Effects of Dietary Iodine Supplementation Levels on Growth Performance, Slaughter Performance, Nutrient Utilization Efficiency, and Nitrogen Metabolism in Wulong Geese (Postprint)

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Abstract

This experiment was conducted to investigate the effects of dietary iodine supplementation levels on growth performance, slaughter performance, nutrient utilization, and nitrogen metabolism in Wulong geese, and to determine the appropriate iodine supplementation level in Wulong goose diets. A total of 360 healthy 4-week-old Wulong geese were selected and randomly allocated into 6 groups with 6 replicates per group and 10 geese per replicate. Group I served as the control group and was fed a basal diet without iodine supplementation; the experimental groups (Groups II-VI) were fed experimental diets supplemented with 0.15, 0.30, 0.60, 1.20, and 2.40 mg/kg iodine in the basal diet, respectively. The experimental period lasted for 12 weeks. The results showed that the average daily gain of Group III was significantly or extremely significantly higher than that of Groups I, II, V, and VI ($P<0.05$ or $P<0.01$), the average daily feed intake of Group III was significantly higher than that of Groups I, II, IV, and VI ($P<0.05$), and the feed-to-gain ratio of Group III was significantly or extremely significantly lower than that of Groups I, II, and V ($P<0.05$ or $P<0.01$). 2) The dressing percentage, semi-eviscerated yield, and eviscerated yield of Group III were all extremely significantly higher than those of experimental Group I ($P<0.01$), the breast muscle percentage of Group III was significantly higher than those of Groups I, IV, V, and VI ($P<0.05$), the leg muscle percentage of Group III was significantly or extremely significantly higher than those of Groups I, II, V, and VI ($P<0.05$ or $P<0.01$), and the abdominal fat percentage of Group IV was significantly or extremely significantly lower than those of Groups I, II, and VI ($P<0.05$ or $P<0.01$). 3) The crude protein utilization rate of Group III was significantly or extremely significantly higher than those of Groups I, II, V, and VI ($P<0.05$ or $P<0.01$), the crude fat and crude ash utilization rates of Group III were both significantly or extremely significantly higher than those of Groups I, V, and VI ($P<0.05$ or $P<0.01$), the calcium utilization rate of Group III was significantly or extremely significantly higher than those of Groups I and VI ($P<0.05$ or $P<0.01$), the phosphorus utilization rate of Group III was significantly or extremely significantly higher than those of Groups I, V, and VI ($P<0.05$ or $P<0.01$), the neutral detergent fiber utilization rate of Group III was significantly higher than that of Group I ($P<0.05$), and the acid detergent fiber utilization rate of Group III was significantly or extremely significantly higher than those of Groups I, V, and VI ($P<0.05$ or $P<0.01$). 4) The nitrogen deposition and deposition efficiency of Group III were both significantly or extremely significantly higher than those of Groups I, II, and VI ($P<0.05$ or $P<0.01$). In conclusion, dietary iodine supplementation can improve growth performance, slaughter performance, and nutrient utilization in Wulong geese, and the appropriate iodine supplementation level in the diet of 5-16 week-old Wulong geese is 0.30 mg/kg.

Full Text

Effects of Dietary Iodine Supplemental Level on Growth Performance, Slaughter Performance, Nutrient Utilization, and Nitrogen Metabolism in Wulong Geese

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Abstract

This experiment was conducted to investigate the effects of dietary iodine supplemental level on growth performance, slaughter performance, nutrient utilization, and nitrogen metabolism in Wulong geese, and to determine the appropriate iodine supplementation level for their diets. A total of 360 healthy four-week-old Wulong geese were randomly divided into six groups with six replicates per group and ten geese per replicate. Group I served as the control group and was fed a basal diet without iodine supplementation, while the experimental groups (Groups II–VI) were fed the basal diet supplemented with 0.15, 0.30, 0.60, 1.20, and 2.40 mg/kg iodine, respectively. The trial lasted for 12 weeks. The results showed the following: (1) The average daily gain (ADG) of Group III was significantly or extremely significantly higher than that of Groups I, II, V, and VI ($P<0.05$ or $P<0.01$), while its average daily feed intake (ADFI) was significantly higher than that of Groups I, II, IV, and VI ($P<0.05$). The feed-to-gain ratio (F/G) of Group III was significantly or extremely significantly lower than that of Groups I, II, and V ($P<0.05$ or $P<0.01$). (2) The dressing percentage, half-eviscerated yield, and eviscerated yield of Group III were extremely significantly higher than those of Group I ($P<0.01$). The breast muscle percentage of Group III was significantly higher than that of Groups I, IV, V, and VI ($P<0.05$), while its leg muscle percentage was significantly or extremely significantly higher than that of Groups I, II, V, and VI ($P<0.05$ or $P<0.01$). The abdominal fat percentage of Group IV was significantly or extremely significantly lower than that of Groups I, II, and VI ($P<0.05$ or $P<0.01$). (3) The crude protein utilization of Group III was significantly or extremely significantly higher than that of Groups I, II, V, and VI ($P<0.05$ or $P<0.01$). The crude fat and crude ash utilization rates of Group III were significantly or extremely significantly higher than those of Groups I, V, and VI ($P<0.05$ or $P<0.01$). The calcium utilization of Group III was significantly or extremely significantly higher than that of Groups I and VI ($P<0.05$ or $P<0.01$), while its phosphorus utilization was significantly or extremely significantly higher than that of Groups I, V, and VI ($P<0.05$ or $P<0.01$). The neutral detergent fiber utilization of Group III was significantly higher than that of Group I ($P<0.05$), and its acid detergent fiber utilization was significantly or extremely significantly higher than that of Groups I, V, and VI ($P<0.05$ or $P<0.01$). (4) The deposited nitrogen and nitrogen deposition efficiency of Group III were significantly or extremely significantly higher than those of Groups I, II, and VI ($P<0.05$ or $P<0.01$). In conclusion, dietary iodine supplementation can improve the growth performance, slaughter performance, and nutrient utilization of Wulong geese, and the appropriate dietary iodine supplemental level for 5–16-week-old Wulong geese is 0.30 mg/kg.

Keywords: iodine; geese; growth performance; slaughter performance; nutrient utilization

Introduction

Approximately 70–80% of iodine in the body is concentrated in the thyroid gland, where it serves as the primary raw material for synthesizing thyroid hormones and constitutes an essential trace element for animals. Iodine plays a vital role in increasing basal metabolic rate, promoting growth and development, enhancing immune function, and ensuring reproductive performance. Previous research has demonstrated that chronic iodine deficiency in young animals can lead to growth and developmental disorders and even central nervous system dysfunction, resulting in cretinism. Studies by Guo Yuming et al. found that broiler chickens fed diets supplemented with 0.70 mg/kg iodine exhibited significantly higher body weight at six weeks of age and optimal feed conversion efficiency compared to those receiving 0.35 mg/kg iodine, and that iodine levels could affect selenium deposition in tissues and selenoenzyme activity. Xu Bin et al. reported that adding 0.41 mg/kg iodine to dairy cow diets improved reproductive and growth performance. Liu Hanzhong and Yang Guozhong found that supplementing growing rabbit and meat rabbit diets with 0.1 and 0.8 mg/kg iodine, respectively, significantly increased average daily gain (ADG). Shen Lei et al. demonstrated that dietary supplementation with 0.8 mg/kg iodine significantly affected the hind leg muscle percentage and extremely significantly influenced the foreleg muscle percentage in rex rabbits.

While numerous studies have investigated iodine supplementation levels in chickens, rabbits, and cattle, research on iodine requirements for geese remains limited and inconsistent. The NRC (1984) recommends an iodine requirement of 0.35 mg/kg for goslings and growing geese and 0.3 mg/kg for breeding geese. The Soviet Institute of Animal Husbandry (1985) suggests a requirement of 0.7 mg/kg, while Australian standards (1976) recommend 0.42 mg/kg for commercial meat geese. Currently, China has not established its own feeding standards for geese. Our laboratory' s previous research examined the effects of dietary iodine supplementation on growth and slaughter performance in 1–4-week-old Wulong geese, finding that 0.4 mg/kg iodine extremely significantly increased half-eviscerated yield, eviscerated yield, and breast muscle percentage, while significantly improving dressing percentage and leg muscle percentage. To further investigate the effects of iodine on growth performance during the later growth stages, this study utilized 5–16-week-old Wulong geese to examine the impacts of dietary iodine supplementation levels on growth performance, slaughter performance, nutrient utilization, and nitrogen metabolism, aiming to determine the optimal iodine supplementation level for this age group and provide a theoretical foundation for establishing Chinese feeding standards and promoting the healthy development of the goose industry.

1.1 Experimental Materials and Diets

The iodine source used in this experiment was potassium iodide (KI) with an effective content of 99%, purchased from Qingdao Puxing Biotechnology Co., Ltd. The basal diet was formulated according to NRC (1994) feeding standards and the Chinese Feed Composition and Nutritional Value Tables, using corn and soybean meal as primary ingredients and corn straw as the fiber source. The composition and nutrient levels of the basal diet are presented in .

** Composition and Nutrient Levels of the Basal Diet (Air-Dry Basis)**

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The trace elements and multivitamin premix provided the following per kilogram of diet: VA 1,500 IU, VD 200 IU, VE 12.5 mg, VB 2.2 mg, VB 5.0 mg, niacin 65 mg, pantothenate 15 mg, VB 2 mg, biotin 0.2 mg, folic acid 0.5 mg, Fe 85 mg, Cu 5 mg, Mn 80 mg, Zn 80 mg, Se 0.42 mg, and Co 2.5 mg.

1.2 Experimental Animals and Design

A total of 360 healthy 28-day-old Wulong geese were randomly allocated into six groups with six replicates per group and ten geese per replicate (equal numbers of males and females with no significant weight differences within sex, $P>0.05$). Group I served as the control group and received the basal diet without iodine supplementation, while the experimental groups (Groups II–VI) received the basal diet supplemented with 0.15, 0.30, 0.60, 1.20, and 2.40 mg/kg iodine, respectively. The experimental period lasted for 12 weeks.

1.3 Husbandry Management

Before the experiment began, the rearing house and feeders were subjected to high-pressure washing and disinfection with caustic soda solution, followed by fumigation with 10% formaldehyde solution and potassium permanganate (28 mL formaldehyde and 14 g potassium permanganate per m^3) for 24 hours with closed doors and windows. The trial commenced one week later. Geese were raised on floor bedding with ad libitum access to water and feed throughout the 12-week experimental period (from 5 to 16 weeks of age).

1.4 Performance Measurements

1.4.1 Growth Performance Indices At the beginning and end of the experiment, geese were fasted and weighed by replicate to calculate average initial weight (AIW) and average final weight (AFW). Daily feed provision and residual feed were recorded to determine feed intake, and health status was monitored daily with mortality and culling recorded. Based on these data, ADG, average daily feed intake (ADFI), and feed-to-gain ratio (F/G) for the 5–16-week period were calculated.

1.4.2 Slaughter Performance Determination At the end of week 16, two geese (one male and one female) were randomly selected from each replicate (72 geese total). After 12 hours of fasting, the geese were weighed and slaughtered via wing vein blood collection. Measurements included carcass weight, half-eviscerated weight, eviscerated weight, abdominal fat weight, breast muscle weight, and leg muscle weight, from which six slaughter performance indices were calculated: dressing percentage, eviscerated yield, half-eviscerated yield, abdominal fat percentage, leg muscle percentage, and breast muscle percentage. Measurements followed the "Poultry Performance Terminology and Measurement Methods" (NY/T 823-2004). Carcass weight was defined as the weight after blood removal, feather plucking, and removal of toe and beak keratin. Half-eviscerated weight was the carcass weight after removal of trachea, esophagus, crop, gizzard contents, keratinous lining, intestines, spleen, pancreas, gallbladder, and reproductive organs. Eviscerated weight was the half-eviscerated weight minus heart, abdominal fat, stomach, and liver. Leg muscle weight comprised the combined weight of both left and right thigh and drumstick muscles, while breast muscle weight included the combined weight of left and right pectoralis major, pectoralis minor, and third pectoral muscles.

Slaughter performance indices were calculated as follows: - Dressing percentage (%) = (carcass weight/pre-slaughter live weight) × 100 - Half-eviscerated yield (%) = (half-eviscerated weight/pre-slaughter live weight) × 100 - Eviscerated yield (%) = (eviscerated weight/pre-slaughter live weight) × 100 - Breast muscle percentage (%) = (combined breast muscle weight/eviscerated weight) × 100 - Leg muscle percentage (%) = (combined leg muscle weight/eviscerated weight) × 100 - Abdominal fat percentage (%) = [abdominal fat weight/(abdominal fat weight + eviscerated weight)] × 100

1.4.3 Nutrient Utilization and Nitrogen Metabolism Determination Nutrient utilization was determined through metabolic trials. On the final day of week 15, one healthy male goose was selected from each replicate (six geese per group, 36 total) and housed in metabolic cages. The trial consisted of a 3-day adaptation period, 1-day fasting period, and 3-day collection period, during which geese had ad libitum water access and were fed a restricted diet of 120 g daily. Total fecal collection was performed on the final day, with contaminants removed using tweezers. Nitrogen was fixed by adding 10% hydrochloric acid, and samples were thoroughly mixed, dried at 65–75°C, equilibrated for 24 hours at room temperature, and ground using a small mill for analysis.

Analytical methods followed national standards: crude ash (GB/T 6438-1992), crude protein (GB/T 6432-1994), ether extract (GB/T 6433-2006), calcium (GB/T 6436-2002), phosphorus (GB/T 6437-2002), neutral detergent fiber (GB/T 20806-2006), and acid detergent fiber (NY/T 1459-2007). Nitrogen metabolism indices were calculated as: - Deposited nitrogen = nitrogen intake –nitrogen excretion - Nitrogen deposition efficiency (%) = (deposited nitrogen/nitrogen intake) × 100

1.5 Data Processing and Statistical Analysis

Data were analyzed using SPSS 17.0 software via one-way ANOVA, with LSD method employed for multiple comparisons. Results are expressed as "mean ± standard deviation." Differences were considered significant at $P<0.05$ and extremely significant at $P<0.01$.

2.1 Effects of Dietary Iodine Supplemental Level on Growth Performance of Wulong Geese

As shown in , ADG of 5–16-week-old Wulong geese increased initially and then decreased with increasing dietary iodine levels, peaking in Group III. Group III exhibited extremely significantly higher ADG than Groups I and VI ($P<0.01$), with increases of 11.91 and 7.74 g/d, respectively, and significantly higher ADG than Groups II and V (P<0.05), with increases of 6.16 and 6.35 g/d, respectively. Group III also had the highest ADFI, which was significantly higher than that of Groups I, II, IV, and VI (P<0.05), with increases of 45.30, 24.49, 27.04, and 26.50 g/d, respectively, but did not differ significantly from Group V (P>0.05). No significant differences were observed among the other groups (P>0.05). The F/G ratio was lowest in Group III, being extremely significantly lower than Group II (P<0.01) with a 7.48% reduction, and significantly lower than Groups I and V (P<0.05) with reductions of 6.37% and 6.19%, respectively, but did not differ significantly from Groups IV and VI (P>0.05).

** Effects of Dietary Iodine Supplemental Level on Growth Performance of Wulong Geese**

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Note: In the same column, values with the same or no letter superscripts indicate no significant difference (P>0.05), adjacent letters indicate significant difference (P<0.05), and alternate letters indicate extremely significant difference (P<0.01). The same applies below.

2.2 Effects of Dietary Iodine Supplemental Level on Slaughter Performance of Wulong Geese

As presented in , dressing percentage, half-eviscerated yield, eviscerated yield, breast muscle percentage, and leg muscle percentage of 5–16-week-old Wulong geese all increased initially and then decreased with rising dietary iodine levels, with Group III achieving the highest values. Group III exhibited extremely significantly higher dressing percentage, half-eviscerated yield, and eviscerated yield than Group I (P<0.01), with improvements of 6.5%, 5.59%, and 4.21%, respectively. Breast muscle percentage in Group III was significantly higher than in Groups I, IV, V, and VI (P<0.05). Leg muscle percentage in Group III was significantly higher than in Groups I, II, and VI (P<0.05) and extremely significantly higher than in Group V (P<0.01). Abdominal fat percentage decreased initially and then increased, with Group IV showing the lowest value, which was extremely significantly lower than Groups I and II (P<0.01) and significantly lower than Group VI (P<0.05).

** Effects of Dietary Iodine Supplemental Level on Slaughter Performance of Wulong Geese**

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2.3 Effects of Dietary Iodine Supplemental Level on Nutrient Utilization of Wulong Geese

As indicated in , dietary iodine supplemental level significantly affected nutrient utilization in 5–16-week-old Wulong geese (P<0.05). Group III achieved the highest crude protein utilization, which was extremely significantly higher than Groups I, II, and VI ($P<0.01$) with improvements of 2.06%, 2.41%, and 2.79%, respectively, and significantly higher than Group V ($P<0.05$) with a 1.84% increase, but did not differ significantly from Group IV ($P>0.05$). Group III also exhibited the highest crude fat and crude ash utilization rates, which were extremely significantly higher than Groups I and VI ($P<0.01$) and significantly higher than Group V ($P<0.05$), but showed no significant differences from Groups II and IV ($P>0.05$). Calcium, phosphorus, neutral detergent fiber, and acid detergent fiber utilization rates all increased initially and then decreased, peaking in Group III. Calcium utilization in Group III was extremely significantly higher than Group I ($P<0.01$) with a 2.39% increase and significantly higher than Group VI ($P<0.05$) with a 2.00% increase, but did not differ significantly from other groups ($P>0.05$). Phosphorus utilization in Group III was extremely significantly higher than Group VI ($P<0.01$) with a 2.71% increase and significantly higher than Groups I and V ($P<0.05$) with increases of 2.06% and 1.99%, respectively, but showed no significant differences from other groups ($P>0.05$). Neutral detergent fiber utilization in Group III was significantly higher than Group I ($P<0.05$) with a 2.39% increase, but did not differ significantly from other groups ($P>0.05$). Acid detergent fiber utilization in Group III was extremely significantly higher than Groups I and VI ($P<0.01$) with increases of 2.10% and 2.33%, respectively, and significantly higher than Group V ($P<0.05$) with a 1.98% increase, but showed no significant differences from other groups ($P>0.05$).

** Effects of Dietary Iodine Supplemental Level on Nutrient Utilization of Wulong Geese**

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2.4 Effects of Dietary Iodine Supplemental Level on Nitrogen Metabolism of Wulong Geese

As shown in , Group III exhibited the highest nitrogen intake and lowest nitrogen excretion, though differences among groups were not significant ($P>0.05$). Deposited nitrogen and deposition efficiency increased initially and then decreased with rising dietary iodine levels, peaking in Group III. Group III achieved the highest deposited nitrogen and deposition efficiency, which were extremely significantly higher than Group I ($P<0.01$) and significantly higher than Groups II and VI ($P<0.05$), but did not differ significantly from other groups ($P>0.05$).

** Effects of Dietary Iodine Supplemental Level on Nitrogen Metabolism of Wulong Geese**

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3.1 Effects of Dietary Iodine Supplemental Level on Growth Performance of Wulong Geese

The primary role of iodine in animals is to synthesize thyroid hormones, which widely participate in metabolic processes and thereby influence growth, development, and reproduction. Appropriate dietary iodine supplementation can improve animal growth performance, though requirements vary by species, age, and physiological state. Guo Yuming et al. found that the optimal iodine supplemental level for broiler chickens fed corn-soybean meal diets was 0.70 mg/kg. Stanley et al. reported that low-level iodine supplementation in drinking water improved growth performance in laying hens and broilers. The present results demonstrate that ADG and ADFI increased initially and then decreased with rising dietary iodine levels, peaking at 0.30 mg/kg iodine supplementation, while F/G showed the opposite trend, reaching its minimum at this level. These findings indicate that 0.30 mg/kg iodine supplementation in 5–16-week-old Wulong geese diets can significantly improve ADG and ADFI while reducing F/G. Our previous research also found that appropriate iodine supplementation in 1–4-week-old Wulong geese diets significantly improved growth and slaughter performance and enhanced antioxidant capacity. This suggests that optimal iodine levels promote thyroid hormone synthesis, which facilitates tissue differentiation, growth, and maturation, thereby increasing ADG and ADFI while enhancing biological antioxidant activity, ultimately benefiting animal health, growth, and reproduction.

3.2 Effects of Dietary Iodine Supplemental Level on Slaughter Performance of Wulong Geese

Iodine deficiency can cause goiter, impair thyroid hormone synthesis, disrupt material and energy metabolism, lead to underdeveloped organs, and reduce slaughter performance. Limited and inconsistent reports exist regarding iodine’ s effects on slaughter performance. Meyer et al. found that dietary iodine supplementation did not significantly affect daily gain or slaughter performance in growing-fattening bulls. Shen Lei et al. reported that iodine supplementation did not significantly affect eviscerated yield, loin muscle percentage, or meat quality in rex rabbits. In contrast, the present study found that 0.30 mg/kg iodine supplementation extremely significantly increased half-eviscerated yield, eviscerated yield, and breast muscle percentage, while significantly improving dressing percentage and leg muscle percentage in Wulong geese. These discrepancies may be attributed to differences in animal species, production type, and environmental conditions, necessitating further research on iodine’ s effects on livestock slaughter performance. Under the conditions of this experiment, the recommended optimal iodine supplemental level for 5–16-week-old Wulong geese is 0.30 mg/kg, which yielded the best slaughter performance.

3.3 Effects of Dietary Iodine Supplemental Level on Nutrient Utilization and Nitrogen Metabolism of Wulong Geese

Iodine' s main function is to participate in thyroid hormone synthesis, regulate metabolism, maintain thermal balance, and control growth, reproduction, erythropoiesis, and blood circulation. The metabolism of various special proteins is associated with thyroid hormones. The present results show that 0.30 mg/kg iodine supplementation improved the utilization of crude protein, crude fat, crude ash, and other nutrients while enhancing nitrogen deposition, indicating that optimal iodine levels promote thyroid hormone synthesis and accelerate metabolic processes and protein synthesis. Zhao Zhongshi found that thyroid hormones can increase RNA polymerase activity in cell nuclei, enhancing RNA synthesis and consequently protein synthesis, which improves enzyme activity related to metabolism. He Shenghu et al. demonstrated that appropriate iodine supplementation (0.45 mg/kg) in broiler diets significantly improved ADG and feed utilization, consistent with our findings. These results suggest that iodine supplementation promotes protein synthesis and nutrient absorption, thereby improving nutrient utilization efficiency.

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4 Conclusion

Dietary iodine supplementation can improve the growth performance, slaughter performance, and nutrient utilization of Wulong geese. The appropriate dietary iodine supplemental level for 5–16-week-old Wulong geese is 0.30 mg/kg.

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Note: Figure translations are in progress. See original paper for figures.