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Biotechnological Methods for Increasing the Efficiency of Market Egg Production

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***Abstract* — This article is about the issue of increasing the egg production of Dekalb White hens through induced molting. For this study, hens at 60 weeks of age were divided into two groups (control and test groups), 53,760 animals in each one. The study continued until birds reached 94 weeks of age. During this study, induced molting for test group was performed in two stages. The first stage included seven days of fasting, watering ad libitum, dimmable lighting in the house for 3 hours. The second stage included the gradual giving of mixed feed starting with a daily intake of 40 g/bird, with an increase of 20 g weekly up to 115 g/bird; lighting period was increased weekly by 3 hours until the established standards were reached. After the end of fasting period, a probiotic preparation based on Bacillus subtilis culture in the amount of 0.2% was added to mixed feed for the test group. It was shown that this scheme allows increasing livability by 2.1%, the number of laid eggs – by 1.2%, reducing feed consumption to 8.1% and getting additional economic profit.**

Keywords—laying hens, egg laying, molting, probiotic, market eggs, production efficiency.

I. Introduction

Rationalization of industry, saving material and technical resources, reducing manufacturing costs in order to reduce production price and increasing production efficiency always were of great importance.

Analysis of modern trends in commercial poultry industry showed that existing chicken crosses have high potential and are able to maintain productivity up to two to three egg-laying cycles. Full realization of genetic potential is possible only by introducing an extended economic life of birds. This can be provided by the use of different induced molting schemes; its results depend on many factors – genotype, age, health condition, etc. [1].

Due to the fact that the impact of stress factors during molting can adversely affect the livability of birds, a search is conducted for biologically active substances that will have a positive effect on the immune status of birds and will increase the possibility of proper induced molting.

II. Literature review

One of the physiological characteristics of birds is their seasonal change of feather – molting. The main factors causing moulting *in vivo* are reduced daylight hours and lower temperatures in autumn-winter period. Seasonal molting lasts for three or four months, in this period birds stop laying eggs. In industrial poultry farms, where the influence of natural factors is minimized due to year-round maintenance of the most favorable temperature and lighting conditions, the start of molting is associated with reaching the age of 52-60 weeks. Such molting is slow and low-intense, lasts up to 6 months or more and adversely affects reproductive organs and further productivity.

In present-day conditions the possibility of increasing the duration of productive use of chickens is of great interest. Poultry farms have experience of the extended use of commercial layers up to 23-24 months [2]. At the same time, there are a number of studies confirming the effectiveness of induced molting which allows accelerating its course and significant reducing the unproductive period of birds [3-7]. At the same time, efficiency level in the second phase of egg production is slightly lower than in the first one but some qualitative indicators of eggs increase [8-11].

Costs associated with induced molting are significantly less than the costs of rearing birds and the full renewal of herd. In addition, there is no need in additional houses for rearing birds. Induced molting helps to restore the reproductive function of birds and strengthen their immunity [12, 13].

Due to the effect of several stress factors, an artificial molting takes place in a short time, ends simultaneously in the entire livestock, and allows receiving market eggs of higher quality less than in a month [14].

Three schemes of induced molting are widespread – with hormonal preparations, with feed restriction, and with the control of certain minerals in diet [3, 16]. It should be noted that the practice of induced molting is quite widespread in the United States, but it is prohibited in Europe. The most widely used method of molting is zootechnical one with different variations. This method is based on the effect of several stress factors: feed and water restriction, as well as reduced intensity and duration of lighting.

Induced molting is usually started at the end of production cycle when hens reach the age of 60-68 weeks, or when the intensity of egg production in the herd decreases to 40-50%.

According to study data, a week before the start of molting, lighting should be reduced to the natural duration of daylight hours. This stimulates hormonal changes in the body of hens and contributes to a more rapid cessation of egg production after feed and water restriction.

To conduct induced molting, depending on the health of livestock, various schemes are used – mild or strict which are characterized by different set of stress factors.

One of the main stress factors is feed restriction or total fasting. During fasting, tissue fat is utilized, plumage changes, and reversible regression of reproductive organs occurs. The duration of fasting period depends on health condition and live weight of birds before molting, the optimal duration is 4-10 days. According to study data, the minimal duration of fasting period results in a more rapid restoration of egg production but at the same time, a rapid decrease in egg laying intensity can be expected in future. Longer fasting which leads to a loss of up to 25% of weight helps to lengthen the second cycle of egg production.

Another important influencing factor, in addition to feeding, is the intensity and duration of lighting. At the initial stage, complete darkness or a sharp decrease in the duration of lighting in the house is recommended. In addition, it is necessary to reduce lighting intensity to 5 lx, and with the beginning of second molting stage of, lighting should be gradually increased by 2 lx until the normal range is reached.

The important period in any moulting scheme is the transition period from the restriction in feed and lighting to normal conditions. At this time, it is necessary to add vitamin-mineral premixes and other components in feed that contribute to the quickest recovery of birds' resources. The use of modern supplementary feeds in order to improve the livability and productivity of birds, as well as to reduce the negative impact of stress factors, is of great practical importance. Probiotics can be used as such supplements. A lot of data were obtained confirming the beneficial effect of probiotics on physiological functions and biochemical processes in the body of chicken. Probiotics inhibit the growth of potentially dangerous microorganisms, restore symbiotic status, increase enzyme activity, immunity and resistance to environmental factors.

The development of probiotics that provide a comprehensive stimulating effect on the bird organism during molting, as well as the development of effective schemes for their use, is quite relevant.

III. Research Methodology

This study was conducted in a commercial poultry plant on laying hens of the Dekalb White Cross. Birds at 60 weeks of age were divided into two groups (control and test), with 53,760 animals in each group. The study continued until birds reached 94 weeks of age.

During the study, hens were kept in battery cages, the duration of daylight hours and room microclimate parameters were automatically adjusted in accordance with hygiene requirements and recommendations for working with the cross. Birds were fed with full-ration balanced mixed feeds.

During the study, induced molting in the test group was carried out in two stages. The first stage included seven days of fasting when hens received limestone daily (at least 5 g/bird per day), watering ad libitum, dimmable light in the house for 3 hours. The second stage included the gradual giving of feed starting with a daily intake of 40 g/bird, with an increase of 20 g weekly to 115 g/bird, the duration of lighting period was increased weekly by 3 hours until the established standards were reached. After the end of fasting period, a probiotic preparation based on Bacillus subtilis culture in the amount of 0.2% was added to mixed feed for the test group.

During this test, the livability of hens, hematological parameters, live weight changes, egg production and feed consumption were taken into account. Livability was registered daily taking into account mortality and induced rejection. The live weight of birds was defined by individual weighing of birds in control cages placed in the different parts of house. Accounting for egg production in groups was automated. Egg laying per hen was determined by dividing the total number of laid eggs by the number of hens in the group. Egg mass was defined by weighing 100 eggs selected by random sampling on an electronic balance. The thickness of eggshell was found using a micrometer, the mass of the components – by weighing them to the nearest 0.1 g. Egg mass production was calculated by multiplying average egg mass by average egg production per period. Feed consumption per group was registered daily. Feed consumption for the production of dozen eggs and egg mass was calculated by dividing consumed feed by the number of dozens eggs and produced egg mass, respectively. Blood for laboratory tests was sampled by puncture from a vein over the elbow joint in hens in control cages (10 animals in each).

Experimental findings were statistically processed using SPSS Statistics software. The difference between groups was considered statistically significant at $P < 0.05$.

IV. Results

A. *Stock livability*

An important factor for the economic efficiency of egg production is stock livability. Table 1 shows the data on the change in the number of hens during study period.

Data analysis reveals that livability was high over the entire study period. Maximal withdrawal in the test group was registered during the period of induced molting, namely, during the first two weeks after fasting stage – 2.6%.

TABLE I. STOCK LIVABILITY, %

Age, weeks	**Group**	
	control	***test***
60-64	98.60	98.70
65-69	98.40	99.20
70-74	98.30	99.00
75-79	98.10	98.90
80-84	97.90	98.50
85-89	97.80	98.40
90-94	98.60	98.70

Then, starting from the age of 65 weeks, the test group has an advantage over the control one for livability, and the difference increases with aging from 0.1 to 0.8%.

Survival rate of the stock during 60-94 weeks of economic life in molted group was 90.5% what is 2.1% more than in the control one.

To control the physiological condition of hens, biochemical blood tests were performed –before the start of experiment, after the first stage, and again in a month after its completion.

Serum proteins are important precursors for protein synthesis in muscle tissue and eggs. The results of analysis revealed that the content of total protein in blood serum after the end of fasting period decreased by 17.8%, mainly due to a decrease in the proportion of albumin by 34.8% what is natural during fasting. Globulin content decreased slightly (0.6%). A month after the start of second stage, there was an increase in the level of total protein and its fractions to 87-98% from the baseline. Despite fluctuations in the total protein level in blood, it was within physiological normal values all the time. Albumin-globulin ratio which indicates the intensity of metabolic processes in the body showed that within a month after the end of fasting stage protein metabolism in bird body was completely restored.

The level of total calcium and inorganic phosphorus in the blood of hens ranged from 3.02–3.82 and 0.48–1.07 mmol/L, respectively. During fasting, there was a decrease in the level of these elements in the blood; the level of phosphorus decreased more significantly but then it was gradually recovered.

The level of blood creatinine was also changed due to the influence of stress factors – after the end of first stage it decreased to 72.4% along with live weight decrease, and then increased to 86.5% from the baseline.

The level of aminotransferases is an important diagnostic sign of metabolic disorders. The amount of aspartate aminotransferase and alanine aminotransferase throughout the study fluctuated slightly and was within normal.

Stress factors negatively affected hemoglobin level – after the end of the first stage it decreased by 26.3%. Later, with proper nutrition, this parameter stabilized and reached its baseline value within four weeks.

B. *Changes in live weight of hens*

Live weight is a parameter that largely determines bird productivity. In this regard, the condition of birds should be taken into account before starting fasting stage which causes the feather to fall quickly. If the weight of hens meets the standards or is higher, and the herd is uniform in this parameter, it is necessary to use a more “strict” scheme with increased fasting period. If the weight of hens is lower than normal, or a large loss was registered, it is necessary to apply a “mild” scheme which provides for a relatively short fasting period (4-5 days). The experience of poultry plants showed that laying hens subjected to a short-term fasting start egg laying earlier, however, the egg production of herd in this case decreases faster. Laying hens that have gone through longer fasting period (8–9 days) and have lost 25% or more of weight start laying eggs later but keep high intensity longer. This research method provided for a seven-day fasting period.

In seven days without feeding, birds reduced their weight by 22% from the baseline. After exposure to stress factors, massive feathers fall began. With bringing daily feeding to normal, the average live weight of laying hens was restored at 95% of the baseline.

C. *Egg production*

Egg production is the main economically useful characteristic of bird which can vary greatly. Even with proper feeding and properly organized keeping of hens, egg production changes due to age, physiological condition and other factors.

Egg production of laying hens is greater during the first year of laying, then it decreases. Egg production of molted birds is, as a rule, about 80% of the baseline.

TABLE II. EGG PRODUCTION CHANGES PER AVERAGE LAYING HEN, PCS.

Age, weeks	**Group**	
	control	***test***
60-64	24.21	5.19
65-69	23.19	16.80
70-74	22.50	24.75
75-79	21.36	26.07
80-84	20.49	25.53
85-89	17.16	23.82
90-94	14.76	23.22

From the data in Table 2, we can see that the greatest egg production in the control group was observed during the first period – 24.21 pcs, then, with aging, it naturally decreases to 14.76 pcs.

In the group that underwent induced molting, the opposite result is observed – during fasting stage of molting hens cease to lay eggs, and then, when feeding becomes normal and metabolism restores, their egg production increases until 75-79 weeks of age, reaching 26.07 pcs. per average laying hen what is 4.7 (22.1%) more than in the control group. Later, despite the decrease in egg production with age, the advantage of the test group compared with the control one continues to increase and by the end of the study it amounts to 8.5 pcs. (57.3%).

Difference in egg production per average laying hen over the entire period of study was 1.71 pcs, or 1.2% in favor of the group subjected to induced molting.

Egg production rate defined as the ratio of the number of laid eggs to the number of birds, by the end of study in the control group decreased to 49.2% what is 28.2% less than in the test group. Continuing the economic life of birds of the control group under these parameters was not economically profitable.

Egg mass is the second most important characteristic of economic importance in the production of egg products. Different factors have the effect on egg mass but the environment has a relatively small effect because this factor is a hereditary feature. Main factor that influences egg mass is the age of laying hen.

Data in Table 3 show that egg mass in the control group during molting (age 60-64 and 65-69 weeks) exceeded that in the test one by 1.4 and 1.0 g, or 2.1 and 1.5%, respectively; in other periods, except the final one, it was 0.1 g, or 0.2% less.

TABLE III. AVERAGE EGG MASS CHANGES

Age, weeks	**Average egg mass changes, g**		**Yield of egg mass per average hen, kg**	
	Group		***Group***	
	control	***test***	***control***	***test***
60-64	65.4±0.69	64.0±1.27	1.58	0.33
65-69	65.9±0.67	64.9±1.09	1.53	1.09
70-74	66.1±0.72	66.2±1.12	1.49	1.64
75-79	66.3±0.76	66.4±1.18	1.42	1.73
80-84	66.3±0.94	66.4±1.15	1.36	1.70
85-89	66.4±0.95	66.5±1.21	1.14	1.58
90-94	66.4±1.10	66.4±1.26	0.98	1.54

Generally, for the entire period of study, the average egg mass in the control and test groups did not differ significantly – by 0.05 g, or 0.04% (P> 0.05).

Since the weight and number of eggs varies depending on the period of laying and the age of bird, egg mass is calculated for a comprehensive assessment of hens by production. With the same egg production, the amount of egg mass can be different what results in different product yield and its cost.

At the age of 60-69 weeks, the yield of egg mass in the control group exceeded that in the test one by 0.44-1.25 kg (28.6-79.0%) what is associated with decreased production during molting (Table 3). In subsequent age periods, the yield of egg mass in the hens of test group was more than in the control one: by 0.15 kg, or 10.1% at the age of 70-74 weeks; by 0.31 kg, or 22.2% at 75-79 weeks; by 0.34 kg, or 24.7% in 80-84 weeks; by 0.44 kg, or 39.0% at 85-89 weeks; by 0.56 kg, or 57.3% at the age of 90-94 weeks.

Over the entire period of study, the difference in the yield of egg mass per average laying hen was 0.12 kg, or 1.3% in favor of the test group.

Another important parameter of egg production is product quality. Evaluation of egg quality was carried out twice – before the start of molting and one month after the end of the second period by random sampling of a batch of eggs in the amount of 100 pcs. When examining the egg-shell, it was found to be smooth, of regular shape, without roughness, with mild marbling. Average thickness was 0.37 mm, mass was 6.4 g. There were no significant changes after molting, egg-shell mass decreased on average by 0.2 g but this difference was not statistically significant. Morphological analysis showed decreased egg white mass and increased yolk mass what led to a change in egg white to yolk ratio but this difference was also not statistically confirmed. The content of carotenoids in yolk during all age periods corresponded to normal values and amounted to 19.4-22.1 μg/g.

D. Feed consumption

When keeping birds, feed cost is about 2/3 of all production costs. It is the reduction in feed costs that is critical in the economy of egg production. The parameters of total feed consumption and consumption per product unit allow comprehensive assessing bird productivity.

Due to the fasting stage of molting and the following period when hens received reduced amount of feed, feed consumption per hen was lower in the test group – it amounted to 20.97 kg what is 1.57 kg, or 7.0% less, than in control group.

TABLE IV. FEED CONSUMPTION, KG

Age, weeks	**Feed per 10 eggs, kg**		**Feed per 1 kg of egg mass, kg**	
	Group		***Group***	
	control	***test***	***control***	***test***
60-64	1.33	3.24	2.03	5.06
65-69	1.39	1.90	2.11	2.93
70-74	1.43	1.30	2.17	1.97
75-79	1.51	1.24	2.27	1.86
80-84	1.57	1.26	2.37	1.90
85-89	1.88	1.35	2.83	2.03
90-94	2.18	1.39	3.29	2.09

Due to the low productivity at the first stage of study, feed consumption for the production of a dozen eggs in the test group was higher than in the control group by 0.51-1.90 kg. After stabilization of the physiological condition in molting birds, feed consumption decreased and amounted to 1.24-1.39 kg what is 0.13-0.79 kg, or 9.1-36.4% less than for the birds in control group.

Over the study period (60-94 weeks), feed consumption per dozen eggs in the test group were 0.3 kg, or 8.1%, less than in the control one.

Similar trend is observed in feed consumption for egg mass production (Table 4). In the age period of 60-64 and 65-69 weeks, feed consumption for egg mass in the test group was 5.06 and 2.93 kg what is 3.02 and 0.82 kg more than in the control group, respectively. In subsequent periods, feed consumption in the test group was 1.2 kg (36.4%) less than in the control one, and this difference increases with aging.

Feed consumption per 1 kg of egg mass for 60-94 weeks of age in the control group reached 2.37 kg what is 0.19 kg (8.12%) more than in the test group.

V. CONCLUSION

Economic effect of induced molting is the sum of the increased economic life of hens and the savings from rearing birds, as well as the additional egg production. The calculation of economic efficiency allows concluding that the use of induced molting leads to the increased profitability of egg production. In the molted group, livability and egg production per average laying hen increased what allowed getting 4.0% more eggs per 1,000 birds. Accordingly, sales revenue also increased by 4.0%. With the same cost of mixed feed, feed consumption in the test group was 5.0% less than in the control one. Due to the abovementioned, the total costs in the test group was by 2.0% less than in the control one. As a result, more profit was obtained from laying hens of the test group what led to the increased profitability of egg production by 6.2%.

Thus, it was found that the use of the described induced molting scheme allows increasing stock livability by 2.1%, the number of laid eggs – by 1.2%, reducing feed consumption by 8.1%, and getting additional economic profit.

The data obtained as a result of this study supplement the available information about the physiological condition and productivity of modern highly productive crosses of chickens with an extended economic life.

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