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# Effects of Different Dietary Crude Protein Levels on Production Performance, Reproductive Performance, and Egg Quality of S3 Line Broiler Breeder Chickens (Postprint)

**Authors:** Wang Qianbao, Li Shoufeng, Zhao Zhenhua, Huang Huayun, Li Chunmiao, Xue Longgang

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## Abstract

This experiment investigated the effects of different dietary crude protein levels on production performance, reproductive performance, and egg quality in broiler breeders through feed restriction. A total of 240 S3 line broiler breeder hens at 25 weeks of age with consistent body weight and laying rate were randomly divided into 4 groups with 6 replicates per group and 10 hens per replicate. The control group was fed a corn-soybean meal basal diet with 16.64% crude protein, while the experimental groups were fed test diets with crude protein levels of 17.64%, 15.64%, and 14.64%, respectively. The experimental period lasted for 40 weeks. The results showed that: 1) Compared with the control group, the laying rate, average egg weight, and daily egg mass of the 17.64%, 15.64%, and 14.64% crude protein groups were significantly reduced throughout the entire laying period ($P<0.05$); the mortality and culling rate of the 15.64% and 14.64% crude protein groups was significantly decreased ($P<0.05$), while feed intake was significantly increased ($P<0.05$). 2) Compared with the control group, the fertilization rate of the 15.64% and 14.64% crude protein groups was significantly increased by 9.7% and 7.9% ($P<0.05$), embryonic mortality rate was significantly decreased by 26.1% and 24.3% ($P<0.05$), and hatchability was significantly increased by 15.8% and 20.6% ($P<0.05$) during the early laying period. 3) Throughout the entire laying period, shell strength of the 15.64% and 14.64% crude protein groups was significantly higher than that of the control group and the 17.64% crude protein group ($P<0.05$), while yolk weight of the 17.64%, 15.64%, and 14.64% crude protein groups was significantly lower than that of the control group ($P<0.05$). These results indicate that feed restriction with 15.64% and 14.64% crude protein diets can significantly affect production performance, reproductive performance, and egg quality in broiler breeders, with

the 15.64% crude protein group showing the best overall effect.

## Full Text

# Effects of Dietary Crude Protein Levels on Performance, Reproductive Performance, and Egg Quality of S3 Broiler Breeders

**WANG Qianbao[1], LI Shoufeng[2]*, ZHAO Zhenhua[2], HUANG Huayun[2], LI Chunmiao[2], XUE Longgang[2]**

[1]Poultry Institute, Chinese Academy of Agricultural Sciences, Yangzhou 225003, China
[2]Poultry Institute, Chinese Academy of Agricultural Sciences, Yangzhou 225003, China

**Abstract:** This experiment investigated the effects of dietary crude protein levels on performance, reproductive performance, and egg quality of broiler breeders using qualitative feed restriction. Two hundred and forty 25-week-old S3 broiler breeder hens with consistent body weight and laying rate were randomly allocated into four groups, each consisting of six replicates with ten hens per replicate. The control group received a corn-soybean meal basal diet containing 16.64% crude protein, while the experimental groups were fed diets with crude protein levels of 17.64%, 15.64%, and 14.64%, respectively. The trial lasted for 40 weeks.

The results showed: (1) Throughout the entire laying period, the 17.64%, 15.64%, and 14.64% crude protein groups exhibited significantly lower laying rate, average egg weight, and daily egg mass compared to the control group ($P<0.05$). The 15.64% and 14.64% crude protein groups demonstrated significantly reduced mortality and culling rates ($P<0.05$) but significantly increased feed intake ($P<0.05$). (2) During the early laying period, the 15.64% and 14.64% crude protein groups achieved significantly higher fertilization rates (9.7% and 7.9% increase, respectively; $P<0.05$), significantly lower embryonic mortality (26.1% and 24.3% reduction, respectively; $P<0.05$), and significantly improved hatchability (15.8% and 20.6% increase, respectively; $P<0.05$) compared to the control group. (3) Across the entire laying period, the 15.64% and 14.64% crude protein groups showed significantly greater eggshell strength than both the control and 17.64% crude protein groups ($P<0.05$), while yolk weight in all experimental groups (17.64%, 15.64%, and 14.64%) was significantly lower than in the control group ($P<0.05$). These findings indicate that qualitative feed restriction using 15.64% and 14.64% crude protein diets can significantly influence the performance, reproductive performance, and egg quality of broiler breeders, with the 15.64% crude protein level demonstrating the most favorable overall effects.

**Keywords:** feed restriction; broiler breeders; performance; reproductive performance; egg quality

## Introduction

Modern broiler breeding programs have prioritized rapid growth and high feed conversion efficiency to meet market demands, inadvertently eliminating the birds' innate ability to self-regulate feed intake according to their nutritional requirements. In broiler breeders, excessive feed consumption and accelerated growth not only impair production and reproductive performance but also contribute to severe feed resource waste, representing a critical challenge in commercial operations. To maximize the genetic potential for production and reproduction, implementing strict feed restriction protocols for broiler breeders with high feed intake and growth capacity has become a focal research area.

Feed restriction strategies encompass quantitative and qualitative approaches. Enting et al. [**?**] and Tolkamp et al. [**?**] demonstrated that quantitative restriction can improve reproductive health in broiler breeders but may induce welfare concerns such as hunger and frustration. Qualitative restriction, conversely, allows ad libitum access to low-nutrient-density diets, increasing feeding time and gastrointestinal satiety while reducing abnormal behaviors. Although numerous studies have investigated low-crude-protein dietary restriction in broiler breeders, findings remain inconsistent, likely because varying restriction methods and intensities differentially affect the expression of laying, reproductive, and egg quality potentials. Furthermore, genetic strain differences and individual variation in feeding capacity influence performance outcomes. Therefore, this study utilized the S3 broiler breeder line to examine how varying dietary crude protein levels under qualitative restriction affect performance, reproductive performance, and egg quality, thereby providing theoretical guidance for commercial broiler breeder production.

### 1.1 Experimental Animals

The S3 broiler breeder line, developed by the Poultry Institute of Jiangsu Province, was employed in this study. This strain was established through over two decades of selection utilizing the dwarf (dw) gene and is characterized by yellow feathers, blue shanks, compact body conformation, high egg production with an extended peak period, and efficient feed and space utilization.

### 1.2 Experimental Design

At 25 weeks of age, 240 S3 broiler breeder hens with uniform body weight and laying rate were selected and randomly assigned to four dietary treatment groups, each comprising six replicates of ten hens. The control group received a corn-soybean meal basal diet formulated to contain 16.64% crude protein, with dietary composition and nutrient levels based on the "Shaobo Chicken

(Commercial Strain)" standard (GB/T 24707-2009). The experimental groups were fed isocaloric diets with crude protein levels of 17.64%, 15.64%, and 14.64%, respectively. The 40-week experimental period was divided into an early laying phase (25-45 weeks) and a late laying phase (46-65 weeks). Dietary compositions and nutrient levels are presented in Table 1 .

### 1.3 Feeding Management and Parameter Measurements

The trial was conducted at the Shaobo Experimental Station of the Poultry Institute under standardized cage-rearing conditions with ad libitum access to feed and water. Lighting and vaccination programs followed conventional broiler breeder management practices. Eggs were collected daily, with replicate records maintained for egg number, egg weight, and defective eggs (sand-shell, soft-shell, double-yolk, misshapen, or cracked eggs). Weekly feed consumption and mortality were recorded by replicate. Body weight was measured at 25, 45, and 65 weeks of age. At 45 and 65 weeks, 2,500 settable eggs per group were incubated to determine fertilization rate through candling, and subsequent hatchability and healthy chick rates were calculated. Additionally, 300 eggs per group were sampled at 45 and 65 weeks for measurement of eggshell strength, shell thickness, albumen weight, yolk weight, shell weight, albumen height, and Haugh units.

### 1.4 Data Processing and Statistical Analysis

Data were analyzed using one-way ANOVA in SPSS 16.0 software. Results are expressed as mean ± standard deviation (mean±SD), and multiple comparisons were performed using the LSD method.

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## Results

### 2.1 Effects of Dietary Crude Protein Levels on Broiler Breeder Performance

As shown in Table 2 , throughout the entire laying period, the control group exhibited significantly higher laying rate, average egg weight, and daily egg mass compared to all experimental groups (17.64%, 15.64%, and 14.64% crude protein; $P<0.05$). During the early laying period, no significant differences were observed between the 17.64% and 15.64% crude protein groups for these parameters ($P>0.05$), though both were significantly superior to the 14.64% group ($P<0.05$). In the late laying period, the 17.64% crude protein group showed significantly lower performance than the 15.64% and 14.64% groups ($P<0.05$), while the 15.64% group maintained significantly higher laying rate and egg weight than the 14.64% group ($P<0.05$). Feed intake and feed-to-egg ratio were significantly lower in the control group compared to the 15.64% and 14.64% groups throughout the experiment ($P<0.05$). Mortality and culling

rates were significantly higher in the control group than in the 15.64% and 14.64% groups (P<0.05), but did not differ significantly from the 17.64% group (P>0.05).

### 2.2 Effects of Dietary Crude Protein Levels on Reproductive Performance

Table 3 reveals that the 17.64% crude protein group showed no significant differences in any reproductive parameters compared to the control group (P>0.05). However, during the early laying period, the 15.64% and 14.64% crude protein groups achieved significantly higher fertilization rates (9.7% and 7.9% increase, respectively; P<0.05), significantly reduced embryonic mortality (26.1% and 24.3% decrease, respectively; P<0.05), and significantly improved hatchability (15.8% and 20.6% increase, respectively; P<0.05) relative to the control group. In the late laying period, the 15.64% and 14.64% groups also maintained significantly different fertilization rates, embryonic mortality, and hatchability compared to the control group (P<0.05).

### 2.3 Effects of Dietary Crude Protein Levels on Egg Quality

As presented in Table 4 , dietary crude protein level primarily influenced egg weight, eggshell strength, albumen weight, and yolk weight. Throughout the laying period, egg weight was significantly lower in the 15.64% and 14.64% groups compared to the control group (P<0.05), with significant differences also observed between these groups and the 17.64% group during the late phase (P<0.05). Eggshell strength was significantly greater in the 15.64% and 14.64% groups than in both the control and 17.64% groups (P<0.05). Yolk weight was significantly reduced in all experimental groups (17.64%, 15.64%, and 14.64%) relative to the control group (P<0.05), while albumen weight was significantly lower only during the late laying period in the experimental groups (P<0.05).

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## Discussion

### 3.1 Effects on Performance

Previous research by Geng et al. [**?**] demonstrated that increasing dietary crude protein levels elevated laying rate during the early production phase, but over time, 16% crude protein diets reduced laying rate in the late phase compared to 15% protein diets, with opposite trends observed for feed-to-egg ratio. Rizzo et al. [**?**] investigated egg quality changes in 48-week-old Hisex White layers fed diets containing 12%, 14%, 16%, and 18% crude protein, finding that egg weight and daily egg mass varied significantly with protein level, increasing linearly up to 16% but decreasing thereafter. These results suggest that within acceptable ranges, increasing crude protein can effectively improve laying performance. Enting et al. [**?**] reported that low-density diets significantly affected feed intake,

reduced body weight and feed conversion ratio, and increased egg weight and yolk weight in broiler breeders, presumably by improving digestible nutrient utilization. Zhu [?] found that optimal crude protein levels differed by production phase for Huainan partridge chickens (16% early, 12.9% late). In the current study, the control group (16.64% crude protein) exhibited superior overall laying performance compared to all experimental groups, indicating this level is optimal for S3 breeders. The reduced performance in the 15.64% and 14.64% groups may be attributed to excessive energy intake from increased consumption, while the 17.64% group likely suffered from excessive protein levels leading to fat deposition and reduced egg production. However, the significantly lower mortality in the 15.64% and 14.64% groups demonstrates that low-protein qualitative restriction can effectively reduce culling rates while maintaining acceptable levels of daily egg mass and feed efficiency. Considering both performance and feed costs, the 15.64% and 14.64% crude protein groups offered overall advantages.

### 3.2 Effects on Reproductive Performance

The primary objective of broiler breeder production is efficient propagation of superior commercial offspring, making reproductive performance a critical consideration. Taherkhani et al. [?] observed that feed restriction in Cobb 500 breeders significantly reduced plasma glucose, triglycerides, cholesterol, and leptin-like substances while increasing estradiol, glucagon, and thyroid hormone levels, substantially improving reproductive performance. Conversely, De Jong et al. [?] noted that low-protein diets only reduced hunger and frustration during early lay without improving late-phase reproductive performance and potentially exerting adverse effects on progeny. Spratt and Leeson [?] reported decreased fertilization and hatchability in breeders fed low-protein diets. Zhu et al. [?] found no significant effects of dietary protein levels (15.5%, 16.5%, 17.5%) on fertilization or healthy chick rates in Lingnan yellow-feathered breeders during peak production (30-39 weeks), though hatchability declined markedly at 17.5% protein. The current results, showing significantly improved fertilization and hatchability with reduced embryonic mortality in the 15.64% and 14.64% groups, align with Spratt and Leeson [?]. This may be attributed to low-protein diets reducing estrogen levels in S3 breeders, thereby acting as estrogen agonists to positively modulate the hypothalamic-pituitary-gonadal axis and enhance reproductive function.

### 3.3 Effects on Egg Quality

Guo [?] evaluated six diets with varying crude protein levels in Huafeng chickens and observed no significant changes in eggshell color, strength, or thickness, attributing this to compensatory increased feed intake meeting nutrient requirements. Bi [?] suggested that egg quality depends on dietary nutrient composition, utilization efficiency, and supplementation timing. Yin [?] reported that eggshell strength increased with crude protein levels (13-17%) in Jining Bairi chickens, while other quality parameters remained unaffected. In contrast, the

current study found significantly greater eggshell strength in the 15.64% and 14.64% groups compared to the control and 17.64% groups, with no other quality differences relative to the control. This discrepancy may reflect that the 15.64% and 14.64% diets adequately met calcium and other nutrient requirements specific to the S3 strain during the laying period.

## Conclusions

The findings indicate that a 17.64% crude protein diet is detrimental to broiler breeder performance, reproductive performance, and egg quality. While a 15.64% crude protein diet reduces laying rate by 4.7%, it significantly decreases mortality and culling rates while improving reproductive performance and egg quality. Therefore, the 15.64% crude protein level represents the most balanced approach for S3 broiler breeder production under qualitative feed restriction.

## References

[1] ENTING H, VELDMAN A, VERSTEGEN M W A, et al. The effect of low-density diets on broiler breeder development and nutrient digestibility during the rearing period[J]. Poultry Science, 2007, 86(4): 720–726.

[2] TOLKAMP B J, SANDILANDS V, KYRIAZAKIS I. Effects of qualitative feed restriction during rearing on the performance of broiler breeders during rearing and lay[J]. Poultry Science, 2005, 84(8): 1286–1293.

[3] General Administration of Quality Supervision, Inspection and Quarantine of the People' s Republic of China, Standardization Administration of China. GB/T 24707-2009 Shaobo Chicken (Commercial Strain)[S]. Beijing: Standards Press of China, 2010.

[4] GENG Ailian, SHI Xiaolin, WANG Haihong, et al. Effects of dietary crude protein level on laying performance and egg quality of free-range Beijing You chickens[J]. Chinese Journal of Animal Nutrition, 2011, 23(2): 307–315.

[5] RIZZO SILVA M F, EMYGDIO DE FARIA D, WICK RIZZOLI P, et al. Desempenho, qualidade dos ovos e balanço de nitrogênio de poedeiras comerciais alimentadas com rações contendo diferentes níveis de proteína bruta e lisina[J]. Revista Brasileira de Zootecnia, 2010, 39(6): 1.

[6] ENTING H, KRUIP T A M, VERSTEGEN M W A, et al. The effect of low-density diets on broiler breeder performance during the laying period and on embryonic development of their offspring[J]. Poultry Science, 2007, 86(5): 850–856.

[7] ZHU Youcai. Study on dietary protein level for Huainan partridge chickens[D]. Master' s thesis. Hefei: Anhui Agricultural University, 2013.

[8] TAHERKHANI R, ZAGHARI M, SHIVAZAD M, et al. A twice-a-day feeding regimen optimizes performance in broiler breeder hens[J]. Poultry Science, 2010, 89(8): 1692–1702.

[9] ZHU Cui, JIANG Zongyong, JIANG Shouqun, et al. Effects of dietary metabolizable energy and protein levels on reproductive performance of Lingnan yellow-feathered broiler breeders aged 30-39 weeks[J]. Scientia Agricultura Sinica, 2014, 45(1): 159–169.

[10] DE JONG I C, ENTING H, VAN VOORST A, et al. Do low-density diets improve broiler breeder welfare during rearing and laying?[J]. Poultry Science, 2005, 84(2): 194–203.

[11] SPRATT R S, LEESON S. Effect of protein and energy intake of broiler breeder hens on performance of broiler chicken offspring[J]. Poultry Science, 1987, 66(9): 1489–1494.

[12] YIN Ruoxin. Effects of dietary crude protein levels on performance and reproductive performance of Jining Bairi chickens[D]. Master' s thesis. Tai' an: Shandong Agricultural University, 2015.

[13] BI Yingzuo. Factors affecting eggshell quality and improvement measures[J]. China Poultry, 2007, 29(4): 28–29.

[14] GUO Peng. Effects of dietary crude protein level on laying performance and egg quality of Huafeng chickens[D]. Master' s thesis. Yangzhou: Yangzhou University, 2012.

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