Effects of Coated Benzoic Acid on Leg Health of Broiler Chickens and Physicochemical Properties of Litter (Postprint)

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Abstract

This study aimed to investigate the effects of dietary supplementation of coated benzoic acid on leg health and litter physicochemical properties in broiler chickens. A total of 2,400 1-day-old Arbor Acres broiler chicks were randomly allocated into 2 groups, with 12 replicates per group and 100 birds per replicate (half male and half female). The control group was fed a basal diet (pellet form), while the treatment group received the basal diet supplemented with 500 g/t coated benzoic acid. The experimental period lasted 35 days. At 35 days of age, 10 broilers were randomly selected from each replicate for footpad and hock joint assessment; litter samples were collected from each replicate to determine moisture content, pH, and total nitrogen content. The results showed that dietary supplementation of 500 g/t coated benzoic acid significantly reduced footpad and hock joint lesion scores in broilers ($P<0.05$), and significantly decreased litter pH and total nitrogen content ($P<0.05$), but had no significant effect on litter moisture content ($P>0.05$). In conclusion, dietary supplementation of coated benzoic acid can reduce footpad and hock joint lesions in broilers, improve litter physicochemical properties, and enhance welfare levels during broiler rearing.

Full Text

Effects of Coated-Benzoic Acid on Leg Health of Broilers and Physicochemical Properties of Bedding

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Abstract: This experiment was conducted to investigate the effects of dietary coated-benzoic acid on leg health and bedding physicochemical properties in broilers. A total of 2,400 one-day-old Arbor Acres broiler chicks were randomly allocated to two groups with 12 replicates per group and 100 birds per replicate (half male, half female). The control group received a basal diet (pelleted feed), while the experimental group received the basal diet supplemented with 500 g/t coated-benzoic acid. The trial lasted for 35 days. At 35 days of age, 10 broilers per replicate were randomly selected for footpad and hock assessments, and bedding samples were collected from each replicate to determine moisture content, pH, and total nitrogen content. The results demonstrated that dietary supplementation with 500 g/t coated-benzoic acid significantly reduced the severity of footpad and hock lesions ($P<0.05$) and significantly decreased bedding pH and total nitrogen content ($P<0.05$), while having no significant effect on bedding moisture ($P>0.05$). These findings indicate that dietary coated-benzoic acid can alleviate footpad and hock injuries while improving bedding physicochemical properties, thereby enhancing broiler welfare during production.

Keywords: coated-benzoic acid; broilers; leg health; physicochemical properties of bedding

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Acidifiers have emerged as one of the most promising antibiotic alternatives due to their high efficiency, non-polluting nature, and lack of residues. Research has shown that dietary acidifiers can reduce intestinal pH and inhibit the growth of pathogenic bacteria in the gut. Currently, acidifiers used in feed production can be categorized into three types: inorganic acids, organic acids, and compound acidifiers. Benzoic acid represents one of the organic acidifiers commonly employed in the feed industry. Poultry cannot fully digest all nutrients in feed, and excreta containing sulfur-containing proteins can be decomposed by microorganisms in the bedding under suitable temperature and humidity conditions, releasing substantial amounts of ammonia. Organic acidifiers can reduce microbial competition for nutrients in the gut, thereby facilitating nutrient absorption and utilization by the animal and consequently decreasing ammonia emissions.

For floor-reared broilers, bedding quality constitutes a critical factor affecting welfare status. When temperature and humidity in the poultry house are excessively high, moist bedding mixed with excreta undergoes fermentation, releasing large quantities of ammonia. Leg health is fundamental for broilers to achieve optimal growth performance and represents an essential component of poultry welfare. One of the primary causes of footpad dermatitis and hock lesions in broilers is the accumulation of excreta in bedding, which increases moisture and ammonia levels, resulting in "ammonia burns" on foot skin. Thus, bedding quality directly influences leg health in poultry.

Despite these known relationships, research on the effects of acidifiers on broiler welfare remains limited. Therefore, this study was designed to investigate the impact of dietary coated-benzoic acid supplementation on broiler leg health and bedding physicochemical properties, explore its influence on broiler welfare, and provide reference data for practical application in production.

1.1 Experimental Design

A total of 2,400 one-day-old Arbor Acres broiler chicks with similar initial body weight were randomly assigned to two groups, each comprising 12 replicate pens with 100 birds per pen (equal numbers of males and females). The control group received a basal diet (pelleted feed), while the experimental group received the basal diet supplemented with 500 g/t coated-benzoic acid (provided by Novus International Trading (Shanghai) Co., Ltd., with benzoic acid content $ $40%). The basal diet composition and nutrient levels are presented in . The experiment was conducted at a commercial broiler farm in cooperation with Shandong Agricultural University.

1.2 Experimental Diets

The experiment utilized corn-soybean meal-corn gluten meal-based diets. The feeding trial was divided into two phases: Phase 1 from 1 to 21 days of age and Phase 2 from 22 to 35 days of age.

1.3 Management Practices

The feeding trial lasted for 35 days, divided into a starter period (1-21 days) and a grower period (22-35 days). The initial brooding temperature was 35°C, which was gradually reduced by 2-3°C weekly until reaching 23°C. Environmental humidity was maintained at 40-50% and adjusted according to broiler growth. The lighting program followed commercial farm management protocols. Electrolyte multivitamins and glucose were added to drinking water during days 1-3. Throughout the trial, birds were raised on floor bedding with ad libitum access to feed and water and received routine vaccinations.

1.4 Measurements and Methods

Weekly feed addition and remaining amounts were weighed to calculate average feed intake, average body weight gain, and feed-to-gain ratio for days 1-21, days 22-35, and the overall period. Overall broiler production status was evaluated, and mortality/culling events were recorded meticulously with body weights of dead or culled birds documented. At 35 days of age, 10 broilers per replicate were randomly captured from areas near water lines, near feeders, and away from both for footpad and hock assessments. Bedding samples were collected from water line areas, feeder areas, and surface areas (partially caked bedding) for determination of moisture content, pH, and total nitrogen content.

1.4.1 Growth Performance Average body weight (g) = final body weight / total number of birds
Average body weight gain (g) = (final body weight - initial body weight) / total number of birds
Average feed intake (g) = total feed consumption / total number of birds
Feed-to-gain ratio (F/G) = total feed consumption / total weight gain (including dead birds)
Mortality rate (%) = 100 × number of dead birds / total number of birds
European Performance Index (EPI) = 10,000 × average body weight × (1 - mortality rate) / (feed-to-gain ratio × days)

1.4.2 Footpad and Hock Lesion Assessment The scoring system was as follows: A) Grade 0, no lesions; B) Grades 1-2, mild lesions; C) Grades 3-4, severe lesions. Based on the percentages of birds with mild and severe lesions, the flock footpad or hock health index (I) was calculated as:

$$I = 100 \times [1 - (B \times 0.5 + C \times 1.0)]$$

where B (%) represents the percentage of birds with mild lesions and C (%) represents the percentage with severe lesions, with weighting factors of 0.5 and 1.0, respectively.

1.4.3 Bedding Moisture, pH, and Total Nitrogen Content **Bedding moisture determination:** Bedding samples were collected using the five-point sampling method. After mixing, 500 g of bedding from each replicate was placed in an oven and dried at 65°C for 72 hours before weighing. **Bedding pH determination:** Ten grams of bedding sample was placed in a 250 mL centrifuge tube, diluted with deionized water at a 1:10 mass-to-volume ratio, shaken for 30 minutes, and then pH was measured. **Bedding total nitrogen content determination:** Following the Kjeldahl method, bedding samples fixed with 10% sulfuric acid were crushed and analyzed using a KjeltecTM 2300 nitrogen analyzer (FOSS, USA).

1.5 Statistical Analysis

Experimental data are expressed as mean ± standard error. The effect of benzoic acid was analyzed using one-way ANOVA with SAS 9.1.3 statistical software. Differences were considered significant at $P<0.05$ and a trend at $0.05 \leq P<0.10$.

2.1 Effects of Dietary Coated-Benzoic Acid on Broiler Growth Performance

As shown in , dietary supplementation with coated-benzoic acid had no significant effect on average body weight at 1, 21, or 35 days of age ($P>0.05$). No significant differences in average body weight gain were observed between the experimental and control groups during days 1-21, days 22-35, or the overall period (P>0.05). During days 1-21, the experimental group showed a trend toward increased average feed intake compared with the control group (P<0.10), while no significant differences were found during days 22-35 or the overall period (P>0.05). Feed-to-gain ratio did not differ significantly between groups during any period (P>0.05). Mortality rates were similar between groups across all periods (P>0.05). The European Performance Index was 351.23 for the experimental group and 350.16 for the control group, with no significant difference between them (P>0.05).

In the same row, values with no letter or the same letter superscripts indicate no significant differences (P>0.05), while different lowercase letters indicate significant differences (P<0.05). The same notation applies to subsequent tables.

2.2 Effects of Dietary Coated-Benzoic Acid on Footpad and Hock Lesions

As illustrated in [Figure 1: see original paper], the health index for footpads and hocks was significantly higher in the experimental group compared with the control group (P<0.05), indicating substantially milder lesion severity in the experimental group.

[Figure 1: see original paper]

2.3 Effects of Dietary Coated-Benzoic Acid on Bedding Moisture

As presented in , no significant differences in bedding moisture content were observed between the experimental and control groups at any sampling location (P>0.05).

**** Effects of dietary coated-benzoic acid on bedding moisture (%)

<table>
<tr><th>Items</th><th>Waterline</th><th>Feeder</th><th>Surface</th></tr>
<tr><td>Control group
P-value</td><td colspan="3">41.40$±2.52|29.21±1.66|48.41±1.34||*Experimentalgroup*|36.40±2.12|29.04±1.78|45.36±$1.52</td></tr>
</table>

2.4 Effects of Dietary Coated-Benzoic Acid on Bedding pH

As shown in [Figure 2: see original paper], bedding pH at water line, feeder, and surface locations was significantly lower in the experimental group compared with the control group (P<0.05). These results demonstrate that dietary supplementation with coated-benzoic acid significantly reduced bedding pH.

[Figure 2: see original paper]

2.5 Effects of Dietary Coated-Benzoic Acid on Bedding Total Nitrogen Content

As depicted in [Figure 3: see original paper], total nitrogen content in bedding at water line, feeder, and surface locations was significantly lower in the experimental group than in the control group ($P<0.05$). This indicates that dietary coated-benzoic acid supplementation significantly decreased bedding total nitrogen content.

[Figure 3: see original paper]

3.1 Effects of Dietary Coated-Benzoic Acid on Broiler Growth Performance

Benzoic acid and its salts are commonly used as preservatives and antimicrobial agents in feed. The present results demonstrate that dietary coated-benzoic acid supplementation had no adverse effects on broiler growth performance. Józefiak et al. reported that supplementation with 0.25% benzoic acid did not significantly affect broiler performance, whereas 0.50% and 0.75% benzoic acid inhibited growth and increased feed-to-gain ratio. Generally, the efficacy of acidifiers is influenced by multiple factors including acidifier type and dosage, diet composition and storage, bird age and body weight, and environmental conditions such as housing sanitation, stocking density, temperature, humidity, and lighting.

3.2 Effects of Dietary Coated-Benzoic Acid on Footpad and Hock Lesions

The primary cause of footpad dermatitis and hock lesions in broilers is the accumulation of excreta in bedding, which increases moisture and ammonia content, leading to "ammonia burns" on foot skin. The current findings show that dietary coated-benzoic acid significantly alleviated footpad and hock lesions, likely by improving feed digestibility and reducing organic matter excretion, thereby decreasing microbial ammonia production and substantially lowering lesion incidence. Previous research has demonstrated that adding acidifiers to broiler drinking water can significantly reduce ammonia emissions through acid-ammonia binding.

3.3 Effects of Dietary Coated-Benzoic Acid on Bedding Moisture, pH, and Total Nitrogen Content

Bedding quality is recognized as a crucial factor affecting poultry welfare, with wet bedding compromising broiler welfare status. Moist bedding elevates temperature and microbial activity, increasing the incidence of breast skin inflammation and blister fluid accumulation, while broilers raised on wet bedding show significantly higher rates of footpad dermatitis and hock lesions. Studies have shown that transferring broilers from wet to dry bedding improves welfare status, particularly by reducing footpad lesion severity. The present results indicate that dietary coated-benzoic acid had no significant effect on bedding moisture, though moisture was higher near water lines than feeder areas, suggesting water line leakage represents an important factor contributing to increased bedding moisture.

The experimental group exhibited significantly lower bedding pH than the control group. Bedding pH plays a critical role in ammonia generation and volatilization in poultry houses, as it affects enzyme and microbial activity, while increased ammonia levels subsequently influence bedding pH. Tiquia et al. observed that as broilers grew and fecal output increased during the later production stages, microbial decomposition of proteins in bedding produced ammonium nitrogen, with continuous nitrogen decomposition generating ammonia and gradually elevating bedding pH.

The significantly lower total nitrogen content in the experimental group bedding can be attributed to poultry manure being the sole nitrogen variable. Miller et al. reported that nitrogen loss during typical aerobic composting of manure can reach 77%. The direct causes of increased bedding nitrogen content include the high nitrogen concentration in poultry feces and substantial nitrogen accumulation from carbon dioxide volatilization during microbial respiration and microbial synthesis of nitrate nitrogen. Dietary acidifier supplementation reduced bedding pH, affecting microbial and enzymatic activities, thereby decreasing carbon dioxide release and microbial synthesis of nitrate and organic nitrogen. This increased the carbon-to-nitrogen ratio in bedding, resulting in reduced total nitrogen content in the experimental group.

In conclusion, dietary supplementation with coated-benzoic acid reduced the severity of footpad and hock lesions, decreased bedding total nitrogen content and pH, and contributed to improved broiler welfare during production.

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