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The effect of Citric Acid in the Diets of Native Chicken on Growth Performance and Carcass Traits

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Aims: The study used native crossbred chickens to evaluate the effects of citric acid on growth performance and carcass traits of these chickens
Study Design: The experiment was a completely randomized design.
Place and Duration of Study: School of Agriculture and Aquaculture's experimental farm, Tra Vinh University, between December 2020 to March 2021 (4 months).
Methodology: This study was a completely randomized design with four diets which were 0%, 0.15%, 0.25%, and 0.5% (CT, CT0.15, CT0.25, and CT0.50 respectively) of citric acid and three replicates per each diet. A total of 10 birds was allotted in each group with a 1:1 sex ratio. Feed and water were given *ad libitum* to the chickens. Data were collected daily throughout the experiment. At the end of the trial, the chickens were butchered to ascertain the weight of the carcass, breast, thigh, and internal organs.
Results: The results showed that chickens in the diet with 0.5% citric acid had a great performance, live weight was higher than other treatments with 632.1 g/bird at 8 weeks of age, daily weight gain, feed intake showed better performance as well. There was a linear feed conversion ratio when citric acid increased from 0 - 0.5% in the diets. Carcass weight, breast weight, and thigh weight were

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significantly different between treatments ($P < 0.05$). However, there were not significantly different between carcass, breast, thigh percentage, and other edible organs' weight.
Conclusion: It can be concluded that adding citric acid with the amount of 0.50% in the diet improved growth performance and some carcass characteristics such as thigh weight and breast weight of the chickens.

Keywords: Citric acid; native crossbred chicken; growth performance; carcass traits.

1. INTRODUCTION

The growth of the global population requires more feed to supply the demands. The poultry industry has been increasing quantitatively and qualitatively. The forbidden of antibiotics in feed leads to a reduction in the ability to against infectious diseases. The utilization of antibiotics was forbidden in many countries from the European Union and in Vietnam. The research of Xu et al. [1] showed that antibiotics had been used as a growth booster in broiler diets for decades, but they are no longer allowed in animal feed due to concerns about antibiotic-residues in animal products and the emergence of antibiotic-resistant microorganisms. As a result, in-feed antibiotics must be alternated by the additives, and the focus on developing the alternatives should be processed as a priority [2].

In poultry nutrition, organic acid is one of the most useful feed additives as one of the alternatives to antibiotics in diets. Organic acid, or especially citric acid, was investigated to be more useful in chickens' diets. Animals' growth performance, intestinal bacteria proliferation, and health status are all improved by organic acids; however, it should be controlled with the suitable amount in the diets [3]. In particular, the use of citric acid has brought many positive effects on the growth performance of chickens [4-6]. Hashemi et al. [7] supplemented the broiler chicken feed with an acidifier mixture (citric, formic, phosphoric acid,…) at a rate of 0.15 percent and found that the organic acid supplemented group gained more bodyweight. When 60 g/kg citric acid was added to the diet, Khosravinia et al. [5] noticed a decrease in feed intake of broilers, and this could be due to poorer appetite. Citric acid-enhanced proventriculus, ileum weight percentage, and gizzard, as well as villus length, crypt depth, in the jejunum, ileum, and duodenum, as compared to the basic treatment. Broilers fed diets containing varying amounts of organic acid, such as lactic and citric acid supplementation, exhibited linearly improved growth performance, according to Sultan et al. [8]. The use of citric acid with other organic acids also showed an enhanced carcass weight [9]. Increase meat quality of chicken by citric acid was also recorded in the study of Fascina et al. [10]. However, there were not many studies can prove that citric acid can increase carcass percentage, breast percentage, thigh percentage, edible organs [11,12]. On the other hand, citric acid reduces the pH in the gut as an acidic environment to develop useful bacteria [10]. Ao [13] recorded that the inclusion of citric acid increased the digestion process by enhancing the activity of the α-galactosidase enzyme.

Scientists are forced to explore alternate alternatives in chicken production to overcome the restrictions of low performance imposed by the removal of antibiotics from the feed. Thus, the study of the effect of citric acid on growth performance and carcass traits of native crossbred chickens was implemented.

2. METHODOLOGY

2.1 Time and Location

From December 2020 to March 2021, the experiment was conducted at Tra Vinh University's School of Agriculture and Aquaculture's experimental farm.

2.2 Animal and Experimental Design

This study used a completely randomized approach to examine the growth performance and carcass features of native crossbred chickens (Noi Lai chickens, which were used in the previous studies [14,15]. Native crossbred chickens were used as the study's experimental animals (between two kinds of local chickens in Vietnam). A total of 120 birds aged from week 4 to week 8 were divided into four groups (10 birds were allotted in replicate and balanced for sex). Experimental birds can *ad libitum* access to feed and water. The experiment consisted of four treatments which were 0, 0.15, 0.25, and 0.5% of citric acid in the diet (CT, CT0.15, CT0.25, and CT0.50). During the trial, the birds were kept in cages located 1.2 m away from the floor, made from net and iron, with 4.8 m^2. The floor was covered by husk and Balasa bio-yeast. The husk floor was changed frequently to keep clean and

prevent disease. Drinking nipples were provided in the cages to utilize the drinking system automatically.

Before starting the experiment, the birds were provided vaccinations to prevent the diseases of Marek, Newcastle, Gumboro, Avian Influenza, Respiratory.

The methods of AOAC [16] were used to analyze the basic composition of ingredients in the diet. The chemicals of feed ingredients are shown in Table 1. The ingredients were purchased from a local feed store in Tra Vinh province during the trial. The chemical composition of all feed ingredients was calculated in table 1, and the experimental diets were created and supplied in mash form. In Table 2, the feed composition in the diets was calculated.

2.3 Data Preparation

Data were collected daily throughout the experiment. The data of feed leftover was recorded in the morning before feeding. The needed amount of citric acid was added to the fresh feed allowance for 24 hours. Chickens were weighed weekly to record the data of daily weight gain, feed intake, and feed conversion ratio (FCR). A digital scale was used to weigh the birds weekly and feed daily. The differences between the initial and final weights were used to compute the weight gain of chickens. The original amount of feed supplied to the birds, minus leftovers, was used to calculate the feed consumption. To calculate the feed conversion ratio, feed intake of experimental animals, the mortality of birds, and the weight of dead chickens were recorded regularly. FCR data was derived using the formula of: FCR equals to feed intake divided by total weight gain.

At the end of the experiment, the birds were butchered to ascertain the weight of the carcass, breast, thigh, and internal organs (gizzard, liver, and heart).

Table 1. Chemical composition of ingredients used for the diets

Criteria	Corn	Broken rice	Rice bran	Soybean meal	DCP	Mineral premix
DM	87.2	86.2	88.7	87.2	100	100
OM	99.4	99.7	92.6	94.2	14.8	-
CP	7.05	7.88	12.8	45.6	-	-
EE	2.32	0.92	10.2	1.71	-	-
NFE	88.8	90.8	62.0	43.2	-	-
CF	1.24	0.10	7.60	3.7	-	-
NDF	18.6	3.23	23.2	16.7	-	-
ADF	4.00	1.98	9.08	10.4	-	-
Ash	0.61	0.28	7.44	5.76	85.2	-
ME (Kcal/kg DM)	3,761	3,496	2,720	2,663	-	-

DM: Cry matter; ADF: acid fiber; ME: Metabolizable Energy; OM: organic matter; EE: Ether Extract; CP: crude protein; NFE: Nitrogen-free extract; NDF: neural fiber; CF: Crude fiber.

Table 2. Feed and chemical composition (% in the diet)

Items	Citric acid in the diet (%)
Ingredients (%)	
Rice bran	42.4
Dicalcium phosphate	0.50
Maize	19.0
Broken rice	15.8
Soybean meal	22.0
Minerals – vitamins #	0.30
Chemical composition	
Crude Protein, %	18.0
ME, kcal/g	3.000

#: Vitamin and minerals were supplied following the demand and requirement of the chickens

2.4 Data Processing

The data were preliminarily processed by Microsoft Excel 365 and analyzed by variance analysis (ANOVA) using the statistical method on Minitab version 20. Tukey test was used to compare treatment mean with 95% confidence. The values of mean were considered as a statistical difference between treatments when $P < 0.05$.

3. RESULTS

3.1 The Effects of Citric Acid on Growth Performance of Experimental Chickens

Table 3 showed that the chickens' daily weight gain and final weight in treatment CT0.50 was higher than other treatments (*P<0.05*). Besides, feed intake and FCR were greater in treatment with 0.50% citric acid.

3.2 The Effects of Citric Acid on Carcass Features

Table 4 showed the positive effects of citric acid on carcass traits of the chickens. The inclusion of citric acid in the diets helped chickens improve their carcass, which is live weight, carcass weight, breast weight, thigh weight significantly (*P<0.05*). The data was highest at the treatment of 0.50% citric acid.

4. DISCUSSION

The positive effects of citric acid in this study on the growth performance of the chickens were recorded. At the starter phase, citric acid improved bodyweight of the chickens as well as improved feed conversion ratio and daily weight gain compared to the treatment without citric acid. It was similar to the study of Abd-El-Hlim et al. [17], with the recommended amount of protein and 1.5% citric acid help broilers improve their body live weight. Besides, ELnaggar and Abo EL-Maaty [18] conducted a study using 2-3% citric acid to enhance the growing production of ducklings. The total daily feed intake was reduced and weight gain were improved greatly in chicks treated with the amount of 30 g citric acid/kg, according to Nourmohammadi and Khosravia [19]. As the function of organic acid, citric acid promotes feed consumption, reduces the ammonia synthesis and the synthesis of other growth-depressing microbial metabolites, improves mineral absorption, and reduces the occurrence of sub-clinical illnesses by activating and enhancing the actions of proteolytic enzymes [20].

Furthermore, the consumption of organic acids such as citric acid may improve production performance by reducing the pH of the digestive tracts and diets, thereby eliminating pathogenic organisms that are vulnerable to low pH or selectively increasing acid-loving lactobacillus and exerting an antimicrobial effect directly [20]. The drop in the pH of gut fluid is most likely responsible for the enhancement in feed conversion ratio and weight gain found in previous studies. The beneficial effects of citric acid also affect gut's size, gut's morphometry, thus improve nutrient digesting [21]. Organic acids, which enhance the minerals' absorption, including Ca, P, Mg, and Zn, may be responsible for the improved FCR [22,23]. Besides, these such minerals might play a crucial role in enzyme activities. From that reason, it is possible to increase digestive enzyme activities by the function of citric acid which might be contributed to the enhancement in nutrient digestibility found in this study. In addition to that, increased activity of intestinal digestive enzymes in birds could be a sign of improved nutrient digestive activity and higher performance [24].

The positive effect of citric acid clearly showed in the improvement of carcass weight, breast weight, and thigh weight in chickens fed citric acid. As the same statement, the use of citric acid had dramatically improved carcass traits of the chickens, according to ELnaggar and Abo EL-Maaty [18]. However, this study showed that there were no differences between carcass percentage, breast percentage, thigh percentage, liver, gizzard, and heart weight of the chickens. Brzoska et al. [11] and Fikry et al. [12] also recorded the same results, which showed no effects citric acid on the carcass, breast, thigh percentage, and edible organs of the chicken. It was also similar to the study of Ahsan-ul-Haq et al. [25], citric acid did not affect the weight of edible organs. It might be because meat traits and quality are determined by various factors, following D'Alessandro and Zolla [26], including breeds, diets, raising environment, and storing conditions before and after slaughter. As a result, we believe that the differences in our findings can be attributable to the breeds, different inclusive amounts, and kinds of organic acid, diet composition, and formulation.

Table 3. Effect of citric acid on growth performance of the experimental chickens

Criteria	Treatments				SEM	*P*
	CT	CT0.15	CT0.25	CT0.50		
Initial weight, g/bird	310.0	308.8	305.5	303.2	2.913	0.399
Final weight, g/bird	561.0^{b}	585.9^{b}	620.0^{a}	632.1^{a}	7.159	0.001
Daily weight gain, g/bird	9.0^{b}	9.9^{b}	11.2^{a}	11.7^{a}	0.282	0.001
Feed intake, g/day	22.4^{c}	25.7^{b}	29.2^{a}	28.1^{ab}	0.704	0.001
Feed conversion	2.83^{a}	2.86^{a}	2.78^{a}	2.63^{b}	0.032	0.004

a,b,c: Mean values with different letters in the same column are statistically significant difference P < 0.05 level

Table 4. The effect of citric acid on carcass traits of the chickens

Criteria	Citric acid in the diet (%)				SEM	*P*
	CT	CT0.15	CT0.25	CT0.50		
Live weight, g	507.3^{b}	556.8^{ab}	614.5^{a}	619.8^{a}	18.45	0.008
Carcass %	67.1	68.3	68.7	68.4	1.097	0.765
Carcass weight, g	340.2^{b}	380.2^{ab}	421.8^{a}	423.2^{a}	10.90	0.002
Breast weight, g	70.0^{c}	82.0^{b}	89.7^{ab}	91.5^{a}	1.882	0.001
Breast percentage	20.6	21.6	21.3	21.6	0.434	0.371
Thigh weight, g	50.9^{b}	57.3^{ab}	63.6^{a}	65.3^{a}	1.856	0.002
Thigh percentage, %	14.9	15.1	15.1	15.4	0.282	0.645
Liver weight, g	15.17	15.23	15.03	15.23	0.286	0.953
Gizzard weight, g	12.80	13.47	13.60	13.50	0.218	0.109
Heart weight, g	3.40	3.43	3.43	3.47	0.091	0.964
Small intestine, cm	112.3	115.7	121.5	125.8	2.987	0.052
Large intestine, cm	8.27	8.13	8.52	8.18	0.179	0.484
Cecal length, cm	11.85	12.28	12.33	11.83	0.335	0.605

a,b,c: Mean values with different letters in the same column are statistically significant differences at P<0.05 level

5. CONCLUSION

The increase in chicken's growth performance and carcass traits follows the increase in citric acid levels in the diets. The supplement of 0.50% citric acid in the diet improved the growth performance of native crossbred chicken as well as improved carcass characteristics at the starter phase significantly. With 0.50% citric acid in the feed, it can be a powerful source of feed additives in alternative to antibiotic for improving daily weight gain, feed intake, feed conversion ratio, and carcass weight of the local poultry.

CONSENT

It is not applicable.

ETHICAL APPROVAL

As per international standard or university standard ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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