

Effects of Complex Organic Trace Elements on Growth Performance and Fecal Trace Element Content in Chongren Partridge Chickens (Post-print)

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Abstract

This experiment aimed to investigate the effects of replacing inorganic trace elements with different levels of complex organic trace elements on growth performance and fecal trace element content in Chongren partridge chickens. A total of 256 Chongren partridge chickens at 28 days of age with similar initial body weight (half male and half female) were randomly allocated to 4 groups with 4 replicates per group and 16 chickens per replicate. Group I served as the control group (standard inorganic group), with trace elements iron, copper, manganese, and zinc supplemented at 80, 8, 80, and 60 mg/kg, respectively (as inorganic salts); Groups II-IV received 50%, 75%, and 100% replacement of inorganic trace elements with complex organic trace elements, respectively. Other nutrient levels were identical across groups. The pre-experimental period lasted 7 d, followed by a 28-d formal experimental period. The results showed: 1) No significant differences were observed in average daily gain, average daily feed intake, or feed-to-gain ratio among all groups of Chongren partridge chickens ($P > 0.05$). 2) Compared with the control group, serum urea nitrogen content in Groups II, III, and IV was significantly reduced ($P < 0.05$); serum alkaline phosphatase and 5' -nucleotidase activities in Groups III and IV were significantly increased ($P < 0.05$). 3) Fecal copper and iron contents showed no significant differences among all groups of Chongren partridge chickens ($P < 0.05$). Compared with the control group, fecal zinc and manganese contents in Group II were significantly decreased ($P < 0.05$). Based on comprehensive evaluation of all indicators, without affecting broiler growth performance, supplementation in the diet

Full Text

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Abstract

This experiment was conducted to investigate the effects of replacing inorganic trace elements with complex organic trace elements at different levels on the growth performance and fecal trace element contents of Chongren chickens. Two hundred fifty-six 28-day-old Chongren chickens (half male and half female) with similar initial body weight were randomly allocated into four groups, each consisting of four replicates with sixteen birds per replicate. Group I served as the control (standard-level inorganic group), with dietary supplementation of iron, copper, manganese, and zinc at 80, 8, 80, and 60 mg/kg, respectively, in the form of inorganic salts. Groups II-IV were fed diets in which 50%, 75%, and 100% of the inorganic trace elements were replaced with complex organic trace elements, respectively. All other nutrient levels were consistent across groups. The experiment included a 7-day preliminary period followed by a 28-day formal trial period. The results showed: (1) No significant differences were observed among groups in average daily gain, average daily feed intake, or feed-to-gain ratio ($P>0.05$). (2) Compared with the control group, serum urea nitrogen content was significantly reduced in groups II, III, and IV ($P<0.05$), while serum alkaline phosphatase and 5' -nucleotidase activities were significantly increased in groups III and IV ($P<0.05$). (3) No significant differences were detected in fecal copper and iron contents among all groups ($P>0.05$). However, fecal zinc and manganese contents in group II were significantly lower than those in the control group ($P<0.05$). Based on comprehensive evaluation of all indicators, replacing inorganic trace elements with 50% complex organic trace elements in the diet effectively reduced fecal copper, iron, zinc, and manganese contents without compromising growth performance.

Keywords: trace elements; Chongren chickens; growth performance; feces

Introduction

Trace elements are essential nutrients for maintaining animal health and normal physiological functions. They primarily participate in various physiological and biochemical reactions as essential components of enzymes (cofactors, prosthetic groups, etc.) or as activators, thereby influencing nutrient metabolism and growth development. To prevent trace element deficiencies, ensure ani-

mal health and normal growth, and improve production performance, livestock and poultry diets are typically supplemented with adequate amounts of trace elements. Currently, trace elements (copper, iron, zinc, and manganese) in livestock and poultry diets are predominantly added as inorganic salts (such as sulfates, oxides, and chlorides). Due to their low cost, inorganic trace elements are often added in excessive amounts to ensure sufficient nutritional levels. However, the absorption rate of inorganic trace elements by livestock and poultry is relatively low, and the unabsorbed portion is excreted in feces, posing significant environmental concerns. Research has demonstrated that organic trace elements (amino acid chelates and protein chelates) offer advantages including better stability, higher absorption rates, and superior biological efficacy. Nevertheless, most studies on organic trace elements in broilers have focused on replacing individual inorganic trace elements with their organic counterparts, while research on replacing inorganic trace elements with complex organic trace elements in broilers, particularly in local high-quality breeds, remains limited.

Chongren chicken is an excellent local breed in Jiangxi Province, recognized as one of China's top ten famous chicken breeds and awarded national geographical indication certification in 2015. It exhibits good stress resistance and superior meat quality, but its slow growth rate severely restricts its commercial development. Therefore, this study was designed to investigate the effects of replacing inorganic trace elements with complex organic trace elements at different levels on the growth performance and fecal trace element contents of Chongren chickens, providing experimental evidence for determining appropriate supplementation levels.

1. Materials and Methods

1.1 Experimental Materials The inorganic trace elements used in this experiment were all feed-grade. Organic trace elements were produced and provided by Guangzhou Longda Feed Co., Ltd. The types and specifications of inorganic and organic trace elements are presented in Table 1 .

1.2 Experimental Design and Basal Diet Two hundred fifty-six 28-day-old Chongren chickens (half male and half female) with similar initial body weight were randomly divided into four groups, each comprising four replicates of sixteen birds. Group I served as the control (standard-level inorganic group) and was fed diets supplemented with iron, copper, manganese, and zinc at 80, 8, 80, and 60 mg/kg, respectively, as inorganic salts, according to the Chinese "Feeding Standard of Chickens" (NY/T 33–2004). Groups II-IV were fed diets in which 50%, 75%, and 100% of the inorganic trace elements were replaced with organic trace elements, respectively. The basal diet contained 7.93, 75.28, 30.72, and 27.37 mg/kg of iron, copper, manganese, and zinc, respectively. All other nutrient levels remained consistent across groups. The composition and nutrient levels of the basal diet are shown in Table 2 .

1.3 Feeding Management The experimental chickens were raised in cages with net flooring under combined natural and artificial lighting, with free access to feed and water. Feed was provided three times daily (morning, noon, and evening), and the health status, feed consumption, water intake, and fecal condition of the birds were monitored daily. Routine disinfection and vaccination procedures were followed. The experiment included a 7-day preliminary period followed by a 28-day formal trial period.

1.4 Measurement Indicators

1.4.1 Growth Performance During the experimental period, feed intake and residual feed were recorded by replicate, and initial and final body weights were measured to calculate average daily gain (ADG), average daily feed intake (ADFI), and feed-to-gain ratio (F/G) for each group.

1.4.2 Serum Biochemical Indices At the end of the experiment, six chickens (three males and three females) with similar body weight were selected from each group. Blood samples (5 mL) were collected from the wing vein, and serum was separated and stored at -20 °C. Serum alkaline phosphatase and 5' -nucleotidase activities were measured using a Thermo Multiscan MK3 microplate reader (Thermo Fisher Scientific, Shanghai), while serum urea nitrogen content was determined using a PUS-2018 semi-automatic biochemical analyzer (Beijing Perlong New Technology Co., Ltd.). All assay kits were purchased from Nanjing Jiancheng Bioengineering Institute.

1.4.3 Trace Element Contents in Feces At the end of the experiment, feed was withdrawn for 24 hours before refeeding. Feces were collected on plastic film-lined trays from the start of refeeding. After 72 hours of feeding, residual feed was removed from the troughs, and feces were collected continuously during a subsequent 24-hour fasting period. Following collection, feathers, dander, and feed residues were carefully removed from the feces (with feed consumption deducted). The feces were then thoroughly mixed, and 150 g samples were accurately weighed, dried in an oven at (65 ± 1) °C, equilibrated for 24 hours, reweighed, ground, and prepared as air-dried samples for trace element analysis. Fecal iron, copper, manganese, and zinc contents were determined using a TAS-986F atomic absorption spectrophotometer (Beijing Purkinje General Instrument Co., Ltd.).

1.5 Data Processing and Analysis Data were analyzed using one-way ANOVA with SPSS 16.0 statistical software. Duncan's multiple comparison test was applied when significant differences were detected. $P < 0.05$ was considered statistically significant. All results are expressed as "mean \pm standard deviation."

2. Results

2.1 Effects of Complex Organic Trace Elements at Different Levels on Growth Performance of Chongren Chickens As shown in Table 3, no significant differences were observed among groups in average daily gain, average daily feed intake, or feed-to-gain ratio of Chongren chickens ($P > 0.05$).

2.2 Effects of Complex Organic Trace Elements at Different Levels on Serum Biochemical Indices of Chongren Chickens Table 4 shows that compared with the control group, serum urea nitrogen content in groups II, III, and IV was significantly reduced by 55.45%, 32.67%, and 43.56%, respectively ($P < 0.05$). Serum alkaline phosphatase activity in groups III and IV was significantly increased by 74.78% and 107.88%, respectively ($P < 0.05$), while serum 5'-nucleotidase activity was significantly increased by 91.76% and 166.47%, respectively ($P < 0.05$).

2.3 Effects of Complex Organic Trace Elements at Different Levels on Trace Element Contents in Feces of Chongren Chickens As shown in Table 5, no significant differences were detected in fecal copper and iron contents among all groups ($P > 0.05$). However, compared with the control group, fecal zinc content in group II was significantly reduced by 29.21% ($P < 0.05$), and fecal manganese content was significantly reduced by 25.62% ($P < 0.05$).

3. Discussion

3.1 Effects of Complex Organic Trace Elements at Different Levels on Growth Performance of Chongren Chickens Previous studies have shown that supplementing broiler diets with low doses of organic trace elements can maintain normal growth requirements. Xu et al. reported that replacing inorganic trace elements with 50% glycine-chelated iron, methionine-chelated copper, methionine-chelated zinc, and methionine-chelated manganese in basal diets could improve broiler growth performance. Lu et al. found that replacing corresponding inorganic trace elements with different proportions of methionine chelates (copper, iron, zinc, and manganese) could enhance broiler production performance to some extent. The present results are consistent with these findings, demonstrating that low-level supplementation of organic trace elements to replace inorganic forms had no significant effect on the growth performance of Chongren chickens.

3.2 Effects of Complex Organic Trace Elements at Different Levels on Serum Biochemical Indices of Chongren Chickens Alkaline phosphatase is a crucial enzyme for animal growth and development, and elevated blood alkaline phosphatase activity can accelerate growth rate. Serum urea nitrogen is an important indicator of protein and amino acid metabolism, with lower levels indicating higher protein synthesis efficiency. 5'-Nucleotidase is

a specific phosphohydrolase that acts on phosphoester bonds to decompose nucleic acids into nucleosides and inorganic phosphate, providing various mononucleotides for energy metabolism and RNA catabolism. The current results indicate that replacing inorganic trace elements with complex organic trace elements significantly reduced serum urea nitrogen content, while supplementation at 75% and 100% replacement levels significantly increased serum alkaline phosphatase and 5' -nucleotidase activities. This suggests that dietary supplementation with complex organic trace elements can promote protein synthesis and utilization in animals and improve growth performance, which aligns with the findings of Xiao et al.

3.3 Effects of Complex Organic Trace Elements at Different Levels on Trace Element Contents in Feces of Chongren Chickens

Insufficient dietary trace elements can affect animal health and production performance, while excessive amounts increase environmental burden through fecal excretion. Research has shown that reducing dietary trace element supplementation levels can effectively decrease fecal trace element contents. Studies have also demonstrated that amino acid chelates exhibit high biological efficacy, and replacing inorganic trace elements with amino acid chelates can reduce supplementation doses and fecal trace element contents. The present results show that replacing inorganic trace elements with 50% complex organic trace elements significantly reduced fecal zinc and manganese contents, indicating that supplementation with highly bioavailable trace element amino acid chelates at reduced dietary levels can effectively decrease fecal trace element excretion, consistent with previous research. However, 100% replacement increased fecal iron, zinc, and manganese contents, suggesting that high-level supplementation of complex organic trace elements not only wastes resources but also elevates fecal trace element contents. This may be because when certain trace elements are present in excess, their absorption mechanisms differ from those during deficiency, leading to reduced utilization efficiency. The specific mechanisms require further investigation.

4. Conclusion

1. Replacing inorganic trace elements with 50%, 75%, or 100% complex organic trace elements in the diet had no significant effect on the growth performance of Chongren chickens.
2. Replacing inorganic trace elements with 50%, 75%, or 100% complex organic trace elements significantly reduced serum urea nitrogen content, while 75% and 100% replacement levels significantly increased serum alkaline phosphatase and 5' -nucleotidase activities.
3. Under the conditions of this experiment, replacing inorganic trace elements with 50% complex organic trace elements in the diet effectively reduced fecal trace element contents in Chongren chickens.

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