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ORIGINAL ARTICLE

Hematological parameters and content of lipids in tissues of the organism of rabbits according to the silicon connection

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The article presents the results of the study for the influence of the rabbits feeding with various amounts of citric acid (25, 50 and 75 μg Si kg^{-1} of body weight, I-III experimental groups) from 52 to 110 days of life of the rabbits, obtained by nanotechnology method and sodium metasilicate (2.5 and 5.0 mg Si kg^{-1} of body weight, IV–V experimental groups) on hematological parameters and total lipid content and their fractional composition in the blood and liver tissue. It was established that the number of erythrocytes in the blood of rabbits in II and III experimental groups was higher by 18.4 and 20.7% ($P<0.05$) at 31 days of study compared with control. At day 58 of the experiment, the total number of red blood cells in animals of the 1st, 2nd, and 3rd experimental groups was respectively higher by 14.9, 19.1, and 17.6% ($P<0.05$) than in the control. According to white blood indexes, the differences from control were found during the feeding of supplements with a significantly higher change of 30.9% ($P<0.05$) in 31 days in the blood of animals in the third experimental group. It was found that the feeding of silicic acid compounds did not significantly change the total lipids and phospholipids content, but led to the redistribution of their classes in the investigated tissues. Under the action of citrate silicon in the amount of 50 and 75 μg Si kg^{-1} of body weight, there was a decrease in the content of triacylglycerols in the blood plasma by 35 and 52% ($P<0.05–0.01$), respectively, compared with control. Investigation of the fractional lipids composition in the liver tissue showed a lower content of triacylglycerols and esterified cholesterol in animals of the II and III experimental groups compared with the control group. Consequently, the results of blood analyses and the fractional lipids composition in the individual tissues of the rabbit body indicate positive changes contributing to metabolic accumulation of energy and plastic components in the trophic chain and confirm the feasibility of adding citrate silicon in the rabbit diet, taking into account its physiologically substantiated amount.

Key words: Rabbits; Nanosilicon; Sodium metasilicate; Blood; Liver

Introduction

Minerals play an important role in the feeding of rabbits (Sharifi et al., 2011; Sedilo et al., 2018). They regulate the metabolism; participate in the protein biosynthesis, in the permeability of cell membranes. The bioavailability of trace elements in their body is important for feeding rabbits. At present, studies were initiated on the effects of the new unknown compounds of mineral substances in the animal body using nanotechnology, in particular the absorption of citrate (Borysevych et al., 2010; De Blas & Wiseman, 2010; Darmohray et al., 2019). The biological role of silicon in the life of all farm animals is multifaceted (Powell et al., 2005). It is essential for the growth and development of animals, the formation of bone and connective tissue, the normal exchange of lipids, proteins, carbohydrates, macro- and trace elements, and vitamins (Jugdaohsingh et al., 2008). High concentrations of silicon are in the connective tissue of an animal body, particularly in the aortic wall, where it is associated with the components of elastin and collagen. Its content decreases with age and during the progression of atherosclerosis. Histologic analysis of the aortic wall of rabbits consuming high levels of lipids in the diet, and in addition, silicon did not show thickening and atherosclerotic changes compared with animals of another group fed without silicon. It is known from literary sources that the addition of silicon to water during feeding mice suspended the processes of the body aging, although the mechanisms are not completely cleared up. (Jugdaohsingh et al., 2015). Adding silicon in the rabbit diet contributed to a decrease in blood pressure at hypertension (García-García et al., 2011). Hematologic studies reflect the physiological sensitivity of the animal to its internal and external factors, which include the healthy diet by nutrients and minerals, which may be important information for comparing nutritional deficiencies and the physiological status of an animal organism (Daramola et al., 2005). The deficiency of mineral substances in the rabbit diet leads to a change in their hematological parameters (Daoud et al., 2012). The problem of modern raising rabbit meat in the world is the

application of new supplements in the diet negatively affecting the hematological parameters and the animals' organism as a whole. In addition, studying the profile of rabbit's blood depending on the components of the diet may indicate the need to adjust some nutrients in the diet increasing or decreasing their amount (Müller et al., 2017). The scientific literature describes the functions of silicon in biological systems and the influence of some its compounds on physiological processes. However, the issue of rationing for the nanoquantity of siliceous substances in different age groups of rabbits for industrial raising rabbit meat and the effect on metabolic processes in their body was not studied. Therefore, the purpose of the study was to investigate the effect of feeding nanosilicon of citrate and sodium metasilicate on hematological parameters and lipid content in the body tissues of rabbits in the period from 52 to 110 days of life.

Material and Methods

Obtaining citrate nanocobalt

The solution of nanosilicon of citrate (0.5 g/dm^3, pH 1.35) was obtained from "Nanomaterials and Nanotechnologies Ltd.", Kyiv. The synthesis of nanosilicon of citrate by aquananotechnology is performed in two stages. In the first stage, an aqueous colloidal solution of silicon nanoparticles is obtained by dispersing high-purity granules of the corresponding metal by pulses of electric current in deionized water. In the second stage, the carboxylates of the biogenic metals themselves are obtained by reaction of the direct interaction between chemically active nanoparticles with citric acid. Since no other substances are included in the reagents, and the nanoparticles are fully involved in the chemical reaction of the citric acid synthesis, the result is the formation of a high purity chemical that does not contain free nanoparticles.

Animals

The studies were carried out on young *Hyla* rabbits, divided into six groups (control and five experimental), 6 animals (3 males and 3 females) in each, selected by analogy at the age of 41 days. Animals were kept in rooms with adjustable microclimate and illumination in mesh cages of 50 × 120 × 30 cm according to the modern veterinary and sanitary standards. The rabbits of the control group were fed without restriction a balanced granulated feed, according to recommendations, with free access to water. Animals of the 1st, 2nd and 3rd experimental groups had the diet of the control group and, during the course of the day, nanosilicon of citrate of 25; 50 and 75 μg Si kg^{-1} of body weight was fed. Young females of the IV and V experimental groups were fed with the diet of the control group and sodium metasilicate ($Na_2SiO_3H_2O$) was added with water in an amount of 2.5 and 5.0 mg Si kg^{-1} of body weight, respectively. The experiment lasted 68 days, including a preparatory period of 10 days, and a test period 58 days. In the preparatory period, samples of blood from the marginal ear vein were taken by puncture with a disposable needle into a sterile syringe at 52 days and in the experimental period of 83 and 110 days (31 and 58 days of provision of supplements) in 4 animals (2 males and 2 females) from the group. The blood-sampling site was treated with alcohol and a solution of dimethoxide for local hyperemia. Blood for hematological examination was taken in test tubes containing dicalcium salt of ethylenediamine - tetraacetic acid (EDTA – K^{2+}), which served as an anticoagulant, 1% heparin, as an anticoagulant, was used for biochemical studies. On the 58th day after the experiment began, animals were slaughtered taking into account the generally accepted bioethical rules of international regulations regarding experimental work on vertebrates (Official Journal of the European Union L276/33, 2010). The material for the study was blood and liver of rabbits. All procedures for tissue processing were carried out in the cold.

Hematologic study

Hematologic studies were performed using an automatic hematologic analyzer (Orphee Mythic 18, Switzerland), analyzing the following indicators: the total erythrocytes number (RBC), hemoglobin (HGB), hematocrit (HCT), mean cell volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red cell distribution width (RDW), leukocyte (WBC), lymphocytes (LYM), monocytes (MON), granulocytes (GRA), total platelet count (PLT) mean platelet volume (MPV), plateletcrit (PCT), platelet distribution width by volume (PDW).

Obtaining total lipids

Blood plasma or homogenized tissue was extracted with chloroform-methanol (2:1, v/v) by the Folche method. The tissue to reagent ratio was 1:20. To purify the lipid extract, a 0.74 M KCl solution was added. The total amount of lipids was determined gravimetrically.

Separation of total lipids into classes

The separation of lipids into classes was carried out using thin-layer chromatography (TLC) on silica gel (silica gel L 5/40μ, LSL 5/40μ, Chemapol, Czech Republic), using hexane-diethyl ether-acetic acid in a ratio of 70: 30: 1 as a mobile phase. (v/v/v). Lipid classes were stained in vapors of crystalline iodine. Identification of individual lipids was carried out by Rf values. Quantitative analysis and calculation of the lipid classes contents were performed by computer processing of plates using the TotalLab TL120 software (Nonlinear Dynamics Limited, UK) and expressed as percentage of the total pool.

Separation of phospholipids

A solvent system chloroform-methanol-water was used for separating phospholipids of TLC on silica gel with the ratio 65: 25: 4 (v/v/v). Phospholipids were stained in vapors of crystalline iodine. Identification of individual phospholipids was carried out with values of Rf. Quantitative analysis and counting of individual phospholipids were performed by computer processing of plates using the TotalLab TL120 software (Nonlinear Dynamics Limited, UK) and expressed as percentage of the total pool.

Statistical analysis

The received digital material was processed by the variation statistics method using the Student's t-test. The mean arithmetic values (M) and the mean arithmetic mean errors (± m) were calculated. The changes were considered probable at $P \leq 0.05$. For calculations, the computer program Statistica 6.0 was used.

Results

Hematologic studies are an important indicator of the animal's physiological state and the provision of nutrients and trace elements, since blood is the main transport system of the organism that first responds to a shortage or excess nutrients in the diet (Afolabi et al., 2010). In rabbits during the study of different amounts of organic and inorganic compounds, silicon was detected by changes in hematological parameters in animals of experimental groups compared to control ones, which, depending on the compound and their number, were within the upper or lower physiological values (Table 1).

Table 1. Red blood parameters of rabbits drink the nanosilicon of citrate and sodium metasilicate, (here and then M ± m, n=5).

Parameters	Group	preparatory 52 day life	Periods of research age/period of feeding supplements, day	
			83/31	110/58
Total erythrocytes number, 1×10^{12} L^{-1}	K	5.16 ± 0.170	5.41 ± 0.250	5.49 ± 0.230
	E-I	5.28 ± 0.350	6.30 ± 0.140	6.31 ± 0.240*
	E-II	5.39 ± 0.300	6.41 ± 0.130*	6.54 ± 0.350*
	E-III	5.25 ± 0.270	6.53 ± 0.370*	6.46 ± 0.250*
	E-IV	5.24 ± 0.310	5.39 ± 0.100	6.16 ± 0.180
	E-V	5.44 ± 0.160	5.55 ± 0.140	6.12 ± 0.230
Hemoglobin, g L^{-1}	K	113.5 ± 3.79	115.2 ± 2.83	119.2 ± 1.65
	E-I	116.5 ± 2.87	118.2 ± 1.54	120.7 ± 2.05
	E-II	117.0 ± 2.48	123.7 ± 1.70*	128.2 ± 2.95*
	E-III	118.2 ± 3.27	123.0 ± 2.27	131.2 ± 4.21*
	E-IV	110.7 ± 3.19	118.5 ± 2.02	125.0 ± 2.38
	E-V	115.7 ± 5.21	119.5 ± 1.84	126.5 ± 2.98
Hematocrit, L L^{-1}	K	0.36 ± 0.011	0.37 ± 0.013	0.38 ± 0.013
	E-I	0.36 ± 0.010	0.39 ± 0.012	0.39 ± 0.016
	E-II	0.38 ± 0.012	0.40 ± 0.024	0.44 ± 0.014*
	E-III	0.37 ± 0.010	0.43 ± 0.017*	0.41 ± 0.018
	E-IV	0.34 ± 0.020	0.39 ± 0.010	0.40 ± 0.015
	E-V	0.35 ± 0.017	0.38 ± 0.014	0.40 ± 0.017
Mean cell volume (MCV), f L^{-1}	K	70.7 ± 1.52	70.5 ± 2.10	71.1 ± 4.78
	E-I	69.3 ± 3.40	62.3 ± 2.91	63.0 ± 2.68
	E-II	71.2 ± 2.84	63.0 ± 3.10	68.0 ± 3.39
	E-III	69.8 ± 1.40	66.3 ± 3.89	64.2 ± 4.16
	E-IV	65.3 ± 4.62	72.2 ± 1.98	65.8 ± 3.38
	E-V	67.4 ± 1.46	69.2 ± 2.58	65.3 ± 1.88
MCH, p g^{-1}	K	21.9 ± 0.73	21.4 ± 1.30	21.8 ± 1.08
	E-I	22.1 ± 1.08	18.7 ± 0.55	19.1 ± 0.51
	E-II	21.8 ± 1.39	19.2 ± 0.41	19.7 ± 1.34
	E-III	22.5 ± 0.76	18.9 ± 1.31	20.4 ± 1.18
	E-IV	21.3 ± 0.94	22.9 ± 0.47	20.3 ± 0.93
	E-V	21.2 ± 0.37	21.5 ± 0.76	20.7 ± 0.81
MCHC, g L^{-1}	K	311.2 ± 10.05	306.1 ± 11.10	308.9 ± 12.90
	E-I	324.8 ± 15.40	301.7 ± 5.86	304.9 ± 10.79
	E-II	308.3 ± 7.98	343.0 ± 6.49*	346.4 ± 8.25*
	E-III	317.2 ± 14.38	348.7 ± 9.26*	318.9 ± 7.17
	E-IV	327.9 ± 14.90	304.6 ± 11.10	309.8 ± 12.22
	E-V	317.1 ± 2.46	311.9 ± 14.27	318.3 ± 10.27
RDV,%	K	9.97 ± 0.44	11.62 ± 0.94	10.47 ± 0.21
	E-I	10.47 ± 0.660	12.12 ± 1.390	10.62 ± 0.280
	E-II	11.37 ± 1.020	12.10 ± 1.220	10.65 ± 0.170
	E-III	10.20 ± 1.260	12.37 ± 0.740	10.50 ± 0.400
	E-IV	11.01 ± 1.020	11.80 ± 1.040	10.60 ± 0.430
	E-V	10.30 ± 0.310	13.07 ± 1.120	9.85 ± 0.550

Note: here and further * P<0.05; ** P<0.01, compared with the control group. C – control, E I-V – experimental groups.

In particular, the number of erythrocytes in the blood of rabbits in II and III experimental groups was higher by 18.4 and 20.7% (P<0.05) at 31 days of study compared with control. At the final stage of the experiment, the total number of erythrocytes in the blood of I, II, and III experimental groups was higher by 14.9, 19.1,and 17.6% respectively (P<0.05) than in the control. The hemoglobin level was significantly higher during the study in the blood of rabbits of the second experimental group and increased by 10% (P<0.05) in group III on day 58 of the experiment compared with the control group. Confirmation of the positive effect of individual amounts of organic compound on the red blood cell index is a probable change in the hemoglobin concentration in a separate erythrocyte, which was higher in the blood of animals of the II and III experimental groups, respectively, by 12.0 and 13.9% (P<0.05) on 31 day of the study and increased in group II by 12.1% (P<0.05) on the 58th day of the experiment compared with the control group. By the white blood indices, differences from control were detected during the experiment with probable changes in the first stage of the study (Table 2). Thus, the total number of leukocytes in the blood of animals in the third experimental group was higher by 30.9% (P<0.05) at 31 days of study, with a tendency to a greater number of them in II-IV groups in the final study period compared with the control group.

Table 2. White blood parameters of rabbits drink the nanosilicon of citrate and sodium metasilicate.

Parameters	Group	preparatory 52 day life	Periods of research age/period of feeding supplements, day)	
			83/31	110/58
Leucocytes, $1 \cdot 10^9$ L^{-1}	K	7.2 ± 1.30	8.4 ± 0.93	8.8 ± 1.12
	E-I	7.6 ± 1.47	8.0 ± 1.34	8.9 ± 1.07
	E-II	8.1 ± 0.69	9.7 ± 1.12	10.2 ± 0.99
	E-III	8.3 ± 0.89	11.0 ± 0.40*	10.5 ± 0.60
	E-IV	6.9 ± 0.75	9.8 ± 0.77	9.2 ± 0.91
	E-V	8.2 ± 0.71	8.8 ± 0.45	9.1 ± 0.49
Lymphocytes, $1 \cdot 10^9$ L^{-1}	K	2.0 ± 0.13	2.7 ± 0.30	2.6 ± 0.24
	E-I	2.2 ± 0.36	2.8 ± 0.49	2.4 ± 0.20
	E-II	2.5 ± 0.37	3.2 ± 0.31	3.0 ± 0.33
	E-III	2.3 ± 0.24	3.4 ± 0.52	3.1 ± 0.40
	E-IV	2.1 ± 0.16	3.3 ± 0.23	3.2 ± 0.18
	E-V	2.8 ± 0.33	2.9 ± 0.11	2.9 ± 0.37
Monocytes, $1 \cdot 10^9$ L^{-1}	K	1.1 ± 0.20	2.0 ± 0.28	1.5 ± 0.20
	E-I	1.9 ± 0.30	1.4 ± 0.10	1.3 ± 0.23
	E-II	1.1 ± 0.16	1.5 ± 0.19	1.9 ± 0.21
	E-III	1.4 ± 0.32	1.3 ± 0.18	1.8 ± 0.17
	E-IV	1.5 ± 0.29	1.5 ± 0.18	1.1 ± 0.10
	E-V	1.3 ± 0.14	1.3 ± 0.15	1.4 ± 0.30
Granulocytes, $1 \cdot 10^9$ L^{-1}	K	6.6 ± 0.42	5.8 ± 0.43	5.9 ± 0.50
	E-I	5.7 ± 0.65	6.2 ± 0.19	6.0 ± 0.54
	E-II	5.8 ± 0.48	5.7 ± 0.73	6.1 ± 0.41
	E-III	5.4 ± 0.54	6.2 ± 1.02	6.2 ± 0.45
	E-IV	5.9 ± 0.44	6.0 ± 0.51	6.5 ± 0.17
	E-V	5.8 ± 0.51	5.9 ± 0.46	5.7 ± 0.33

Analysis for the absolute number of lymphocytes, monocytes and granulocytes in rabbits showed a tendency to increase their numbers in the II-IV experimental groups and less pronounced changes in the I and V groups, although these changes were unlikely compared to controls. Despite the significant role of platelets in the rabbit body, the study of their functional state is normal. In particular, the presentation of different amounts of silicon compounds did not reveal significant differences between the control and experimental groups of animals (Table 3).

Despite the variability of hematological parameters in rabbits, depending on the breed and individual characteristics, the indices of erythrocytes, leukocytes and platelets were within the limits of physiological parameters. However, the studied indices of red and white blood in animals of the I and V groups were at the lower level of the physiological norm compared to the control group, which may be attributed to the insignificant effect of the lower studied amount of the silicon organic compound and the higher sodium metasilicate on the rabbit body. In addition, the results of the study indicate that the feeding of nanosilicon of citrate to animals of the 2nd and 3rd experimental groups positively influenced the hematopoietic system of their organism.

It is known that silicon is involved in the lipid metabolism of animals, the results of the study showed that the feeding of organic and inorganic silicon compounds did not significantly affect the total lipid content in blood plasma and liver tissue of rabbits (Figures 1 and 2). It is necessary to note the tendency to increase the content of total lipids in blood plasma and liver of animals in the 2nd and 3rd experimental groups, which were fed with nanosilicon of citrate, which may indicate some adaptive reorganization of metabolic processes in their organism, depending on the compound and amount in the diet.

Results of the fractional composition of total lipids in the blood plasma and liver tissues of rabbits show more pronounced changes in animal experimental groups than in the control (Tables 4 and 5). In particular, a marked tendency to increase the content of phospholipids in the blood and liver of animals of the 2nd and 3rd experimental groups compared to control. The content of triacylglycerols in the blood plasma of rabbits in II and III experimental groups was respectively lower by 35% ($P<0.05$) and 52% ($P<0.01$) compared with control, obviously their use was increased for the energy needs of the tissues in the rabbit organism. In the metabolic processes of the body, the rabbit liver performs a trophic and protective function.

It is the largest gland of the digestive system and is central to lipid metabolism. Studies of the fractional lipids composition in the liver tissues revealed a lower content of triacylglycerols and esterified cholesterol in animals of the II and III experimental groups, respectively, at 31.6 and 30.8% and 25.1 and 31.9% ($P<0.05$) compared with the control group (Table 5). Reducing the amount of triacylglycerols and esterified cholesterol in the liver is evidence of the lipid synthesis activation and its use for the energy needs of the body.

Table 3. Platelet parameters of blood rabbits drink the nanosilicon of citrate and sodium metasilicate.

Parameters	Group	preparatory 52 day life	Periods of research age/period of feeding supplements, day	
			83/31	110/58
Platelet, $1 \cdot 10^9$ L^{-1}	K	408.7 ± 10.98	571.7 ± 38.89	600.0 ± 18.91
	E-I	447.2 ± 16.68	631.7 ± 14.53	648.0 ± 17.80
	E-II	424.5 ± 8.06	626.0 ± 36.30	633.2 ± 11.25
	E-III	403.5 ± 5.23	652.7 ± 7.28	643.7 ± 28.01
	E-IV	422.0 ± 12.06	654.7 ± 17.70	614.0 ± 8.92
	E-V	432.5 ± 13.76	623.0 ± 12.02	620.0 ± 12.06
Mean platelet volume (MPV), fl	K	5.02 ± 0.17	5.17 ± 0.130	5.32 ± 0.110
	E-I	4.95 ± 0.180	5.05 ± 0.310	5.07 ± 0.170
	E-II	5.02 ± 0.160	5.01 ± 0.230	5.25 ± 0.190
	E-III	4.87 ± 0.170	5.30 ± 0.150	5.10 ± 0.100
	E-IV	5.17 ± 0.170	5.37 ± 0.160	5.22 ± 0.130
	E-V	5.30 ± 0.160	5.10 ± 0.300	5.20 ± 0.140
Platelet crit (PCT).%	K	0.227 ± 0.010	0.306 ± 0.030	0.358 ± 0.020
	E-I	0.262 ± 0.030	0.319 ± 0.050	0.356 ± 0.030
	E-II	0.282 ± 0.040	0.352 ± 0.040	0.390 ± 0.040
	E-III	0.296 ± 0.030	0.373 ± 0.010	0.414 ± 0.030
	E-IV	0.267 ± 0.030	0.397 ± 0.030	0.383 ± 0.030
	E-V	0.277 ± 0.020	0.337 ± 0.020	0.404 ± 0.020
PDW,%	K	13.2 ± 0.44	14.3 ± 0.55	14.4 ± 0.83
	E-I	12.0 ± 0.99	14.0 ± 0.85	13.5 ± 0.30
	E-II	12.5 ± 0.61	13.0 ± 0.63	13.4 ± 1.11
	E-III	12.0 ± 1.13	13.5 ± 1.25	13.9 ± 0.91
	E-IV	13.2 ± 0.60	13.7 ± 0.52	13.3 ± 0.69
	E-V	14.0 ± 0.55	13.8 ± 0.84	13.7 ± 0.70

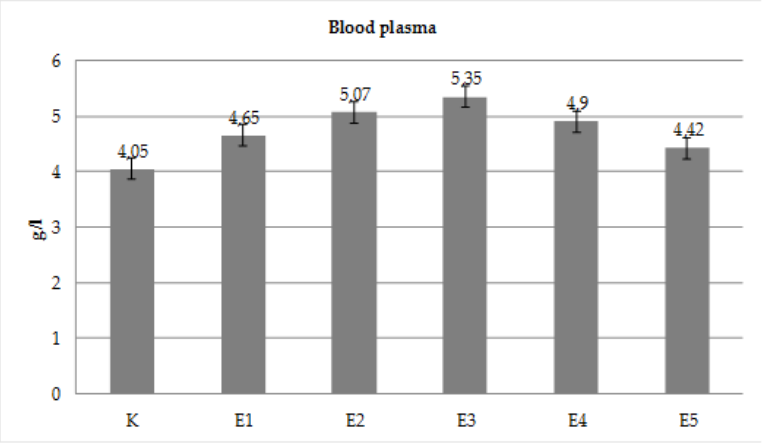

Figure 1. The content of total lipids in blood plasma.

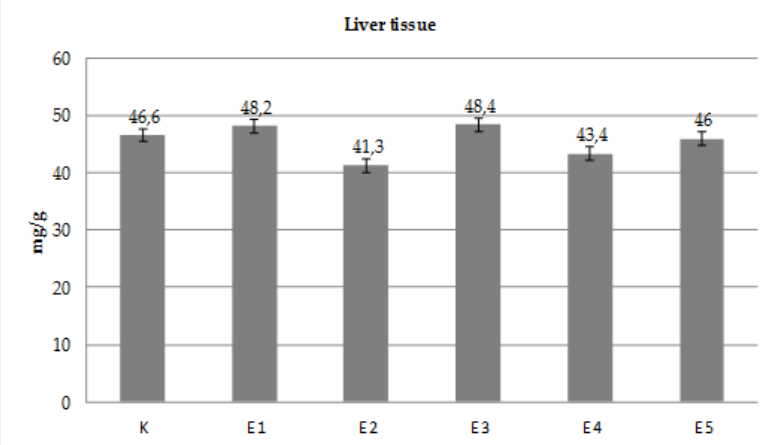

Figure 2. The content of total lipids in liver tissue.

Table 4. Fractional composition of total lipids in blood plasma,% (n = 4).

Class of lipids	Control group	Experimental group				
		I	II	III	IV	V
Phospholipids	30.1 ± 3.48	30.4 ± 1.01	35.7 ± 1.98	35.3 ± 1.67	36.7 ± 1.82	28.7 ± 1.12
Nonesterifed cholesterol	8.5 ± 2.11	10.9 ± 3.24	12.1 ± 1.84	11.9 ± 2.44	10.6 ± 2.09	13.0 ± 1.97
Mono- and diglycerides	15.4 ± 1.02	14.6 ± 1.13	15.4 ± 1.55	15.3 ± 1.60	11.0 ± 0.66	16.9 ± 0.50
Free fatty acids	10.2 ± 1.27	11.1 ± 0.66	13.3 ± 1.51	13.9 ± 1.86	13.5 ± 1.76	11.8 ± 0.96
Triglycerides	15.7 ± 1.94	10.6 ± 2.88	5.5 ± 1.84**	8.1 ± 1.80*	11.3 ± 0.45	12.1 ± 0.82
Esterifed cholesterol	20.0 ± 1.59	22.3 ± 0.93	17.9 ± 0.84	15.3 ± 0.38	16.7 ± 1.63	17.5 ± 0.94

Table 5. Fractional composition of total lipids in liver,% (n=4).

Class of lipids	Control group	Experimental group				
		I	II	III	IV	V
Phospholipids	30.8 ± 2.02	36.3 ± 1.07	42.8 ± 4.5	40.3 ± 3.8	35.9 ± 1.50	35.6 ± 2.24
Nonesterifed cholesterol	7.4 ± 1.39	6.9 ± 1.57	6.1 ± 0.82	7.7 ± 1.45	6.4 ± 0.37	5.3 ± 0.93
Mono- and diglycerides	10.3 ± 0.92	11.7 ± 2.67	9.6 ± 1.42	10.0 ± 1.05	11.4 ± 1.22	10.9 ± 1.94
Free fatty acids	6.7 ± 1.64	6.1 ± 2.07	6.6 ± 2.11	7.9 ± 1.89	5.9 ± 1.63	5.8 ± 1.39
Triglycerides	22.9 ± 1.67	18.6 ± 0.88	17.4 ± 1.17*	17.5 ± 0.86*	19.4 ± 1.47	17.9 ± 1.05
Esterifed cholesterol	21.9 ± 1.11	20.5 ± 1.84	17.5 ± 1.18*	16.6 ± 1.44*	20.9 ± 2.33	24.4 ± 2.12

The obtained research results of the fractional lipids composition of individual tissues in rabbits indicate positive changes contributing to the processes of metabolic accumulation of energy and plastic components in the trophic chain and confirm the expediency of the feeding of nanosilicon of citrate in the rabbit diet, taking into account its physiologically substantiated amount.
Feeding rabbits with Si citrate, corresponding to 50 and 75 μg Si kg^{-1} of body weight, caused stimulating effects on the hematopoietic function of the rabbit organism, which was marked by a higher (P<0.05–0.01) amount of red blood cells, leukocytes and hemoglobin concentration both in a separate erythrocyte and in the blood in general on 31 and 58 days of the study compared with the control. The use of nanosilicon of citrate in the amount of 50 and 75 μg Si kg^{-1} of body weight affected by changes in the fractional lipids composition in individual tissues of the rabbits body, in particular in blood plasma, lower than 35 and 52% (P<0.05–0.01) of triacylglycerols respectively and in the liver tissue was lower by 31.6 and 30.8% and 25.1 and 31.9%, respectively (P<0.05), triacylglycerols and esterified cholesterol, respectively, at 58 days of the experiment compared with the control group.

Discussion

The number of erythrocytes in the blood of rabbits in experimental groups was higher at 31 and 58 days this compared with control. This may indicate a more pronounced dose-dependent effect of the organic silicon compound on the hematopoietic function of the rabbit organism over a long period of additive application. Similar trends were observed in changes in hemoglobin content, which was more pronounced when feeding nanosilicon of citrate in an amount of 50 μg Si/kg of body weight. The analysis of changes in the indicators of red blood of rabbits indicates a stable physiological and alimentary status of their organism, which is confirmed by the literature sources [18] and was more pronounced for prolonged feeding of the silicon organic compound in the amount of 50 and 75 μg Si/kg of body weight in animals of II and III experimental groups on the processes of erythropoiesis stimulation and hemoglobin formation. From literary sources (Lawrence-Azua et al., 2013; Khariv et al., 2017; Kysera et al., 2018; Slivinska et al., 2019; Kisera et al., 2019; Rudenko et al., 2019), it is known that the lymphocytes function of in the animal body is associated with processes of immunogenesis; monocytes and granulocytes are active phagocytes of blood. The obtained results of the study may indicate a more pronounced positive dose-dependent effect of silicate citrate on nonspecific factors of body protection and phagocytic activity of rabbit blood, confirming previously obtained data on the immunophysiological reactivity of their organism (Ivanytska et al., 2017). It should be noted that all changes in white blood cell parameters were within the limits of physiological parameters, which may indicate the stimulatory effect of the silicon organic compound on the main populations of leukocytes and hemopoiesis (Gordova et al., 2015). The presentation of different amounts of silicon compounds did not reveal significant differences between the control and experimental groups of animals. This may indicate that there is no adverse effect of feeding organic and inorganic compounds of silicon on the rabbit body. In the body of mammals, platelets play an important role in the physiological norm. They constantly circulate in the blood and maintain normal structure and function of blood vessels, participate in the coagulation processes (Gary et al., 2013). Violation of one of the functions leads to changes in the system of hemostasis and the body as a whole. Thrombocytes play an essential role in resistance because they are the first reacting to infectious agents, resulting in the formation of specific antibodies that join the surface of the antigen, forming an antigen-antibody complex activating the response to inflammation. Thrombocytes have receptors recognizing these complexes, that is, the platelets themselves, and not the blood-white blood cells, are the first to respond to infection (Harkness et al., 2013). In particular, a marked tendency to increase the content of phospholipids in the blood and liver of animals of the 2nd and 3rd experimental groups compared to control. Phospholipids are the main components in the functioning of cell membranes necessary for the stabilization and aggregation of individual components in enzyme and protein complexes, as well as for the formation of its hydrophobic structure (Boguszewska-Czubara & Pasternak, 2011). The obtained results may indicate the activation of metabolic accumulation of plastic components in cell membranes, which was more pronounced by the action of the organic silicon compound.

Conclusion

Consequently, the results of blood analyses and the fractional lipids composition in the individual tissues of the rabbit's body indicate positive changes contributing to metabolic accumulation of energy and plastic components in the trophic chain and confirm the feasibility of adding citrate silicon in the rabbit diet, taking into account its physiologically substantiated amount.

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