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Obtaining Organic Poultry Breeding Products in Prevention of Mycotoxicosis

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Abstract: The article is devoted to the prevention of mycotoxicosis in poultry farming as one of the main components of effective management of the industry. Despite the step-by-step control, the synergy of mycotoxins has a detrimental effect on the bird's body, especially at the final stage of fattening. Growth inhibition, as well as sudden death syndrome, reduce the economic impact. We tested and proposed for introduction into production the organic sorbent "Toxfin dry", which contributed to improving the sanitary quality of feed and reduced the level of mycotoxins-by 46.3-85.3%. We obtained a positive effect of the use of the mycotoxin adsorbent when introduced into the diets of broiler chickens. The experimental bird was fed mixed feed of various quality. The best productive qualities were possessed by broilers from the 3rd experimental group, where in addition to the mixed feed seeded with mycotoxins, for the prevention purpose, the mycotoxin adsorbent "Toxfin dry"was set. During the experimental work, the bird of the 3rd group was stress-resistant, calmly reacted to the work of the poultry house, timely approached the feeders and drinkers. The live weight at the slaughter age exceeded the results of the analogues by 2.1-6.8%. Feed costs for the production of a unit of production, in comparison with poultry from the 2nd group, decreased by 5.1%. The studies conducted with the help of the test object Tetrahymena Piriformis showed that the relative biological value of the experimental meat samples of the 3rd group was higher than the control indicators - by 1.2%. The introduction of the mycotoxin adsorbent "Toxfin dry" with mixed feed, for preventive purposes, contributed to an increase in the average live weight of broilers - by 4.2%, safety-by 2.8 percentage points and a decrease in feed consumption-by 13.9%. The European Broiler meat Production Efficiency Index increased by 59.6 points. The economic effect of using the mycotoxin adsorbent was 15.4 rubles per 1 ruble of costs. Taking into account the technologies used for raising poultry, as well as the livestock located in the poultry house, the economic effect can increase proportionally. The introduction of mycotoxin adsorbents into the diets of broiler chickens for preventive purposes is a necessary condition for the prevention of mycotoxicosis and, consequently, a guaranteed increase in the profitability of production.

Keywords: Broiler Chicken, Mycotoxin, Adsorbents, Productiveness, Meat, Profitability

Introduction

Providing nutrition to people around the world is becoming an increasingly difficult goal. An increase in the population creates new problems for food producers, increasing pressure on livestock/poultry breeding and requiring the production of a sufficient amount of environmentally friendly proteins for human consumption (Kuzmenko *et al*., 2011; Kapitonova, 2010; Al-Agaby *et al*., 2014a). Since growth-promoting feed antibiotics are no

longer used worldwide because of fears of the development of resistant forms of bacteria that are dangerous to humans, the need arose to develop alternative methods and means of maintaining high productivity at the proper level. The use of probiotics, prebiotics, synbiotics, acidifiers, adsorbents, enzymes, etc., which preserve the nutritional qualities of feeds, at the same time inhibit the growth of pathogenic microflora and, ultimately, improve the quality of livestock production, has been particularly successful (Kapitonova, 2008a-b; 2010; Khomich *et al*., 2008; Al-Agaby *et al*., 2014b; 2014a).

Increasing the volume of agricultural products intended for export is one of the key tasks that managers at different levels are called upon to solve. To provide the country's population with all the necessary consumer goods, including energy resources, the agricultural sector needs to annually increase the level of profit from exported products. Realizing that the search for European markets is a priority, our countries are trying to meet the high requirements of European consumers and are forced to switch to the production of organic livestock products.

The main criteria for organic animal husbandry are:

1) organic feeding (lack of antibiotics, hormones, stimulants and other synthetic additives), maintaining the health of animals
2) the period of growing animals/birds
3) compliance with the requirements for the premises and the availability of free-range for animals/birds

Organic livestock production should be oriented towards a large partner as the Russian Federation, which works in this area in accordance with Interstate Standard 33980-2016 “Organic Production. Rules for the production, processing, labeling and sale”, as well as for foreign partnerships, taking into account the requirements of the Technical Regulations of the European Council (CE) 834/2007 and the European Commission (CE) 889/2008 (currently a new technical regulation is being prepared, which will come into force in 2021) (Shabayev, 2019; Chambre d’agriculture de Bretagne, 2018).

It should be noted that Interstate Standard 33980-2016, adopted by the Russian Federation, Kyrgyzstan and Tajikistan, is not something special that goes against European partners, but a document developed on the basis of the regulatory frameworks of the international standard included in the Codex Alimentarius code, CAC/GL 32-1999 “Guidelines for the Manufacture, Processing, Labeling and Sale of Organic Food Products”.

It should be noted that there is currently an overproduction of poultry products on the Belarusian market (Medvedskiyi, 2011; Yearbook, 2019) and the country needs a trade partnership with the Russian Federation, where it has a stable sales market. However, Russian Federation Government Decree No. 48 “On Measures for the Protection of Russian Poultry Production” adopted back in 2003 made it possible to limit imports of products, including from Belarus. As a result, by 2020, there was an increase in poultry meat production from 1.3 to 4.6 million tons in slaughter weight (3.3 times), thanks to agricultural organizations and agricultural holdings (Shabayev, 2019) and the adoption of Federal Law N 280-FZ “On Organic Products” (August, 2018) opened the way for the development of organic (extensive) poultry breeding, i.e., there is a differentiation of poultry production technologies.

In the Republic of Belarus on November 9, 2018, the Law of the Republic of Belarus No. 144-Z “On the Production and Circulation of Organic Products” was signed. The law provides for the prevention of mixing of organic and inorganic products at all stages of production (production, sorting, labeling, storage, etc.) and, despite the fact that each producer of organic products can affix the mark “Organic Product” and certify products in order to be included in the register of producers of organic products, as practice shows, at present they bear substantial costs Organic agriculture in Belarus is the fate of enthusiasts, 2012.

Kazakhstan works in the field of organic production within the framework of the Commercial Code of the Republic of Kazakhstan (Articles 41-49), which was approved at the end of 2015 and repealed the law “On peasant farm or husbandry farm”, as well as the presidential message of the country “Kazakhstan2050 Strategy” (Nazarbayev, 2014).

Currently, the problem of harmful effects of mycotoxins on the body of animals, including birds, is widely discussed all over the world. According to leading scientists, the use of inert components capable of binding mycotoxins is an effective way to reduce the toxic load on the animal/bird organism. By now, a number of organic mycotoxin adsorbents have already been developed and recommended, which can limit the absorption of toxins in the gastrointestinal tract and, therefore, prevent poisoning and death of animals (Glaskovich *et al*., 2013; Radchikov, 2013; Krasochko, 2006; Kapitonova, 2008c; Krasochko *et al*., 2008a).

Currently, mycotorxin adsorbents from various foreign manufacturers are used and widely used in livestock/poultry production: "Mikosoft", "Fungisorb Forte", "Kovelos Sorb", "Minazel", "Globafix plus", "detox Plus", etc.

As it is known, one of the biological characteristics of birds, including agricultural ones, is the rapid passage of feed from the moment of consumption to the release of

processed residues (Medvedskiyi and Kapitonova, 2012a-b; Medvedskiyi *et al.*, 2011; Shlyakhtunov, 2016; Glaskovich *et al*., 2017). In a short time, the feed dissolves under the action of the chyme and all the nutrients of the feed must be absorbed by intestinal villus, so that they can be dispersed to the smallest particles throughout the body with the blood stream (Glaskovich *et al*., 2011; Glaskovich *et al*., 2008; Krasochko *et al*., 2008b).

The intestine of a bird differs from the intestines of mammals, the small intestine is short and does not exceed 140 cm in chicken. Separately, the length of the duodenum, jejunum and ileum in chicken is 30, 102, 18 cm. The entire surface of the small intestine is covered with villi. The villi of the bird are thin, delicate, leaf-shaped and finger-shaped. The colon of the bird is represented by caecum and the rectum. The length of the caecum ranges from 17 to 30 cm and the rectum is shorter and is 8-11 cm. The rectum passes into the cloaca. Filling of caecum with chyme occurs periodically - once every 35-70 min (Podobed, and Yu, 2017; Podobed *et al*., 2016). Between the intestinal villi are depressions liberkey crypts. The bottom of each crypt reaches the muscle layer of the intestinal mucosa and the mouth opens into a gap between the villi. Usually there are 4-7 crypts for each villi and only 7 in the duodenum. The chromaffin cells of crypts produce serotonin, which, once in the blood, regulates the tone of vascular muscles. When the intestine is affected by toxins, not only the villi are destroyed, but also the crypts are smoothed, which serves the intestinal absorption function.

The intestinal villi are very thin and tender, so any toxic effect of the feed acts on them dismally. The villi degrade and reduce the absorption capacity. The nutrients of the feed are in transit, which reduces the productivity of the bird.

One of the distinguishing features of growing poultry by organic type is its longer feeding without any antibiotics. For the prevention of intoxication of the poultry organism, mycotoxins, which can form in the feed during prolonged storage, are the use of mycotoxin adsorbents. In connection with the above, we believe that the theme of our research work is relevant, has scientific novelty and practical significance. We have tested the toxfin dry mycotoxin adsorbent. Which is produced by the company "Kemin Europa N. V." (Belgium), which delivers the adsorbent of mycotoxins through its dealers around the world.

Materials and Method

Adsorbent "Toxfin dry" is a set of ingredients created to protect feed from mold fungi and mitigate their harmful effects. The main components are bentonite, sepiolite, steatites, silicon dioxide, organic acids and antioxidant. It does not contain GMOs, is non-toxic, does not cause irritation, does not have corrosive properties, does not contain dioxins. "Toxfin dry" is safe for use in feed and when working with the drug, no special protective measures are required.

To test the drug "Toxfin dry", we took 45 heads of the cross "Cobb-500" at a daily age weighing 39 g. Broiler chickens were divided into 3 groups, taking into account the formation by sex. Laboratory tests were conducted in the clinic of the Department of Parasitology and Invasive Diseases of the Vitebsk State Academy of Veterinary Medicine, according to the scheme of experience (Table 1).

In the 2nd group, we created a projection of long-stored all-mash (or its components) in rooms that do not comply with sanitary and hygienic standards, in humid, unventilated conditions (Abraskova *et al*., 2012; Glaskovich *et al*., 2013; Kapitonova *et al*., 2012; Medvedskiyi, 2019). For laboratory tests, the feed was seeded with the above-mentioned mycotoxins at a rate exceeding the MPC by 2.5 times, in the conditions of the Department of Microbiology and Virology of the Vitebsk state academy of veterinary medicine.

When observing chicken of the control and experimental groups, their clinical condition, reason for disposal, live weight gain (weekly by weighing) and meat yield were taken into account. At the end of the experiment, an analysis of the quality of livestock products was performed.

As the basic diet for the experimental bird, all-in-one feed was used, which nutritional value corresponded to the technical conditions of the Republic of Belarus (STB 1842-2008).

Table 1: Experimental design

Group №	Title of work performed Laboratory tests
1st control	basic diet (BD)
2nd experimentalBD + mycotoxins (zearalenone, T-2 toxin, deoxynivalenol, aflatoxin, fumonisin)	
3rd experimental	BD + mycotoxins + adsorbent “Toxfin dry” (5 g/kg) Production tests
1st control	Basic Diet (BD)
2nd experimental	BD + adsorbent "Toxfin dry" (5 g/kg)

Results

At the very beginning of our research, we determined the sorption ability of the mycotoxin adsorbent "Toxfin dry" feed additive. The results of the sanitary assessment of feed before the introduction of mycotoxin "Toxfin dry" and after are presented in Table 2.

As can be seen from the indicators presented in Table 2, the introduction of the toxfin dry sorbent additive into the all-mash contributed decrease in the level of mycotoxins by zearalenone by 46.3%, by deoxynivalenol by 61.6%, by T-2 by 80, 0% and aflatoxin - 85.3% and consequently increase the sanitary quality of feed. An additional introduction of all-mash with adsorbents helps to reduce the loss of livestock products.

After we became convinced of the organic adsorbent effectiveness, we prepared a batch of all-mash for feeding birds.

Due to the fact that we tried to grow broiler chicken under conditions close to organic, no antibiotics, hormones and growth-stimulating drugs were fed to them during the poultry growing period. Realizing that the live weight of the bird may not be as great as under technogenic (production) conditions, we still tried to maintain the purity of the experiment.

At the end of the poultry rearing period, we carried out a control weighing of the experimental bird. The results of Zootechnics accounting of broiler chicken are shown in Table 3.

From Table 3 it can be seen that by the end of the period of growing broiler chicken, the maximum live weight was in birds of the 3rd experimental group. The achieved indicator significantly exceeded the level of live weight in the 1st control group - by 2.1% (+45.1 g). Also, the live weight of broilers of the 3rd group was higher than the indicators of the 2nd group by 6.8% (+141.7 g), which convincingly testified in favor of introducing the toxfin dry adsorbent mycotoxins into poultry diets.

The indicator of the 2nd experimental group was lower than in the 1st control group - by 4.4% (-96.6 g), which indicated the inhibitory effect of mycotoxins on the bird's body. Moreover, the totality of mycotoxins, their synergistic effect, had a detrimental effect on the young broiler, which led to the death of 2 individuals.

Discussion

During the diagnostic examination of the dead broiler chicken in the 2nd experimental group, we recorded the following changes: Emaciation, softening of the tarsometatarsus, inflammation of the gastrointestinal tract membranes, deposition of urates in the ureter, pronounced myocardial dystrophy, acute venous pulmonary hypertension. Such a phenomenon as "sudden death syndrome", without visible signs of poultry disease, confirmed the posthumous diagnosis of mycotoxicosis.

During the experimental work, we recorded the etiological behavior of broilers. In groups No. 1 and No. 3, the bird calmly reacted to the appearance of the poultry woman when she was feeding and changing the water, they were calm and at the first noise of food crumbling in the feeder they approached and actively consumed it. The bird of the 2nd group was shy and not stress-resistant, when the poultry woman worked in the box, the chicken was scared and slaughtered in a remote corner and after a certain time poultry woman left, they gradually went out for feeding.

The average daily gain shows the growth rate of broilers over the growing period. Despite the fact that in this experiment we grew poultry according to the organic principles of poultry farming (without antibiotics, hormones and growth-promoting additives), we obtained a fairly good average daily gain over the period of the experiment.

In the 1st control group, the average daily gain was 51.2 g, which is a quite good indicator for this organic method of growing birds. In the 3rd group, the average daily gain was the highest - 52.3 g, which was 2.1% higher than in the 1st group. Unfortunately, in the 2nd group, the average daily increase was lower than in the 1st control group by 4.5% and lower than in the 3rd experimental group by 6.9%.

The obtained growth results are consistent with live weight at the slaughter age of the experimental bird. Thus, we can conclude that the reduction of the toxic load on the poultry organism with the organic toxin adsorbent "Toxfin dry" is relevant and has practical importance.

The cost of feed for the entire growing period and for 1 kg live weight gain is the most economically reliable indicator of poultry growing. The share of feed costs in the cost of production is 70-73%. Therefore, the lower the cost of feed when reaching maximum live weight the more efficient the industry.

In the 1st control group, 1.78 feed units were consumed for unit of production. In the 2nd experimental group, feed consumption increased by 5.1% and amounted to 1.87 feed units. (+0.09). The decrease in the absorption capacity of the villi, their destruction, contributed to the poor digestibility of the nutrient elements of the feed and its overrun. So an overrun of 90 g/kg of feed is very significant and economically unprofitable. In the 3rd experimental group, feed consumption was at the same level as the 1st control group. However, additionally obtained live weight production contributed to the economic efficiency of the organic adsorbent mycotoxins useage.

Further, we conducted researches to study the veterinary-sanitary state of the meat of experimental broiler chicken. According to organoleptic researches, experimental carcasses met the requirements of the standard: The carcass surface is dry with an existing crust

of drying, subcutaneous and internal fat is pale yellow, the muscles in the cut are slightly moist, pale pink, elastic consistency; the smell is specific, peculiar to fresh poultry meat. When boiled, the broth from the birds of the 1st and 3rd groups was transparent and fragrant. There was no extraneous smell and taste.

100% of carcasses from the 1st and 3rd groups were assigned to first quality. Carcasses from birds of the 2nd group were divided into varieties, 20% of the carcasses were assigned to the second quality and 80% to the first quality.

Further, under the conditions of the Vitebsk state academy of veterinary medicine clinic, we carried out physico-chemical research of experimental meat samples (Table 4).

From the data presented in Table 4 it can be seen that the physico-chemical indicators of the control and experimental groups did not have significant differences and were within the normal range. The smallest indicators were found in meat and fat samples obtained from poultry of the 2nd experimental group. The best performance was noted in samples of the 3rd experimental group, which corresponded to high quality of the product.

To determine the microbial content of tissues and the biological value and harmlessness of meat, we used the test object of Tetrahymena Piriformis Ciliata according to the Methodological Guidelines for the Toxicological and Biological Assessment of Meat, Meat Products and Milk Using Tetrahymena Piriformis Ciliata, 1997.

Content of tissues and organs, experimental samples after experimental mycotoxicosis are presented in Table 5.

From the data presented in Table 5, it can be seen that the biggest content of organs and tissues by microorganisms was observed in samples of the 2nd group in which experimental mycotoxicosis was recreated. Indicators of microbial content of the 2nd group exceeded the results of the 1st group almost 2 times and the 3rd group - 5.8 times. The indicators of the 3rd group (the adsorbent "Toxfin dry") improved performance compared with the control group by 3.3 times.

The results obtained indicate the inadmissibility of feeding poor-quality feed to birds, because this leads to a decrease in their sanitary quality and contamination of human food.

The results of toxicological and biological researches are shown in Table 6.

As can be seen from the data in Table 6, the indicators of the biological value of the meat of the control and experimental groups did not have significant differences. Manifestations of general toxicity for the test object of Tetrahymena Piriformis Ciliata in the 1st control and 3rd experimental groups have not been established. In the 2nd group, ciliates showed weak mobility and the presence of dead individuals, which reduced the relative biological value of meat by 1.9%. At the same time, the active reproduction of protozoa, their mobility and activity of movements spoke in favor of the additional introduction of the organic sorbent "Toxfin dry" into the diet of broilers. The relative biological value of experimental sample of meat of the 3rd group was higher than the control indicators - by 1.2%. Therefore, the use of the adsorbent of mycotoxins "Toxfin dry" helps to improve the properties of meat.

Further, we organized and carried out production tests of the organic adsorbent of mycotoxins in the conditions of the poultry house No. 12 of the poultry farm of JLLC "Vitkonproduct" of the Shumilina District of the Vitebsk Region (Republic of Belarus). The house was divided into sections. The bird was in uniform zoohygienic conditions.

Before starting the production tests, the feed was tested for the presence of mycotoxins. According to the results of researches, excesses of the TLV are not fixed. The feed was in compliance with the product safety protocol. The results of production tests of the Toxfin dry adsorbent are presented in Table 7.

Table 2: The results of the sorption ability of the "Toxfin dry" additive, mg/kg

Indicators	Feed	Feed + additive	Feed + mycotoxins	Feed + mycotoxins + additive	%
Aflatoxin	0,01	--	0,17	0,025	85,3
Zearalenone	0,4	0,06	1,6	0,86	46,3
Desoxynivalenol	0,1	0,01	2,0	0,77	61,6
T2 - Toxin	0,08	0,02	0,4	0,08	80,0

Table 3: The main zootechnical indicators when adsorbent mycotoxins "Toxfin dry" was introduced into the diet of broiler chicken, (M±m)

	Groups		
Indicators	1st control	2nd experimental	3rd experimental
Live weight when quit fattening, g	2191,0+38,3	2094,4+64,2	2236,1***+36,3
Average daily gain, g	51,2	48,9	52,3
Mortality	-	2	-
The cost of feed per 1 kg of growth during the growing period, kg	1,78	1,87	1,78

Note: *** - P<0.001

Table 4: Physico-chemical indicators of meat and fat from experimental birds, (M±m)

	Groups		
Indicators	1st control	2nd experimental	3rd experimental
Reaction to ammonia and ammonium salts	Negative	Negative	Negative
Reaction to peroxidase	Positive	Positive	Positive
Fat acidity value, mg KOH	0,780+0,01	0,80+0,09	0,71+0,05
Peroxide fat number, iodine %	0,008+0,002	0,009+0,002	0,008+0,002
pH	5,91+0,13	5,89+0,2	5,88+0,1

Table 5: Microorganisms content in organs and tissues of birds

	The frequency of microflora excretion from organs and tissues					
Groups	White muscles	Red muscles	Spleen	Liver	Heart	Total
1st control	4	5	3	7	4	23
2nd experimental	9	7	5	12	8	41
3rd experimental	1	2	1	2	1	7

Table 6: Toxicological evaluation of meat, (M±m)

	Groups		
Indicators	1st control	2nd experimental	3rd experimental
Relative biological value, %	100	98,1+0,6	101,2+0,4
Toxicity, % of pathologic cells form:	0,1+0,05	0,2+0,05	0,3+0,05
- meat	0,1+0,08	0,2+0,08	0,3+0,08
- liver	0,1+0,06	0,1+0,06	0,2+0,06
Total:			

Table 7: The results of production tests of the mycotoxin adsorbent "Toxfin dry" usage in the conditions of the poultry farm JLLC "Vitkonproduct"

Indicators	Unit of measurement	1st control group	2nd group "Toxfin dry"
Received for raising	animal units	500	500
Received for slaughter	animal units	475	489
Livestock safety	%	95	97,8
Average live weight of 1 bird at the end of the experiment	g	2085,3	2172,6
Live weight of the group at the end of the experiment	kg	990,5	1062,4
Average daily gain	g	51,1	53,3
Feed consumption per 1 kg of growth	kg	2,01	1,73
European poultry meat production efficiency index	unit.	236,3	295,9
Economical effectiveness			
Cost of used up on feeding feed	rub.	4242700	3948186
Cost of used additives	rub.	-	91800
Cost of feed and additives	rub.	4242700	4039986
Prime cost of bird's liveweight gain	rub.	6061000,0	5771412,8
Proceeds from meat sold	rub.	6376353	7498992
Profit	rub.	315353	1727509
Extra profit	rub.	-	1412156
Recoupment of development by 1 rub. of additional costs	rub.	-	15,4

From Table 7 it is seen that the additional introduction of the organic adsorbent of mycotoxins "Toxfin dry" into the poultry diet contributed to the accumulation of feed mycotoxins and their removal from the body of the experimental group chicken. The safety of the livestock in the 2nd group was 97.8%, which was 2.8% points higher than the control indicators. The safety parameters of the control group were in the lower limit of the norm.

At the end of the technological period, the average live weight of broilers of the 2nd group was 2172.6 g, which was 4.2% higher than in the 1st group (+87.3 g). The suppression of toxins in the bird's body helped to strengthen nonspecific immunity and had a growth-promoting effect on the bird's body.

Feed consumption per 1 kg of liveweight gain is the most valuable indicator in the production of poultry meat

and in the experimental group amounted to 1.73 kg, which was 13.9% more economical than control one (-0.28).

Currently, the most capacious and indicative criterion for the effectiveness of poultry farming is EIPE. This is a complex index, which includes feed consumption, live weight of poultry grown and safety for the growing period. In the 2nd group ("Toxfin dry"), the European index of production efficiency of broiler chicken meat amounted to 295.9 units, which was higher than the control achievements by 25.2% (+59.6 units), which indicates the effectiveness of the introduction of mycotoxin adsorbent "Toxfin dry" into broiler diets.

At the end of the production tests, we calculated the economic efficiency of poultry meat production in monetary terms. Due to the efficiency of absorption of the nutrient elements of the feed and the reduction of its consumption per unit of production, the cost of all-mash and additives in the 2nd group was, although insignificantly, but less than the all-mash in the 1st group - by 4.8%. Accordingly, the prime cost of poultry products in the 2nd group was lower than in the 1st group - by 4.8%.

The recoupment of costs associated with the giving of an organic origin adsorbent of mycotoxins paid off fully, for 1 ruble of the invested costs 15.4 ruble was received.

We think that transition to organic poultry should be systematic, phased, well thought out and backed up by the legal framework, taking into account all risks. Improving the sanitary and hygienic quality of the feed base will improve the sanitary quality of meat and therefore will help to maintain the health of consumers.

Conclusion

Based on the research, it was found that the organic sorbent "Toxfin dry" helps to reduce the level of mycotoxins in feed by 46.3-85.3%. Introduction in the rations of broiler chickens of adsorbent at a rate of 5 kg/t increases: the average live weight of poultry - by 4.2%, the keeping of livestock by 2.8 p. p. European efficiency index of meat production - 59.6 points while reducing feed consumption per 1 kg of live weight gain - 0.28 food. According to organoleptic, physico-chemical, bacteriological and other indicators, broiler meat is of high-quality and meets the requirements of GOST 52469-2005, STB 1945-2010, GOST 31470-2012, GOST 31962-2013, GOST 7269-2015, GOST 7702.2.1-2017. The economic effect of using the proposed development amounted to 15.4 rubles per 1 ruble of additional costs.

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Author's Contributions

Alena Kapitonova: Conceived and planned the study.

Makhabat Saginbayeva: Conceived and planned the study, revised the manscript.

Kulbaram Bayazitova and Tleubergen Bayazitov: Conducted lab work and drafred the manuscript.

Alma Aubakirova: Did statistical analysis of data.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and there are no ethical issues involved.

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