Effect of supplemental dietary with different protein levels on production performance and egg quality of Hy-Line brown hens

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Abstract: *This paper investigated the effects of adding different protein levels to the breeding rations of Hyland Brown hens on their production performance and egg quality. A total of 180 Hyline brown hens were randomly selected and divided into three groups, each group was divided into five test groups with 12 hens in each test group, and three different protein levels were designed, with the protein levels of the diets for the breeding period in test groups A, B and C being 14%, 16% and 18%, respectively, 16% and 18%, respectively. The hens were fed diets with different protein levels from 7 weeks of age to the start of laying, and the same commercial diet was fed to all groups after the start of laying. The trial was divided into two phases: the first phase was the breeding period from 7 to 19 weeks of age and the second phase was the laying period from 20 to 26 weeks of age. The egg production performance of the hens was counted from 20 weeks and the egg quality was measured at 20 and 26 weeks of age. The results showed that the egg production rate of test B and C. groups was significantly higher than that of test A (P<0.05); the average egg weight of test B. group was higher than that of test A and C. groups, but in most cases this difference was not In terms of egg quality, egg shell strength, egg shape index, protein height and Hastelloy unit were significantly higher in test group B than in test groups A and C (P<0.05). The egg production performance and egg quality of test group B were the best in all test indexes. Therefore, it is most appropriate to add 16% egg quality to the diets of Hy-line brown hens during the breeding period.*

Keywords: *Hy-line brown hens, Different protein levels, Performance, Egg quality*

1. Introduction

Eggs as a protein source for humans with highly percentage of methionine, an essential amino acid non-contain in cereals and legumes. The quality and demand for eggs and their derivatives have been increasing rapidly in recent years, and the scale of egg production in the livestock industry has been expanding. Due to the increasing demand for food quality, people are now developing a consumer philosophy that requires both safety and environmental protection as well as nutritional health, and therefore farmers need to produce eggs of excellent quality [1]. The cost of feed for laying hens is mainly determined by the proportion of protein ingredients. Determining the appropriate protein level in the ration will ensure egg quality while also helping to reduce production costs and thus improve the economic efficiency of the farming industry. In addition, ammonia emissions are an important issue in the poultry industry and can be reduced by controlling protein dietary levels, so it is particularly important to determine the optimal crude protein ratio in the ration [2]. In conclusion, exploring the appropriate dietary protein level suitable for the needs of laying hens during the breeding period is not only important to bring into play the excellent production performance of laying hens and produce high-quality eggs, but also to reasonably develop feed resources, reduce environmental pollution from nitrogen emissions in poultry excreta, and improve the economic returns of farming.

Hy-line brown hens are one of the main varieties of laying hens in large-scale breeding. Compared with other laying hens, Hy-line brown hens have many advantages, such as less response to stress, higher feed reward, more eggs and higher survival rate [3]. The country of origin of Hy-line brown hens is the United States. This breed was introduced in our country in the 1980s. Its opening day-laying age is averaging about 20 weeks of age, until the egg production begins to decline gradually when it reaches 80 weeks of age [4] [5].

Proteins are known to have an irreplaceable role in the life activities of any animal. On the one hand, they not only contribute to the biosynthesis of tissues and are one of the main raw materials for the construction of body tissues and cells, but also have many biological functions, which are used to promote the growth of the body and the renewal of cells [6]. On the other hand, many enzymes involved in physiological reactions in the body, hormones produced by secretory glands, immunoglobulins that defend the body against bacteria and viruses, etc. are mainly composed of proteins, which play a key role in the physiological processes in the body. By optimizing the ratio of protein nutrients, the growth progress of laying hens can be improved and their immune function enhanced.

Previously, nutrient requirements for poultry were adjusted to improve growth and production performance, and the problem of nutrient excesses was easily overlooked. Excess nutrients in the ration can lead to waste of feed resources and increased costs of breeding, and can also cause hens to grow too fast or even beyond their normal weight range, thus affecting their egg production performance; if the nutrients in the feed are not sufficient, it can be detrimental to the normal fattening of hens, disrupting their normal growth and dissipating the high production performance they should have [7]. Since the unconsumed portion of amino acids consumed by poultry is removed as amino acid derivatives, most of which are removed through urine in the form of uric acid (80%), ammonia (10%) and urea (5%), poultry excreta in modern large-scale farming can cause nitrogen pollution to the environment [8] [9]. Based on this understanding, proper optimization of nutritional intake in poultry diets is beneficial for the improvement of egg production performance as well as for the reduction of environmental pollution produced by poultry.

2. Experiment

2.1 Experiment procedure

Protein requirements can be influenced by the breed, size, feeding method, environmental temperature, as well as different stages of production and nutrient concentration of feed. The external temperature affects protein requirements mainly by influencing the amount of food consumed by the poultry, but also at different stages of growth and egg production, due to changes in body weight and egg production [10] [11].

The first phase of the experiment was the growing period from 7 to 19 weeks of age, during which the groups were fed diets with different levels of protein. The second phase of the trial was the egg-laying period from 20 to 26 weeks of age, during which the egg-laying performance and egg quality were measured. The diets and drinking water were supplied uniformly, and the chicken house used nipple-type waterers to ensure clean and sufficient drinking water.

The experimental subjects were 180 randomly selected 7-week-old healthy Hy-line brown hens, randomly divided into three groups, five replicates per treatment group, 12 hens per replicate. The protein level was divided into three treatment groups according to a gradient, and the three groups were fed diets with different protein levels and the same energy level during the breeding period, with the protein level of 13.5% in test group A, 15.5% in test group B and 18% in test group C. The energy level of the diets for all three groups was 2640 kcal/kg. The hens were fed and watered freely during the trial period. At the second stage of the trial period, i.e. 20-26 weeks of age, egg collection was carried out regularly at 5 pm every day and the feed intake was recorded every Monday morning for 7 weeks from 20 to 26 weeks of age. At 20 and 26 weeks of age, egg quality was measured, and each time the eggs were collected for one day for egg quality determination.

2.2 Production Performance

As can be seen from Table 1, the egg production rate of test C group was significantly higher than that of test A group at 26 weeks of age ($P<0.05$), and the effect of egg production rate at 26 weeks of age was significant ($P<0.05$). at 28 weeks of age, the egg production rate of test A group was significantly lower than that of test C group ($P<0.05$), and the effect of different protein levels on egg production rate at 28 weeks of age was significant ($P<0.05$). There was no significant difference in egg production between groups in the remaining weeks ($P>0.05$). In general, the egg production rate of test B and C groups was significantly higher than that of test C group ($P<0.05$).

It can be seen from Table 2 that at 26 weeks of age, the mean egg weight was 61.28 g in test group A, 62.61 g in test group B and 61.90 g in test group C. The mean egg weight value was highest in test group B. The mean egg weight of test group B was significantly higher than that of test group A ($P<0.05$), and

ISSN 2616-5910 Vol. 4, Issue 1: 8-13, DOI: 10.25236/AJALS.2023.040102

there was no significant difference in the mean egg weight among the groups in the remaining weeks (P>0.05).

From Table 3, it can be seen that at 24 weeks of age, the maximum amount of food intake was 124.3 g in treatment group B and the minimum amount of food intake was 105.57 g in treatment group A. The amount of food intake in test group B was significantly higher than that in test group A (P<0.05), but there was no significant difference between the groups in the remaining weeks (P>0.05).

Table 1: Comparison of egg production rates (%) at different protein levels

	Group A	Group B	Group C	Value F	Value P
20 weeks	83.23±2.63	85.93±2.95	83.77±2.74	0.28	0.5953
21 weeks	87.94±2.62	93.21±1.21	92.58±1.41	1.79	0.1818
22 weeks	85.69±3.28	91.56±1.37	92.86±1.51	2.21	0.1564
23 weeks	89.42±3.29	92.29±1.64	93.68±2.03	0.88	0.4231
24 weeks	87.36±3.17	93.31±1.70	95.74±1.43	3.50	0.0467
25 weeks	90.75±2.73	93.76±1.43	94.92±1.77	1.01	0.3923
26 weeks	90.26±2.29	92.82±1.84	96.43±0.90	2.75	0.0767
Total	87.86±0.93	92.73±0.96	92.88±1.58	4.32	0.0279

Table 2: Comparison of mean egg weight (g) at different protein levels

	Group A	Group B	Group C	Value F	Value P
20 weeks	62.29±1.75	64.37±0.38	61.10±1.18	0.71	0.5089
21 weeks	57.24±0.66	58.19±0.81	57.64±0.34	1.41	0.2436
22 weeks	59.15±0.48	60.37±0.34	60.95±0.19	2.54	0.1137
23 weeks	60.63±0.44	61.11±0.38	61.51±0.43	1.52	0.2377
24 weeks	61.15±0.18	62.39±0.37	61.37±0.31	2.42	0.1069
25 weeks	61.43±0.64	62.76±0.34	61.75±0.37	2.42	0.1242
26 weeks	62.09±0.47	63.37±0.21	62.19±0.27	2.13	0.1431
Total	60.37±0.63	61.92±0.49	61.92±0.38	0.94	0.3155

Table 3: Comparison of average daily feed intake (%) for different protein levels

	Group A	Group B	Group C	Value F	Value P
20 weeks	116.71±1.68	120.13±1.58	119.04±1.35	1.31	0.2324
21 weeks	120.21±1.18	120.73±2.11	115.08±1.80	2.52	0.1542
22 weeks	118.57±2.41	117.55±1.70	120.13±1.63	0.91	0.4131
23 weeks	113.29±1.24	118.92±2.59	115.59±0.79	1.34	0.2964
24 weeks	106.75±5.18	124.64±6.64	115.42±3.70	2.59	0.0153
25 weeks	117.63±1.09	113.81±2.94	117.16±2.58	0.74	0.4924
26 weeks	116.26±1.69	120.03±1.94	118.40±2.73	1.56	0.3419
Total	115.68±1.39	119.20±1.19	117.32±0.64	1.72	0.1624

2.3 Egg Quantity

As can be seen from Table 4, the egg shape index was significantly higher (P<0.05) in test group A than in test group C when the first egg quality test was performed at 24 weeks of age. The egg shell strength was 4.46 kg. f in test group A, 4.70 kg. f in test group B and 4.36 kg. f in test group C. The egg shell strength and egg white height were significantly higher in test group B than in test group A (P<0.05). The egg yolk color was significantly higher in test group C than in test groups A and B (P<0.05). The detection value of Hastelloy unit was 84.13 in test group A, 90.31 in test group B and 87.49 in test group C. The Hastelloy unit in test group B was significantly higher than that in test group A (P<0.05). There was no significant difference between the three groups for yolk specific gravity and shell specific gravity (P>0.05).

It can be seen from Table 5 that the egg shell strength of test A group was significantly higher than that of test C group when the second egg quality test was performed at 28 weeks of age (P<0.05); there were no significant differences among the three groups in other egg quality indexes (P>0.05).

ISSN 2616-5910 Vol. 4, Issue 1: 8-13, DOI: 10.25236/AJALS.2023.040102

Table 4: Egg quality of the first detection

Egg quality indicators	Group A	Group B	Group C	Value F	Value P
Eggshell thickness (mm)	31.69±0.32	33.21±0.18	32.34±0.37	0.59	0.5496
Egg-shaped Metrics	1.28±0.42	1.27±0.14	1.26±0.01	2.32	0.1137
Eggshell strength(kg.f)	4.46±0.19	4.70±0.04	4.36±0.07	6.71	0.0019
Protein height (mm)	7.19±0.32	8.38±0.01	8.06±0.23	8.69	0.0003
Egg yolk color	9.39±0.08	9.65±0.23	10.29±0.16	7.64	0.0005
Hastelloy Unit (HU)	84.34±1.05	90.61±1.15	87.94±1.93	4.39	0.0184
Specific gravity of egg yolk(%)	23.24±0.21	23.63±0.32	24.57±0.25	2.84	0.0669
Specific gravity of eggshell (%)	10.87±0.10	11.06±0.05	10.91±0.08	0.39	0.6526

Table 5: Egg quality of the second detection

Egg quality indicators	Group A	Group B	Group C	Value F	Value P
Eggshell thickness (mm)	33.29±0.38	33.87±0.36	34.06±0.40	1.04	0.3581
Egg-shaped Metrics	1.25±0.02	1.27±0.01	1.25±0.01	0.57	0.5103
Eggshell strength(kg.f)	4.49±0.08	4.43±0.06ab	4.23±0.09b	2.49	0.0894
Protein height (mm)	7.13±0.24	7.36±0.12	7.17±0.13	0.79	0.4243
Egg yolk color	7.02±0.23	7.68±0.33	7.58±0.09	1.69	0.1582
Hastelloy Unit (HU)	84.23±0.87	84.84±1.42	84.49±0.86	0.05	0.9364
Specific gravity of egg yolk(%)	25.21±0.21	25.13±0.18	25.56±0.24	0.69	0.4224
Specific gravity of eggshell (%)	10.62±0.07	10.63±0.07	10.79±0.08	2.11	0.1278

3. Discussion

3.1. Effect of protein level on the production performance of Hyland Brown eggs

Wei Yumei et al. showed that when 15.5%, 16%, 16.5% and 17% protein were added to the diets of Jing Hong hens during the peak laying period, the highest egg production rate was achieved when 16.5% protein was added. The test showed that the egg production rate of hens with 16% and 18% protein in the breeding diet was significantly higher than that of hens with 14% protein ($P<0.05$). Therefore, egg production rate and egg quality improved with increasing protein levels, which is consistent with the findings reported by Xu Ning.

Qin Peng pointed out that the average egg weight of Isha brown hens fed high-protein diets with 16.5% and 17.5% protein levels was higher than that of the low-protein group fed 15.6% protein levels, indicating that egg weight was influenced to a greater extent by protein level. This experiment showed that at 26 weeks of age, the mean egg weight was significantly higher ($P<0.05$) at a dietary protein level of 16% than at a level of 14%, and the mean egg weight was highest at a protein level of 16%, but did not continue to increase when the protein level in the diet was increased to 18%, which may be related to the inappropriate protein-energy ratio ration. The protein-energy ratio in the diet has a great influence on the egg production performance of hens. Feeding high protein diets to hens will lead to an imbalance of the protein-energy ratio in the diet, and high protein metabolism will produce more energy loss, so when the protein level is high, it will reduce the average egg weight.

3.2. Effect of protein level on the quality of Hyland brown eggs

A shell thickness of 0.27-0.40 mm is considered normal, and the range is generally considered to be better for preservation and transport when the thickness exceeds 0.35 mm. The greater the shell thickness, the lower the breakage rate of the eggs, and also the slower the deterioration process. The eggshell thickness was within the normal range for all groups in this test, but the protein level did not have a significant effect on eggshell thickness.

Egg shape index is strongly influenced by genetics and varies among breeds, with normal values ranging from 1.20 to 1.35. The egg shape index measured in this experiment did not exceed the normal range on both occasions.

The greater the shell strength, the greater the ability of the shell to resist impact during circulation. The first egg quality test showed that the shell strength was greater when 16% protein was added to the diet than when the protein level was 14% or 18%. The second result of egg quality showed that the eggshell strength was significantly higher ($P<0.05$) when 14% protein was added to the diet than when the protein level was 18%. This result indicates that high protein levels are not conducive to egg shell strength.

Protein height can indicate the freshness of the egg; the fresher the egg, the higher the protein height will be. Protein height is strongly influenced by genetic factors, as well as by genetic factors and protein level. The results of the first egg quality measurement showed that the eggs had the lowest Haptogram unit value at 14% protein level and the highest Haptogram unit value at 16% protein level, and the Haptogram unit value was significantly higher in test group B than in test group A ($P<0.05$). The results of the second egg quality measurement showed that the Hastelloy unit value was also slightly higher in eggs at 16% protein level than in the other two groups, but there were no significant differences in Hastelloy unit values between the groups ($P>0.05$). This result indicates that a dietary protein level of 16% is beneficial for the freshness of the eggs.

Consumers prefer eggs with darker yolks and higher yolk ratios, and studies have shown that the feed normally consumed by hens affects yolk color. The first egg quality test showed that the yolk color was significantly higher at 18% protein than at 14% and 16% protein ($P<0.05$), but the second egg quality test showed no significant difference in yolk color between the groups ($P>0.05$). Both egg quality measurements showed no significant difference in specific gravity of the yolk between the groups ($P>0.05$).Both egg quality measurements showed no significant differences between groups for specific gravity of eggshell ($P>0.05$).

In general, Hy-line brown hens showed higher production performance and best egg quality at 16% protein level. Therefore, the highest production performance and the best egg quality were easily obtained when 16% protein was added to the diet.

4. Conclusion

When the dietary protein level was 16% and 18%, the laying performance of Hy-line brown hens was significantly higher than that when the dietary protein level was 14% ($P<0.05$), and different protein levels also had certain effects on egg quality. In general, eggs had the best quality and the highest laying performance when the protein level was 16% in the growing diet. According to the indexes measured during the experiment, the optimal proportion of protein in the diet of Hy-line brown hens at growing stage was 16%.

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