ORIGINAL ARTICLE

Veterinary Research Forum. 2024; 15 (8): 391 - 396
doi: 10.30466/vrf.2024.2019127.4115
Journal Homepage: vrf.iranjournals.ir

Veterinary Research Forum

Effect of wet feeding on performance, blood plasma indices, intestinal histomorphometry, and economics of broiler chickens under hot climatic conditions

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Article Info

Article history:

Received: 30 December 2023
Accepted: 07 May 2024
Available online: 15 August 2024

Keywords:

Blood plasma
Economics
Histomorphometry
Performance
Wet feed

Abstract

The study aimed to investigate the impact of wet feeding on broiler chicken performance and intestinal histomorphometry. The research was conducted at the Veterinary College, Udaipur, India, using 144 commercial broiler chicks from day 1 to 6 weeks of age. The chicks were divided randomly into three experimental groups, each with four replicates comprising 48 birds. The control group (G1) was fed dry; while, group 2 (G2) received wet feed supplemented with 1.00 g water *per* g of feed and group 3 (G3) received wet feed supplemented with 1.20 g water *per* g of feed. Results revealed that G3 had significantly superior feed conversion ratios, lower feed intake, and increased body weight and weight gain compared to G2 and G1. Among the three treatment groups, there were no variations in blood plasma indicators. In comparison with G1, duodenum and ileum in G2 had higher villus height. The G3 revealed higher net profit margins and 18.89% saving of feed compared to G1, suggesting that it may be a valuable tool for lowering chicken feed costs.

Introduction

Poultry is widely accepted as a cost-effective and efficient way to transform agricultural and industrial goods into high-quality, nutritionally complete, and affordable animal protein meet human needs for a balanced diet.[1] However, the availability of poultry meat and eggs *per* person *per* year in India is far less than what is recommended by the Indian Council of Medical Research, to reach the recommended levels; multiple inputs, including feed, are necessary for the birds to grow at a rapid rate.[2] One management technique that has recently gained popularity is wet feeding.[3] This technique has been shown to improve feed conversion ratio (FCR), promote nutrient retention, and accelerate growth.[4] It is also known to help birds tolerate high ambient temperatures better than dry diets.[5] In fact; conventional feed ingredient production and supply are not keeping up with the rising demand for poultry products.[6]

Also, high ambient temperatures can negatively impact the productivity of poultry, as they can only regulate their body temperature within a relatively small range of environmental temperatures.[7] To address these challenges, poultry nutritionists are focusing on two main goals including 1) replacing conventional feed ingredients with inexpensive, locally available non-conventional ingredients and 2), nutritional manipulation, such as adding enzymes, probiotics, and acidifiers to poultry diets to increase nutrient availability and uptake and improve feed conversion efficiency.[8]

Wet feeding has been reported to stimulate dry matter intake, increase growth rate, and decrease FCR of broilers.[1,9] Studies have shown significant improvements in the feed intake (FI), FCR, and daily weight gain of broilers when fed on wet feed.[10] Wet feeding, which involves mixing ingredients near the feeding area, allows for more frequent and customized changes to the birds' diet. This means that the major nutrients can be adjusted daily based on the birds' predicted needs depending on factors like growth potential, and environmental temperature. Locally produced materials can be combined with proprietary concentrates on a daily basis to adjust the nutrient content, and trace materials such as amino acids and medicines can be added without needing to order

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large quantities of feed in advance. In other words, the diet can be tailored to the birds' needs on a daily basis or even more frequently, leading to optimal growth and health.[1] However, there is limited information available regarding the effects of wet feeding on broiler chickens in regions with high ambient temperatures, such as Rajasthan, India, where the average summertime temperature is above 41.00 ˚C. Therefore, to address this problem, the current study focused on reducing feed costs using wet feeding method, which can act as an important feeding strategy to overcome feed costs to some extent without compromising poultry performance and health.

Materials and Methods

Location and climate of study area. During the summer season, the experiment was conducted in the poultry unit of the College of Veterinary and Animal Science in Navania, Udaipur, India. The area where the experiment took place has an altitude of 5,988 m above sea level, an annual mean temperature of 32.50˚C, and an annual precipitation of 637 mm.

Birds and experimental design. A total of 144 commercial broiler chicks of Cobb500 strain were used for the study. The chicks were purchased from Kewalramani Hatcheries in Ajmer, Rajasthan, India, and weighed upon arrival. The chicks were randomly divided into three experimental groups, each containing four replicates with 48 birds. The experiment lasted until the chicks reached 42 days of age. The birds were kept in replicate pens, and each pen was covered with 5.00 cm thick wood shavings with an area of 2.00 m^2. The Institutional Animal Ethics Committee approved the research under the AEC/RES/ 02/09 regulations. Throughout the study period, the birds received similar management and care, and deep litter housing system was used. The birds were given infectious bursal disease and Ranikhet disease (F1 strain) vaccinations on the 4th and 14th day, respectively, and monitored closely. Group 1 was the control group (G1) and received dry feed, group 2 (G2) received a fresh wet feed diet prepared by mixing the diet with tap water in a ratio of 1.00 g water *per* g of feed, and group 3 (G3) received a wet feed diet mixed with tap water at a ratio of 1.20 g water *per* g of feed. The birds were offered water and maize-soybean meal-based starter (1 to 21 days) and grower (22 to 42 days) diets *ad libitum* (Table 1). The experimental diets were formulated according to the recommendation of Cobb500 Broiler Performance and Nutrition Supplement Guide.[11] Hygiene procedures were strictly followed throughout the experiment.

Productivity traits. During the experimental period, the body weight of the birds was recorded weekly from the start until the end of the experiment (42 days of age). The FI was estimated by measuring the amount of feed offered and residue left, and the FCR was calculated as FI in g divided by weight gain in g.

Plasma examination. At the end of the experiment, blood samples were collected from six birds *per* group, labeled, and stored at –20.00˚C until analysis. The plasma lipid concentrations, including high-density lipoprotein (HDL), low-density lipoprotein (LDL), total cholesterol, and triglycerides were measured using standard commercial kits (Precision Biomed Pvt. Ltd., Chomu, India).

Intestinal histomorphometry. Four birds from each group were selected randomly and sacrificed for samples at the end of the experiment. The duodenum, ileum and cecum tissue samples were set in Bouin's solution (Central Drug House (P) Ltd., New Delhi, India) for 18 to 24 hr. Following fixation, the samples were dehydrated using ethyl alcohol in increasing concentrations (from 70.00 to 100%), cleaned in xylene and then, prepared to undergo histological analysis. Hematoxylin and Eosin were used to stain sections of 4.00 - 5.00 µm thickness for general morphometry.[12] Using image analysis software, crypt depth and intestinal villi height were assessed (NIH, Bethesda, USA). Four intestinal cross-sections comprising a total of four villi and villus-associated crypts were chosen randomly, and the average was determined.

Table 1. Composition of the broiler starter and grower diets.[11]

Ingredients (%)	Starter diet	Finisher diet
Maize	55.80	69.80
Vegetable oil	4.20	4.70
Soyabean meal	36.32	32.60
Di-calcium phosphate	2.10	1.37
Limestone	1.02	0.97
Vitamin and mineral pre-mix*	0.29	0.29
Salt	0.27	0.27
Total	100	100
Calculated composition		
Crude protein	22.16	19.31
Metabolizable energy (kcal kg^{-1})	2975	3176
Lysine	1.23	0.96
Methionine	0.47	0.43
Methionine + Cystine	0.90	0.82
Tryptophan	0.21	0.19
Threonine	0.85	0.68
Arginine	1.27	1.08
Calcium	0.90	0.75
Available phosphrous	0.44	0.37
Sodium	0.22	0.21
Chloride	0.24	0.24

* Vitamin A: 11,000 IU; Vitamin D_3: 6,000 IU; Vitamin E: 131 mg; Vitamin K_3: 3.71 mg; Vitamin B1: 3.10 mg; Vitamin B_2: 7.99 mg; Vitamin B_6: 4.97 mg; Vitamin B12: 0.19 mg; Niacin: 60.20 mg; Folic acid: 2.09 mg; D-Biotin: 200 mg; Calcium D-pantothenate: 18.35 mg; Copper: 79.00 mg; Iodine: 2.00 mg; Selenium: 150 mg; Iron: 70.00 mg; Manganese: 100 mg; Zinc: 80.00 mg; Cobalt: 500 mg.

Economics of broiler chickens. Broiler chicks rearing cost was determined by taking into considerations the overall cost of production, which included the feeding cost, cost of broiler chicks, labor expenses, medication, vaccination, and overhead costs.

Statistical analysis. The experiment was designed using complete randomization. Data on body weight, weight gain, FI, FCR, and plasma blood parameters were recorded on Microsoft Excel (version 15.0; Microsoft Corporation, Redmond, USA). The experiment's results were presented as the mean ± standard error, and statistical analysis was performed using SPSS Software (version 23.0; IBM Corp., Armonk, USA). One-way analysis of variance was used to analyze the data, and the least significant difference test was used to identify statistically significant differences between means at $p < 0.05$.

Results

Productivity traits. Table 2 presents the results of the performance traits of broiler chickens fed with dry and wet feeds. The dry feed G1 showed a significant decrease ($p < 0.05$) in the final body weight and weight gain compared to the wet feed groups (G2 and G3), which had considerably higher values. The birds fed with wet feed (G2 and G3) recorded significantly ($p < 0.05$) lower feed consumption compared to those fed with dry feed (G1) at six weeks of age. Additionally, the final FCR was significantly ($p < 0.05$) not decreased in the wet feed groups (G2 and G3) compared to the dry feed G1.

Blood plasma examination. As shown in Table 3, the statistical analysis of the plasma lipids contents revealed that the wet feed groups (G2 and G3) caused a numerically higher but insignificant increase in the plasma HDL, LDL, total cholesterol, and triglyceride concentrations than G1 that was offered dry feed.

Intestinal histomorphometry. The duodenum, ileum and cecum of broilers fed with dry and wet feeds showed significant ($p < 0.05$) changes in the intestinal structure, as depicted in Figure 1. Duodenal and ileal villi heights were increased in the birds of G2 compared to the G1 being offered with dry feed.

Economics of broiler chickens. The total cost of production for treatment groups G1, G2, and G3 was 202.40, 201.72 and 179.28 rupees *per* bird, respectively (Table 4). Consequently, the returns earned *per* kg of live bird weight were 226.24, 231.84 and 245.28 rupees for groups G1, G2 and G3, respectively. The net profit was 23.84, 30.12, and 66.00 rupees *per* bird for the G1, G2 and G3, respectively (Table 4).

Discussion

This study reveals that feeding wet feed to birds had a positive impact on their growth performance. This includes an increase in body weight and weight gain, and a decrease in FI and better FCR. Various management practices, including wet feeding, have been proven to be beneficial in reducing the effects of heat stress on birds. The results of the present study are consistent with research reported significant improvements in body weight and weight gain, and a marginal decrease in FI and FCR in the birds fed with wet food.[13] These findings are also supported by the other researchers who observed an improvement in the body weight and weight gain, and a reduction in FI and FCR when broiler chickens were fed wet food (700 g kg^{-1} of feed) compared to the dry feed G1.[14]

Table 2. Effect of wet feeding on performance and blood plasma parameters of broiler chickens.

Parameters	Groups	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
BW (g)	G1	172.70 ± 0.26^{a}	387.85 ± 0.19^{ab}	681.32 ± 0.26	1,062.77 ± 0.10^{a}	1,501.95 ± 3.68^{a}	2,027.34 ± 6.12^{a}
	G2	173.94 ± 0.24^{b}	386.78 ± 0.16^{a}	682.17 ± 0.23	1,063.75 ± 0.11^{b}	1,543.15 ± 2.99^{b}	2,070.15 ± 5.89^{b}
	G3	175.95 ± 0.23^{c}	387.30 ± 0.16^{b}	681.99 ± 0.21	1,063.50 ± 0.16^{b}	1,526.0 ± 3.82^{b}	2,198.57 ± 6.04^{c}
BW gain (g)	G1	138.18 ± 0.03^{a}	215.23 ± 0.32^{c}	293.32 ± 0.30^{a}	381.60 ± 0.23	440.92 ± 3.20^{a}	523.07 ± 6.98^{a}
	G2	138.61 ± 0.07^{b}	212.89 ± 0.34^{b}	295.48 ± 0.27^{ab}	381.37 ± 0.29	475.68 ± 3.80^{b}	520.17 ± 7.12^{a}
	G3	138.68 ± 0.07^{b}	211.25 ± 0.32^{a}	294.68 ± 0.31^{b}	382.11 ± 0.26	461.81 ± 3.50^{b}	672.80 ± 7.29^{b}
FI (g)	G1	143.0 ± 0.61^{b}	364.91 ± 0.15^{b}	486.20 ± 0.32^{b}	658.21 ± 0.42^{b}	864.32 ± 0.07^{b}	1,085.58 ± 0.57^{b}
	G2	139.04 ± 0.63^{a}	363.72 ± 0.11^{a}	481.22 ± 0.28^{a}	655.35 ± 0.39^{a}	863.35 ± 0.05^{a}	1,083.70 ± 0.60^{ab}
	G3	139.16 ± 0.66^{a}	364.08 ± 0.17^{ab}	481.10 ± 0.30^{a}	653.58 ± 0.41^{a}	863.25 ± 0.05^{a}	1,081.00 ± 0.60^{a}
FCR (g)	G1	1.03 ± 0.004^{b}	1.69 ± 0.001^{a}	1.65 ± 0.001^{c}	1.72 ± 0.001^{b}	1.96 ± 0.02^{b}	2.11 ± 0.01^{c}
	G2	1.00 ± 0.002^{a}	1.70 ± 0.002^{b}	1.62 ± 0.002^{ab}	1.71 ± 0.001^{a}	1.83 ± 0.01^{ab}	2.09 ± 0.02^{b}
	G3	1.00 ± 0.002^{a}	1.72 ± 0.002^{c}	1.63 ± 0.004^{b}	1.71 ± 0.001^{a}	1.89 ± 0.02^{a}	1.61 ± 0.01^{a}

BW: Body weight; FI: Feed intake; FCR: Feed conversion ratio.
^{abc} Means in distinct columns with different superscripts differ significantly ($p < 0.05$).

Table 3. Effect of wet feeding on blood plasma parameters of broiler chickens.

Groups	Total cholesterol	High-density lipoprotein	Low-density lipoprotein	Triglycerides
G1	126.18	78.08	36.51	86.47
G2	126.38	78.83	37.29	87.09
G3	126.79	78.10	36.99	86.83

G1: Control; G2: 1.00 g water *per* g of feed; G3: 1.20 g water *per* g of feed.

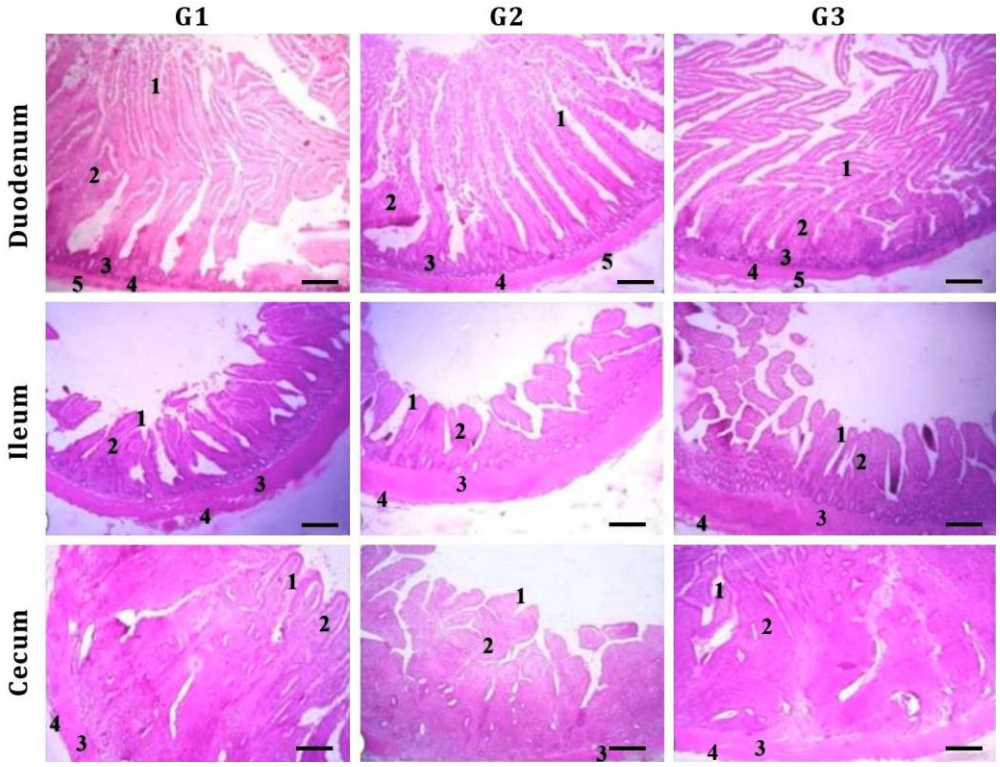

Fig. 1. Photomicrographs of broiler chicken intestine from three treatment groups (n = 48). G1: Control; G2: 1.00 g water *per* g of feed; G3: 1.20 g water *per* g of feed. **Duodenum:** 1) Simple columnar epithelium of tunica mucosa; 2) Connective tissue core of intestinal villi; 3) Intestinal glands; 4) Tunica muscularis; 5) Tunica serosa. **Ileum:** 1) Simple columnar epithelium of tunica mucosa; 2) Connective tissue core of intestinal villi; 3) Tunica muscularis; 4) Tunica serosa. **Cecum:** 1) Simple columnar epithelium of tunica mucosa; 2) Lymphatic cells with substantial deposits of lamina propria; 3) Tunica muscularis; 4) Tunica serosa, (Hematoxylin and Eosin staining; Bars = 100 µm).

Table 4. Effect of wet feeding on the economics of broiler birds.

No.	Particulars	G1	G2	G3
1	Cost of day-old chick (Rupees)	32.00	32.00	32.00
2	Cost of feed in rupees *per* kg or 1700 Rs *per* 50 kg *per* bag	34.00	34.00	34.00
3	Total cost of feed in rupees per kg	34.00	34.00	34.00
4	Average total feed consumption *per* bird in lg	3.60	3.58	2.92
5	Cost of feed consumed *per* bird in (Rupees).	122.40	121.72	99.28
6	*Rearing cost *per* bird in rupees	48.00	48.00	48.00
7	Total cost of production in rupees (1+5+6)	202.40	201.72	179.28
8	Average Body weight at the end of 6th week in kg	2.02	2.07	2.19
9	Price obtained at Rs.112 *per* kg live weight	226.24	231.84	245.28
10	*Net profit *per* bird in (Rs)	23.84	30.12	66.00

G1: Control; G2: 1.00 g water *per* g of feed; G3: 1.20 g water *per* g of feed.

Furthermore, significant results obtained in the FCR were observed to be similar and have been reported in the FCR of laying hens receiving wet feed (800 mL water *per* kg feed) compared to the G1.[1,15]

In this study, it was observed that growth performance was better in the G3, followed by the G2, compared to the G1 which received dry feed. The most likely reason for the beneficial effects of wet feeding on broiler performance is improved feed digestibility. A reduction in food intake, such as FI restriction, results in food particles spending more time in the digestive tract, which, in turn, leads to better digestion. Another reason could be the increased dry matter intake in wet feed, increasing micro- nutrient intake, being responsible for the improved performance of poultry in high environmental temperatures. These results, however, are in disagreement with those of a few other studies who found no change in the weight gain and FCR of broilers and Muscovy ducks when fed dry or wet feeds. Furthermore, it was recorded that wet-fed geese exhibited increased feed consumption and FCR in addition to slightly reduced body weight and weight gain.[15-19]

According to the current investigation, neither the dry nor the wet feeds' effects on the blood plasma values were statistically significant. This is in line with the results of a study that found no relationship between the type of feed and concentrations of total cholesterol, HDL, or blood

glucose.[20] Similarly, it was reported that neither wet feed nor dry feeding had an impact on the growth of Muscovy ducklings in terms of total serum protein, albumin, globulin, aspartate aminotransferase, alanine amino-transferase, glucose, and total cholesterol.[7] However, when compared to the G1, one of the reporters revealed that feeding on wet feed led to a substantial increase in blood metabolites such as blood glucose, total cholesterol, and HDL, as well as a decrease in triglyceride concentrations.[10]

The results of this study demonstrate a significant increase in the height of villi in the duodenum and ileum of birds being fed wet feed. Earlier research on pigs and broilers has shown that providing wet feed can improve gut morphology.[6,13,21] In contrast to broilers being given dry feed, those fed wet feed in a prior study exhibited significantly greater villi height and cecal weight.[3] However, one study found that the histomorphometry of broilers being given wet and dry feeds did not differ significantly.[14]

The birds in G3, which were given the highest water level of 1.20 g *per* g dry feed, had the highest net profit of Rupees/–66.00 *per* bird. The birds in G2, which were given a lower water level of 1.00 g *per* g dry feed, had a net profit of Rupees/– 30.12 *per* bird. The G1 fed with dry feed had the lowest net profit of Rupees/–23.84 *per* bird. The wet feed G3 had a higher profit margin in terms of live weight (Rupees/–245.28 *per* kg) followed by G2 (Rupees/–231.84 *per* kg) than G1 dry feed group (control) which had the lowest profit in terms of *per* kg live weight of Rupees 226.24. The results revealed that supplementing broiler birds' diet with 1.20 g of water for every g of dry feed (G3) resulted in the maximum profit in terms of live weight *per* kg of broiler birds and reduced feed consumption, leading to an 18.89% feed savings over the G1.

It is worth noting that the discrepancies in the observations could have been caused by variations in the amount of water supplementation in the feed, the breed of broiler bird, climatic conditions, and other factors. However, there is no literature available to support or refute the economics of wet feeding on broiler birds.

In this experiment, wet feeding resulted in a more effective conversion of food to weight increase, which decreased production costs. The results show that wet feeding during heat stress significantly improves the performance of broiler chickens. Increased utilization efficiency by broiler chickens can be achieved by combining poultry food with water to create a porridge consistency (around 1.20 g of water for every g of dry food). Wet feeding is particularly suitable for warm and dry regions like Rajasthan, India, where there is a lower risk of problems with wet litter. Interestingly, the current research indicates that adding water to chickens' diet during hot weather reduces feed costs by 18.89% without compromising bird performance, making it a cost-effective solution for poultry rearers. However, further research is needed to understand the relationship between feed intake and its ability to retain water at a molecular level.

Acknowledgments

The author expresses gratitude to the In-charge Poultry Unit of the Livestock Farm, College of Veterinary and Animal Science, Navania, Udaipur, Rajasthan University of Veterinary and Animal Sciences, India, for providing the necessary facilities to conduct this research.

Conflict of interest

The author declares no conflict of interest.

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