respectively, 57.8± 1.80 and 61.3± 1.80 mg%.

The content of zinc (Zn) and iron (Fe) in cows' milk also increased within the norms against the background of the use of the additive, and the level of copper (Cu) decreased, which probably can indicate its intensive use in metabolic processes (Figure 4).

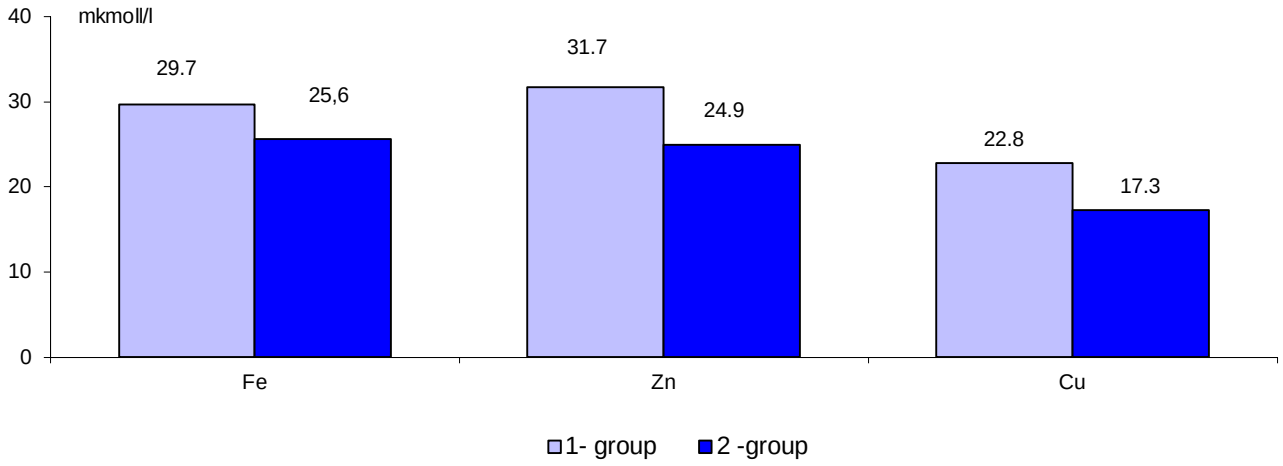

Figure 3: The content of mineral elements in the blood serum of cows when using activated zeolite enriched with amino acids.

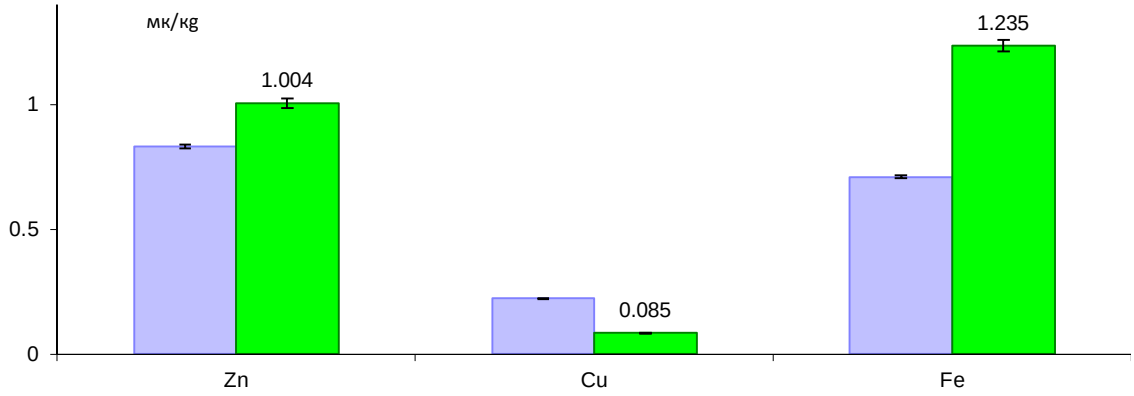

Figure 4: The concentration of Zn, Cu, and Fe in cow's milk.

The use of an additive of activated zeolite enriched with amino acids, which was processed in the factory, also stimulated milk production in cows, but the effect was several times higher (Table 5).

An increase in the average daily milk yield was revealed: in 2-3 months of lactation by 14.3%, in 3-4 months of lactation - by 19.7%, in 4-5 months of lactation by 29.3%, in 5-6 months of lactation by 40.3% (at $p<0.001$), in 6-7 months of lactation by 29.3% compared with the control.

Against this, there was an increase in milk yield fat (kg), respectively, by: 21.8 %; 21.3 %; 15.9 %; 21.7 %; 7.2%.

A similar pattern was established for the yield of milk protein, which increased by 0.842 ± 0.066 kg, against 0.728 ± 0.066 kg in the control and increased monthly by 15.7 ... 40.0% relative to the data in the group of analogues.

There was no noticeable effect of feeding activated zeolite enriched with amino acids to cows on the fat content of milk. During the experiment, it was established that the dry fat-free milk residue – SOMO in cow milk of all groups was approximately the same and amounted to 8.86...9.51, characterizing the naturalness of this milk, high content of dry substances in it and less - water.

The changes revealed in the organism of cows contribute to better use of feed nutrients and increase productivity, and the qualitative composition of milk improves.

4 Discussions

Our results are consistent with the studies of individual scientists e.g. Shlenkina (2019), Vorotnikova (2019), and Lubin (2020) in the field of the use of natural zeolites as feed additives in animal husbandry.

When feeding zeolite supplements to animals, researchers note an improvement in hematological parameters, hemoglobin, erythrocytes, and leukocytes (Lyubin, 2020; Akhmetova, 2020).

Table 6: Indicators of dairy productivity of cows with the addition of activated zeolite enriched with amino acids

Group/ experiment period	Indicators, unit.	1 group (control - OP)	2 group (OR+ Za+Am)
experiment beginning 1-2 months of lactation	Average daily milking/ per 1 cow, kg	30.33±1.42	29.67±1.43
	Weight fraction of fat, %	3.77±0.21	3.88±0.17
	Butterfat yield, kg	1.143±0.085	1.147±0.057
experiment 2-3 months of lactation	Average daily milking/ per 1 cow, kg	23.33±1.99	26.67 ±2.46
	% from control	100.0	114.30
	Weight fraction of fat, %	3.88±0.18	4.21±0.20
	Butterfat yield, kg	0.917±0.115	1.117±0.108
	% from control	100.0	121.8
experiment 3-4 months of lactation	Average daily milking/ per 1 cow, kg	22.00±1.57	26.33±2.30
	% from control	100.0	119.70
	Weight fraction of fat, %	4.33±0.23	4.41±0.19
	Butterfat yield, kg	0.952±0.079	1.155±0.016
	% from control	100.0	121.3
experiment 4-5 months of lactation	Average daily milking/ per 1 cow, kg	18.17±0.79	23.50±2.49
	% from control	100.0	129.3
	Weight fraction of fat, %	4.21±0.16	3.83±0.14
	Butterfat yield, kg	0.785±0.058	0.910±0.122
	% from control	100.0	115.9
experiment 5-6 months of lactation	Average daily milking/ per 1 cow, kg	17.33±1.58	24.33±1.98***
	% from control	100.0	140.3
	Weight fraction of fat, %	4.60±0.17	4.39±0.23
	Butterfat yield, kg	0.86±0.128	1.05±0.046
	% from control	100.0	121.7
experiment 6-7 months of lactation	Average daily milking/ per 1 cow, kg	14.17±1.01	17.67±1.12
	% from control	100.0	129.3
	Weight fraction of fat, %	4.64±0.26	4.18±0.33
	Butterfat yield, kg	0.69±0.052	0.74±0.088
	% from control	100.0	107.2

Note: ***p<0.001 compared to the indicator in the control

Scientists indicate an increase in the intensity of protein metabolism and the activity of enzyme systems (Ziruk, 2020; Zyalalov, 2020).

The authors say about the productive use of amino acids in metabolism against the background of zeolites (Vorotnikova, 2019; Dezhatkina, 2019; 2021).

Note a decrease in the urea concentration in the blood of animals, which indicates a positive nitrogen balance in their body and the use of nitrogen feed for anabolic processes, researchers (Akhmetova, 2020; Serdyuchenko, 2020; Ivanova, 2021; Ospichuk, 2021).

The data we obtained also indicates the normalization of mineral homeostasis in the body of cows, and an increase in the blood and milk of cows of mineral elements (Ca, Mg, Fe, Zn, etc.). This is consistent with the authors, whose data also reflect this (Sharonina, 2018; Shlenkina, 2019; Zhukov, 2021).

The changes revealed in the organism of cows contribute to better use of feed nutrients and increase productivity, and the qualitative composition of milk improves.

Several researchers indicate that the activated form of zeolite enriched with amino acids has a good effect (Zyalalov, 2020; Akhmetova, 2020; Dezhatkina, 2019; 2021).

5 Conclusion

Mechanism of action of modified zeolite enriched with amino acids "VitAmin" is: Amino acids enter into a synergetic interaction at the ultramolecular level with zeolite. Ion exchange activates in the body due to the high biological activity of amino acids that can easily penetrate through the walls of the stomach and intestines. Amino acids ensure the transport of macro-and-microelement ions into tissues, increasing their availability and assimilation. In the body, mineral elements perform their role, including contributing to the assimilation of nutrients and biologically active substances of feed. There is a stimulation of metabolic processes, processes of growth and development in young animals, and activation of reproductive and productive functions in adult animals. In addition, working as an enterosorbent, modified zeolite absorbs and removes various toxins, allergens, radionuclides, heavy metals, harmful gases, and substances from the body.

The established results indicate that the use of new technologies, innovative processing, and enrichment of quarry mineral-zeolite makes it possible to strengthen the existing properties and increase the effectiveness of its action on the animal's body, contributing to an increase in productivity and quality of the products obtained.

6 Availability of Data and Material

Data can be made available by contacting the corresponding author.

7 Author's Contribution

This work is the result of complex scientific research. The entire team of authors participated in the preparation of the article: SD, NF, NP and ES with SD as a leader, carried out the selection of the topic, the organization of the work, the analysis and interpretation of the results, and the writing of the manuscript. NF, NP, and ES conducted an experiment and data collection, laboratory research, and biometric data processing. All the authors participated in the reading and editing of the paper.

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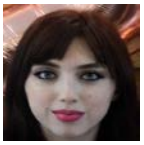

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