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Effect of Black Cumin (*Nigella sativa*) supplementation in laying hen diets on the achievement of 5% hen day average (HDA) production age

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Abstract

This study aimed to determine the effect of black cumin (*Nigella sativa*) supplementation in the diet on the age at 5% Hen-Day Average (HDA) production and early production performance of Lohmann Brown laying hens. The experiment was designed using a completely randomized design with 200 Lohmann Brown laying hens aged 90 days. The birds were divided into 4 treatment groups of black cumin supplementation at 0 (control), 600, 1200, and 1800 mg/kg of feed. Parameters observed included the age at 5% production, body weight at 5% production, egg weight at 5% HDA, total feed intake, and feed conversion ratio. The results showed that black cumin supplementation had a highly significant effect ($P < 0.01$) on all performance parameters. Supplementation of black cumin at 1200 mg/kg of feed resulted in the fastest age at sexual maturity (127 days), the highest body weight (1677.00 g), as well as the lowest feed intake (2848.63 g) and feed conversion ratio (1.70). It is recommended to apply black cumin powder at a dose of 1200 mg/kg of feed during the pre-lay phase to improve the feed conversion ratio and accelerate the onset of sexual maturity.

Keywords: Laying Hens; Black Cumin; Sexual Maturity; Production Performance.

1. Introduction

The commercial chicken egg commodity plays a strategic role in the livestock sector as a primary, affordable source of animal protein for community nutrition and the culinary industry [1, 2, 18]. One of the dominant superior commercial strains cultivated in Indonesia is the Lohmann Brown, known for its high egg production and feed efficiency [3, 12]. Despite its great potential, the operational aspect of this agribusiness is highly vulnerable to climate fluctuations and ration quality, which can hinder the livestock's metabolism [4]. The most vulnerable maintenance phase to these stresses is the pre-lay period, particularly when pullets reach 90 days of age [5, 6]. At this age, chickens experience a massive surge in growth and biochemical changes to allocate nutrient intake for the development of functional reproductive organs, such as the ovary and oviduct [5, 6]. Failure in nutritional management during this critical phase risks delaying sexual maturity, which leads to a delay in achieving initial egg production (5% Hen-Day Average/HDA) and triggers economic losses due to swelling operational feed costs without any income [1].

Supplementation with natural feed additives such as black cumin (*Nigella sativa*) offers a highly promising solution to minimize the risk of production failure during this transition period [7]. Black cumin is rich in the bioactive compound thymoquinone, which has a dual function as an antimicrobial, antioxidant, and immunomodulatory agent [8, 20]. As a strong antioxidant, thymoquinone plays a crucial role in protecting ovarian tissues from cellular damage caused by oxidative stress that typically increases during puberty, ensuring a smooth distribution of nutrients for follicular maturation. In addition, black cumin has proven effective in maintaining metabolic balance in the face of environmental stress and increasing antibody titers [9, 10, 11]. With a robust immune defense system, metabolizable energy that is usually depleted to fight diseases can be fully partitioned (diverted) to support somatic growth and the accelerated maturation of reproductive organs [7].

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Despite its enormous potential, studies on the utilization of black cumin have so far been dominated by evaluations on broilers [15] or improvements in the egg quality of older hens [13, 14, 16, 17, 19], while scientific information regarding its interaction with the hormonal mechanisms of hens approaching their first laying period remains very limited [7]. This study was conducted to comprehensively evaluate the effectiveness of adding black cumin (*Nigella sativa*) to the diet in an effort to fill this gap in the literature. The main objective of this study was to evaluate and determine the most optimal dosage level in accelerating the age of achieving 5% HDA production, as well as to analyze its impact on the early production performance parameters of laying hens.

2. Materials and methods

2.1. Study Site

The entire series of livestock rearing activities, application of treatments, and primary data collection were carried out at the Majeti Hamlet Livestock Group Farm, Krama Jaya Village, Narmada District. West Lombok, Indonesia.

2.2. Experimental Material and Design

This study used 200 Lohmann Brown laying hens (*Gallus gallus domesticus*) aged 90 days. The equipment used included battery cages, feed and water troughs, and high-precision digital scales (accuracy of 0.01 g and 1 g) to ensure the accuracy of the black cumin dosage, chicken body weight, and egg weight. The experimental design applied was a one-way Completely Randomized Design (CRD). A total of 200 birds was divided into 4 treatment groups of black cumin powder supplementation. Each treatment was replicated 5 times, with each replication unit consisting of 10 chickens. All experimental units were managed under uniform environmental conditions to minimize design bias and ensure that the responses generated were purely due to the treatments.

2.3. Hen Rearing Management

Rearing was carried out intensively from the time the chickens were 90 days old until they entered sexual maturity and early production. All experimental chickens were randomly placed into 100 units of group battery cages, where each cage unit was filled with 2 chickens. During the rearing period, feed was provided twice a day, in the morning at 07:00 and in the afternoon at 15:30; the amount of feed provided was based on standards issued by the breeder. Meanwhile, drinking water was provided ad libitum.

2.4. Experimental Diet Preparation

The basal diet used was composed of a mixture of local feed ingredients. The diet formulation consisted of 50% yellow corn, 35% laying hen concentrate, and 15% fine rice bran. The composition and calculated nutritional values of the basal diet mixture are presented in detail in Table 1; black cumin (*Nigella sativa*) supplementation was applied in powder form and weighed using a high-precision digital scale. The black cumin powder was then homogeneously mixed into the basal diet. The treatment levels for the black cumin powder dosage applied to each kilogram of feed were as follows:

Control: Basal diet without black cumin powder addition.

- 600 mg/kg: Basal diet + 600 mg black cumin powder per kg diet.
- 1200 mg/kg: Basal diet + 1200 mg black cumin powder per kg diet.
- 1800 mg/kg: Basal diet + 1800 mg black cumin powder per kg diet.

Table 1 Composition and Nutritional Content of the Basal Diet

Nutritional Content[1]	**Corn (50%)**	**Concentrate (35%)**	**Rice Bran (15%)**	**Total (100%)**
Metabolizable Energy (kcal/kg)	1685	875	420	2980
Crude Protein (%)	4,3	12,6	1,8	18,7
Crude Fat (%)	1,95	1,05	1,05	4,05
Crude Fiber (%)	1,1	2,45	1,8	5,35
Calcium (%)	0,01	4,2	0,015	4,225
Phosphorus (%)	0,15	0,35	0,15	0,65

Note: [1] Based on the calculation of feed ingredient nutritional content according to [21, 22, 23].

2.5. Observed Variables and Data Analysis

The measurement of hen performance focused on several variables serving as indicators of success during the transition to the laying phase, including:

Initial Body Weight: Obtained by weighing each individual chicken at the beginning of the rearing period (90 days of age) before the feed treatments were given to ensure sample uniformity.

Feed Intake (g/bird/day): Obtained by summing all the feed provided minus the residual feed (consumed feed) during the study period. The calculation started from the beginning of the rearing period (90 days of age) until the group of chickens in each treatment reached 5% Hen-Day Average (HDA) egg production.

Feed Conversion Ratio (FCR): Obtained by comparing the amount of feed intake consumed with the body weight gain produced over the same time period.

Age at 5% Production (days): Obtained by recording and calculating the number of days counted from the time the chicks hatched (DOC) until they reached 5% Hen-Day Average (HDA) egg production.

Body Weight at Sexual Maturity (g): Obtained by weighing the body weight of individual chickens in the treatment group on the day they reached 5% HDA production.

Egg weight at 5% HDA production (g): Obtained by directly weighing the eggs produced when reaching 5% HDA production from each treatment. Egg weight at 5% HDA production (g): Obtained by directly weighing the eggs produced when reaching 5% HDA production from each treatment.

All collected quantitative data were tabulated and statistically analyzed using Analysis of Variance (ANOVA). If the analysis of variance results indicated a significant ($P < 0.05$) or highly significant ($P < 0.01$) effect of the treatment, testing was continued using Duncan's Multiple Range Test

3. Result and discussion

Data on the effect of black cumin supplementation on all observed variables showed a highly significant effect ($P < 0.01$), as presented in Table 2.

Data in Table 2 shows that black cumin supplementation affected the age at 5% production ($P < 0.01$). The fastest achievement occurred in the chicken group with a black cumin dose of 1200 mg/kg of feed, which was at 127 days of age, while the slowest achievement was recorded in the control group, at 148 days of age. This acceleration of sexual maturity is caused by the optimal growth rate and efficiency of nutrient absorption due to the action of the bioactive compounds in black cumin. The explanation by Salam et al. [24] asserts that the active substance thymoquinone in black cumin powder stimulates the secretion of digestive enzymes, thereby maximizing the digestibility of the ration. Reaching this physiological body weight threshold faster activates the Hypothalamus-Pituitary-Ovary (HPO) axis to immediately secrete reproductive hormones. Increasing the dose to 1800 mg/kg of feed actually had a negative effect in the form of delaying the time of oviposition by 3 days. This delay is closely related to the high accumulation of saponin compounds from the concentrated black cumin; Melia et al. [26] reported that saponins in normal doses act as immunostimulants, but in excessive doses, their function changes to immunosuppressants which can depress the physiological performance of livestock, thus inhibiting the maturation rate of reproductive organs compared to the 1200 mg/kg dose.

Cumin supplementation in the feed also affected body weight upon reaching 5% HDA egg production ($P< 0.01$). The highest achievement was found in the treatment group with a black cumin dose of 1200 mg/kg of feed, which was 1677.00 g/bird, inversely proportional to the body weight of the control group which produced the lowest weight, namely 1563.60 g/bird. This highly significant increase in body weight is a direct effect of the smooth circulation of oxygen and nutrients in the blood of livestock consuming black cumin. Essential minerals such as iron (Fe) and zinc (Zn) in black cumin interact directly to trigger the process of erythropoiesis (red blood cell formation) in the bone marrow. Findings from Melia et al. [26] prove that black cumin supplementation is effectively able to increase hemoglobin levels and hematocrit values in chicken blood. This prime physiological condition of the blood leads to an optimal flow of nutrients to all body tissues to precisely maximize somatic growth (meat and bones) before the laying phase begins.

Table 2 Effect of black cumin supplementation on the early production performance of laying hens from 90 days of age to the achievement of 5% HDA

Performance	**Black Cumin Level in Diet (mg/kg)**				**P-value**
	Control	600	1200	1800	
Age at 5% Production (Days)	148	135	127	130	
Body Weight at Sexual Maturity (g)	1563,60±17,18[a]	1665,40±33,33[b]	1677,00±28,95[b]	1660,75±42,15[b]	0,000
5% HDA Egg Weight (g)	36,88±1,06[a]	38,57±1,07[a]	41,13±1,70[b]	42,15±1,72[b]	0,000
Feed Intake (g/bird)	4459,04±00,00[d]	3459,60±0,00[c]	2848,63±00,00[a]	3081,60±0,00[b]	0,000
Feed Conversion Ratio (FCR) (g/g)	2,85±0,03[d]	2,08±0,04[c]	1,7±0,03[a]	1,86±0,05[b]	0,000

Note: The age of 5% production was determined by calculating the number of days from hatch (DOC) until the hens in each treatment group cumulatively produced daily eggs reaching 5% of the total population in that unit (Hen-Day Average).

The average egg weight upon reaching 5% HDA production indicates that the black cumin supplementation treatment had a highly significant effect (P< 0.01), with the highest results obtained in the groups receiving 1800 and 1200 mg/kg of black cumin supplementation, reaching 42.15 g and 41.13 g, respectively. This is inversely proportional to the egg weight produced by the control group (without black cumin supplementation) which only reached 36.88 g. The dose level of 1200 mg/kg of feed is fundamentally the best and most efficient treatment, considering that this level is able to produce a highly competitive egg weight that does not differ greatly from the achievement of the maximum dose of 1800 mg/kg. The superior achievement of egg weight at both doses is due to the activity of bioactive compounds in black cumin. The thymoquinone content as a strong antioxidant agent plays a crucial role in protecting the liver from oxidative stress that typically increases approaching the puberty phase of chickens. This maximally protected liver function ensures the smooth synthesis of vitellogenin (the main precursor protein of egg yolk) and the lipogenesis process. The synthesized essential nutrients are then massively transferred through the blood plasma into the developing oocytes. The concentration of active compounds at a dose of 1800 mg/kg is able to provide a more abundant supply of antioxidants so that liver organ performance becomes slightly more maximized, but the difference in the resulting increase in egg weight is not drastic enough to ignore the high level of efficiency at the 1200 mg/kg dose. Salam et al. [24] validated this protection mechanism by stating that black cumin supplementation is proven to be safe and maintains liver function, characterized by the stability of the enzymes Aspartate Aminotransferase (AST) and Alanine Aminotransferase (ALT).

The total feed intake level during the rearing period showed that the provision of black cumin had a highly significant effect (P < 0.01), where the treatment group with a dose of 1200 mg/kg resulted in the lowest intake level (2848.63 g/bird), while the highest feed intake was found in the control group which consumed up to 4459.04 g/bird of feed. This drastic decrease in total feed consumption is directly correlated with the accelerated age at 5% HDA production. The chicken group at the 1200 mg/kg dose successfully reached sexual maturity 21 days earlier than the control group, so the rearing duration in the pre-lay phase became much shorter and automatically reduced the total accumulation of feed consumed. This accelerated sexual maturity originates from the high efficiency of nutrient absorption due to the action of black cumin phytobiotics. Alwi and Harifuddin [25] stated that bioactive compounds in herbal plants play an active role in repairing intestinal villi and the digestive tract ecosystem of poultry. A very healthy digestive organ condition allows all macronutrients from the basal diet to be perfectly absorbed to meet physiological body thresholds. This efficient nutrient absorption accelerates the maturation of reproductive organs while providing a physiological signal of satiety, so that livestock feed intake can be drastically suppressed while egg production can start earlier.

The feed conversion ratio showed that the black cumin dose level had a highly significant effect (P < 0.01), with the most efficient value produced in the treatment group with 1200 mg/kg of black cumin supplementation, which was 1.70. Next, the control group produced the highest feed conversion ratio, which was 2.85. This improvement in feed conversion ratio is a mathematical and physiological accumulation of the low level of total feed intake coinciding with the successful achievement of the highest body weight at the 1200 mg/kg dose (1677.00 g/bird). Sanjaya [27] asserts that the quality and balance of nutrients in feed strongly determine the level of performance and efficiency of feed conversion in chickens; the presence of phytobiotics from black cumin at a dose of 1200 mg/kg acts as a catalyst that perfects the quality of the basal diet by modifying the metabolic rate. Every gram of feed consumed by the livestock is successfully converted maximally into body tissue without many nutrients being wasted, thus optimizing the preparation period of the chicken towards the laying phase with a very economical feed ratio.

4. Conclusion

Supplementation of black cumin (*Nigella sativa*) in the diet can accelerate sexual maturity, increase body weight at sexual maturity and egg weight, and reduce feed intake and feed conversion ratio ($P < 0.01$). Supplementation of 1200 mg/kg of black cumin in the feed yields the fastest age at sexual maturity, as well as the lowest feed intake and feed conversion ratio. Thus, in the practical cultivation of laying hens, it is recommended to apply a black cumin supplementation of 1200 mg/kg of feed during the pullet phase.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript .

Statement of ethical approval

All rearing procedures and treatments of experimental animals in this study have complied with animal welfare guidelines and have been approved by the relevant institutional animal ethics committee.

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