The Effect of Citric Acid on Performance and Carcass Characteristics of Broiler Chickens

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Abstract
The objective of this study was to investigate the effect of dietary citric acid (CA) on the performance and carcass characteristics of broiler chickens. A total of 240 one-day-old Ross 308 broiler chickens were randomly assigned to four groups (n=60) and reared for a period of 42 days. The drinking water of groups 1, 2, 3 and 4 was supplemented with 0%, 0.50%, 1% or 1.50% CA. At the age of 42 days, 10 birds from each group were slaughtered. The results indicated that birds with CA additions were heavier compared with control birds (P<0.05). Feed consumption was improved (P<0.05) in birds of the CA groups. Citric acid supplementation did not have a significant effect (P>0.05) mortality of broiler chickens. We observed higher (P<0.05) breast, liver, gizzard and small intestine percentage in the groups that were added CA. Thick percentage and carcass yield were not affected (P>0.05) by dietary treatments. Significant reduction (P<0.05) in abdominal fat weight was found with increased level of citric acid in drinking water. It may, therefore, be concluded that the addition of 1.50% CA in drinking water has most effective effect in broiler chickens fattening.

Keywords: carcass, chicken, citric acid, fattening, performance.

1. Introduction

Antibiotic growth promoters have been used in broiler nutrition to improve body weight and feed efficiency [1].
However, there are consumer fears that their addition in feed may promote resistant strains of pathogens against those antibiotics. Some researchers have found that antibiotic growth promoters [2] caused development of resistant strain of pathogen in the human population via the food from animal origins. In some cases, the antibiotics are thought to have caused development of resistant strains of pathogens in the host animal [3].
Thus, the researchers developed physiological additives such as acidifiers, prebiotics, and probiotics to raise immunity and improve performance. These additives help in the development of normal physiological functions in animals or meet their deficiencies [4,5].
Organic acids have been used for decades in feed preservation, either for protecting feed from microbial and fungal destruction or to increase the preservation effect of fermented feed, e.g. silage [6].
Organic acids, if used correctly along with nutritional, managerial and biosecurity measures, they can be a powerful tool in maintaining the health of the gastrointestinal tract of poultry,

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resulting in improving their performances. Feeding of organic acids may suppress the growth of certain species of bacteria, particularly acid intolerant species such as *E. coli*, *Salmonella* sp. and *Campylobacter* sp. [7].
Citric acid (CA) has been used in diets due to its positive effect on broiler chicken's health and growth [8]. Citric acid shows sufficient antimicrobial activity to preserve feed against bacterial spoilage, but simultaneously reduces the levels of undesirable bacteria in the gastrointestinal tract can ultimately improve growth rate [9,10].
This study aims at investigating the effect of different levels of citric acid in drinking water on productivity, carcass characteristics and organ development of broiler chickens.

2. Materials and methods

A total of 240 one-day-old Ross 308 broiler chicks were housed in a close ventilated broiler house with deep litter. Temperatures were maintained at 33°C in the 1st week and this was reduced by 2°C every week then decrease gradually until reach 23°C in the 6th week. The experiment was realized in housing density 30 $kg.m^{-2}$. Moisture was retained during fattening period between 50 to 60%. Lighting in the poultry house first day was 24 hours and by starting the 5 day became permanent and 23 hours, used the 40-watt bulbs.
Ross 308 broiler chickens were divided to four dietary groups (n=60) namely control and experimental groups with supplementation of citric acid to drinking water (basal +0.50%; basal +1.00% and basal +1.50%). Broiler chickens were fed commercial feed mixtures (PD Prašice, Slovak Republic): starter (days 1 to 21), grower (days 22 to 35) and finisher (days 36 to 42). Feeding and watering were *ad libitum*. The nutritive values of the feed mixtures are presented in Table 1.
During the experiment broiler chickens were weighted for individual body weight at 1, 7, 14, 21, 28, 35 and 42 day of age and body weight gain were calculated as the difference between the final and initial chicken weight. Feed consumption and mortality were recorded at 42 day of fattening period.
In 42 day of fattening, representative 10 chickens with body weight similar to the mean were chosen from each group for slaughter weighed and subjected to a 12-hours feed withdrawal. After slaughter, carcasses were weighed and subjected to simplified dissection. Abdominal fat, breast and drumstick were collected and weighed. The organs development was measured by taking weight of the broilers after slaughtering. Neck, crop, heart, proventriculus, gizzard (empty gizzard), liver (without gall bladder), pancreas, caecum, kidney, small intestine and large intestine weights were recorded individually and their percentages in relation to live body weight were calculated. The results obtained were used to calculate dressing percentage and the percentage of carcass components.
Data were analysed using analysis of variance [11]. Significant difference was used at 0.05 probability level and differences between groups were tested using the Duncan's Multiple Range Test [12].

3. Results and discussion

Table 2 represents the body weight and body weight gain of broiler chickens in control and experimental groups with addition of citric acid. In period to 14 days of age, the no significantly lower ($P>0.05$) body weight was found in chickens in control group compared to all experimental groups.
In second part of period, there were beneficial impact ($P<0.05$) of citric acid additions on body weights in all experimental groups.
Our results were equally with [3,8,10,13-18] who reported that supplementation of various doses of citric acid (0.25-3%) increased body weight of broiler chickens.
In contrast, [19-23] no fond positive effect of organic acids on final body weight of chicks.
Significantly highest weight gain ($P<0.05$) was observed in period from 14 to 42 day of age in acetic acid fed broiler chickens compared to control group. The improved body weight gain is probably due to the beneficial effect of organic acids on the gut flora. The organic acids may affect the integrity of microbial cell membrane or cell macromolecules or interfere with the nutrient transport and energy metabolism causing the bactericidal effect [6,24].

Table 1. Nutritional value in 1 kg complete feed mixture

Nutrient	Unit	Starter	Grower	Finisher
Crude protein	%	min. 20.00	min. 18.30	min. 17.00
Fat	%	min. 4.80	min. 4.00	min. 6.00
Fibre	%	max. 4.00	max. 5.00	max. 5.00
Methionine	%	min. 1.20	min. 1.10	min. 0.90
Calcium	%	min. 0.52	min. 0.48	min. 0.45
Phosphorus	%	min. 0.80	min. 0.80	min. 0.55
Sodium	%	min. 0.55	min. 0.55	min. 0.50
Cooper	mg	min. 0.12	min. 0.12	min. 0.12
Zinc	mg	min. 15.00	min. 15.00	min. 15.00
Manganese	mg	min. 80.00	min. 80.00	min. 80.00
Iron	mg	min. 120.00	min. 70.00	min. 100.00
Selenium	mg	min. 0.20	min. 0.10	min. 0.10
Vitamin A	m.j.	min. 12000	min. 10000	min. 10000
Vitamin D3	m.j.	min. 5000	min. 5000	min. 5000
Vitamin E	mg	min. 60.00	min. 50.00	min. 50,00
Natrium salinomycinate	mg	60.00	60.00	-
Endox	mg	125.00	125.00	125.00

In present study was significant difference ($P<0.05$) in feed consumption among control group (1.74 kg) and the addition of citric acid 0.5% (1.71 kg), 1.00% (1.69 kg) and 1.50% (1.68 kg) during fattening period. Equally, this observation was not found by [8,23,26] who reported that, the effects of citric acid on feed intake of broiler chickens were significant. However, [3,25] found, that the addition of citric acid did not affect feed intake in broiler chickens.

The mortality in control and experimental groups with 0.50 and 1.50% levels of citric acid was identical (1.67 %), highest mortality we recorded in experimental group with 1% of citric acid (3.33%) in 42 days. Our result is partly supported by [27] that addition of citric acid decreases the mortality in broiler chickens.

Carcass yield and thick proportion were no significantly affected ($P>0.05$) by addition of citric acid (Table 3). However, in case of breast proportion, we observed a statistical increase ($P<0.05$) in favour of the experimental groups. Several authors [3,28-31] reported that the addition of citric acid to a broiler diet improved carcass yield. Acidification might has increased the cell proliferation and in this manner increased the muscle size. Our results are in line with [8,13,32, 33] who supplemented citric acid to broilers and concluded non-significant effect on carcass yield

The abdominal fat weight was decreased significantly ($P<0.05$) in all experimental groups (Table 3). The results of present study are in agreement with [13,34] who reported significant decrease in abdominal fat by the addition of citric acid in broilers feed. Our result was not in line with the findings of [30,32,34] who reported statistically non-significant effect on abdominal fat by the use of organic acid. Whereas, [28] reported that abdominal fat was increased by the use of organic acid mixture. Difference in results may be due the energy content of the feed and level of citric acid used in broiler feed.

The results showed in Table 4 that liver, gizzard and small intestine proportions were decreased significantly ($P<0.05$) in broiler chickens containing 0.50% citric acid supplementation compared to 1 and 1.50% though no significant ($P>0.05$) difference were observed with other groups. The neck, crop, heart, proventriculus, pancreas, caecum, kidneys and large intestine weights among control and experimental groups didn't show statistical differences ($P>0.05$). Equally, [8,35-38] found that citric acid statistically significant increased proportion of liver and gizzard. However, [8,29,30,32-34] have not observed a positive effect of citric acid on the weight of the intestinal organs.

Table 2. Effects of different levels of citric acid on body weight and body weight gain of broiler chickens

Day of fattening	Control	0.50% CA	1.00% CA	1.50% CA
		Body weight (g)		
1.	44.39±2.74	45.05±2.81	44.78±2.82	44.57±2.76
7.	111.26±20.24	113.29±20.61	112.87±21.15	113.07±20.86
14.	302.54±47.67	314.87±49.28	313.29±49.51	314.97±48.85
21.	608.67±87.04	662.78±89.23[a]	661.83±90.41[b]	664.19±90.11[c]
28.	1135.74±135.24	1223.61±137.11[a]	1227.14±138.34[b]	1228.84±137,54[c]
35.	1614.25±188.15	1711.56±192.74[a]	1725.84±193.09[b]	1735.04±193.21[c]
42.	2068.51±211.29	2179.36±212.52[a]	2188.85±212.97[b]	2199.73±213.41[c]
		Body weight gain (g)		
1.-7.	9.55±2.76	9.75±2.89	9.73±2.81	9.79±2.79
7.-14.	27.33±4.71	28.80±4.77	28.63±4.74	28.84±4.76
14.-21.	43.73±6.47	49.70±6.66[a]	49.79±6.59[b]	49.89±6.61[c]
21.-28.	75.30±7.78	78.69±7.82[a]	80.76±7.86[b]	80.66±7.91[c]
28.-35.	68.36±5.97	71.14±6.32[a]	71.24±6.38[b]	72.31±6.41[c]
35.-42.	64.89±5.54	66.83±5.69[a]	66.06±5.73[b]	66.38±5.74[c]

Values shown are mean±SD (standard deviation)
[a,b] means in a row with different superscript differ significantly

Table 3. Effects of different levels of citric acid on carcass characteristics of broiler chickens

Parameter	Control	0.50% CA	1.00% CA	1.50% CA
Breast (%)	29.86±1.52	30.65±1.51[a]	30.71±1.53[b]	30.78±1.54[c]
Drumsticks (%)	31.41±1.48	31.39±1.42	31.36±1.44	31.37±1.41
Carcass yield (%)	74.81±2.09	75.03±2.11	75.09±2.18	75.14±2.14
Abdominal fat (g)	46.38±3.91	37.47±3.58[a]	37.14±3.47[b]	36.98±3.51[c]

Values shown are mean±SD (standard deviation)
[a,b] means in a row with different superscript differ significantly

Table 4. Effects of different levels of citric acid on proportion of internal organs

Intestinal organ	Control	0.50% CA	1.00% CA	1.50% CA
Neck (%)	2.98±0.38	3.11±0.36	2.96±0.39	2.96±0.39
Crop (%)	0.29±0.08	0.25±0.06	0.26±0.06	0.26±0.06
Heart (%)	0.62±0.11	0.64±0.13	0.64±0.14	0.64±0.14
Liver (%)	2.02±0.26	1.96±0.32[a]	2.08±0.35	2.08±0.35
Proventriculus (%)	0.35±0.09	0.39±0.08	0.40±0.08	0.40±0.08
Gizzard (%)	0.96±0.07	0.92±0.08[a]	0.97±0.08	0.97±0.08
Pancreas (%)	0.15±0.05	0.16±0.04	0.14±0.06	0.14±0.06
Caecum (%)	0.51±0.12	0.49±0.09	0.55±0.14	0.55±0.14
Kidneys (%)	0.69±0.09	0.72±0.13	0.71±0.11	0.71±0.11
Small Intestine (%)	2.33±0.32	2.27±0.29[a]	2.34±0.35	2.34±0.35
Large Intestine (%)	0.14±0.03	0.12 ±0.02	0.15±0.02	0.15±0.02

Values shown are mean±SD (standard deviation)
[a,b] means in a row with different superscript differ significantly

4. Conclusions

Based on the achieved results, we can conclude that supplementation of citric acid is a suitable alternative to antibiotic growth stimulants. From used concentrations, the addition of 1.50% citric acid in drinking water has most effective effect in broiler chickens fattening.

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