Efficiency of using chitosan complex in feeding technology for broiler chickens under conditions of increased stocking density

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Abstract. The purpose of the research was to determine the effectiveness of using the chitosan complex "KX-1" in the technology of feeding broiler chickens under conditions of increased stocking density of 23.5 birds/m². Broilers of the 1st control group received feed with standard nutritional value; broilers of experimental groups 2-4 were additionally introduced to a similar diet with a chitosan complex at the rate of 50, 70 and 100 g/t throughout the entire growing period. It was found that the highest efficiency of growing broiler chickens was in the 3rd experimental group, which received the chitosan complex "KX-1" at the rate of 70 g per 1 ton of feed. At 39 days of age, the chickens of this group in live weight exceeded their peers from the control group by 3.5%, from the 2nd experimental group - by 1.9%, and from the 4th experimental group - by 1.2%. The European productivity index in the 3rd experimental group was 9-20 units. (2.3-5.3%) higher than in other groups. The chitosan complex "KX-1" had a positive effect on the zootechnical parameters of poultry rearing under conditions of increased stocking density at a broiler factory and is a valuable feed additive for broilers.

1 Introduction

The general trend in poultry farming is to ensure the welfare of birds at all stages of production and the quality of the final product. Nutrition research has become important due to the growing need to improve poultry productivity and the ban on the use of antibiotics as growth promoters. In recent years, researchers have shown growing interest in biologically active additives of natural origin, which have a positive effect on productivity, meat quality, the formation of intestinal microflora, the use of feed nutrients, the health and safety of broiler chickens [1-5].

Testing and searching for new, inexpensive and environmentally friendly natural biologically active feed additives that stimulate the vitality, growth and development of young animals is an urgent problem in modern poultry farming. Chitosan is a biosynthetic polysaccharide, which is a deacytylated derivative of chitin. The shell of crustaceans, the cell wall of filamentous fungi and the cuticle of insects are the main natural sources of

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chitin [6-8]. Chitosan is one of the promising natural polymers and additives that has attracted much attention due to its biological properties such as biocompatibility, biodegradability, non-toxicity, antioxidant, antimicrobial and anti-inflammatory activity [9-11]. Recent publications have shown that chitosan is an effective feed additive for poultry health and an alternative to feed antibiotics [12-13].

The analysis of publications confirms the importance and promise of expanding scientific research aimed at using chitosan and its derivatives as an immunostimulant, a means of increasing the productivity of broiler chickens, and also improving the quality of the resulting products. In this regard, the goal was set to determine the effectiveness of using the chitosan complex "KX-1" in the technology of feeding broiler chickens under conditions of increased stocking density.

2 Materials and methods

Experimental studies were carried out in the production conditions of "Svezhenka Closed-Cycle Production Association" LLC (POZTS Svezhenka LLC) according to the scheme presented in Table 1. Feeding conditions, technological and zoohygienic rearing parameters complied with the recommendations of the Federal Scientific Center "VNITIP" RAS and the recommendations of the Aviagen company on working with the Ross-308 cross. A 4-phase feeding of broiler chickens with complete feed was used: starter (1-10 days of life), growth (11-21 days), finish-1 (22-33 days) and finish-2 (34-39 days). The nutritional value of feed for raising broiler chickens is presented in Table 2.

Table 1. Scheme of scientific and economic experience.

Group	Number of goals in group	Planting density, heads/m^2	Features of feeding broilers
1 control	35	23.5	Basic diet (BD), balanced for all nutrients in accordance with VNITIP recommendations, 2018, 2021.
2 experienced	35	23.5	BD + chitosan complex "KH-1" at the rate of 50 g per 1 ton of feed
3 experienced	35	23.5	BD + chitosan complex "KH-1" at the rate of 70 g per 1 ton of feed
4 experienced	35	23.5	BD + chitosan complex "KH-1" at the rate of 100 g per 1 ton of feed

Table 2. Nutritional value of feed for raising broiler chickens.

Components	Start (1-10 days)	Growth (11-21 days)		Finish-1 (22-33 days)		Finish-2 (34-40 days)	
		KB-95%	KB-95%+whole grain-5%	KB-90%	KB-90%+whole zsrno-10%	KB-88%	KB-88%+whole zsrno-12%
Metabolic energy + enzyme, kcal/100 g	298.0		308.0		318.0		320.0
Crude protein, %	23.00	22.05	23.21	20.50	22.78	19.82	22.52
Crude fat, %	4.30	5.60	5.89	6.67	7.41	7.21	8.19
Crude fiber, %	3.25	3.50	3.68	3.70	4.11	4.28	4.86

The chitosan complex "KX-1" (loose powder) was introduced into the feed at a feed mill using a stepwise mixing method using standard microdosers-mixers, which made it possible to evenly distribute the additive in the feed.

When conducting studies on broiler chickens, generally accepted zootechnical indicators were taken into account. The study of the intestinal microbiome of broilers was carried out using the real-time PCR method on the basis of the molecular genetic laboratory of "BIOTROF+" LLC.

3 Results

It was found that the highest efficiency of growing broiler chickens was in the 3rd experimental group, which received the chitosan complex “KX-1” at the rate of 70 g per 1 ton of feed. At 39 days of age, the chickens of this group in live weight exceeded their peers from the control group by 3.5% ($P < 0.01$), from the 2nd experimental group - by 1.9%, and from the 4th experimental group - by 1.2% (table 3). The safety of chickens at the end of growing in all groups was 100%. Feed costs per 1 kg of live weight gain in experimental group 3 were equal to 1.57 kg, which is 0.6-1.9% lower than in other groups. The European productivity index in the 3rd experimental group was 9-20 units. (2.3-5.3%) higher than in other groups.

Table 3. Productivity of broiler chickens using chitosan complex “KX-1” (M±m, n=35) (experiment 2).

Index	Group			
	1control	**2 experienced**	**3 experienced**	**4 experienced**
Live weight of one-day-old chick, g	41.08±0.19	41.06±0.20	41.12±0.21	41.11±0.18
Number of chickens, heads.	35	35	35	35
Growing time, days	39	39	39	39
Safety, %	100	100	100	100
Average daily increase, g	59.20	60.16	61.30	60.57
Average live weight of one head, g	2349.88±16.11	2387.22±23.67	2431.88±23.22**	2403.17±20.90*
Feed costs per 1 kg of live weight gain, kg	1.6	1.58	1.57	1.59
European productivity index, units	377	387	397	388

Note: differences with control are significant at: * $p < 0.05$.

During the molecular genetic study, a comparison was made of the average microflora values of the detected microorganisms. As a result of the study, the taxonomic landscape of the intestinal tract microflora was determined in samples of the intestinal contents of birds. The vast majority of microorganisms in all samples were bacteria of the Bacteroides and Clostridia families (Table 4). The highest average content of the bacteroid family was detected in samples of experimental group 4 - $3.4x10^9$, and the clostridia family in samples of group 3 - $1.7x10^9$ cells/gram. They are representatives of normal symbiotic microflora with cellulolytic activity; they are classified as cellulose and amylose decomposing microorganisms, as well as amino acid fermenting microorganisms. The largest number of microorganisms of the genus Eubacterium, which contribute to the absorption of feed components and protection of the body from the effects of pathogens, was determined in the 4th experimental group and amounted to $2.6x10^8$ cells/gram. In connection with the

above, it can be assumed that birds from these groups better absorb plant components from feed.

Table 4. Contents of representatives of symbiotic microflora in samples, cells/g.

Bacteria	Group			
	1 control	2 experienced	3 experienced	4 experienced
Bacteroides of the genera *Prevotella* and *Porphyromonas*	7.8×10^8	1.5×10^9	2.7×10^9	3.4×10^9
Eubacteria of the genus *Eubacterium*	7.1×10^7	1.9×10^8	1.8×10^8	2.6×10^8
Clostridia of the genera *Lachnobacterium*, *Clostridium*	9.0×10^8	1.0×10^9	1.7×10^9	1.3×10^9
Lactobacilli of the genus *Lactobacillus*	2.5×10^7	5.2×10^7	7.0×10^7	4.8×10^7
Lactate-utilizing bacteria of the genera *Megasphaera spp., Veillonella spp., Dialister spp.*	4.1×10^8	1.1×10^8	2.3×10^8	2.2×10^8

The highest content of representatives of lactobacilli, exhibiting antimicrobial and immunomodulatory activity and capable of synthesizing lactate necessary for the production of volatile fatty acids, was found in experimental group 3 - $7.0\text{x}10^7$ cells/g. These microorganisms are associated with a barrier function, from which we can conclude that birds of this group have a lower susceptibility to developing diseases.

4 Discussion

An analysis of publications has shown that the results obtained when using various forms of chitosan in poultry farming are not always unambiguous. According to some authors [14-18], chitosan is an effective feed additive that has a positive effect on the digestibility and assimilation of nutrients, the microbiota of the gastrointestinal tract, immune status, fattening and slaughter productivity of broiler chickens. However, other authors point out the lack of a positive effect of chitosan on the growth and development of poultry [19-20].

When studying the effectiveness of feeding small doses of chitosan (0.01-0.06%), a slight increase in the average daily gain of live weight and overall feed consumption by broilers of the experimental group was established, however, there were significant differences in feed conversion and quantitative carcass indicators between poultry of the control and experimental groups there was no [21].

The purpose of the study [22] was to study the effect of feeding chitosan on the microflora of the intestinal tract in male broilers of the Ross 308 cross. At the beginning of rearing, there were no significant differences in the ratio of beneficial and pathogenic microflora in the intestinal tract in male broilers of all groups, but by the age of 39 days in broilers experimental groups there is a tendency to increase the concentration of bacteria of the genus Bacillus and Lactobacillus while simultaneously reducing bacteria of the E. coli group.

In other experiments [13, 23], broilers fed selenium-chitosan had high live weight and low feed conversion compared to their counterparts from the control group. Their intestinal microflora showed a decrease in the number of coliform bacteria and an increase in lactobacilli.

It should also be noted that biocorrection of metabolism in broiler chickens using biologically active and feed additives, aimed at increasing their safety and productivity, is an essential element of industrial technology for the production of poultry meat. The main

criterion for the effectiveness of using feed additives in feeding broiler chickens is to increase the economic efficiency of poultry meat production [24-25].

Thus, the results of our research do not contradict the results of other authors and confirm the importance and promise of expanding exploratory research aimed at the use of chitosan and its derivatives in industrial poultry farming.

5 Conclusion

Thus, the chitosan complex had a positive effect on the zootechnical parameters of poultry rearing under conditions of increased stocking density at a broiler factory and is a valuable feed additive for broilers. The data from the conducted studies provide the basis for further study of the effectiveness of the use of chitosan complexes in poultry production technology. In particular, as part of the project, it is planned to conduct research to study the effectiveness of liquid forms of the "Chitosan Complex "KX-Aqua" and "Chitosan Complex with Nano-Copper "KXM-Aqua"," which are distinguished by their ease of use.

The composition of the feed additive "Chitosan complex "KH-aqua" is as follows: 89% – purified water, contains at least 7% chitosan with different molecular weights; the composition also includes succinic acid, ascorbic acid, lactic acid, acetic acid. The drug does not contain antibiotics, palm oil, hormonal drugs or growth stimulants.

The composition of the feed additive "Chitosan complex with nanocopper "KXM-Aqua" is as follows: 88.25% – purified water, contains at least 7% chitosan with different molecular weights; 0.75% nanocopper stabilized with chitosan, also contains succinic acid, ascorbic acid, lactic acid, acetic acid. The drug does not contain antibiotics, palm oil, hormonal drugs or growth stimulants.

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