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Effects of Different Feed Processing Technologies and Vitamin Supplementation Levels on Growth Performance and Slaughter Performance of Broilers (Postprint)

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Abstract

The present study aimed to investigate the effects of different feed processing technologies and vitamin supplementation levels on growth performance and slaughter performance of broiler chickens. A total of 480 one-day-old Arbor Acres broiler chickens with similar body weight were randomly allocated to 4 groups, each consisting of 8 replicates with 20 chickens per replicate. The control group (Group A) was fed diets processed using conventional feed processing technology, with normal levels of vitamin premix added to the formula [starter phase (1-21 days) 350 mg/kg, grower phase (22-42 days) 250 mg/kg]; the experimental groups were fed diets processed using high-efficiency conditioning low-temperature pelleting technology, with reduced vitamin premix supplementation levels (Group B: starter phase 280 mg/kg, grower phase 200 mg/kg; Group C: starter phase 224 mg/kg, grower phase 160 mg/kg; Group D: starter phase 180 mg/kg, grower phase 128 mg/kg). The experimental period lasted 42 days. The results showed that during the starter phase, the starch gelatinization degree of feed in Group A was significantly lower than that in Groups B, C, and D ($P<0.05$). During the grower phase, the pellet durability index of feed in Group A was significantly lower than that in Groups B, C, and D ($P<0.05$). During the starter phase, grower phase, and overall period (1-42 days), there were no significant differences among groups in final body weight, average daily gain, average daily feed intake, and feed conversion ratio of broiler chickens ($P>0.05$). There were no significant differences among groups in leg weight/slaughter weight ratio, breast meat weight/slaughter weight ratio, heart weight/slaughter weight ratio, liver weight/slaughter weight ratio, spleen weight/slaughter weight ratio, gizzard weight/slaughter weight ratio, and proventriculus weight/slaughter weight ratio of broiler chickens ($P>0.05$), and no significant differences in length and weight of duodenum, jejunum, and ileum among groups ($P>0.05$). These results indicate that the use of high-efficiency conditioning low-temperature pelleting technology for broiler diets produced superior pellet feed processing quality compared with conventional feed processing technology, and that reducing vitamin supplementation levels in the feed formula had no significant effects on growth performance and slaughter performance of broiler chickens compared with conventional feed processing technology, suggesting that this technology can reduce vitamin usage.

Full Text

Abstract

This experiment was conducted to investigate the effects of different feed processing technologies and vitamin supplementation levels on the growth performance and slaughter performance of broiler chickens. A total of 480 one-day-old Arbor Acres broilers with similar body weight were randomly allocated into four groups, each consisting of eight replicates with 20 birds per replicate. The control group (Group A) received diets processed using conventional feed processing technology with normal levels of compound vitamins [early stage (1–21 days): 350 mg/kg; late stage (22–42 days): 250 mg/kg]. The experimental groups received diets processed using high-efficiency conditioning and low-temperature pelleting technology with reduced vitamin supplementation (Group B: early stage 280 mg/kg, late stage 200 mg/kg; Group C: early stage 224 mg/kg, late stage 160 mg/kg; Group D: early stage 180 mg/kg, late stage 128 mg/kg). The experiment lasted for 42 days.

The results showed that during the early stage, the dietary starch gelatinization degree in Group A was significantly lower than that in Groups B, C, and D ($P < 0.05$). During the late stage, the pellet durability index (PDI) in Group A was significantly lower than that in Groups B, C, and D ($P < 0.05$). Throughout the early, late, and entire experimental period (1–42 days), no significant differences were observed among groups in final body weight, average daily gain (ADG), average daily feed intake (ADFI), or feed-to-gain ratio (F/G) ($P > 0.05$). Additionally, no significant differences were found among groups in leg weight/slaughter weight, breast meat weight/slaughter weight, heart weight/slaughter weight, liver weight/slaughter weight, spleen weight/slaughter weight, muscular stomach weight/slaughter weight, glandular stomach weight/slaughter weight, or in the length and weight of the duodenum, jejunum, and ileum ($P > 0.05$). These findings indicate that the high-efficiency conditioning and low-temperature pelleting process improves pellet feed quality compared to conventional processing technology, and that reducing vitamin supplementation does not significantly affect broiler growth or slaughter performance. Therefore, this technology can achieve substantial savings in vitamin usage.

Keywords: feed processing; growth performance; slaughter performance

Introduction

Vitamins are essential micronutrients that must be obtained from feed to maintain normal physiological functions, playing crucial roles in growth, metabolism, and development. Feed processing methods directly affect the biological activity of vitamins. In conventional livestock feed production, excessive conditioning temperatures cause severe vitamin losses, reducing efficacy [1-2]. To compensate, manufacturers often resort to over-supplementation, which leads to high costs and resource waste. To overcome these limitations, a novel production process involving high-efficiency conditioning followed by cooling and low-temperature pelleting can be employed. This process first conditions the mixed feed (excluding heat-sensitive components and additives) into a gelatinized powder, which is then pelleted at low temperature, thereby maximizing the retention of heat-sensitive substances.

Previous studies have extensively investigated the effects of dietary vitamin supplementation levels and different formulation ratios on broiler growth performance [3-4], but few have considered the impact of processing technology on vitamin content. Therefore, this experiment compared a control group using conventional feed processing technology with normal vitamin supplementation against experimental groups using high-efficiency conditioning and low-temperature pelleting with reduced vitamin levels. By comparing growth and slaughter performance between groups, this study aimed to demonstrate that the new processing technology can reduce compound vitamin supplementation without compromising broiler performance, thereby achieving savings in heat-sensitive feed ingredients.

1.1 Experimental Design and Grouping

Four hundred eighty one-day-old Arbor Acres broilers with an initial body weight of (48.00 ± 0.05) g were randomly divided into four groups (eight replicates per group, 20 birds per replicate) with consistent sex ratios. The 42-day experiment included vitamin supplementation levels and group assignments as shown in . Group A used conventional feed processing technology with a conditioning time of approximately 30 seconds at 80°C. Groups B, C, and D employed high-efficiency conditioning and low-temperature pelleting technology, with a conditioning time of approximately 30 seconds at 80°C for the main ingredients, followed by cooling of the gelatinized powder, addition of premix and other heat-sensitive additives, and low-temperature pelleting at 60°C for approximately 30 seconds.

The feeding trial was conducted at the Nankou Experimental Base of the Chinese Academy of Agricultural Sciences for 42 days. Crumbled feed was provided during the early stage (1–21 days), and 3.0 mm pellets were fed during the late stage (22–42 days). The vitamin composition and levels in broiler diets are presented in .

1.2 Experimental Diets

Diet formulations were designed according to NRC (2012) broiler nutrition standards. The basal diet composition and nutrient levels are shown in . The vitamin premix composition is detailed in . The mineral premix provided the following per kilogram of diet: for 1–21 days, Fe (as ferrous sulfate) 100 mg, Cu (as copper sulfate) 8.0 mg, Zn (as zinc sulfate) 100 mg, Mn (as manganese sulfate) 120 mg, I (as potassium iodide) 0.7 mg, Se (as sodium selenite) 0.3 mg; for 22–42 days, Fe 80 mg, Cu 8.0 mg, Zn 80 mg, Mn 100 mg, I 0.7 mg, Se 0.3 mg. Crude protein was measured, while other values were calculated.

1.3 Sample Collection

For Group A, three samples were collected before conditioning and at the pellet mill discharge. For experimental groups, three samples were collected after main ingredient conditioning, before low-temperature pelleting, and at the pellet mill discharge. The hot, moist powder and pellets were cooled, then reduced to 2 kg using the quartering method, sealed in bags, and stored at 4°C for analysis.

1.4 Measurement Indicators and Methods

1.4.1 Starch Gelatinization Degree Starch gelatinization was measured using the simplified enzymatic method commonly employed in the U.S. feed industry, as described by Xiong Yiqiang [5].

1.4.2 Pellet Hardness Pellet hardness was determined according to the method described by Gu Junhua [6].

1.4.3 Pellet Durability Index (PDI) PDI was measured following the method of Thomas et al. [7]. Briefly, 500 g of screened pellets were placed in a tumbling box, rotated at 50 rpm for 10 minutes, and the weight of remaining pellets (m1) was recorded. PDI was calculated as: PDI = m1 × 100 / 500.

1.4.4 Growth Performance Indicators Feed was withheld for 24 hours before weighing on days 21 and 42, while water remained available. Birds were weighed individually, and average body weight was calculated per replicate. Daily feed consumption was recorded, and feed consumption was adjusted when mortality occurred to calculate total feed intake per stage.

Average daily feed intake (ADFI) = Total feed intake / (number of birds × days)
Average daily gain (ADG) = Total weight gain / (number of birds × days)
Feed-to-gain ratio (F/G) = Total feed intake / Total weight gain

1.4.5 Slaughter Performance Indicators Slaughter performance was measured according to the agricultural industry standard NY/T 823—2004 "Poultry Production Performance Terminology and Measurement Methods."

1.5 Data Processing

Data are expressed as mean ± standard deviation. All data were analyzed using SAS 9.2 software for one-way ANOVA and factorial analysis. Duncan's multiple range test was used to detect significant differences at $P < 0.05$.

Results

2.1 Effects of Feed Processing Technology on Pellet Quality

The effects of feed processing technology on pellet quality are shown in . During the early stage, Group B had significantly higher PDI than Groups A and D ($P < 0.05$), but did not differ significantly from Group C ($P > 0.05$). The starch gelatinization degree in Group A was significantly lower than in Groups B, C, and D ($P < 0.05$). During the late stage, Group A had significantly lower PDI than Groups B, C, and D ($P < 0.05$). Group C showed significantly higher starch gelatinization than Groups B and D ($P < 0.05$), though Group A' s gelatinization was slightly lower than Groups B and D ($P > 0.05$). No significant differences in pellet hardness were observed among the four groups ($P > 0.05$).

2.2 Effects of Feed Processing Technology and Vitamin Supplementation on Growth Performance

The effects of feed processing technology and vitamin supplementation on growth performance are presented in . During the early stage, no significant differences were found among groups in final body weight, ADG, ADFI, or F/G ($P > 0.05$), with Group D' s F/G only 3.8% higher than Group A. During the late stage, no significant differences were observed in these parameters ($P > 0.05$), with Group D' s F/G only 0.5% higher than Group A. Throughout the entire period (1-42 days), no significant differences were detected in ADG, ADFI, or F/G among groups ($P > 0.05$).

2.3 Effects of Feed Processing Technology and Vitamin Supplementation on Slaughter Performance

The effects of feed processing technology and vitamin supplementation on slaughter performance are shown in . No significant differences were found among groups in live weight, slaughter weight, leg weight/slaughter weight, breast meat weight/slaughter weight, heart weight/slaughter weight, liver weight/slaughter weight, spleen weight/slaughter weight, muscular stomach weight/slaughter weight, glandular stomach weight/slaughter weight, or in the length and weight of the duodenum, jejunum, and ileum ($P > 0.05$).

Discussion

3.1 Effects of Feed Processing Technology on Pellet Quality

Optimal formulations and high-quality raw materials can only produce superior feed when processed through reliable equipment and scientific processes. Once the formulation is established, processing technology becomes a critical factor affecting pellet quality. Current livestock feed processing technologies include conventional processing, expanded ingredient low-temperature pelleting, double pelleting, and clean powder production. Expanded ingredient low-temperature pelleting and double pelleting are commonly used in piglet feed, while clean powder production is often applied in layer feed. Sun Jie [8] systematically compared different piglet feed processing technologies and found significant effects on pellet quality and piglet growth performance. Yang Dechuan et al. [9] reported that clean powder production is increasingly adopted in livestock feed manufacturing to produce high-quality products. In this study, Group A used conventional processing while Groups B, C, and D used high-efficiency conditioning and low-temperature pelleting. During the early stage, Group B showed significantly higher PDI than Groups A and D, but not significantly different from Group C. However, differences among groups did not exceed 1%, likely due to non-significant differences in starch gelatinization during the early stage. Gelatinized starch acts as a binder during pelleting, and higher gelatinization generally increases PDI. During the late stage, Group C exhibited significantly higher starch gelatinization than other groups, possibly due to higher steam addition, which directly affects gelatinization degree.

3.2 Effects of Feed Processing Technology and Vitamin Supplementation on Growth Performance

Vitamins are essential micronutrients that must be obtained from feed to maintain normal physiological functions, playing vital roles in growth, metabolism, and development. Since monogastric animals cannot synthesize most vitamins, they must acquire them from feed. While feed processing improves raw material utilization, it also causes significant vitamin destruction. Lewis et al. [10] investigated the effects of conditioning temperature and time on vitamin retention, finding that 88°C resulted in significantly lower retention than 77°C. Processing technology also affects vitamin retention beyond just temperature and time. Yan Fangfang [11] studied the effects of different processing technologies on vitamin retention in fish feed, finding that vitamin C crystal loss reached 71% during pelleting, with the conditioning stage causing the highest losses. Considering these losses, Shi Yongfeng [12] reported safety factors for vitamin supplementation, with niacin requiring a minimum safety factor of 1–3. Previous studies have shown that vitamin supplementation promotes broiler growth performance [13-15]. In this study, Group A had a vitamin safety factor of 2.5, while Group D had the lowest at 1.28. The lack of significant differences in growth performance suggests that vitamin losses were higher in Group A and lower in Groups B, C, and D, resulting in similar final vitamin concentrations across groups. Although formulated vitamin levels were analyzed, the low supplementation rates prevented detection in the finished feed. Therefore, based on the non-significant differences observed, we can infer that the high-efficiency conditioning and low-temperature pelleting process can save vitamin usage. The slightly higher F/G in experimental groups compared to the control (by approximately 0.02) may be attributed to broiler health status during the trial, and the lack of statistical significance indicates that reducing vitamin supplementation did not significantly affect growth performance.

3.3 Effects of Feed Processing Technology and Vitamin Supplementation on Slaughter Performance

Vitamins are essential nutrients that improve animal growth performance, immune function, and meat quality [16]. Xie Hongbing et al. [14] found that vitamin C and E and their interactions improved broiler growth performance. Other studies have reported that dietary vitamins enhance growth performance, antioxidant capacity, meat quality, and phosphorus metabolism in bone [17]. However, this study found no significant differences among groups in slaughter weight, organ weights relative to slaughter weight, or intestinal dimensions. This may be because processing losses resulted in similar effective vitamin concentrations across groups. These findings align with Zhang Min et al. [18], who reported that increasing vitamin E supplementation improved slaughter performance and lipid metabolism but without significant differences among groups. Similarly, Lei Jianping et al. [19] found that increasing vitamin D3 supplementation improved organ indices and meat quality in yellow-feathered broilers, but differences were not significant. Therefore, when considering the effects of heat-sensitive feed ingredients like vitamins on animal performance, one must account not only for supplementation level and type but also for retention rates during feed processing.

Conclusions

1. The high-efficiency conditioning and low-temperature pelleting process for broiler diets can reduce vitamin usage without significantly affecting growth or slaughter performance compared to conventional feed processing technology.

2. Pelleted feed produced using this technology achieves PDI values above 96% for both early and late-stage diets, with starch gelatinization degrees slightly higher than those from conventional processing.

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