



Original research article

Effects of feed form and feed particle size on growth performance, carcass characteristics and digestive tract development of broilers



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ABSTRACT

This study was conducted to evaluate the effects of feed form (mash and crumble-pellet) and feed particle size (fine, medium and coarse) on growth performance, carcass characteristics and digestive tract development of broilers. A total of 1,152 one day-old Ross 308 mixed-sex broilers were used in a factorial arrangement (2×3) based on a completely randomized design with six replicates of 32 birds each. Higher average daily gain (ADG) and average daily feed intake (ADFI) were observed ($P < 0.01$) for birds fed the crumble-pellet diets (CPD) than for those fed the mash diets (MD) during starter, grower and the entire experiment period. From d 1 to 40, birds fed CPD had a higher ($P < 0.01$) body weight (BW) than those fed MD. Birds fed CPD had a lower ($P < 0.01$) feed:gain ratio (F:G) during the starter phase than those fed MD. Medium or coarse particle size increased ($P < 0.01$) ADG and ADFI during the starter phase, but birds fed fine particle size diets had lower ($P < 0.01$) F:G during the grower phase. In MD, medium and coarse particle sizes resulted in higher ($P < 0.05$) BW, ADG and ADFI than fine particle size during the whole experiment. In CPD, particle size had no significant effect on growth performance, as indicated by a feed form \times particle size interaction ($P < 0.05$). At 41 days of age, ten birds per treatment were randomly selected and killed for slaughter yields and digestive tract characteristics determination. It was shown that particle size and feed form alone had no significant effect on slaughter yields, so changes was the feed form \times particle size interaction. The relative empty weight of the gizzard was greater ($P < 0.01$) and the relative length of the ileum was longer ($P < 0.05$) in birds fed MD than in those fed CPD. Overall, CPD improved growth performance during the entire period of the study with effects being less evident during the finisher phase than during the starter and grower phases, and the effect of feed particle size varied depending on feed form.

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1. Introduction

Physical feed form is considered to have a very significant impact on broiler growth and feed intake (Dozier et al., 2010). Feed form and feed particle size of cereals require a significant amount of attention when producing broiler feed. Today, commercial feed

mills are producing different forms of broiler feed for birds at different ages (Jahan et al., 2006). While feed processing to change feed form increases the cost of feed it can be balanced out by improved performance. Many researchers report that broilers fed pelleted diets have higher BW and improved feed conversion than those fed mash feed (McKinney and Teeter, 2004; Amerah et al., 2008; Chewning et al., 2012), and today pelleting has become a common processing method widely employed by the feed manufacturers to improve farm animal performance. Compared with mash, pellets enhance bird performance by decreasing feed wastage, alleviating selective feeding, destroying pathogens, improving palatability and increasing nutrient digestibility. One disadvantage is that pelleting costs about 10% more than producing mash feed (Jahan et al., 2006). With regards to feed particle size, one traditional view was that a smaller particle size would be

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associated with a larger surface area of the grain, possibly resulting in higher digestibility in poultry due to a greater interaction with digestive enzymes in the gastrointestinal tract (Preston et al., 2000). In more recent years, however, it is thought that a large particle size aided by some structural components is beneficial to gizzard functions and gut development (Hetland et al., 2002; Svihus et al., 2004; Choct, 2009).

The objective of this study was to investigate the effects of feed form (mash and crumble-pellet) and feed particle size (fine, medium and coarse) on broiler performance and development of the digestive tract.

2. Material and methods

The study was approved by the Animal Care and Experiment Committee of New Hope Liuhe Corporation. The experiment was divided into three phases, i.e., starter (d 1 to 21), grower (d 22 to 32) and finisher (d 33 to 40). A total of 1,152 one day-old Ross 308 mixed-sex broilers (1:1 ratio of males and females) were used in a completely randomized design with six treatments and six replicates of 32 birds each. They were arranged in a 2×3 factorial design: two feed forms (mash and crumble-pellet) and three feed particle sizes (fine, medium and coarse). The pelleting process was performed at a temperature of 75°C, and pellets were 4 mm in diameter. The pellets were crumbled in a roller mill, resulting in a crumbled diet. The 3 particle sizes were achieved by grinding the wheat, corn and soybean meal in the hammer mill to pass through 2-, 5- and 8-mm sieves, then particle size of the three ingredients was measured. The particle sizes for corn were 573, 865, 1,027 μm , for wheat 566, 1,110, 1,183 μm , and for soybean meal 490, 842, 880 μm , respectively. The particle size was determined by the method devised by the American Dairy Science Association (1970).

Birds on mash treatments were fed mash diets from d 1 to 40, whereas those on crumble-pellet diets were fed crumbles from d 1 to 21 and pellets from d 22 to 40. Corn and soybean meal-based diets (Table 1) were formulated to meet Ross 308 strain recommendations and differed only in particle size and feed form. Uniformity in the management practices was maintained as much as possible. The birds were housed in 200×180 cm floor pens with 4 nipples per pen. Initial room temperature was 34°C and was then decreased by 2°C per week until a temperature of 26°C was achieved. Feed and water were supplied *ad libitum*. All birds were immunized according to the routine immunization program, and the health and wellbeing of the birds was observed every day.

On d 1, 21, 32 and 40, chicks were weighed by pen and feed consumption was recorded. ADG, ADFI, F:G, and BW, including mortality weight, were calculated for each phase. On d 41, ten birds per treatment were randomly selected and weighed, then killed by exsanguinations after CO₂ stunning. After removal of feathers, feet and head, carcass yield was determined. Cut-up parts such as thigh, breast and abdominal fat were weighed. Meanwhile, proventriculus, gizzard, duodenum, jejunum and ileum were removed and the empty digestive tracts were weighed. In addition, the length of the small intestines was also measured.

All the data were analyzed by the GLM procedures of SAS 9.1. The statistical model included the effects of feed form (mash vs. crumble-pellet), feed particle size (fine, medium and coarse), and their interactions. Results were expressed as least squares means and standard error of the means (SEM). Duncan mean separation test was used to determine significant differences between treatment mean values ($P < 0.05$).

Table 1

Diet composition and nutrient levels (as-fed basis).

Items	d 1 to 21	d 22 to 32	d 33 to 40
Ingredients, %			
Corn	48.98	49.64	50.15
Wheat	10.00	15.00	20.00
Soybean oil	2.74	3.30	4.09
Soybean meal	34.57	28.73	22.77
Limestone	0.95	0.95	0.94
Dicalcium phosphate	1.88	1.50	1.12
Sodium chloride	0.31	0.31	0.31
L-Lysine	0.00	0.04	0.11
DL-methionine	0.17	0.13	0.11
Premix ¹	0.40	0.40	0.40
Total	100.00	100.00	100.00
Calculated analysis			
Crude protein, %	21.00	19.00	17.00
Calcium, %	0.90	0.80	0.70
AME, Kcal/kg	2,820	2,920	3,020
Lysine, %	1.00	0.90	0.80
Methionine + Cystine, %	0.76	0.68	0.61

¹ Supplied per kilogram of complete diet: Mg, 100 mg; Zn, 75 mg; Fe, 80 mg; I, 0.65 mg; Cu, 80 mg; Se, 0.35 mg; vitamin A, 9,000 IU (retinyl acetate); vitamin D₃, 2,000 IU (cholecalciferol); vitamin E, 11 IU (DL- α -tocopheryl acetate); vitamin K₂, 1.0 mg; vitamin B₁, 1.2 mg; vitamin B₂, 5.8 mg; niacin, 66 mg; pantothenic acid, 10 mg; vitamin B₆, 2.6 mg; biotin, 0.10 mg; folic acid, 0.7 mg; vitamin B₁₂, 0.012 mg.

3. Results

3.1. Growth performance

The effects of feed particle size and feed form on broiler performance are shown in Table 2. During the starter phase, medium or coarse particle size increased ($P < 0.01$) broiler ADG and ADFI significantly. Birds fed with crumble-pellet diets had better performance than those fed with mash diets ($P < 0.01$). Interaction for ADG and ADFI was significant ($P < 0.01$) between feed particle size and feed form. In the grower phase, birds fed the fine particle size diets had lower ($P < 0.01$) F:G than those fed medium or coarse particle size diets. Interaction for ADFI between feed particle size and feed form was significant ($P < 0.05$). No significant effect for performance was observed in the finisher phase ($P > 0.05$). During the whole period, particle size had no significant effect on broiler performance ($P > 0.05$), while birds fed with crumble-pellet diets had higher BW, ADFI and ADG than those fed with mash diets ($P < 0.01$). The interaction between feed particle size and feed form was significant for BW, ADFI and ADG. The survival rate did not differ significantly between crumble-pellet and mash fed birds, nor between different particle size treatments.

3.2. Carcass characteristics and digestive tracts development

There was no remarkable difference for carcass yield values (Table 3) among all treatments and yields ranged from 74.2 to 75.9%. Similarly, other carcass traits such as breast, thigh and abdominal fat relative weight showed little variation ($P > 0.05$). No feed particle size \times feed form interaction for carcass traits was observed in this study.

Among the relative empty weight of digestive tracts, the gizzard weights of crumble-pellet fed birds were significantly ($P < 0.05$) lower than mash fed birds measured on day 41 (Table 4). Further to that, the ileum weight decreased progressively with feed particle size, and the ileum length differed between birds fed crumble-pellet and mash diets. No feed

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