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Production performance and egg quality parameters in Hy-line brown laying hen in response to extra feed supplementation

Md Mortuza Hossain, Jae Hong Park, In Ho Kim*

Department of Animal Resource and Science, Dankook University, Cheonan 31116, Korea

*Corresponding author: inhokim@dankook.ac.kr

Abstract

The purpose of this experiment was to determine the influence of providing laying hens with extra feed on egg production and egg quality parameters. A total of 480 laying hens (38-weeks old), were divided into five treatment groups (eight replicate cages/treatment and 12 layer/replicate) according to their starting body weight (1.98 ± 0.05 kg) in this four-week feeding trial. Five different feed allowances of the same diet (105, 110, 115, 120, and 125 $g \cdot day^{-1} \cdot bird^{-1}$) were assigned to layers. Daily inspections of remaining feed (around 0.1g) and layer mortality (0%) showed no harmful impact of supplying extra feed to layers. Providing 120 and 125 g of feed per day to layers resulted in the highest final body weight, large-egg ratio, and improved yolk color among all treatment groups. Layers receiving 125 g of feed daily had the highest egg weight, but the highest egg production ratio was observed in layers receiving 110 g of feed/day. The additional supply of feed did not have a negative impact on the productive performance or egg quality of the layers. The provision of 125 g feed per day led to an improvement of large-egg ratio, egg weight, and yolk color, but likely led to obesity of the layers, which manifested as an increase in body weight and a decline in the egg production ratio. We concluded that 110 grams of feed was the proper quantity after taking into consideration the significance of the health of the laying hen to the overall production performance.

Key words: egg quality, extra feed supply, laying hen, productive performance

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Introduction

The poultry industry is growing rapidly because it offers rapid profit and produces affordable animal proteins (Rahman et al., 2017). The egg industry and nutritionists have been looking for novel strategies to maximize production efficiency in laying hens (Zaefarian et al., 2016). Birds need to get nutrients from feed to maintain their growth, productivity, reproduction, and a series of physiological activities. Therefore, an appropriate amount of daily feed intake is important to the animals to maximize their productive traits. In commercial laying hen farms the guidelines provided by the breeder company are usually followed. It is a well-known fact that hens modify the amount of feed they consume to correspond with the amount of energy they need. If hen consume more feed, they will have access to more of the nutrients they need to production and growth, ultimately this will result in increased growth and productivity. But unrestricted feeding of layers had negative effects on growth and productive performance (Chen et al., 2006). However, the effects of the extra feed supply strategy on the growth and productive performance of layers are variable. It was reported that increasing feed intake of layers through dietary manipulation could improve growth performance, egg quality, egg production ratio, and immune status (Wan et al., 2021). Increased albumen and yolk weights were found through dietary fat supplementation, but no effect was seen on the weight of egg components (Grobas et al., 1999). Higher production rate was found in high-energy-feed supplemented group in laying hen (Mathlouthi et al., 2002). However, the effects of extra feed supply strategy on growth and productive performance had only been investigated in the broiler breeders (Chen et al., 2006), while not fully investigated in layers. According to the recommendations of the breeding company (Hy-Line, 2018), the feed intake of Hy-line brown laying hens based on age and body weight. The daily feed intake of layers in the control group was set at 105 g. The formulation of the extra feed supply model adopts a strategy, in which the amount of feed supply is increased in a moderate range to form different groups (105, 110, 115, 120, and 125 $g \cdot day^{-1} \cdot bird^{-1}$). The increment of feed supply was far less than that reported in the study of Chen et al. (2006), in which the extra feed supply model was set at 145 versus ≥ 290 $g \cdot day^{-1} \cdot bird^{-1}$. We hypothesized that the extra feed supply used in this study could improve the productive performance and egg quality in layers. Therefore, the objective of this study was to evaluate the effects of extra feed supply on the productive performance and egg quality in layers, to evaluate the appropriate feed supply for improving productive performance and egg quality.

Materials and methods

The Animal Care and Use Committee of Dankook University, South Korea gave their approval to the protocol of the study before it was carried out (DK-1-2033).

Experiment design, animals, and housing

A total of 480 Hy-line brown laying hens (38-week-old) with an average initial body weight of 1.98 ± 0.05 kg were used for a 28-day trial. All layers were caged individually and randomly assigned to 5 treatments based on the initial body weight. There were 8 replicate cages per treatment and 12 layers per replicate. Layers were fed a mash diet designed to fulfill NRC standards for certain nutrients (NRC, 1994). The composition of the dietary feed used in this study is shown in Table 1. The layers were fed the same food in different amounts. Five different feed allowances (105, 110, 115, 120, and 125 $g \cdot day^{-1} \cdot bird^{-1}$) were assigned to layers. Each layer was reared in 38 cm × 50 cm × 40 cm steel cage with a nipple drinker, a shared trough for food and water, and a plate for collecting eggs in a room with natural ventilation and sunlight. The average ambient temperature was 23 degrees Celsius over the whole of the trial. In addition, there were 16 hours of daylight (05:00 - 21:00; 5.2 lux) and 8 hours of darkness every day. At all times throughout the trial, the chickens had free access to water.

Table 1. Composition and nutrient levels of the experimental basal diet (%, as-fed basis).

Ingredient	%
Corn	66.05
Soybean meal	23.28
Dicalcium phosphate	1.00
Limestone (fine)	2.76
Limestone (coarse)	6.44
Salt	0.05
Methionine	0.12
Vitamin premix[y]	0.10
Mineral premix[z]	0.10
Choline	0.10
Total	100.00
Calculated composition (%)	
Dry matter	89.85
Moisture	10.15
Crude protein	16.02
Crude fat	2.70
Crude fiber	3.08
Crude ash	4.57
Calcium	3.76
Phosphorus	0.55
Available phosphorus	0.32
Lysine	0.75
Methionine	0.38
Methionine + cystine	0.65
Threonine	0.59
Tryptophan	0.21
Arginine	1.03
Alanine	0.84
Aspartic acid	1.54
Glutamic acid	2.85
Glycine	0.64
Proline	1.00
Serine	0.76
Tyrosine	0.59
Isoleucine	0.68
Valine	0.77
Leucine	1.44
Phenylalanine	0.79
Histidine	0.43
Metabolism energy ($MJ\cdot kg^{-1}$)	11.51
Linoleic acid	1.55

[y] Provided per kg of diet: vitamin A, 8,000 IU; vitamin D_3, 3,300 IU; vitamin E, 20 g; vitamin K_3, 2.5 g; vitamin B_1, 2.5 g; vitamin B_2, 5.5 g; vitamin B_6, 4 g; vitamin B_{12}, 23 mg; biotin, 75 mg; folic acid, 0.9 g; niacin, 30 g; D-calcium pantothenate, 8 g.

[z] Provided per kg of diet: Fe, 40 g as ferrous sulfate; Cu, 8 g as copper sulfate; Mn, 90 g as manganese oxide; Zn, 80 g as zinc oxide; 1.2 g as potassium iodide; Se, 0.22 g as sodium selenite.

Sampling and measurements

The body weight of laying hens was weighed on days 1 and 28. Residual feed was recorded daily in each replicate cage. The number of dead layers was checked daily to measure the mortality. The number of eggs were recorded daily on a replicate basis to calculate the egg production ratio. Based on the recommendation of USDA Agricultural Marketing Service (2010), eggs with over 56.8 g were defined as large-egg and used to calculate the large-egg ratio in percentage. On 28th day, about 32 eggs (4 eggs per replicate) were randomly selected and weighed from each treatment for evaluating the egg quality parameters. After breaking the egg, a vernier caliper was used to calculate the albumen height. The haugh unit and yolk color were measured using an egg multi-tester (Touhoku Rhythm Co., Ltd., Tokyo, Japan). The eggshell without inner membrane was used to measure the eggshell thickness. A dial pipe gauge (Ozaki MFG. Co., Ltd., Tokyo, Japan) was used to measure the eggshell thickness at the rounded end, pointed end, and middle. The value of eggshell thickness was defined as the average. Eggshell force gauge type II (Robotmation Co., Ltd., Tokyo, Japan) was used to perform the evaluation of eggshell strength.

Statistical analyses

All of the data were analyzed statistically using a randomized block design and a one-way analysis of variance (ANOVA). Differences in mean values were tested using Tukey's procedures. Differences were considered significant at $p < 0.05$.

Results

Supplementation of 120 and 125 g of feed/day supplemented layers had the higher ($p < 0.05$) final body weight compared to the 105, 110, and 115 g of feed/day supplemented layers (Table 2). However, extra feed supply did not affect the residual feed and the mortality in layers throughout the experimental period. Layers receiving 115, 120, and 125 g of feed/day had the higher ($p < 0.05$) large-egg ratio compared to the 105 and 110 g of feed/day supplemented layers during days 1 - 7. In addition, 120, and 125 g of feed/day supplemented birds showed higher ($p < 0.05$) large-egg ratio compared to the 105, 110, and 115 g of feed/day supplemented group during days 15 - 28 ($p < 0.05$). However, higher ($p < 0.05$) large-egg ratio was found in 120 and 125 g of feed/day diet group in overall (day 1 - 28) feeding trial compared to the other group. In terms of egg production, significantly higher ($p < 0.05$) egg production was found in layers with 110 g of feed/day during the total experimental period. Supplementation of extra feed supply did not affect the egg quality parameters such as haugh unit, albumen height, eggshell strength, and eggshell thickness (Table 3). However, improved ($p < 0.05$) egg weight and yolk color were found through supplying extra feed in layers. Layers receiving 125 g of feed/day had the highest ($p < 0.05$) egg weight compared to other treatment groups. Moreover, 120 and 125 g of feed/day group of layers was found with higher ($p < 0.05$) yolk color.

Table 2. Effects of extra feed supply on body weight and productive performance in Hy-line brown laying hens.

Item	Feed supply (g·day^{-1}·bird^{-1})				
	105	110	115	120	125
Body weight (kg)					
Initial	1.99 ± 0.04	1.96 ± 0.04	1.96 ± 0.04	1.97 ± 0.06	2.00 ± 0.06
Final	1.77 ± 0.05c	1.80 ± 0.03c	1.96 ± 0.03b	2.05 ± 0.03a	2.03 ± 0.02a
Mortality (%)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Residual feed (g)					
Days 1 - 7	0.00 ± 0.00	0.03 ± 0.01	0.03 ± 0.02	0.04 ± 0.04	0.06 ± 0.02
Days 8 - 14	0.01 ± 0.02	0.03 ± 0.03	0.06 ± 0.04	0.07 ± 0.05	0.07 ± 0.04
Days 15 - 21	0.02 ± 0.02	0.03 ± 0.02	0.05 ± 0.03	0.08 ± 0.08	0.06 ± 0.04
Days 22 - 28	0.01 ± 0.01	0.02 ± 0.03	0.13 ± 0.18	0.08 ± 0.03	0.06 ± 0.03
Days 1 - 28	0.01 ± 0.01	0.02 ± 0.01	0.07 ± 0.05	0.07 ± 0.03	0.06 ± 0.01
Large-egg ratio (%)					
Days 1 - 7	27.13 ± 2.35b	27.17 ± 2.08b	34.13 ± 2.89a	36.72 ± 2.97a	33.98 ± 2.02a
Days 8 - 14	30.39 ± 2.05b	30.83 ± 3.46b	34.85 ± 2.40a	36.45 ± 3.34a	35.77 ± 2.33a
Days 15 - 21	29.47 ± 4.33c	31.47 ± 3.83c	45.88 ± 2.92b	53.46 ± 2.29a	51.21 ± 3.00a
Days 22 - 28	27.54 ± 2.10c	29.90 ± 2.15c	38.66 ± 1.43b	44.80 ± 2.15a	46.59 ± 2.68a
Days 1 - 28	28.63 ± 1.42c	29.84 ± 1.50c	38.38 ± 1.77b	42.86 ± 1.36a	41.89 ± 1.83a
Egg production ratio (%)					
Days 1 - 7	88.10 ± 3.18b	92.56 ± 2.68a	86.16 ± 3.71b	89.88 ± 3.18ab	88.54 ± 1.55ab
Days 8 - 14	88.99 ± 3.29b	93.60 ± 2.54a	85.12 ± 2.20bc	84.23 ± 4.01c	89.43 ± 2.88ab
Days 15 - 21	82.85 ± 2.94c	90.99 ± 2.70a	86.67 ± 2.69b	81.19 ± 1.82c	88.05 ± 2.81ab
Days 22 - 28	84.77 ± 2.22c	93.36 ± 2.94a	89.97 ± 2.94ab	85.68 ± 1.34c	89.45 ± 2.70b
Days 1 - 28	86.17 ± 1.21c	92.63 ± 1.77a	86.98 ± 1.10bc	85.24 ± 1.96c	88.87 ± 1.49b

a - c: Different superscripts within same row indicate a significant difference ($p < 0.05$).

Table 3. Effects of extra feed supply on egg quality parameters in Hy-line brown laying hens.

Item	Feed supply (g·day^{-1}·bird^{-1})				
	105	110	115	120	125
Haugh unit	89.20 ± 11.07	87.77 ± 7.74	88.57 ± 7.05	87.69 ± 7.54	87.68 ± 6.82
Egg weight (g)	59.57 ± 3.49b	59.23 ± 3.61b	59.46 ± 2.77b	60.91 ± 3.61ab	62.64 ± 4.22a
Yolk color	7.73 ± 0.58c	7.93 ± 0.58bc	8.13 ± 0.51ab	8.33 ± 0.48a	8.43 ± 0.57a
Albumen height (mm)	8.16 ± 2.25	7.92 ± 1.52	7.73 ± 1.53	7.88 ± 1.25	7.77 ± 1.31
Eggshell strength (kg·cm^{-2})	5.41 ± 1.43	5.05 ± 0.87	4.76 ± 0.93	4.98 ± 0.83	4.72 ± 1.15
Eggshell thickness (10^{-2} mm)	39.31 ± 1.79	38.91 ± 3.02	39.29 ± 1.52	39.22 ± 1.20	37.97 ± 2.12

a - c: Different superscripts within same row indicate a significant difference ($p < 0.05$).

Discussion

The body weight of the hen is highly significant for egg production, and it has a continuous impact on the efficiency of egg production throughout the production. Eggs produced by birds with lower overall body weights are also lower in weight (Connie et al., 1985). Higher body weight was found through the supplementation of surplus feed in laying hens in this study. In previous study, Onagbesan et al. (2006) reported that the increase of feed intake of layers led to higher body weight. Layers could get more nutrient ingredients through increasing feed intake, which was directly manifested in the increase of body weight. Generally, the increase of body weight of layers was beneficial for productive performance and egg quality

(Marono et al., 2017). However, obesity-induced body weight increase had negative effects on the performance of layers. Indeed, increasing feed supply will lead to obesity in layers (Richards et al., 2003). It has been reported that obesity-induced body weight increase in layers was related to the impairment of egg production ratio (Onagbesan et al., 2006). The ovaries of layers were particularly sensitive to over-feeding. Chen et al. (2006) mentioned that increasing feed supply of layers from 145 to 290 g per day led to obesity, ovarian abnormalities, apoptosis induced atresia occurred in the hierarchical follicles, and the decrease of fractional ovarian weight percentage, which directly manifested in the increase of body weight and the reduction of egg production ratio. In this particular investigation, giving layers 110 g of feed per day had no effect on their body weight but had a considerable impact on their egg production ratio. In previous study increase in egg production was found when higher feed intake as shown in laying hen, and this increased feed intake resulting in a greater supply of nutrients available for egg production (Pérez-Bonilla et al., 2012). However, a decrease in egg production ratio was observed when the daily feed allowance for laying hens was either increased or decreased from 110 g of feed per day. In comparison with 110 g of feed/day, providing 115, 120, and 125 g of feed per day was excessive for layers and may lead to obesity, which was manifested in the increase of body weight and the decline of egg production ratio. Previous studies explained that the fall in egg production may be due the obesity in layer (Onagbesan et al., 2006). In brief, in terms of egg production, providing 110 g of feed daily could maximize the egg production ratio in layers.

Due to the consumers preference for large-egg, in some way it is beneficial to improve the commercial value of eggs to improve the large-egg ratio in poultry production through certain strategies (USDA Agricultural Marketing Service, 2010). The size of the egg may be the third most significant element in determining the amount of profit that can be made from a layer, behind the number of eggs deposited and the viability of the eggs. The only method to improve egg size in laying chickens, other than via genetics, is through proper feeding. In the present study, the extra feed supply strategy was beneficial to improve the large-egg ratio. In addition, we found that the weight of eggs used to measure egg quality was positively affected by the extra feed supply. This indicates the improvement of egg weight through supplying 120 - 125 g of feed/day in laying hen. According to Wu et al. (2005), an increased dietary energy intake causes laying hens to produce eggs with a heavier weight. Jiang et al. (2013) noted that the increase of feed intake will lead to excessive energy intake of layers, which will increase the available energy for egg production and lead to the production of large egg. Overall, the extra feed supply strategy was beneficial to the improvement of the large-egg ratio, which was helpful to increase the commercial value of eggs. Increasing feed supply did not adversely affect the egg quality of layers. However, the yolk color was improved through the extra feed supplementation. Egg yolk is an important parameter for consumer preference. The age of the hens, as well as their genetic makeup, and nutrition had a major impact on the color of the egg yolk (Kim et al., 2019; Kraus and Zita, 2019). Most importantly the pigment of egg yolk depends on the carotenoid contents in the feed (Grashorn, 2016). By supplying the carotenoid rich feed to laying hen, the yolk color can be improved through an increase in carotenoid deposition in the yolk. Additionally, it has been reported that increasing fat intake could enhance the deposition of carotenoids in the yolk (Chung et al., 2004). Sustained egg production was an energy intensive process (Richards et al., 2003), extra feed supply will increase the lipid supply to support the demand for egg yolk formation. In addition, the additional feed intake also led to an additional carotenoid intake. Therefore, increasing feed supply could improve the yolk color, thus improving the acceptance of consumers and benefiting the commercial value of eggs (Grashorn, 2016).

Conclusion

According to the findings of this research, the production performance and egg quality of Hy-line layers increased when the feed supply was administered in accordance with the recommendations made by the breeding company. In particular, giving layers 110 g of feed/day was suitable for increasing the egg production ratio. While feeding layers 125 g per day may be an effective way to boost their large-egg ratio, egg weight, and yolk color, it likely also caused them to gain weight and slow down on the egg production ratio. But because the health of the laying hen is so important to their productive performance, we considered that 110 g was the appropriate amount of feed.

Conflict of Interests

No potential conflict of interest relevant to this article was reported.

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Authors Information

Md Mortuza Hossain, https://orcid.org/0000-0002-6732-286X
Jae Hong Park, https://orcid.org/0000-0002-2025-0141
In Ho Kim, https://orcid.org/0000-0001-6652-2504

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