

ESTIMATION OF QUALITY AND EFFICIENCY OF APPLICATION
OF A POULTRY FEED SUPPLEMENT IN FEEDING HUBBARD
BROILER CHICKENS

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Received June 15, 2017; Accepted in revised form October 24, 2017; Published December 26, 2017

Abstract: Poultry farming is one of the largest branches of agriculture with a high level of production of a variety of organic wastes that require special approaches to useful utilization. The article describes the problem of processing evisceration waste and keeping poultry in quality feed supplements and the estimation of their effectiveness in feeding broiler chickens. In accordance with the studies, it has been established that the studied feed supplements, with a share of feather-down waste of more than 80%, differ in a balanced amino acid composition, a high content of protein (89.9–90.2%) and sulfur-containing amino acids, that is cystine and tryptophan that have a high value in the process of fattening the bird. The ratio of 8 : 2 (feather-down waste : litter) is recognized rational and optimal for a further use - the feed supplement produced using this method contains glycine, the most important amino acid for chickens, and is characterized by a high content of calcium and phosphorus due to the components of litter. According to the safety indicators established by the regulatory documents, the feed supplement is recognized high-quality and safe. When estimating the toxicity of the feed supplement using the test organism *Tetrahymena pyriformis*, no adverse effect on the survival, mobility, growth and behavior of the cells was detected. When analyzing the relative biological value of the feed supplement using *Tetrahymena pyriformis*, it has been established that the average number of the cells grown with the use of the feed supplement is $(8.9 \pm 0.9) \times 10^4$ cells, which indicates its high nutritional value. Taking into account the results of the studies on the chemical and amino acid composition of the feed supplement, the data of microbiological and toxicological studies, and taking into account the toxicity estimation, it has been concluded that the studied supplement is safe and can be used in the birds diet.

Keywords: Feed supplement, poultry waste, effective microorganisms, waste bioconversion, microbial disposal, biopreparation, broiler chickens

DOI 10.21603/2308-4057-2017-2-137-144

Foods and Raw Materials, 2017, vol. 5, no. 2, pp. 137–144.

INTRODUCTION

Poultry farming is one of the key areas of business activity in the structure of agriculture. This is a science-intensive and dynamically developing industry with an annual world production growth rate of 6–9% [1, 2].

In the Russian Federation, along with the significant successes in poultry farming, there is an annual increase in the volume of waste generation of poultry enterprises that now make up more than 17 million tons per year [3, 4].

Waste of evisceration and poultry keeping is the most promising from the point of view of useful utilization and the creation of non-waste technologies. As for the chemical composition - the content of amino acids, the balance of micro and macro elements – feather-down raw materials, litter and other types of

waste are a valuable source of nutrients in the production of feed supplements [5, 6]. Table 1 presents the chemical composition of feather-down raw materials. Table 2 presents the amino acid composition of feather-down raw materials in comparison with a human hair, a horse hair and sheep wool.

Table 1. Chemical composition of feather-down raw materials

Low-value keratin-containing raw materials	Mass fraction of			
	protein, %	mineral salts, %	fat, %	moisture, %
Chicken feather, turkey feather	76.4	1.5	3.3	18.8
Hen underwings	79.2–81.9	2.9	1.7	13.2–16.2
Broiler feather	82.5	2.2	1.8	13.5

Table 2. Amino acid composition of feather-down raw materials in comparison with a human hair, a horse hair and sheep wool

Amino acids	Human hair	Horse hair	Sheep wool	Hen feather
Alanine	6.88	1.5	4.4	5.21
Valine	–	0.9	2.8	6.02
Leucine	12.12	7.1	11.5	10.83
Asparagine acid	–	0.3	2.3	7.04
Glutamic acid	8.0	3.7	12.9	14.03
Proline	–	3.4	4.4	–
Phenylalanine	0.62	–	–	4.74
Thirosine	3.3	3.2	2.9	5.06
Serine	–	0.6	0.9	5.28
Cystine	11.55	–	7.3	5.28

The existing technologies for processing poultry waste are based on the processes in which the bioavailability of useful components and their decontamination is achieved mainly through a high-temperature hydrothermal treatment or using acidic (alkaline) hydrolysis. Such methods often lead to the loss and racemization of essential amino acids, the formation of cyclopeptides and a significant decrease in the total biological value of the final feed products [7].

High-temperature drying or incineration is used in the technologies for useful litter disposal, which leads to a loss of more than 40% of nutrients. Sometimes formaldehyde is used to disinfect litter, but it also significantly reduces the nutritional and protein value of the feed produced [8, 9].

The analysis of the technologies used shows that the processing industry have some tasks of developing new modern environmentally friendly technologies for recycling waste from poultry enterprises, which allows, at high economic efficiency values, to produce feed, feed supplements and other technical products with improved characteristics.

A principally new approach of this trend is the creation of the bioconversion technologies based on the use of effective systems of destroying microorganisms [10, 11]. Such microorganisms are able to synthesize enzymes and enzyme complexes into the environment and provide the process of conversion of complex organic compounds that are part of waste into available forms. A unique feature of such strains is the ability to suppress the growth and development of pathogenic microflora of waste [11].

Thus, the study aimed at improving the biotechnological methods for recycling poultry wastes and developing a technology for producing a feed supplement from them is a relevant task, the solution of which is directed both at deep processing and the complete neutralization of waste.

STUDY OBJECTS AND METHODS

The object of the studies was a feed supplement from a mixture of feather-down raw materials and litter from Lohmann Brown chickens.

The paper aimed at estimating the quality and effectiveness of the developed feed supplement based

on a mixture of poultry waste (chicken feather : litter) in feeding Hubbard broiler chickens.

Study of the feed supplement indicators. The process of utilization of mixtures of feather-down waste and litter was conducted under laboratory conditions as follows: the ground waste mixture was fed to a BioStat A plus bioreactor, 5 dm³ in volume, and treated with an active culture of destroying microorganisms: *Bacillus pumilus* SAFR-032, *Microbacterium terregens* AC1180, *Bacillus fastidiosus* B11090, *Arthrobacter globiformis* AC1529, *Streptomyces olivocinereus* AC1169, *Acinetobacter* sp. B3905, which were in a nutrient medium (in the ratio of nutrient medium: microorganisms – 15 : 1). The bioconversion process begins immediately after the application of microorganisms and lasts for 72 hours. Upon completion, the microorganisms must be inactivated. The parameters of inactivation have been selected taking into account the cessation of the effect of extracellular enzymes of microorganisms on the substrate and the termination of the processes of division of the microorganisms themselves. After inactivation, the resulting enzymatic hydrolysis product is filtered using a filter with a mesh size from 1 to 0.5 mm to separate the coarse fraction.

The drying stage is feeding the spray dryer, the excess moisture is removed and the resulting feed supplement takes on a powdery form. The following stages include prepackaging and packaging the supplement.

For comparison, the samples of unprocessed waste mixtures are taken as the control samples:

- the chemical composition of the feed supplement was studied in accordance with GOST 17681-82 "Flour of animal origin. Test methods";
- the amino acid composition of the feed supplement was determined according to the requirements presented in GOST 32195–2013 "Feeds, compound feeds. Method for determination of amino acids" and GOST 32201–2013 "Feeds, compound feeds. Method for determination of tryptophan";
- the acid number was determined according to the requirements presented in accordance with GOST 13496.18-85 "Mixed fodder and fodder raw stuff. Methods for determination of fat acid value";
- the peroxide number was determined in accordance with the requirements presented in GOST 31485–2012 "Mixed feeds, protein-vitamin-mineral concentrates. Method for determination of peroxide number";
- the content of toxic elements was studied in accordance with GOST 30692–2000 "Fodders, mixed fodders and animal raw foodstuff. Atomic absorption method for determination of copper, lead, zinc and cadmium";
- the silver content was determined in accordance with GOST 18293–72 "Drinking water. Methods for determination of lead, zinc and silver content";
- the content of arsenic and mercury was determined according to the requirements of MBI FR.1.31.2002.00593 "The procedure for performing measurements of the mass concentration of arsenic

and mercury ions in feeds, feedstuff products and feed additives by the method of inversion voltammetry";

– the presence of pesticides was studied according to the "Guidelines for determination of organochlorine pesticides in water, food, feed and tobacco products by chromatography in a thin layer" (approved on 28.01.1980, No. 2142–80);

– to determine the content of radionuclides, a method based on the activity of gamma-emitting radionuclides in the sample using an SRP-68-01 radiometer was used. The studied sample of the feed supplement in a flat-bottomed chemical beaker was placed at the bottom of the well. A radiometer detector was placed in the sample of the supplement, which was covered with a plastic bag, so as to provide a position of the lower end of the device at a level of 2–3 cm from the bottom of the beaker.

– the microbiological studies were conducted in accordance with GOST 25311-82 "Feeding flour of animal origin. Methods of bacteriological analysis"; The selection for carrying out microbiological studies was carried out in accordance with the requirements of GOST 17536-82 "Feeding flour of animal origin. Specifications";

– the toxicity of the feed supplement was determined according to the "Methodological guidelines for the accelerated determination of toxicity of livestock products and 56 feeds" (approved by the Veterinary Department of the Ministry of Agriculture of the Russian Federation on 16.10.2000, No. 13-7-2/2156);

– the relative biological value (RBV) was determined according to the "Methodological recommendations for the use of the rapid method of biological assessment of products and feeds" (approved by the All-Union Academy of Agricultural Sciences named after Lenin, 1990);

Estimation of the effectiveness of the use of a feed supplement in feeding broiler chickens. In the course of the studies of zootechnical indices of the developed feed supplement for Hubbard broiler chickens, a supplement was added to the mixed feeds for the chickens of the control and experimental group (the number of birds is 45). The groups have been formed from day-old broiler chickens using a method of analogues. The stocking density, the light and temperature conditions are in accordance with the existing recommendations.

The groups were fed with crumbled mixed feeds with the application of a feed supplement in the premixes, in full. The same complete mixed feed was given to the chickens of all the groups (the control and the experimental one). The chickens of the experimental group consumed mixed feed with the addition of 100 g/100 kg of feed; the first group - 50 g/100 kg of feed. The chickens of the second group received dry crumbled mixed feed without a feed supplement (the negative control sample).

The following indicators were taken into account: feed consumption (daily accounting of feed residues); poultry livability (daily accounting of the dead bird); an increase in the live weight of the bird (alternate weighing using electronic scales); the daily average gain of live weight was calculated based on the results of the control weights; the conversion of feed was

calculated as the feed costs required to increase 1 kg of weight gain over the growing period;

– the protein content was determined according to the requirements of GOST 25011-81 "Meat and meat products. Methods of protein determination";

– the moisture content was determined in accordance with GOST R 51479-99 "Meat and meat products. Methods for determination of moisture content";

– the fat content was determined according to GOST 23042-86 "Meat and meat products. Methods of fat determination";

– the ash content was determined in accordance with GOST 31727-2012 "Meat and meat products. Determination of total ash";

– the amino acid content was determined using an Aracus amino acid analyzer (PMAGmbH, Germany) according to standard procedures. The operation principle of the analyzer is based on the separation of a mixture of amino acids followed by postcolumn derivatization with ninhydrin.

– the content of oxyproline was determined according to GOST 23041-78 "Meat and meat products. Method for determination of oxyproline";

– the content of fat-soluble vitamins A and E was determined according to the regulations of GOST 32307-2013 "Meat and meat products. Determination of fat-soluble vitamins by high performance liquid chromatography";

– the content of water-soluble vitamins - in accordance with GOST R 55482-2013 "Meat and meat products. Method for determination of water-soluble vitamins";

– the content of minerals in meat was determined in accordance with the requirements of GOST R 55573-2013 "Meat and meat products. Determination of calcium by atomic absorption and titrimetric methods";

– the content of phosphorus was determined in accordance with GOST R 51482–99 "Meat and meat products. Spectrophotometric method for determination of total phosphorus content";

– the iron content was determined according to GOST 26928-86 "Food-stuffs. Method for determination of iron";

– the content of manganese was determined in accordance with GOST 55484-2013 "Meat and meat products. Determination of sodium, potassium, magnesium and manganese by flame atomic absorption";

– the silver content was determined in accordance with GOST 18293-72 "Drinking water. Methods for determination of lead, zinc and silver content";

– the concentration of hydrogen ions (pH) was determined according to the requirements of GOST R 51478–99 "Meat and meat products. Reference method for measurement of pH";

– the content of toxic elements such as lead and cadmium was determined in accordance with GOST 30178-96 "Raw materials and food-stuffs. Atomic absorption method for determination of toxic elements". Arsenic - according to GOST 26930-86 "Raw material and food-stuff. Method for determination of arsenic

content". The mercury content was determined according to GOST 26927–nation of mercury";

- the safety of meat of broiler chickens was determined in accordance with the requirements of the "Guidelines for the accelerated determination of the toxicity of animal and forage products" (approved by the Veterinary Department of the Ministry of Agriculture of the Russian Federation on 16.10.2000, No. 13-7-2/2156);
- the relative biological value (RBV) was determined according to the "Methodological recommendations for the use of the rapid method of biological assessment of products and feeds" (approved by the All-Union Academy of Agricultural Sciences named after Lenin, 1990);

All the studies were carried out in three replicates. The reliability of the values was determined using the Student's t-test.

RESULTS AND DISCUSSION

The quality of the feed supplement produced and the optimum ratio of substrate components (feather-down waste : litter) was estimated using the chemical and amino acid composition and biological value.

The safety of the feed supplement was estimated using the microbiological indicators, toxicity, pesticide and radionuclide content, acid and peroxide number.

Tables 3 and 4 present the results of the study of the chemical and amino acid composition of the feed supplement.

Table 4. Amino acid composition of the feed supplement*

1	Calcium, g/kg	0.2	0.5	1.3	1.8	1.7
2	Arginine	4.4	4.7	5.3	5.5	5.4
3	Valine	4.6	4.9	5.9	6.1	6.2
4	Histidine	0.3	0.4	0.5	0.7	0.8
5	Glycine	3.3	4.9	4.8	5.4	5.2
6	Isoleucine	3.2	5.8	5.2	5.5	5.4
7	Leucine	4.0	7.1	7.2	7.8	7.9
8	Lysine	0.3	1.3	1.9	2.2	2.1
9	Methionine	0.1	0.2	0.2	0.4	0.6
10	Threonine	2.1	3.8	3.9	4.9	4.2
11	Tryptophane	0.2	0.6	0.5	0.7	0.6
12	Phenylalanine	2.7	4.7	4.4	4.8	4.6
13	Cystine	1.1	2.1	2.2	2.6	2.6
14	Thirosine	1.0	1.4	1.5	2.1	2.0

Note. *the average value for three observations, $P < 0.05$.

Table 3. Chemical composition of the feed supplement*

Subitem No.	Designated parameter	Ratio of substrates (feather-down waste : litter)				
		0 : 1	2 : 8	5 : 5	8 : 2	1 : 0
1	Mass fraction of moisture, %	6.8	6.6	5.9	5.4	5.4
2	Mass fraction of fat, %	0.4	0.5	0.6	0.9	1.0
3	Mass fraction of protein, %	65.7	70.7	75.3	89.9	90.2
4	Mass fraction of ash, %	5.8	4.3	3.8	3.4	3.3
5	Mass fraction of phosphorus, %	0.1	0.1	0.1	0.3	0.2

Note. *the average value for three observations, $P < 0.05$.

The study used the ratios of the substrates of feather-down waste: litter of 0 : 1; 2 : 8; 5 : 5; 8 : 2 and 1 : 0 respectively.

Analyzing the data presented in Tables 3 and 4, it can be concluded that the studied feed supplements, with a share of feather-down waste of more than 80%, differ in a balanced amino acid composition, a high content of protein (89.9–90.2%) and sulfur-containing amino acids, that is cystine and tryptophan that have a high value in the process of fattening the bird. The highest content of these amino acids was noted in the cases of the experiment using the waste ratios in the shares of 8 : 2 and 1 : 0.

The ratio of 8 : 2 is recognized rational and optimal for a further use as the feed supplement produced using this method contains glycine, the most important amino acid for chickens, and is characterized by a high content of calcium and phosphorus due to the components of litter. Table 5 presents the results of the study of the safety indices of the feed supplement.

It can be seen from Table 5 that all the obtained indicators to determine do not exceed the established standards, which indicates the high quality and safety of the raw materials studied.

When estimating the toxicity of the feed supplement using the test organism *Tetrahymena pyriformis*, no adverse effect on the survival, mobility, growth and behavior of the cells was detected. The morphological indicators were also normal, which indicates the absence of toxicity.

When analyzing the relative biological value of the feed supplement using *Tetrahymena pyriformis*, it has been established that the average number of the cells of *Tetrahymena pyriformis* grown with the use of the feed supplement is $(8.9 \pm 0.9) \times 10^4$, which indicates its high nutritional value.

Taking into account the results of the studies on the chemical and amino acid composition of the feed supplement, the data of microbiological and toxicological studies, and taking into account the toxicity estimation, it can be concluded that the studied supplement is safe and can be used in the birds diet.

The genetic features, sex, age and physiological condition of poultry, keeping conditions, as well as taste and the structure of feeds and feed supplements determine the level of consumption for poultry.

When estimating the effectiveness of the feed supplement, an additive was applied to mixed feeds and feed mixtures at a dosage of 100 g/100 kg of feed for Hubbard chickens.

Table 5 presents the safety indices of the feed supplement.

Table 5. Safety indices of the feed supplement*

Subitem No.	Designated parameter	Result	MAL (maximum allowable limit)
Toxic elements, mg/kg, no more than			
1	Lead	0.17	5.0
2	Cadmium	0.014	1.0
3	Mercury	0.01	0.2
4	Arsenic	0.01	4.0
5	Argentum	0.8	50.0
Pesticides, mg/kg, no more than			
1	HCH (total of α , β , γ - isomers)	not detected	0.1
2	Dichlorodiphenyltrichloroethane and its metabolites	not detected	0.1
Radionuclides, Bq/kg, no more than			
1	Caesium -137	12	600
2	Strontium - 90	8	200
Microbiological indicators			
1	QMAFAnM, CFU/g, no more than	1.5×10^5	5×10^5
2	Salmonella, in 25 grams	not detected	not permitted
3	Coliforms, per 1 g	not detected	not permitted
4	Anaerobia in 50 g	not detected	not permitted
Physico-chemical parameters			
1	Acid number, mg KOH/g	0.5	20
2	Peroxide number, moles of active oxygen/kg	2.9	23.6

Note. *the average value for three observations, $P < 0.05$

Table 6. Feed consumption by broiler chickens

Period, days	Experimental group		Control 1		Control 2	
	Fact, g/day	For the period, g	Fact, g/day	For the period, g	Fact, g/day	For the period, g
Starting period (0–10)	28.7	287.0	27.9	279.0	28.8	288.0
Growing period (11–25)	88.4	1326.0	86.5	1297.5	87.5	1312.5
Finishing period (26–41)	170.8	2732.8	165.5	2648.0	166.5	2664.0
Total, g	–	4351.8	–	3947.7	–	3979.4

When estimating the effectiveness of the feed supplement, the supplied was added to the mixed feed of Hubbard chickens.

Table 6 presents the studies of consumption of the feed supplement by broiler chickens.

According to the data presented in Table 6, it can be concluded that the feed consumption at the first stage is at the same level in all the groups. This is explained by the identity of mixed feed during the starting period. At the second stage, the difference was 29 g for the first control sample and 14 g for the second. During the finishing period, the difference increased to 84.8 and 68.8 g respectively. Thus, we can talk about an increase in feed consumption by broiler chickens when the developed supplement is included in mixed feeds.

The livability of the bird is one of the most important indicators, which is characterized by the ratio of the final number of birds to the initial. Table 7 provides the results of the analysis of poultry livability.

Analyzing the data it can be said that the livability of broiler chickens was high and amounted to 100% for the experimental sample, and this indicator was 97.7% at the end of the finishing period for the control ones. However, the analysis of cases of a decrease in livability showed that it was not due to the effect of diets in the control groups. The use of the feed supplement does not adversely affect the livability of broiler chickens.

Table 8 presents the results of determining the live weight of broiler chickens.

Table 7. Livability of broiler chickens

Group	Number of birds at the beginning of the experiment	Starting period (0–10)		Growing period (11–25)		Finishing period (26–41)	
		Number of birds	%	Number of birds	%	Number of birds	%
Experimental group	45	45	100	45	100	45	100
Control 1	45	44	97.7	44	100	43	97.7
Control 2	45	45	100	45	100	44	97.7

Table 8. Live weight of broiler chickens

Period, days	Experimental group		Control 1		Control 2	
	Live weight, g	Average daily weight gain, g	Live weight, g	Average daily weight gain, g	Live weight, g	Average daily weight gain, g
11	290 ± 5.0	25.0	285 ± 4.3	24.7	289 ± 4.9	24.9
26	1230 ± 20.0	61.2	1190 ± 15.0	56.9	1213 ± 17.1	59.5
42	2600 ± 35.5	87.9	2570 ± 32.5	85.6	2597 ± 31.0	87.3

Table 9. Costs of mixed feed per unit of output

Parameters	Groups		
	Experimental	Control 1	Control 2
Total consumption, kg	220.5	208.0	217.5
Gain per group, kg	130.9	122.0	127.3
Feed consumption per kg of gain, kg	1.68	1.70	1.71

It follows from the data presented in Table 6 that starting from the second period, the growing one, there were deviations in the three groups. In the experimental group, the live weight was 1230 g, which is almost 3% higher than that in the control groups. In the finishing period, the difference will increase to 4.5%.

Thus, the use of feed supplements has a beneficial effect on the live weight of broiler chickens and contributes to its increase.

Feed conversion is an important indicator of its quality and nutrient utilization efficiency. This is a coefficient that shows the ratio of the amount of feed expended to the unit of output.

Table 9 presents the costs of mixed feed per unit of output.

Based on the obtained data, it was found that the feed conversion rate in the experimental group was 1.66%, which is lower than the values for the control groups. The feed costs in the experimental group correspond to the zootechnical norms. The best digestibility of nutrients contributed to an increase in the live weight of broiler chickens.

The indicators of meat of broiler chickens were estimated by such parameters as the chemical and amino acid composition, the content of minerals and vitamins and a biological value.

Table 10 presents the chemical composition of meat of broiler chickens, in particular the pectoral and femoral muscles.

The analysis of the chemical composition of the muscular tissue of broiler chickens has shown that the addition of mixed feed with a developed feed supplement to the diet has a positive effect on the composition of the muscle tissue - a high protein content, a decrease in the percentage of fat, and hence the improved quality of meat.

It should be noted that the total protein and fat content in meat is not sufficient for a full description of its nutritional value. Together with the essential amino acids that are part of complete proteins, there are incomplete proteins in the meat of broiler chickens. Thus, for the most complete estimation of nutritional value, the amino acid composition of the pectoral muscles was analyzed, the results of the analysis are presented in Table 11.

Table 10. Chemical composition of meat of broiler chickens*

Designated parameter	Groups		
	Experimental	Control 1	Control 2
Pectoral muscles			
Water	73.5	74.02	74.34
Solids	26.8	26.09	25.3
Protein	21.01	20.65	19.8
Fat	2.55	2.56	2.58
Ash	1.15	1.10	1.09
Nutritional value, kcal	117.89	115.83	114.92
Femoral muscles			
Water	72.45	73.09	72.98
Solids	27.67	27.09	26.87
Protein	17.65	17.12	16.74
Fat	9.02	8.94	8.54
Ash	1.13	1.12	1.12
Nutritional value, kcal	155.55	149.03	149.34

Note. *the average value for three observations, $P < 0.05$.

Table 11. Beginning. Amino acid content in the meat of broiler chickens

Amino acid	Groups		
	Experimental	Control 1	Control 2
Pectoral muscles			
Lysine	1.834 ± 0.001	1.820 ± 0.001	1.790 ± 0.004
Methionine	0.567 ± 0.003	0.528 ± 0.003	0.463 ± 0.003
Tryptophane	1.213 ± 0.001	1.214 ± 0.002	1.209 ± 0.001
Leucine	1.556 ± 0.003	1.534 ± 0.005	1.542 ± 0.004
Isoleucine	1.009 ± 0.006	1.001 ± 0.004	1.002 ± 0.006
Threonine	0.899 ± 0.005	0.846 ± 0.005	0.853 ± 0.003
Valine	0.947 ± 0.002	0.933 ± 0.004	0.949 ± 0.004
Histidine	0.618 ± 0.002	0.578 ± 0.001	0.564 ± 0.001
Arginine	1.401 ± 0.001	1.376 ± 0.003	1.381 ± 0.003
Phenylalanine	0.817 ± 0.004	0.805 ± 0.004	0.806 ± 0.001
Total of essential amino acids	10.989 ± 0.004	10.827 ± 0.004	10.745 ± 0.004
Alanine	1.390 ± 0.002	1.385 ± 0.004	1.367 ± 0.004
Glycine	1.439 ± 0.001	1.421 ± 0.001	1.428 ± 0.001
Cystine	0.210 ± 0.005	0.205 ± 0.006	0.194 ± 0.007
Glutamic acid	3.480 ± 0.003	3.473 ± 0.002	3.476 ± 0.002
Asparagine acid	0.218 ± 0.001	0.176 ± 0.002	0.200 ± 0.001
Proline	1.031 ± 0.002	1.026 ± 0.002	1.034 ± 0.004
Serine	0.884 ± 0.007	0.867 ± 0.006	0.871 ± 0.006
Oxyproline	0.249 ± 0.008	0.228 ± 0.005	0.236 ± 0.013
Total of nonessential amino acids	8.896 ± 0.005	8.856 ± 0.004	8.869 ± 0.005
Total	19.885 ± 0.005	19.683 ± 0.003	19.614 ± 0.002

Table 11. *Ediing.* Amino acid content in the meat of broiler chickens

Amino acid	Groups		Amino acid	Groups	
	Experimental			Experimental	
Femoral muscles					
Lysine	1.414 ± 0.001		1.400 ± 0.001	1.391 ± 0.004	
Methionine	0.447 ± 0.001		0.421 ± 0.001	0.393 ± 0.001	
Tryptophane	1.202 ± 0.001		1.189 ± 0.002	1.191 ± 0.001	
Leucine	0.956 ± 0.001		0.894 ± 0.003	0.942 ± 0.004	
Isoleucine	0.799 ± 0.003		0.781 ± 0.003	0.724 ± 0.005	
Threonine	0.779 ± 0.005		0.736 ± 0.005	0.743 ± 0.003	
Valine	0.835 ± 0.002		0.823 ± 0.004	0.802 ± 0.003	
Histidine	0.523 ± 0.002		0.508 ± 0.001	0.504 ± 0.001	
Arginine	1.675 ± 0.001		1.666 ± 0.003	1.590 ± 0.003	
Phenylalanine	0.890 ± 0.005		0.815 ± 0.005	0.845 ± 0.003	
Total of essential amino acids	9.456 ± 0.004		9.365 ± 0.003	9.412 ± 0.003	
Alanine	1.380 ± 0.002		1.364 ± 0.004	1.343 ± 0.004	
Glycine	1.215 ± 0.001		1.209 ± 0.001	1.234 ± 0.001	
Cystine	0.169 ± 0.004		0.156 ± 0.004	0.144 ± 0.004	
Glutamic acid	0.280 ± 0.002		0.243 ± 0.001	0.286 ± 0.001	
Asparagine acid	0.183 ± 0.001		0.171 ± 0.002	0.154 ± 0.001	
Proline	0.926 ± 0.001		0.902 ± 0.002	0.925 ± 0.004	
Serine	0.743 ± 0.005		0.734 ± 0.005	0.671 ± 0.004	
Oxyproline	0.367 ± 0.003		0.333 ± 0.003	0.341 ± 0.014	
Total of nonessential amino acids	5.302 ± 0.002		5.235 ± 0.002	5.245 ± 0.002	
Total	14.758 ± 0.005		14.600 ± 0.003	14.657 ± 0.002	

Note. *the average value for three observations, $P < 0.05$.

When analyzing the composition of amino acids of broiler chickens meat, it was found that there are more amino acids in the pectoral muscles than in the femoral muscles. It was noted that the difference in total of all amino acids in the pectoral muscles in the experimental group was 0.202% and 0.271% in comparison with the control groups. The highest amino acid content was noted in the femoral muscle protein of the experimental group, it exceeded the value of the first control group by 0.158% and the second group by 0.101%. Such an excess was mainly due to the essential amino acids of femoral muscles.

In the human body, vitamins are not synthesized and must be supplied with food. Table 12 presents the content of vitamins in meat.

In accordance with the analysis of the data on the determination of the content of vitamins in the meat of broiler chickens, it has been established that the maximum amount of vitamins was in the meat of the experimental group that consumed mixed feeds with a

feed supplement. The content of vitamin A and B12 in the pectoral muscles exceeded their content in the femoral muscles. The femoral muscles had a high content of vitamin B1.

Another important indicator of meat quality is the content of minerals. Along with proteins, fats and carbohydrates, they are a vital component of human nutrition (Table 13).

The data presented in Table 13 show that the accumulation of micro elements was the most complete in the femoral muscles. In general, a higher accumulation of microelements is noted in the experimental group.

The accumulation of calcium is on average higher by 20% in the experimental group than that in the control groups. The difference in phosphorus accumulation was more than 5% in the pectoral and more than 10% in the femoral muscles. The accumulation of iron and manganese have not shown a significant difference between the groups.

Table 12. Content of vitamins in the meat of broiler chickens

Vitamins	Groups		
	Experimental	Control 1	Control 2
Pectoral muscles, mg/100 g			
A(retinol)	0.40 ± 0.009	0.38 ± 0.011	0.34 ± 0.012
E(tocopherol)	0.17 ± 0.005	0.13 ± 0.005	0.15 ± 0.007
B1(thiamine)	0.071 ± 0.001	0.062 ± 0.0001	0.049 ± 0.001
B2(riboflavin)	0.18 ± 0.002	0.18 ± 0.002	0.15 ± 0.002
B3(pantothenic acid)	0.47 ± 0.001	0.36 ± 0.002	0.33 ± 0.001
B6(pyridoxin)	0.37 ± 0.007	0.33 ± 0.002	0.36 ± 0.002
B12(cyancobalamin)	0.41 ± 0.001	0.40 ± 0.001	0.39 ± 0.001
Femoral muscles, mg/100 g			
A(retinol)	0.33 ± 0.005	0.32 ± 0.001	0.29 ± 0.004
E(tocopherol)	0.014 ± 0.004	0.14 ± 0.009	0.011 ± 0.01
B1(thiamine)	0.087 ± 0.001	0.071 ± 0.002	0.079 ± 0.002
B2(riboflavin)	0.15 ± 0.002	0.12 ± 0.001	0.14 ± 0.003
B3(pantothenic acid)	0.54 ± 0.002	0.51 ± 0.005	0.50 ± 0.001
B6(pyridoxin)	0.32 ± 0.003	0.31 ± 0.002	0.31 ± 0.001
B12(cyancobalamin)	0.30 ± 0.004	0.30 ± 0.002	0.27 ± 0.001

Note. *the average value for three observations, $P < 0.05$.

Table 13. Content of minerals in the meat of broiler chickens*

Mineral substances	Groups		
	Experimental	Control 1	Control 2
Pectoral muscles, g/kg			
Calcium	0.57 ± 0.22	0.46 ± 0.28	0.29 ± 0.13
Phosphorus	4.23 ± 0.13	4.03 ± 0.16	3.89 ± 0.21
Iron	7.54 ± 0.31	7.51 ± 0.22	6.94 ± 0.24
Manganese	0.23 ± 0.091	0.13 ± 0.02	0.21 ± 0.032
Femoral muscles, g/kg			
Calcium	0.66 ± 0.35	0.53 ± 0.31	0.45 ± 0.25
Phosphorus	5.08 ± 0.13	4.99 ± 0.16	4.56 ± 0.16
Iron	8.5 ± 0.31	8.40 ± 0.19	8.01 ± 0.24
Manganese	0.22 ± 0.011	0.20 ± 0.015	0.22 ± 0.015

Note. *the average value for three observations, $P < 0.05$.

Analyzing the data obtained during the study of the chemical composition of broiler chicken meat, it can be concluded that the use of mixed feeds with the addition of the developed feed supplement had a positive effect

on the chemical and amino acid composition of the chicken meat of the experimental group, and also contributed to an increase in its food and energy values.

ACKNOWLEDGEMENT

The study was carried out within the framework of a comprehensive project funded by the Ministry of Education and Science of the Russian Federation in the framework of the Government Decision No. 218 “Organization of high-technology production of high-protein feed additives and biofertilizers based on complex processing of downy raw materials and other low-value poultry waste” under State Contract No. 02.G25. 31.0151 dated 01.12.2015. The leading organization Federal State Budget Educational Institution of Higher Education “Kemerovo Technological Institute of Food Industry (University)”.

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Please cite this article in press as: Dolganyuk V.F., Noskova S.Yu., and Chaplygin O.S. Estimation of Quality and Efficiency of Application of a Poultry Feed Supplement in Feeding Hubbard Broiler Chickens. *Foods and Raw Materials*, 2017, vol. 5, no. 2, pp. 137–144. DOI: 10.21603/2308-4057-2017-2-137-144.

