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Effects of physical form of diet and intensity and duration of feed restriction on the growth performance, blood variables, microbial flora, immunity, and carcass and organ characteristics of broiler chickens

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ABSTRACT

This study was conducted to investigate the effects of physical form of diet and duration and intensity of feed restriction on growth performance, carcass and organ characteristics, immunity, cecal microbiota, and hematology of broiler chickens. Four hundred male broiler chickens (approximately 44.0 g) were randomly assigned to 10 treatment groups with 4 replicate cages with 10 broiler chickens per cage. Dietary treatments consisted of diet form (pellet and mash), intensity of feed restriction (12.5 and 25%), and duration of feed restriction (7 and 14 d) in a $2 \times 2 \times 2$ factorial arrangement of treatments. Two additional treatments, pellet and mash control diets without feed restrictions, were included. Feed intake (FI) and weight gain (WG) were recorded weekly. At the end of the study (at 42 d of age), 1 chicken per replication and 4 chickens per treatment were selected for blood collection. Carcass composition, cecum microflora, and characteristics of gastrointestinal tracts were also assessed. The humoral immune responses of chickens to Newcastle vaccine, influenza vaccine, and sheep red blood cells (SRBC) were measured at 15 and 26, 31 and 40, and 28 and 35 d of age, respectively. Broiler chickens fed the pelleted diet had greater FI ($P < 0.01$), WG ($P < 0.01$), carcass weight ($P < 0.01$), and breast ($P < 0.01$) relative to the carcass weight, better feed conversion ratio ($P < 0.01$), and lower weight of pancreas ($P < 0.01$), duodenum ($P = 0.02$), and cecum ($P < 0.01$) relative to the carcass weight than those fed the mash diet. Compared with broiler chickens fed the mash diet, the Lactobacillus concentration in cecum decreased ($P < 0.01$) and plasma total protein and globulin concentrations increased ($P = 0.01$ and 0.02, respectively) in those fed the pelleted diet. Physical form of the diet did not affect antibody titres against Influenza, Newcastle disease, and SRBC. Within the diet form, feed restriction had a limited influence on the traits studied at slaughter compared with the pellet or mash diet feed restriction. In conclusion, the diet form played an important role on the growth performance and carcass characteristics of broiler chickens, whereas the feed restriction seemed to be insufficient to markedly improve the feed conversion ratio and carcass characteristics of broiler chickens at slaughter.

1. Introduction

Constant genetic selection results in broiler chickens with rapid growth rate, although this improvement in performance is often associated with an increase in skeletal diseases (Sahraei, 2012). In broiler chickens fed ad libitum, the feed costs often exceed 60% of the total production costs. In addition, over-feeding often leads to a reduction in the quality of carcass and increase in fat deposition (Aliakbarpour et al., 2013). Feed restriction programs followed by re-feeding periods have been introduced in the management of broiler chickens to reduce feed cost and improve feed efficiency through the compensatory growth mechanism. However, the effect of feed restrictions on broiler chicken performance is variable (Lippens et al., 2009; Sahraei, 2012). Furthermore, although feed restriction reduces mortality and leg abnormalities (Lippens et al., 2000; Wijttens et al., 2010), its effect on carcass fat deposition is controversial (Urdaneta-Rincon, Leeson, 2002). The inconsistency of these results may be due to many factors, including the intensity and duration of feed restriction. It should also be realized that a suppression effect of feed restriction on immune system of broiler chickens cannot be excluded (Cook, 1991).

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Another factor that is able to modify the performance of broiler chickens is the diet form. Pelleted diet enhances feed intake and growth of animals probably because it reduces feed waste, decreases energy expended for consumption, improves palatability, and reduces dustiness of feed (Abdollahi et al., 2013). However, as compared to the mash diet, the pelleted diet can reduce starch digestibility (Svihus, 2001), modify intestinal characteristics and microflora (Abdollahi et al., 2013; Engberg et al., 2002), and increase mortality of broiler chickens (Brickett et al., 2007). Consequently, the diet form could interact with feed restriction and compensatory growth mechanism to decrease the performance and health of broiler chickens. Lippens et al. (2009) observed that feed restriction of 20% from the ad libitum intake level from 4 to 7 d leads to different growth patterns in broiler chickens fed either the pellet or the mash diet.

Although the effect of diet form and feed restriction programs on broiler chicken performance have been widely investigated, little research has been done to simultaneously study the collective effects of diet form and intensity and duration of feed restriction on not only the growth performance but also on metabolism, immunity, and intestine characteristics of broiler chickens. Hence, the objective of this study was to investigate the effects of physical form of diet and duration and intensity of feed restriction on performance, carcass and organ characteristics, immunity, cecal microbiota, and hematology of broiler chickens.

2. Materials and methods

The experiment was conducted at a commercial poultry farm located at Lahidjan city in Iran. All procedures used in this experiment were approved by the Animal Ethics Committee at the Islamic Azad University, Rasht Branch, Iran.

2.1. Animal, management, and diets

A total of 400 male broiler chickens (Ross 308; Aviagen, Huntsville, AL) with similar body weight (44.0 ± 0.4 g) were randomly assigned to 10 treatment groups with 4 replicate cages and 10 broiler chickens per cage. Dietary treatments consisted of diet form (pellet and mash), intensity of feed restriction (12.5 and 25%), and duration of feed restriction (7 and 14 d) in a $2 \times 2 \times 2$ factorial arrangement of treatments. Two additional treatments, pellet and mash control diets without any feed restrictions, were included.

Broiler chickens were housed in floor cages ($1.4 \times 1.0 \times 0.5$ m). Broiler chickens in different treatments were equally distributed between first, middle, and end positions to minimize the effect of the location of cages. All broiler chickens were fed ad libitum before and after the restriction period that started at 8 d of age. The ingredient composition as well as the calculated nutrient composition of the diets used during starter (1–14 d of age), grower (15–28 d of age), and finisher periods (29–42 d of age) are presented in Table 1. Nutritional requirements were provided based on the standard recommendations (Ross, 2007). Broiler chickens were not able to consume feed assigned to the adjoining replicate. Moreover, each floor cage was equipped with an individual feeder and nipple drinker, and water was supplied ad libitum throughout the experimental period. All broiler chickens were housed in a windowless and environmentally controlled room, with room temperature kept at 32 to 22 °C based on broiler chicken age. Light cycle was maintained at 23 h/d during rearing period. The study was conducted during 1–42 d of age.

2.2. Sample collection and measurements

Feed intake and body weights were recorded weekly to calculate weight gain (WG) and feed conversion ratio (FCR). During the study, 4 broiler chickens per treatment (1 broiler chicken per replication) were randomly selected and their blood samples were collected at 15 and 26 d, at 31 and 40 and at 28 and 35 d of age to assess their humoral immune response to Newcastle disease vaccine, avian influenza vaccine, and sheep red blood cells (SRBC), respectively. At slaughter (42 d of age), 4 chickens per treatment (1 chicken per replication) were selected for assessment of carcass, organs, and gastrointestinal segments, and for blood and cecal microflora analysis. Care was taken to choose the most representative broiler chicken with respect to body weight compared to the cage mean body weight. After slaughter and plucking operations, the head and legs were removed and broiler chickens were eviscerated. The carcass, organs, and gastrointestinal segments were weighed followed by measurement of duodenum, jejunum, ileum, cecum, rectum, and colon. Relative weights (RW) were calculated as [weight of cut, organ or gastrointestinal segment (g)/100 g of carcass weight].

Table 1
Ingredients and chemical composition of diets used during starter (1–14 d of age), grower (15–28 d of age), and finisher periods (29–42 d of age).

Item	Starter	Grower	Finisher
Ingredients (g/kg as-fed)			
Corn	413	464	471
Soybean meal	363	240	202
Wheat	130	220	25.0
Soybean oil	15.0	8.5	10.0
Maize gluten meal	20.0	0	0
Canola meal	0	30.0	30.0
Na chloride	2.4	3.0	2.9
Dicalcium phosphate	15.0	12.5	11.6
Ca carbonate	10.8	10.7	11.0
Na bicarbonate	2.2	0.9	1.1
DL-Met	2.7	1.4	1.5
Lys≅HCl	2.2	0.6	1.1
Vitamin premix[a]	1.0	1.0	1.0
Mineral premix[b]	1.0	1.0	1.0
Multi-enzyme	0.3	0.3	0.3
Phytase	0.3	0.3	0.3
Disinfectant liquid	0.5	0	0
Powdered milk	20	0	0
Bentonite	0	5.4	5
Prebiotics	1.7	0	0
Salinomycin	0.0	0.5	0.1
Calculated chemical composition (g/kg unless stated otherwise)			
Metabolizable energy (MJ/kg)	11.8	11.3	12.2
Crude protein	223	201	177
Ether extract	38.5	33.6	35.0
Linoleic acid	17.2	15.5	16.0
Crude fiber	39.9	37.1	34.4
Ile	9.3	8.1	6.8
Leu	18.8	16.2	14.1
Lys	13.5	11.1	11.0
Met	6.0	4.7	4.2
Thr	8.6	7.7	6.6
Trp	2.8	2.5	2.1
Val	10.4	9.2	7.9
Available P	4.9	4.5	4.2
Ca	9.8	9.3	9.0

[a] Mineral premix provided per kilogram of diet: *trans*-retinol, 5000 IU; cholecalciferol, 500 IU; α-tocopherol acetate, 3 mg; menadione, 1.5 mg; riboflavin, 1 mg; Ca pantothenate, 4 mg; niacin, 15 mg; and pyridoxine, 13 mg.
[b] Vitamin premix provided per kilogram of diet: Cu, 3 mg; Zn, 15 mg; Mn, 20 mg; Fe, 10 mg; and K, 0.3 mg.

2.3. Cecum microflora

To determine the presence of bacteria, agar plates were