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RESPONSE OF BROILER CHICKEN TO DIETARY SUPPLEMENTATION OF ORGANIC ACIDS

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ABSTRACT

The aim of the study was to determine the effect of dietary supplementation of organic acids on the performance, gut health and carcass characteristics of broiler chicken. Results indicated that the birds fed diets supplemented with organic acids showed significantly ($p<0.05$) higher body weight gains and feed conversion ratio. Maximum improvement was achieved in the group fed 3% fumaric acid in the diet. Differences in the cumulative feed consumption were non-significant ($p>0.05$) among all the treatment groups. Addition of organic acids in broiler diets increased the villus height in all the segments of small intestines but the differences were non-significant ($p>0.05$) in case of ileum. No effect ($p>0.05$) on carcass characteristics was observed among all treatments except for length and weight of small intestines which were significantly ($p<0.05$) increased in the groups fed supplemental organic acids.

Keywords: Broiler chicken, organic acids, performance, gut health, carcass characteristics

INTRODUCTION

High levels of production and efficient feed conversion are the need of the modern broiler industry which to a certain extent could be achieved by the use of specific feed additives. Antibiotic growth promoters and antibiotic resistance are clearly connected and increased concern about the potential for antibiotic resistant strains of bacteria has compelled the researchers to use other non therapeutic alternatives like organic acids, enzymes, probiotics, prebiotics, herbs, essential oils, immunostimulants as feed additives in poultry production. Among these organic acids have showed some potential in this regard in broiler chicken and constitute an important component of modern feeding practices. The nondissociated (non-ionised, more lipophilic) organic acids can penetrate the bacteria cell wall and disrupt the normal physiology of certain types of bacteria [4]. Organic acid supplementation have been reported to decrease colonization of pathogens and production of toxic metabolites, improve digestibility of protein and minerals like Ca, P, Mg and Zn and also serve as substrates in the intermediary metabolism [11]. Dietary supplementation of organic acids increases the body weight and feed conversion ratio in broiler chicken [21] and reduces colonization of pathogens on the intestinal wall, thus preventing damage to the epithelial cells [12]. As against antibiotics, organic acids have properties of lowering chyme pH and consequently enhancing protein digestion [6]. The objectives of the present study were to determine the effect of organic acids supplementation on the performance, gut health and carcass characteristics of broiler chicken.

MATERIALS AND METHODS

An experiment with 315 Cobb broiler chicken was conducted up to 42 days of age. At 7 days, birds were individually weighed and randomly assigned into seven groups having three replicates of 15 chicks each. The chicks were placed in battery cages. The temperature was gradually reduced from 32 to 20^{0}C on day 42. The chicks were maintained on a 24 hours consistent lighting schedule. Fresh feed and water were provided daily and were available ad libitum. The feeding programme consisted of a starter diet until 21 days and a finisher diet until 42 days of age. Birds in the control group were given diets without additives (T_1). The ingredients and composition of the control diet are listed in Table 1. The chemical analysis was done as per AOAC [1]. The other six treatment groups were given the same diets as fed to the control groups, but supplemented with 2% butyric acid (T_2), 3% butyric acid (T_4), 2% fumaric acid (T_4), 3% fumaric acid (T_5), 2% lactic acid (T_6) and 3% lactic acid (T_7). All diets for each period were prepared with the same batch of ingredients and all diets within a period had the same composition.

The chickens were individually weighed weekly and body weight gain was worked out. Weekly feed intake per replicate was measured throughout the experiment and feed conversion ratio (FCR) on weekly basis per replicate was calculated. For histopathological analysis, tissue samples from the duodenum, jejunum and ileum were collected from slaughtered birds and fixed in 10 % buffered formalin saline. Tissues were dehydrated by immersing through a series of alcohols of increasing concentrations (from 70% to absolute), infiltrated with xylene and embedded in paraffin. A microtome was used to make cuts of 5μm which were mounted on glass slides and stained with hematoxylin-eosin. The values were measured using a light microscope. At the end of experimental trial, six birds per treatment group were randomly taken for slaughtering. Birds were fasted for 12 hours and individually weighed before and after slaughtering. After scalding, feather picking and evisceration were performed and different body parts and organs were weighed. The data obtained were statistically expressed as means ± standard error and assessed by analysis of variance (ANOVA) through General Linear Model procedure of SPSS software [22]. Duncan's multiple range test [5] was used to test the significance of difference between means. Differences were considered significant at $p \leq 0.05$.

RESULTS AND DISCUSSION

Birds fed the diets supplemented with organic acids attained higher ($p<0.05$) body weight gains compared to unsupplemented group (Table 2). Highest body weight gains were achieved in the birds fed 3% fumaric acid in the diet. These results are in harmony with the other workers [9, 26, 8, 14] who reported that supplementation of organic acids in broiler chicken improved the body weight gain in broiler chicken. In the present study, the effect of dietary organic acids on body weight gain was highly significant (p<0.05) from 3 to 6 weeks of age confirming earlier results of Senkoylu et al. [20]. The improvement in body weight gain might be due to direct antimicrobial effect of organic acids as reported by Ricke [18] that organic acids may affect the integrity of microbial cell membrane or cell macromolecules or interfere with nutrient transport and energy metabolism causing bactericidal effect. Gunal et al. [7] also reported that the use of organic acid mixture significantly decreased the total bacterial and gram negative bacterial counts in broiler chicken. Furthermore, organic acids supplementation has pH reducing properties in various gastro-intestinal segments of broiler chicken as was observed by Abdel- Fattah et al. [2]. The lowered pH is conducive for the growth of favourable bacteria simultaneously hampering the growth of pathogenic bacteria which grow at relatively higher pH. Together the direct antimicrobial and pH reducing properties of organic acids might have resulted in inhibition of intestinal bacteria leading to the reduced bacterial competition with the host for available nutrients and diminution in the level of toxic bacterial metabolites as a result of lessened bacterial fermentation resulting in the improvement of protein and energy digestibility, thereby ameliorating the weight gain and performance of broiler chicken. Moreover, the increased villus height in the small intestines, as was observed in the present study, has been related to a higher absorptive intestinal surface [13] which might have facilitated the nutrient absorption and boosted the growth promoting effect of organic acid supplementation. The feed consumption was found statistically non-significant (p>0.05) among all the treatment groups (Table 3). These results are in agreement with Hernandez et al. [10] who found no difference in the cumulative feed consumption between the groups fed organic acids and the control group. However, Patten and Waldroup [15] and Pirgozliev et al. [17] found reduction in the feed consumption in the groups fed supplemental organic acids which they have associated with the strong taste associated with the organic acids which would have decreased the palatability of feed and reduced the feed intake but no such effect was observed in the present study. Chicks fed the diets supplemented with organic acids showed a significant (p<0.05) improvement in the FCR as against the chicks fed control diet (Table 4). The improvement in FCR could be possibly due to better utilization of nutrients resulting in increased body weight gain (Table 2) in the birds fed organic acids in the diet. These results are in concordance with the reports of earlier researchers [25, 19] who reported that dietary supplementation of organic acids improved the feed conversion ratio in broiler chicken.

Dietary supplementation of organic acids increased the villus height in duodenum, jejunum and ileum (Table 5) but the values were significant (p<0.05) only in duodenum and jejunum when compared with the control group. The increase in the villus height in different segments of the small intestine may be attributed to the fact that organic acids reduce the growth of many pathogenic or non-pathogenic intestinal bacteria, thereby decrease the intestinal colonization and infectious processes, ultimately reducing the inflammatory reactions at the intestinal mucosa, resulting in the improvement of villus height in the intestines of broiler chicken [13,16].

Slaughter characteristics of broiler chicken (Table 6) fed diets supplemented with organic acids showed no significant differences ($p>0.05$) between various treatments. These results are in agreement with Thirumeignanam et al. [24] who found no effect on the carcass characteristics of broiler chicken fed organic acid based diets. In the present study, it was observed that the chicks fed diets supplemented with organic acids had increased ($p<0.05$) length and weight of small intestines when compared with the control group. Similar observations were recorded by Denli et al. [3] who reported that supplementation of different organic acids resulted in remarkable increase in the intestinal weight and length of broiler chicken. These results could be attributed to the fact that organic acids have direct stimulatory effect on the gastro-intestinal cell proliferation as was reported by other workers that short chain fatty acids increase plasma glucagon-like peptide 2 (GLP-2) and ileal pro-glucagon mRNA, glucose transporter (GLUT2) expression and protein expression, which are all signals which can potentially mediate gut epithelial cell proliferation [23].

An inference could, thus, be drawn from the results of present study that dietary supplementation of organic acids improved the performance in terms of body weight and feed conversion ratio, thus may be incorporated in the diets of broiler chicken as growth promoters.

Table 1: Ingredient and chemical composition of experimental basal diets

Ingredients (%)	Starter (up to 3 wks)	Finisher (3-6 wks)
Maize	52.60	59.70
Soya bean meal	35.80	32.10
Fishmeal	8.50	5.10
Limestone	1.28	1.50
DCP	0.84	0.85
vitamin premix*	0.19	0.19
Trace mineral mixture**	0.23	0.23
Salt	0.30	0.30
L-lysine	0.08	0.03
DL-methionine	0.18	0.10
ANALYZED VALUES:		
Crude protein %	22.49	20.22
Crude fiber %	4.915	4.997
Ether extract %	7.235	8.614
Total ash %	4.013	3.731
CALCULATED VALUES:		
Metabolizable energy (Kcal/Kg diet)	2861.12	2933.92
Calcium %	1.486	1.294

Available phosphorus %	0.756	0.687
Lysine %	1.292	1.073
Methionine %	0.581	0.460

* Vitamin premix provided the following per 2.5 kg of diet: vitamin A 15.000 IU, vitamin D3 1.500 IU, vitamin E 20 mg, vitamin K3 5 mg, vitamin B1 3 mg, vitamin B2 6 mg, niacin 25 mg, Ca-D-pantothenate 12 mg, vitamin B6 5 mg, vitamin B12 0.03 mg, folic acid 1 mg, D-biotin 0.05 mg, choline chloride 400 mg and carophyll-yellow 25 mg.
**Trace mineral premix provided the following per kg of diet : Mn 80 mg, Fe 60 mg, Zn 60 mg, Cu 5 mg, Co 0.2 mg, I 1 mg and Se 0.15 mg.

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Table 2: Average weekly body weight gain (g) of broiler chicken fed diets supplemented with organic acids

Week	Treatment groups						
	C	2% BA	3% BA	2% FA	3% FA	2% LA	3% LA
1-2	222.8 ± 7.08	213.4 ± 7.30	221.2 ± 7.08	211.2 ± 6.96	222.55 ± 7.77	208.2 ± 7.31	216.5 ± 6.03
1-3	471.0 ± 13.3	472.4 ± 10.8	484.8 ± 14.0	473.3 ± 14.7	488.5 ± 13.5	474.4 ± 13.5	482.8 ± 13.7
1-4	790.4a ± 18.9	852.1ab ± 21.4	868.8b ± 24.4	854.4ab ± 23.7	878.7b ± 24.4	846.2ab ± 22.9	866.2b ± 26.56
1-5	1139.2a ± 27.8	1212.5ab ±25.5	1242.4b ± 23.0	1217.6ab ± 24.2	1255.4b ± 27.7	1214.1ab ± 24.4	1235.3b ± 32.4
1-6	1525.4a ± 23.6	1629.8bc ± 27.6	1666.7bc ± 22.1	1631.8bc ± 29.9	1704.2b ± 26.3	1602.4c ± 32.6	1673.0bc ± 26.8

Means within the same row with different superscripts are significantly different (P ≤ 0.05), C = control, BA= butyric acid, FA= fumaric acid and LA= lactic acid.

Table 3: Average weekly feed consumption (g) of broiler chicken fed diets supplemented with organic acids

Week	Treatment groups						
	C	2% BA	3% BA	2% FA	3% FA	2% LA	3% LA
1-2	316.6 ± 5.84	299.3 ± 11.6	302.0 ± 8.08	299.6 ± 8.41	303.3 ± 7.68	300.3 ± 9.90	304.6 ± 9.40
1-3	735.6 ± 18.2	675.6 ± 18.4	688.3 ± 2.65	667.3 ± 22.9	693.6 ± 37.3	678.3 ± 8.29	690.3 ± 23.3
1-4	1359.3 ± 4.67	1329.0 ± 48.5	1372.6 ± 23.5	1315.3 ± 19.9	1362.3 ± 31.2	1320.6 ± 26.5	1351.3 ± 31.4
1-5	2141 ± 29.5	2097.3 ± 12.6	2161.3 ± 49.0	2094.6 ± 53.1	2159.6 ± 26.3	2100.3 ± 28.8	2149.6 ± 28..8
1-6	3081.3 ± 53.0	2998.6 ± 56.3	3083.3 ± 43.3	2986 ± 41.9	3118.6 ± 63.7	2964.3 ± 113.8	3078.3 ± 40.9

C = control, BA= butyric acid, FA= fumaric acid and LA= lactic acid.

Table 4: Average weekly feed conversion ratio of broiler chicken fed diets supplemented with organic acids

Week	Treatment groups						
	C	2% BA	3% BA	2% FA	3% FA	2% LA	3% LA
1-2	1.42 ± 0.04	1.40 ± 0.05	1.37 ± 0.07	1.41 ± 0.05	1.36 ± 0.07	1.44 ± 0.07	1.40 ± 0.05
1-3	1.56 ± 0.05	1.43 ± 0.05	1.41 ± 0.04	1.41 ± 0.06	1.42 ± 0.07	1.43 ± 0.03	1.42 ± 0.03
1-4	1.72a ± 0.06	1.55b ± 0.05	1.57b ± 0.02	1.53b ± 0.02	1.55b ± 0.04	1.56b ± 0.03	1.56b ± 0.03
1-5	1.87a ± 0.03	1.73b ± 0.01	1.73b ± 0.03	1.72b ± 0.08	1.72b ± 0.02	1.73b ± 0.04	1.74b ± 0.06
1-6	2.02a ± 0.03	1.84b ± 0.03	1.85b ± 0.05	1.83b ± 0.05	1.83b ± 0.02	1.85b ± 0.11	1.84b ± 0.03

Means within the same row with different superscripts are significantly different ($P \leq 0.05$), C = control, BA= butyric acid, FA= fumaric acid and LA= lactic acid.

Table 5: Effect of supplementation of organic acids on villus height of small intestines

Parameter	TREATMENT GROUPS						
VILLUS HEIGHT (μm)	C	2% BA	3% BA	2% FA	3% FA	2% LA	3% LA
DUODENUM	1166.88a ±56.32	1252.51ac ±29.83	1410.38bc ±46.41	1237.84ac ±24.85	1378.05bc ±20.55	1161.40a ±30.85	1321.61c ±38.53
JEJUNUM	984.05a ±25.77	1117.28b ±27.41	1124.72c ±28.40	1106.75b ±31.01	1256.94c ±48.08	1074.2b ±13.03	1212.95c ±21.88
ILEUM	676.13 ± 49.03	739.17 ± 46.15	876.32 ± 22.37	898.85 ± 103.8	841.0 ± 29.46	749.19 ± 46.68	863.71 ± 66.42

Means within the same row with different superscripts are significantly different ($P \leq 0.05$), C = control, BA= butyric acid, FA= fumaric acid and LA= lactic acid.

Table 6: Slaughter characteristics of broiler chicken supplemented with dietary organic acids

Parameters	Treatment groups						
	C	2% BA	3% BA	2% FA	3% FA	2% LA	3% LA
Dressing percentage*	70.79 ± 0.63	71.74 ± 0.57	72.70 ± 0.79	71.77 ± 1.35	72.07 ± 0.97	70.77 ± 1.43	71.30 ± 0.38
Ready to cook yield (%)*	76.30 ± 0.79	76.47 ± 0.65	77.62 ± 0.96	77.73 ± 1.22	77.18 ± 1.02	76.42 ± 1.37	76.57 ± 0.40
Length of small intestines (cm)	174.40a ± 2.07	180.56bc ± 1.97	182.63bc ±1.61	179.40ab ± 1.33	180.43bc ± 0.40	181.56bc ± 2.31	185.43c ± 1.10
Weight of small intestines (g)	43.36a ± 1.16	49.46b ± 1.14	51.43bc ± 0.83	48.43b ± 0.90	48.23b ± 1.47	51.66bc ± 1.53	53.60c ± 1.00
Gizzard weight (g)	38.33 ± 0.88	36.33 ± 2.72	38.0 ± 3.05	43.33 ± 2.33	40.66 ± 0.33	42.66 ± 4.09	41.66 ± 4.40
Heart weight (g)	10.33 ± 0.33	10.0 ± 0.57	12.0 ± 1.52	10.0 ± 1.00	11.0 ± 1.15	11.0 ± 1.52	0.55 ± 0.66
Liver weight (g)	41.66 ± 3.17	49.0 ± 2.51	47.33 ± 0.88	50.0 ± 1.73	44.66 ± 1.20	51.66 ± 6.00	41.33 ± 4.05
Total giblets weight (g)	90.33 ± 2.02	95.33 ± 5.69	97.33 ± 2.40	103.3 ± 4.66	96.33 ± 2.60	105.3 ± 7.26	92.66 ± 3.38
Blood weight (g)	107.3 ± 16.3	126.0 ± 23.4	114.3 ± 16.8	123.3 ± 16.0	137.6 ± 31.7	146.0 ± 16.2	123.0 ± 3.60
Feather weight (g)	160.6 ± 24.9	212.6 ± 17.1	184.3 ± 17.3	186.6 ± 9.82	172.6 ± 31.4	221.0 ± 19.0	198.0 ± 5.29
Head weight (g)	50.0 ± 5.77	53.3 ± 3.33	65.0 ± 8.66	58.3 ± 4.40	55.0 ± 7.63	56.6 ± 12.0	50.0 ± 5.57
Shank weight (g)	84.6 ± 9.95	101.3 ± 12.1	103.6 ± 4.09	91.0 ± 4.92	92.3 ± 5.36	97.0 ± 14.2	78.6 ± 0.66
Breast weight (g)	377.3 ± 7.68	412.8 ± 17.3	466.8 ± 24.0	435.8 ± 24.7	421.8 ± 28.3	387.3 ± 21.0	399.3 ± 7.05
Drumsticks weight (g)	157.3 ± 6.43	188.8 ± 16.6	208.5 ± 2.02	181.5 ± 10.8	181.5 ± 3.28	179.8 ± 13.7	186.3 ± 8.41
Thighs weight (g)	186.0 ± 4.58	199.1 ± 11.3	232.0 ± 14.7	210.5 ± 4.09	203.0 ± 17.2	215.6 ± 12.3	192.0 ± 4.61
Wings weight (g)	105.6 ± 31.8	145.6 ± 6.99	156.3 ± 7.62	139.3 ± 5.60	149.5 ± 7.36	141.8 ± 10.8	137.0 ± 2.51
Back weight (g)	229.6 ± 8.37	259.5 ± 25.9	291.6 ± 6.00	272.1 ± 18.1	291.5 ± 14.0	264.8 ± 24.8	260.6 ± 21.6
Neck weight (g)	51.66 ± 2.18	66.33 ± 11.6	73.83 ± 3.21	53.33 ± 10.8	66.83 ± 10.2	54.33 ± 1.85	77.66 ± 6.48

Means within the same row with different superscripts are significantly different ($P \leq 0.05$), C = control, BA= butyric acid, FA= fumaric acid and LA= lactic acid.