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The Impact Of Energy-Sugar-Protein Concentrate 'Espc' On The Carbohydrate-Lipid Metabolism Of Broiler Chickens

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ABSTRACT. The study aimed to analyze the effect of the energy-sugar-protein concentrate 'ESPC'on the carbohydrate-lipid metabolism of meat-cross broiler chickens. The authors usedexperimental, laboratoryand statistical methods. The best result was obtained in the experimental group, where 28% of wholesome feedwas replaced by extruded ESPC with peeledlupine. The feed with this compositionhad a positive effect on the carbohydrate-lipid metabolism, physiological status and productive qualities of broiler chickens. The authors proved the feasibility of introducing ESPC into the feed ration of meat-cross chickens and noted its beneficial effect on the physiological status, growth, development and bodily resistance of chickens.

KEYWORDS: protein, lupine, rapeseed, triticale, extrusion, blood.

I. INTRODUCTION

Modern cross breeding pays considerable attention to wholesome feeding of poultry. High productivity and normal physiological state of poultry requires thorough regulation of energy and nutrients. That can be achieved by introducing optimal components into the feeding ration. Compound feed should be balanced not only in terms of metabolizable energy, crude protein, lysine, methionine, cystine, crude fat and crude fiber but also in terms of calcium, phosphorus, sodium chloride, sodium, and moisture. [7,17,22]

The main source of vegetable protein in Russia is leguminous crops, particularly lupine, which can be cultivated everywhere and may become a local traditional raw material for poultry feed.[11, 19, 23]

The modern varieties of fodder lupine contain 0.05% of alkaloids. That is 6 times lower than the maximum permissible level, which leads to visible changes in the body of warm-blooded animals. Thus, the concentration of alkaloids cannot be a reason for excluding lupine form the poultry diet. [14,15]

Science continues searching for non-expensive alternative feed products that would not be inferior to high-priced protein feed of animal and plant origin in their biological value and could replace grain, for which poultry compete with humans in terms of consumption. Alternative feeds may include rapeseed, lupine, triticale, the products of microbiological synthesis or fat and oil production, the discards of livestock processing (meat and bone meal, meat meal, meat and feathers meal made from keratinous and leather residues), as well as distillers dried grain, brewer's grain and others.[12,21,24]

Lupine has some undoubted advantages: it is highly active in nitrogen fixation and can grow on different soils, simultaneously creating favorable air and water conditions for the soil. [1, 2]

The amount of crude protein in white lupine exceeds the protein content in such cereals as peas, vetches and broad beans. This species is not inferior to soybeans in quality and digestibility and surpasses it in yield. Unlike soybeans, lupine seeds almost do not contain trypsin inhibitors, which allows its inclusion into feed without heat treatment.[3, 25]

Preparation of high-protein components for compound feed has become a new, very important direction of scientific studies. Researchers established the necessity of lupine grainpeeling; it is mandatory for young poultry, animals and valuable fish species. Unpeeled lupine is not competitive as a high-protein component, since the fiber content reaches 8%in the seeds of white lupine (Lupinus albus), 15% in the narrow-leaved lupine (Lupinus angustifolius), and 18% in yellow lupine (Lupinus luteus). Once peeled, the lupine core becomes a unique protein component with the fiber content of only 1.5-2.0% and the protein content of up to 50% (for comparison: the highest quality soybean meal made from peeled soybeans contains at least 3.5% fiber). The experiment on peeling lupine by the abrasive method proved it completely unsuitable for the species because its core loss reached 25%. Rolling or gentle shredding between metal cutting discs were considered to be most suitable; these methods led to the core loss of no more than 2%. [4, 5, 10]

Energy-sugar-protein concentrate (ESPC) can be used with a particular purpose since it influencesthe physiological status of the organism, the efficiency of feed, the productivity of animals and the quality of products. [9]

Animals’ metabolism follows general cycles of transformation of nutrients and biologically active substances in the processes of digestion and absorption. However, these processes in birds are specific in many respects.[6]

Proper feeding compensates the need of poultry for essential nutrients and creates favorable conditions for normal metabolism and high productivity.[6, 9]

MATERIALS AND METHODS

The scientific experiment was carried out in cooperation with the All-Russian Research Institute of Lupine of the Russian Academy of Agricultural Sciences atthe Experimental Production Facility'Bryanskoye', Michurinsky village, Bryansk district of Bryansk Oblast. The groups for the experiment were formed of healthy birds, according to the principle of analogues. The meat-cross chickens were identical in their physiological state and general development; they were 5 days of age and came from one brood. Each test bird was individually ringed, weighed and then randomly distributed into two groups: control and experimental. Each group consisted of 15 heads, kept under the same conditions. The difference in the average weight and productivity of poultry between the groups did not exceed 3%. The birds were marked with different colors to simplify visual observation in the formed groups.

After a one-week foreperiod, the birdswere transferred to the experimental diet. This transfer lasted 5 days (Table 1).

Table 1.The scheme of transfer of broiler chickens to the experimental diet

Groups		
Control	Experimental	
Wholesome feed, %	Wholesome feed, %	ESPC (peeled lupine), %
100	100	-
100	80	20
100	60	40
100	40	60
100	20	80
100	-	100

The composition of feed mixtures was balanced in the main nutrients andprepared to take into account the poultry feeding norms. [13] The feeding was rationed and given three times a day. Table 2 shows the feeding scheme for both groups.

Table 2.The feeding scheme for broiler chickens

Groups	Feeding conditions
Control	Wholesomefeed
Experimental	72% of wholesome feed +28%of extruded ESPC (peeled lupine)

In general, the diet was balanced in essential nutrients, yetthere was a slight deficiency of amino acids and macronutrients. They were replenished with synthetic amino acids: lysine (monochlorohydrate) with the lysine content of 80%, DLmethionine 98%, and threonine 93%. The norm of calcium and phosphorus were adjusted via introduction of feed chalk and monocalcium phosphate. The rest of biologically active substances (BAS) and nutrients were balanced with a premix, the composition of which is shown in Table 3.

Table 3. The list of BAS added to the compound feeds, per 1 kg

BAS	Measuring units	Value
Pantothenic acid	mg	12.00
Vitamin A	1000 IU	10.00
VitaminE	mg	50.00
VitaminD	1000 IU	3.50
Vitamin K	mg	2.00
Vitamin B_1	mg	2.00
Vitamin B_2	mg	6.00
Vitamin B_5	mg	35.00
Vitamin B_6	mg	3.00
Vitamin B_{12}	mg	0.01
Fe	mg	60.00
Mn	mg	137.92
Zn	mg	100.00
Cu	mg	16.00
S	mg	0.36
J	mg	1.25
Ethoxyquin	mg	2.00

The feed setswere identical in both groups except for the fact that thediet in the experimental group contained extruded ESPC that replaced some part the feed in terms of nutritional value (metabolizable energy). The proportion of the replaced part (ESPC with peeled lupine) in the experimental group was 28%, which accounted for 25.5% of the dietary metabolizable energy and 61.5% of crude protein. Inclusion of ESPC allowed decreasing the content of sunflower oil by 20.45%. As a result, ESPC replaced 14.47% of fermented wheat, 100% of sunflower meal, 94.8% of soybean meal, 92% of meat and bone meal and 20.45% of sunflower oil. The diet was balanced for raw protein. There was a slight deficiency

of crude fiber (0.78%) but it was within the permissible standards. The deviations for the rest of the nutrients were within the normal range (Tables 4 and 5).

The reference period lasted in the age range between day 5andday 42.Slaughter was carried out at the age of 42 days.

The feeding schedulesfor the experimental and control groupsdid not differ.

The poultry were kept in cages with retractable floors. The galvanized mesh bottom of the cages allowed the droppings to fall thorough. That gave a possibility to keep careful records of the consumed feed and the droppings in both the main and physiological experiment. Waterers and feeders were installed so that the birds had free access to food and water. The feeder and waterer spaceperbird was 4 cm. The cages were placed along the entire length of the vivarium. Technological passagewayswere locatedbetween the cages and at the ends of the poultry house. The room was disinfected with a bleach solution containing 25% active chlorine and with ultraviolet lamps. After disinfection and prior placement of birds, the room was sanitized for 5 days.

The temperature in the vivarium was measured at various points of the poultry location; it was 21-220C. The air velocity in the room was 0.4 m/s, the amount of fresh air supplied to the vivarium was 5.5 m3/h per 1 kg of live weight. The humidity in the vivarium was monitored using a psychrometer. Relative humidity was 65-70%.

The condition of broilers was examined daily, taking into account their appetite, mobility and safety. The growth of chickens was determined by live weight, and absolute and relative gain in live weight. Live weight was determined by individual weekly weighing. The weighing during the growing period made it possible to calculate absolute, average daily and relative gain in live weight, as well as labor costs per 1 kg of the gain.

During the balance experiment, the workers recorded the amount of food eaten, its residues and the amount of droppings on daily basis. The droppings were collected twice a day (in the morning and in the evening) and weighed. Then the droppings were ground to a homogeneous mass in a mortar. In every analytical test, 50 g of homogenized dropping mass was placed in a jar with a tight lid. Ammonia was fixed with 0.1N oxalic acid solution poured into each sample of droppings (4 ml per 100 g of droppings).

The tests were carried out in the laboratory of the Department of Normal and Pathological Morphology and Physiology of Animals of Bryansk State Agricultural Academy, Bryansk Interregional Veterinary Laboratory and the All-Russian Research Institute of Lupine of the Russian Academy of Agricultural Sciences.

The chemical analysis of feed and droppings was carried out at the All-Russian Research Institute of Lupine of the Russian Academy of Agricultural Sciences. The analysis was done according to the following methods: total nitrogen - according to the Kjeldahl method andRussian State Standard GOST

R. 51417-99 (%),crude fat mass fraction – GOST 13496.15-97 (%), crude fiber mass fraction – GOST 13496.2-97 (%), crude ash – GOST 26226-95 (%), calcium – GOST 26570-95 (%),and phosphorus – GOST 26657-97 (%) [18].

Blood samples were taken from 3 broiler chickens in each group on days 21 and 42. Blood was obtained from brachial wing vein days and then stabilized with anticoagulant (heparin).

The control of the clinical and physiological state of broiler chickens was done by means of morpho-biochemical blood tests.

The number of erythrocytes and leukocytes in the whole blood and its serum was determined by counting in the Goryaev chamber,the hemoglobincontent - by hemoglobincyanidemethod [16].

Total protein was determined using a refractometer.

The content of calcium, phosphorus, magnesium, sodium, potassium, glucose, L-amylase, LDH, cholesterol, triglyceride was determined using a Humalyzer equipment (Germany).

Liver samples were obtained for morphological examinationupon slaughter. In the laboratory, the samples were subjected to paraffin dehydration. After Hystomix was completely solidified, the block was removed from the mold and shaped with a scalpelforits convenient fixation on a wooden block. Then thehistological sections were stained with hematoxylin and eosin. Upon application of one drop of Canada balsam onto the cuts, the samples were covered with a cover glass.

Anatomical cutting of carcasses was carried out according to Sh.Imangulov'smethod. Three birds were taken from each group.

Anatomical cutting allowed studying the following indicators:

- carcass weightbefore gutting (without blood, feathers and down);

- weight of a half-gutted carcass (without blood, feathers, goiter, glandular stomach, intestines);

- dressed carcass weight(without blood, feathers, head, legs, wings, goiter, genitals, gastrointestinal tract);

- weight of edible parts (muscles, liver, heart, gizzard, kidneys, lungs, skin, subcutaneous and internal fat);

- weight of non-edible parts (head, legs, parts of the limbs, wings of the elbow joint, larynx, trachea, esophagus, goiter, glandular stomach, cuticle, intestines, spleen, pancreas, gallbladder, oviduct, ovaries).

The carcass grade was determined according to GOST 25391-82 "Meat of broiler chickens".

The study of the chemical composition of the muscle tissue (%) was carried out in accordance with applicable standards: protein mass fraction was obtained by the Kjeldahl method (GOST 25011-81), fat mass fraction - by Soxhlet method (GOST 23042-86), ash - by GOST R 53642-2009, and moisture - by GOST R 51479-99. The muscle tissue sampleswere limbs (thigh and lower leg) and breast. The images were taken witha Minivid camera on an Olympus CX-21 binocular microscope.

The obtained data were processed by variation statistics using Microsoft Excel2010 software.

The significance thresholds for the differences vs. control valueswere *$p<0.05$, **$p<0.01$ and ***$p<0.001$.

Table 4. The diet for broiler chickens in the experimental group

Feed	Amount of feed, %	Replaced by ESPC, %	Metabolizable energy, MJ	Crude protein, %	Crude fat, %	Crude fiber, %	Arginine, %	Lysine, %	Threonine, %	Tryptophan, %	Methionine, %	Methionine + Cystine, %	Ca, %	P, %	P available, %	K, %	Na, %	Linoleic acid, %
Norm	-	-	1.33	21.00	7.09	4.00	1.14	1.14	0.77	0.21	0.44	0.84	1.20	0.70	0.40	0.50	0.20	2
Wheat + Enzyme	52.60	14.47	0.73	8.99	1.22	2.26	0.39	0.22	0.31	0.09	0.21	0.26	0.05	0.22	0.07	0.03	0.01	0.25
Barley	10.00	-	0.12	1.22	0.20	0.22	0.06	0.04	0.04	0.02	0.03	0.04	0.01	0.04	0.01	0.01	0.00	0.10
ESPC	28.00	100.00	0.34	10.07	4.36	0.69	0.71	0.47	0.26	0.07	0.14	0.24	0.41	0.18	0.04	0.22	0.01	0.32
Soybean meal SP-45	0.50	94.80	0.01	0.25	0.15	0.04	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Meat and bone meal	0.50	92.00	0.00	0.22	0.15	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.05	0.02	0.01	0.03	0.01	0.00
Fodder yeast SP-47	0.50	66.00	0.00	0.25	0.05	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
Sunflower oil	3.50	20.45	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.06
Lysine (monochlorine hydrate)	0.44	-	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methionine 98,5	0.16	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.16	0.00	0.00	0.00	0.00	0.00	0.00

Chalk feed	1.20	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.00
Monocalcium phosphate	1.60	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.30	0.29	0.00	0.00	0.00
Threonine 93	0.14	-	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Choline chloride 70	0.04	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sodium bicarbonate	0.11	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00
Table salt	0.20	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00
Potassium iodate	0.01	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rovimix for broilers	1.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Contained in the diet	100	-	1.33	21.00	6.13	3.22	1.20	1.13	0.77	0.19	0.54	0.72	1.20	0.76	0.42	0.29	0.18	2.74
Deviation to the norm	-	-	0.00	0.00	-0.96	-0.78	0.06	-0.01	0.00	-0.02	0.10	-0.12	0.00	0.06	0.02	-0.21	-0.02	0.74

Table 5. The structureandchemicalcompositionofextrudedandnon-extrudedESPC

Name	Processing type	Dry matter, %	Fiber,%	Crude protein, %	Crude fat, %	Ash, %	N, %	Ca, %	P, %	Alkaloids
1	2	3	4	5	6	7	8	9	10	11
Wintertriticale	Extruded	90.47	2.36	9.06	1.59	2.0	1.60	0.18	0.34	
Winter triticale	Shredded	88.95	2.42	10.45	1.85	1.93	1.66	0.18	0.36	-
Winter rapeseed	Extruded	88.70	12.50	29.50	21.58	4.00	4.72	0.40	0.10	-
Winter rapeseed	Shredded	93.55	14.54	20.84	43.71	4.17	3.03	0.50	0.78	-
Non-peeled lupine ‘Snezhet’	Extruded	91.01	12.00	32.60	4.74	3.38	5.22	0.39	0.50	-
Non-peeled lupine ‘Snezhet’	Crushed	90.67	14.97	32.3	5.17	3.25	4.69	0.41	0.48	0.03
Peeled lupine ‘Snezhet’	Extruded	91.00	1.78	38.00	6.00	3.30	6.00	0.40	0.50	0.02
Peeled lupine ‘Snezhet’	Crushed	90.39	1.91	37.9	6.51	3.45	5.51	0.61	0.67	0.03
ESPC (lupine+rapeseed+triticale 70+25+5%)	Non-peeled	91.30	10.94	31.78	14.64	3.41	4.12	1.23	0.47	-
ESPC (lupine+rapeseed+ triticale 70+25+5%)	Peeled	91.11	2.48	33.18	15.58	3.55	4.7	1.46	0.63	-
ESPC (lupine+rapeseed+	Non-peeled	91.07	10.85	31.37	12.55	3.30	4.06	1.03	0.45	-

triticale 70+20+10%)										
ESPC (lupine+rapeseed+ triticale 70+20+10%)	Peeled	90.88	2.39	32.77	13.48	3.44	4.63	1.25	0.62	-

1	2	3	4	5	6	7	8	9	10	11
ESPC (lupine+rapeseed+ triticale 60+30+10%)	Non-peeled	91.36	9.86	30.10	16.40	3.39	3.89	1.41	0.47	-
ESPC (lupine+rapeseed+ triticale 60+30+10%)	Peeled	91.19	2.61	31.3	17.2	3.51	4.38	1.60	0.61	-
ESPC (lupine+rapeseed+ triticale 50+35+15%)	Non-peeled	91.42	8.87	28.42	18.16	3.37	3.65	1.59	0.47	-
ESPC (lupine+rapeseed+ triticale 50+35+15%)	Peeled	91.28	2.74	29.42	18.83	3.47	4.06	1.75	0.59	-
ESPC (lupine+rapeseed+ triticale 65+30+5%)	Non-peeled	91.45	10.45	31.15	16.57	3.46	4.04	1.42	0.47	-

ESPC (lupine+rapeseed+ triticale 65+30+5%)	Peeled	91.27	2.59	32.45	17.44	3.59	4.57	1.63	0.63	-
ESPC (lupine+rapeseed+ Triticale+oats+barley+ wheat 8+2+35+12+15+18)	Non-peeled	91	4.85	15.98	7.58	3.43	4.10	0.57	0.37	-

1	2	3	4	5	6	7	8	9	10	11
ESPC (lupine+rapeseed+triticale+oats+ barley+wheat 8+12+35+12+15+18)	Peeled	91.1	3.96	13.58	10.21	3.50	4.5	0.59	0.39	-
ESPC (lupine+rapeseed+triticale+ oats+ barley+wheat 11+12+7+8+27+35)	Non-peeled	90.8	5.31	15.7	7.68	3.30	4.42	0.57	0.37	-
ESPC (lupine+rapeseed+triticale+oats+barley+wheat 11+12+7+8+27+35)	Peeled	91	4.09	12.4	11.29	3.33	4.23	0.60	0.39	-

ESPC (lupine+rapeseed+triticale 70+25+5%)	Extrudednon-peeled	91.0	9.00	32.00	12.00	3.4	4.41	1.30	0.55	0.01
ESPC (lupine+rapeseed+triticale 70+25+5%)	Extrudedpeeled	91.4	2.48	37.38	14	3.55	5.89	1.50	0.68	0.007

Fig. 1 shows a photograph of ESPC.

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Fig. 1.ExtrudedESPC (peeled lupine)

3. RESULTS AND DISCUSSION

Carbohydrates contained in the poultry feed provide energy for various physiological processes in the body; it is their main function in bird nutrition. Fats are essential components of protoplasm and play a key role in cellular metabolism. Carbohydrates enter the digestive tract with feed as polysaccharides, disaccharides and monosaccharides.In the digestive tract, they are absorbed and come to the bloodas monosaccharides,mainly in the form of glucose. Glucose moves to the liver where 3-5% of its amount is converted into glycogen, and the rest enters the blood and tissues.

According to Table 5, the blood glucose level of broilers inboth groups corresponded to the physiological norm.

Table 5. Indicators of carbohydrate-lipid metabolism in the blood serum of the tested broiler chickens

Groups (n=3)	Age, days	
	21	42
Glucose, mmol/L		
Control(n=3)	6.42±0.05	6.56±0.07
Experimental (n=3)	7.39±0.08	7.48±0.06
L-amylase, U/L		
Control(n=3)	290.8±24.5	306.9±80.91
Experimental (n=3)	352.9±60.1	533.7±97.56
LDH, U/L		
Control(n=3)	1228.87±78.7	4448.55±754.95
Experimental (n=3)	1325.54±92.6	4784.66±330.74
Cholesterol, mmol/L		

Control(n=3)	2.80±0.01	3.96±0.26
Experimental (n=3)	2.90±0.03	4.52±0.80
Triglycerides, mmol/L		
Control(n=3)	0.40±0.06	1.07±0.06
Experimental (n=3)	0.50±0.20	1.50±0.19

On day 21, the broiler chickens from the experimental group showed a tendency to increase the blood glucose content by 15.10%in comparison with the control group. The increase in blood glucoseapparently accompanied its higher consumption to ensure biosynthesis in the muscle tissue, which is consistent with the total protein level in the blood of the birds and with a higher intensity of their growth.

In this study, the content of triglycerides in the blood serum of broiler chickens was slightly belowthe physiological norm. This indicatorwas increasing in both groups from day 21to day 42, being higher by 40%in the experimental group compared with the control group. That may indicate that the intensity of synthesis and decomposition of lipids in the experimental group is higher.

The functions of the liver are extremely diverse – it renders metabolic products harmless and deactivates hormones, biogenic amines and a number of drugs. The liver is involved in the body's defense reactions andformation of glycogen (the main source of constant concentration of glucose in the blood). The organ synthesizes the most important proteins of blood plasma (fibrinogen, albumin, prothrombins, etc.) and metabolizes iron and forms bile necessary for the absorption of fats in the intestine.

The histological examination of the samples stained with hematoxylin and eosin revealed that the structure of hepatic parenchyma in the broiler chickens of the control group was disturbed. The classic hexagonal lobules were distorted and their structure was not discernible on the sample. In the cytoplasm of cells, there were fat capsulesthat coalesced to form large formations. Hepatocytes were rounded, the nucleus and cytoplasm were pushed to the periphery (cricoid form).A large part of the capillaries was compressed.Comparative morphology of the liver of the chickens from the control group revealed granular fatty degeneration and proliferation of reticuloendothelial elementsat the age of 42 days. (Fig. 2)

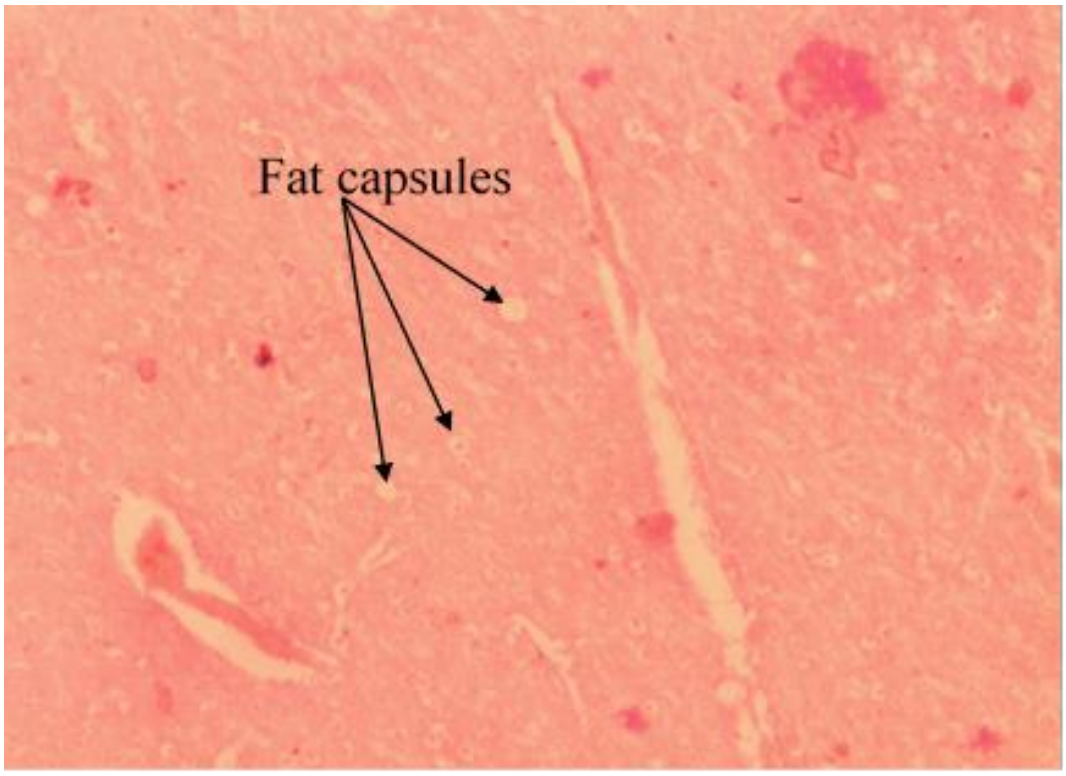

Fig. 2. Fatty degeneration of broiler chicken liver (control group)

In broiler chickens of the experimental group, the liver was surrounded with fibrous capsule covered withperitonealmesothelium. Thin, weakly expressed septa spreadingfrom the capsule divided the gland into hexagonal classic lobules (CL). Theblood vessel system included the portal vein branches, the hepatic artery branches, lymphatic vessels and bile ducts, which reached the tops of the lobules along the connective tissue septa and formed the hepatic triads (portal tracts). Various structures of the portal area were accompanied by connective tissue.

The hepatic lobules were formed by strands of liver cells (cords of hepatocytes) – radially oriented, branching and converging to the center of the lobule. Hepatocytes were arranged in two lines, between which there were bile canaliculi that blindly started at the center and went to the lobule periphery. Sinusoidal blood capillaries passed between the cords of hepatocytes and joined the central vein (CV).

The hepatocytes were angular and had well-defined boundaries. The nuclei were spherical, located in the central part of the cell. The contacting surfaces of opposing hepatocytes formed the bile duct wall. The cell surface facing the hepatic sinusoids had many short microvilli; there was a small number of lipocytes between hepatocytes. (Fig. 3)

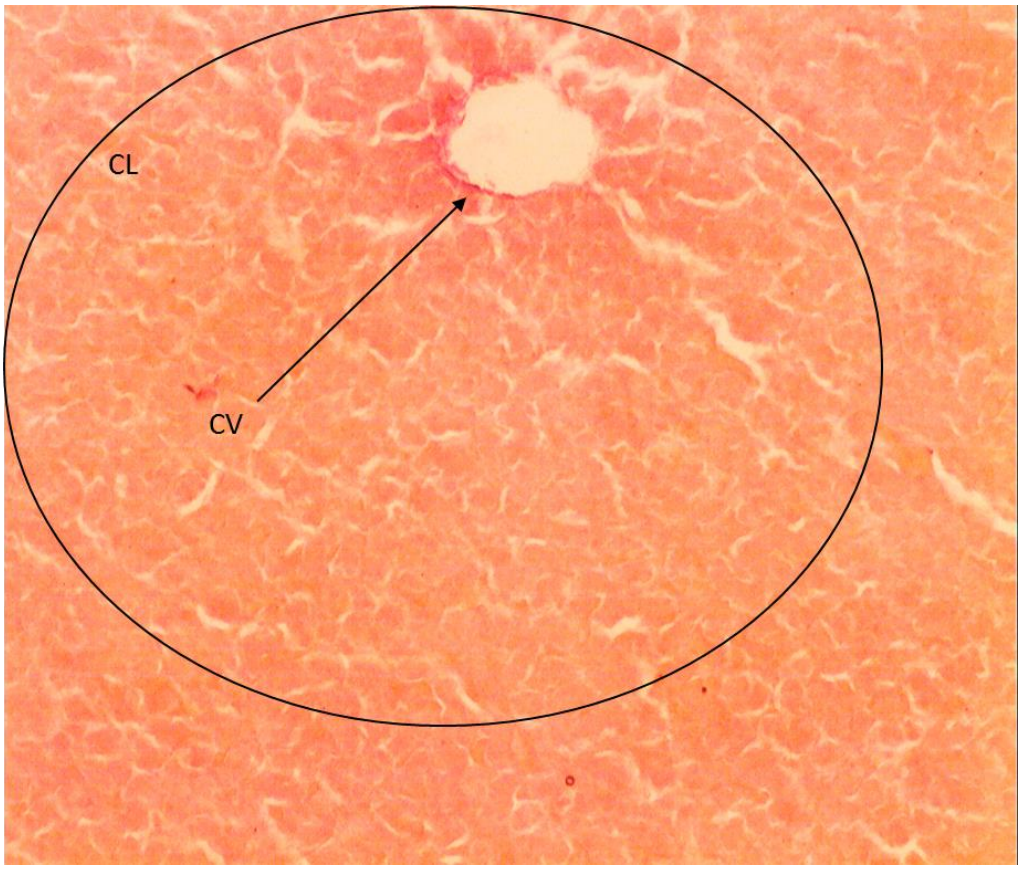

Fig.3. Broiler chicken liver without changes (experimental group)

In the liver triad of the control group broilers, there was diffuse fat deposition in hepatocytes and perivascular edema. That was not observed in the liver of the chickens from the experimental group, where the amount of lipocytes between hepatocytes was insignificant.

Table 6 shows that both groups had similar indicatorsof thecontent of minerals in the blood, except for calcium, sodium and potassium.

Table 6.Indicators of mineral metabolism in the blood serum of the test broiler chickens

Group (n=3)	Age, days	
	21	42
Calcium, mmol/L		
Control (n=3)	2.49±0.05	2.58±0.06
Experimental (n=3)	2.79±0.05*	2.86±0.03*
Phosphorus, mmol/L		
Control(n=3)	1,93±0,04	2,10±0,15
Experimental (n=3)	2,07±0,03	2,50±0,15
Iron, mmol/L		
Control(n=3)	7.01±1.40	10.2±1.8

Experimental (n=3)	8.68±1.45	12.6±4.3
Magnesium, mmol/L		
Control(n=3)	0,96±0,03	0,80±0,17
Experimental (n=3)	1,14±0,05	1,50±0,31
Sodium, mmol/L		
Control(n=3)	154.9±1.36	129.36±1.88
Experimental (n=3)	160.7±1.57	135.8±1.04*
Potassium, mmol/L		
Control(n=3)	4.69±0.09	9.7±0.78
Experimental (n=3)	5.06±0.12	10.4±1.14*

Note. * $p<0.05$ (compared with the control group)

Calcium is essential for bone formation; it is present in bones in the form of carbonic and phosphate salts and is necessary for normal functioning of cardiac, nervous and muscular activity. Calcium increases the protective functions of the body and regulates the reproductive functions.

On days 21and 42, the blood serum calcium content of the experimental broilers was significantly higher(by 10.85%, $p<0.05$) than the values of the control group.

The phosphorus content in the broiler chickens of the experimental group was within the physiological norm and did not significantly differ from broiler chickens in the control group for the entire period of the experiment.

The tests of magnesium content in the blood serum determined that the experimental group showed a tendency to an increase in this indicator both on days 21and 42. More significant results were obtained in the experimental group on day 42. By this period, the content of magnesium reached 1.50 ± 0.31 mmol/L, which is 87% higher ($p>0.05$) than that of the control group with a non-significant difference.

In the experimental group, there was a significant increase in sodium (by 4.98%) and potassium (by 7.22%) on day 42. The physiological role of potassium is vital: it participates in the regulation of acid-base balance, in maintaining the osmotic pressure of the body, and in the active transport of amino acids through biological membranes. It is possible that potassium affects cell membranes and thus normalizes the transport of iodine and its binding with amino acids.

The physiological studies revealed that the broilers of the experimental group digested all nutrients better than the broilers ofthe control group. In other words, there is a clearly expressed positive influence of the ESPC on the gastrointestinal tract – an increase in the digestibility and diet nutrients utilization in the broiler chickens of the experimental group (Tables 7, 8).

Table 7. Coefficients of digestibility of feed nutrients

Indicators	Groups	
	Control	Experimental
Crude protein	92.52±3.19	93.51±1.83
Crude fat	71.30±0.57	75.37±1.03
Crude fiber	25.30±0.55	35.63±1.09

The broiler chickens from the experimental group showed a tendency to increase the digestibility of crude protein by 1%, crude fat by 4.07%, and of crude fiber by 10.30%.

Table 8. Indicators of broiler chicken productivity and feed costs per 1 kg of gain

Indicators	Groups	
	Control (n=15)	Experimental (n=15)
Average live weight on day 21, g	761.33± 23.22	752.00± 20.50
Average live weight at the end of the experiment, g	1868.00±64.85	2011.67± 47.99
Gross gain, g	1106.67±50.24	1259.67 ±36.61*
Average daily gain, g	52.70± 2.39	59.98± 1.74*
% to the control group	100.0	113.8
Livestock safety, %	100.0	100.0
Costs per 1 kg of growth: metabolizableenergy, MJ	25.24	22.17
% to the control group	100.00	87.85
Protein, g	398.68	350.09
% to the control group	100.00	87.81
Feed, kg	2.66	2.33
% to the control group	100.00	87.85

Note. * p <0.05 (compared with the control group)

The extruded ESPC had a positive effect on the consumption of metabolizable energy and crude protein. The lowest valuesof consumption were observed in the experimental group, wheretheenergy consumption was lower by 3.07 MJ (12.15%) and crude protein consumption - by 48.59 g (12.19%).

Thus, inclusion of the ESPC into the broiler chickens' ration increased the gain in live weight and helped to reduce the consumption of feed nutrients per unit of production.

The meat productivity of poultry depends on the growth rate, meat early maturity, poultry live weight, compensation of feed withgrowth, and meat quality. The latteris determined by a combination of physical, chemical, biological and organoleptic characteristics.

The comparative assessment of the meat qualitieswas carried out after control slaughter and anatomical cutting of carcasses of 42-day-old broilers.

The meat productivity of chickens is understood as their ability to produce a certain amount of high-quality meat in a short time at certain feed costs per unit of growth. Table 9 shows the indicators of meat productivity.

Table 9. Indicators of meat productivity

Indicators	Group (n=15)	
	Control	Experimental
Pre-slaughter live weight, g	2220±15.3	2318.3±71.3
Carcass weight, g	2002±49.4	2116±69.8
Half-guttedcarcassweight, g	1889±52.9	1998±86.1
Dressedcarcassweight, g	1622±53.6	1726±66.9
Dressing percentage, %	73.20	74.46
Glandular stomach, g	11.0±1.0	15.33±0.3**
Gizzard, g	27.7±1.4	46.0±2.1**
Intestines, g	96.7±3.3	111.7±0.9*
Weight of edible parts, g	390.7±21.2	402.3±26.2

Note. * $p < 0.05$; ** $p < 0.01$ (compared with the control group)

The obtained data testify to the good meat qualities of the broiler chickens. Pre-slaughter weight of broiler chickens was the highest in the experimental group (2318.3 g). Compared with the control group, the difference exceeded 98.3 g (4.43%). The weight of a half-gutted carcass in the experimental group was higher by 5.77%.

The carcass weight in the control group was less than in the experimental group by 6.41%.

The use of ESPC in the diet had a positive effect on the dressing percentage and the development of the gastrointestinal tract. Thus, in the experimental group, the weight of half-gutted carcasses was 1.07-1.78% higher than in the control group.

In the broiler chickens of the experimental group, there was a significant ($p<0.05$) increase in the glandular stomach (by 39.36). Tests also showed a significant ($p<0.01$) increase in the gizzard – by 66.24% relatively the control group.

The broiler chickens of the experimental group had more developed intestines; their weight was 15.52% higher ($p<0.05$) than in the control group.

The weight of edible parts in the experimental group exceeded correspondingvalues of the control group by 2.96%.

Thus, it can be argued that the largest pre-slaughter live weight, the weight of the whole carcass, glandular stomach, intestines, gizzard and the weight values of the dressed carcass and edible parts were higher in the broiler chickens from the experimental group. That is explained by more intensive metabolic processes and absorption of the feed main nutrients. In general, the internal organs had anatomically correct shapes without visible pathological changes.

All the observed changes were within the physiological norm.

Thus, the research results indicate the positive effect of the ESPC on the mineral metabolism in broiler chickens.

The economic efficiency of theexperimentcalculated upon its completion. The calculations took into account the productivity of broiler chickens, the cost of feed and the ESPC, the carcasses sales value at the time of the experiment and the cost of electricity consumed during the production of the extruded and non-extruded concentrate (Table 10).

The profitability of broiler meat production is mainly determined by the live weight at the age of slaughter. The growth rate during the fattening period depends onnumerous factors, yet the main ones are the genetic potential of the cross and the correct organization of feeding.

The study of economic efficiency based ontotal feed costs and the cost of additional weight gain showed that animals with a large average daily gain accounted for less feed costs in monetary terms. The cost of feed in the experimental group was lower and amounted to 4.18 rubles.

Table 10. Economic efficiency of the ESPC in broiler chicken diets

Indicators	Groups	
	Control (n=15)	Experimental (n=15)
Number of animals	15	15
Average live weight on day 21, kg	761.33	752.00
Average live weight at the end of the experiment (day 42), kg	1868.00	2011.67
Gross gain per head, g	1106.67	1259.67
Dressed weight, g	1622	1726
Feed cost per head, RUB	52.00	37.44
Cost of ESPC per head, RUB	-	7.38

Electricitycosts, RUB	-	3.00
Productioncost, RUB/kg	38.10	31.92
Selling price per kg, RUB	130.00	130.00
Salesrevenue, RUB	177.43	194.74
Profit from sales, RUB	125.43	146.92
Additional revenue, RUB	-	21.49
Revenue per 1 ruble of costs, RUB	-	0.45

The cost of production was the lowest in the experimental group – 31.92 rubles; all this proves the economical profitability of the ESPC in the diet of broiler chickens.

4. CONCLUSION

It is advisable to introduce the energy sugar protein concentrate into the diet of broiler chickens since it has a beneficial effect on the morpho-biochemical and carbohydrate-lipid indicators of blood and tissues in broiler chickens, as well as on digestibility and efficiency of feed nutrients.

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