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Effect of organic acid supplementation through drinking water on growth performance and feed efficiency of broiler Chickens

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Abstract
The present study was conducted to evaluate the effect of organic acid supplementation through drinking water on carcass characteristics and feed efficiency of broiler chickens as a potential alternative to antibiotic growth promoters. A total of 120 day-old commercial broiler chicks were randomly allotted to four treatment groups with three replicates of ten birds each for a period of 28 days. The treatment groups consisted of T1 (control, tap water), T2 (0.2% citric acid), T3 (0.2% acetic acid), and T4 (0.1% citric acid + 0.1% acetic acid). Birds were maintained under uniform management conditions with ad libitum access to feed and water. At the end of the experiment, carcass traits, carcass cut-up parts, giblet yield, visceral organ weights, external offal, and feed efficiency were evaluated using standard procedures. Supplementation of organic acids did not significantly (p >0.05) influence dressing percentage, eviscerated yield, carcass cut-up parts, giblet weights, or external offal characteristics compared with the control. However, birds receiving the combined supplementation of citric and acetic acids (T4) exhibited a significantly (p <0.05) lower intestinal weight, indicating improved gastrointestinal efficiency without adversely affecting other visceral organs. Overall, the use of organic acids through drinking water maintained normal carcass characteristics while supporting gut health and feed utilization. The findings suggest that citric acid, acetic acid, and their combination can serve as safe and effective alternatives to antibiotic growth promoters in broiler production, contributing to sustainable poultry farming and improved production efficiency.

Keywords: Broiler chicken, Organic acids, Citric acid, Acetic acid, Drinking water supplementation, Carcass characteristics

Introduction
High levels of production and efficient feed conversion are the need of the modern poultry industry, which to a certain extent could be achieved by the use of specific feed additives. Antibiotic feed additives as growth promoters have long been supplemented to poultry feed to stabilize the intestinal microbial flora, improve the general performances and prevent some specific intestinal pathology (Hassan *et al*. 2010) [7]. The poultry sector is continuously in look for new feed additives in order to improve the feed efficiency and health of poultry birds. Alternative strategies comprising of organic acids and their salts, probiotics, prebiotics and enzymes were developed to cope up with antibiotic residual problem in meat which can ultimately give rise to antibiotic resistance issue. One such substitute was the use of organic acids as a feed additive in the animal production. Organic acids stimulate the epithelial growth of the intestinal wall (Langhout and Sus, 2005) [18].
India's poultry sector is one of the most dynamic segments of its agricultural economy. From the humble backyard flock to large-scale commercial integrations, the country has built a significant poultry industry that places it among the top producers globally. According to the Department of Animal Husbandry and Dairying (DAHD), the 20th Livestock Census recorded India's total poultry population at approximately 851.81 million birds with increase in 16.81 per cent during 2019. Over 45.78 per cent increase in backyard poultry and total backyard poultry is 317.07 million in 2019. The commercial poultry has increased by 4.5 per cent and the total commercial poultry is 534.74 million (DAHD, 2019). The total Egg

production in the country is estimated as 149.11 billion nos. during 2024-25 and registered a growth of 4.44% the production has increased annually by 3.18% during 2023-24. The per capita availability of eggs increased from 62 nos/annum in 2014-15 to 106 nos/annum in 2024-25. The total Meat production in the country is estimated as 10.50 million tonnesduring 2024-25 and registered a growth of 2.46% the production was increased over 2023-24. The meat production from poultry is 5.18 million tonnes, contributing about half of total meat production. (BAHS 2025).

Feed additives are now considered essential for the optimum performance and productivity in modern poultry production (Shahid *et al*. 2015) [15]. Antibiotic growth promoters have been used in livestock production systems for several years (Haulisah *et al*., 2021) [1]. However, in 2006, the European Union prohibited the administration of these growth promoters due to the continuous development of antibiotic resistance. The hazardous use of antibiotics leads to the destruction of beneficial intestinal flora and the emergence of resistant bacteria, which are transmitted to humans through the food chain (Robinson *et al*., 2019, Khan *et al*., 2022) [5, 6]. Therefore, the search for suitable alternatives has become an urgent issue, especially for the poultry production system (Dai *et al*., 2021, Hafeez *et al*., 2021, Scicutella *et al*., 2021) [8, 9, 10]. The European Union permitted the use of acidifiers or organic acids (OAs) and their salts in poultry production due to their safety [Adil *et al*., 2010] [11]. They also have many advantages, such as the absence of pollution, drug resistance, and residues, as well as beneficial effects on health. Dietary OAs promote the production of prebiotics and probiotic lactic acid bacteria.

Organic acids were originally added in the food animal industry as an antifungal agent, however, in the past, there is evidence that the different acids such as formic acid and propionic acids have been used for their antibacterial activities against contaminated food- borne pathogens especially *Salmonella species*. The improved performance of broilers in response to the supplementation of organic acid is due to enhanced digestibility of energy and protein contents of the feed and reduction of microbial pathogens, improving the immunity, lowering the infectious level, and reducing the ammonia and other harmful metabolites.

The present study will be highly useful for researchers, scientists, veterinary professionals, poultry and pharmaceutical industry to enrich their knowledge in promoting organic acid usage in poultry industry helping to draw a line for anti biotics as feed additive.

2. Materials and Methods

The present investigation was carried out at the Poultry Unit, Department of Poultry Science, College of Veterinary and Animal Science, Rajasthan University of Veterinary and Animal Sciences, Bikaner, Rajasthan.

The experimental trial was conducted for a duration of 28 days. A total of one hundred twenty (120) unsexed, clinically healthy, day-old commercial broiler chicks were utilized for the study. The experimental birds were assigned to different treatments, and organic acids were supplemented through drinking water as per the following treatment schedule:

S. No.	Treatment Group"s	Treatment Details	No. of chicks per treatment			Total number of chicks per treatment group
			R1	R2	R3	
1	T1	Control (Tap water)	10	10	10	30
2	T2	Tap water+0.2 per cent Citric acid	10	10	10	30
3	T3	Tap water+0.2 per cent Acetic acid	10	10	10	30
4	T4	Tap water+0.1 per cent Citric acid + 0.1 per cent Acetic acid	10	10	10	30

Strict hygiene and sanitary conditions of the poultry shed were maintained throughout the experimental period. Feed and water were provided ad libitum to all treatment groups for the entire duration of the study. All day-old chicks were individually weighed upon arrival, and subsequent body weight measurements were recorded at weekly intervals throughout the trial.

At the termination of the experiment, six birds from each treatment group (two per replicate), with body weights approximating the respective group mean, were selected for the evaluation of carcass characteristics, while the remaining birds were disposed of on a live weight basis. The selected birds were individually weighed and subjected to a 12-hour feed withdrawal prior to slaughter, with free access to water maintained. Slaughtering was performed following the halal method.

Subsequently, flaying was carried out, and internal organs including the heart, liver, gizzard, lungs, pancreas, proventriculus, and intestines were carefully excised and weighed individually for the assessment of carcass parameters. Carcass yield (dressed weight percentage) was determined after bleeding, decapitation, flaying, and removal of shanks using the appropriate formula. The carcass was then systematically divided into seven portions, namely head, neck, back, whole wings, breast, drumsticks, and thighs, each of which was weighed separately and expressed as a percentage of live body weight.

The pH of different segments of the gastrointestinal tract and intestinal contents was measured using a "LABMAN LMPH-12 Digital pH meter" in the Department of Livestock Products Technology, CVAS, Bikaner.

The average cost of feed and organic acid per kg body weight gain was determined based on records of feed consumption, the prevailing cost of readymade feed, the cost of organic acids used in each treatment, and the corresponding body weight gain. The data generated for various parameters during the study were analyzed using one-way analysis of variance (ANOVA) as per the procedure outlined by Snedecor and Cochran (2004), employing SPSS (version 21). The treatment means were compared for statistical significance ($p < 0.05$) using Duncan's New Multiple Range Test

3. Result and Discussion

At the end of the four-week experimental period, three birds from each replicate (i.e., nine birds per treatment), with body weights approximating the mean body weight of their respective groups, were selected for the assessment of carcass characteristics.

3.1 Carcass Characteristic

The data pertaining to carcass characteristics of broiler birds subjected to organic acid treatments are presented in Table 1.1. Overall, supplementation of citric acid, acetic acid, or their combination via drinking water did not exert a significant influence on the dressing percentage or eviscerated yield of broilers. The mean eviscerated yield (%) for groups T1, T2, T3, and T4 was 66.81 ± 0.32, 67.30 ± 0.22, 67.21 ± 0.22, and 66.69 ± 0.36, respectively. Although relatively higher numerical values were observed in T2 and T3, statistical analysis revealed that the differences among treatments were not significant (p >0.05). The highest eviscerated yield was recorded in group T2, followed by T3, whereas the lowest value was observed in T4.

The mean dressed weight (%) for T1, T2, T3, and T4 was 74.53 ± 0.34, 74.74 ± 0.20, 74.85 ± 0.18, and 74.02 ± 0.32, respectively. The highest value was noted in T3, followed closely by T2 and T1, while T4 exhibited a comparatively lower percentage. Despite these numerical differences, the variations among treatments were also statistically non-significant (p >0.05). The results obtained for dressed weight percentage and eviscerated yield are in agreement with the findings of Nezhad *et al*. and Thokwane, who reported no significant effect of citric acid supplementation on dressed weight and eviscerated yield in broilers.

3.2 Various carcass cuts weight (%)-

The mean weight (%) of different carcass cuts is summarized in Table 1.1. The head weight (%) recorded for groups T1, T2, T3, and T4 was 2.74 ± 0.04, 2.67 ± 0.04, 2.66 ± 0.01, and 2.81 ± 0.07, respectively, with no statistically significant variation among the treatments. Likewise, the mean weight (%) of neck, wing, back, thigh, and breast did not differ significantly across the experimental groups.

A marginal numerical increase in drumstick weight (%) was observed in groups T3 and T4. The corresponding values for T1, T2, T3, and T4 were 8.75 ± 0.11, 8.95 ± 0.09, 9.24 ± 0.14, and 9.20 ± 0.18, respectively.

Overall, supplementation of organic acids did not significantly influence the weight (%) of back, thigh, breast, wing, neck, and head. However, Mohammed reported a significant enhancement in the weight (%) of back and head, which was not evident in the present investigation. The observations related to head and neck weight (%) are in agreement with Sohail *et al*. (2015) [21]. Furthermore, the slight numerical improvement in drumstick weight (%) in organic acid-supplemented groups corroborates the findings of Islam *et al*. (2008) [19].

3.2 Weight (%) of Giblets

The weight (%) of giblets, including liver, heart, gizzard, and total giblets across different treatment groups, is summarized in Table 1.1. The total giblet yield ranged from 5.04 ± 0.25% in T4 to 5.50 ± 0.08% in T2, with no statistically significant differences observed among the treatments. Similarly, the individual organ weights—heart (0.54–0.58%), liver (2.37–2.45%), and gizzard (2.08–2.46%)—remained statistically comparable across all groups. Although a slightly higher gizzard weight was recorded in T3, the variation was not significant.

Giblet yield, comprising the liver, heart, and gizzard, is an important parameter reflecting internal organ development and the physiological response of broilers to dietary interventions. The present findings indicate that supplementation of citric acid, acetic acid, or their combination through drinking water did not significantly influence giblet yield.

These results are consistent with previous reports suggesting that organic acid supplementation at moderate levels does not affect the development of internal organs in broilers. Sohail *et al*. (2015) [21], Mahmoud *et al*. (2020) [23], and Saleem *et al*. (2020) [24] similarly reported no significant effect of organic acid supplementation via drinking water on the weight percentages of gizzard, liver, and giblets. The present observations are also in agreement with the findings of Haq *et al*. (2017) [22].

3.3 Overall visceral inedible weight (%)

The weight (%) of visceral inedible components, including intestines, lungs, pancreas, proventriculus, kidneys, spleen, and crop of broiler birds under different treatments, is presented in Table 4.1. A statistically significant difference (p<0.05) was observed in intestinal weight (%), with T4 (4.57 ± 0.00) exhibiting the lowest value. The corresponding values for T1 (5.00 ± 0.03), T2 (4.90 ± 0.05), and T3 (4.85 ± 0.09) were statistically similar but significantly higher than T4, indicating a possible improvement in gut efficiency with combined acid supplementation. In contrast, the mean weight (%) of lungs, spleen, and crop did not differ significantly among the treatment groups.

The highest mean weight (%) of pancreas was recorded in T3 (0.87 ± 0.45); however, the large standard error suggests considerable variability, and the differences among treatments were statistically non-significant (p >0.05). The values for T1 (0.42 ± 0.01), T2 (0.35 ± 0.02), and T4 (0.43 ± 0.01) were relatively similar, indicating comparable treatment effects on pancreatic weight. For the proventriculus, the highest values were observed in T1 (0.47 ± 0.01) and T3 (0.47 ± 0.01), followed by T2 (0.45 ± 0.02), while the lowest value was recorded in T4 (0.44 ± 0.01). Although T1 and T3 exhibited comparatively higher values than T4, the differences were not statistically significant (p >0.05). Regarding kidney weight (%), T2 (0.46 ± 0.02) and T3 (0.49 ± 0.01), as well as T1 (0.51 ± 0.01) and T4 (0.51 ± 0.02), showed statistically comparable values across treatments.

Overall, the significant reduction in intestinal weight in T4 may indicate improved digestive efficiency due to the synergistic effect of citric and acetic acid supplementation. Other visceral inedible organ weights remained unaffected, suggesting that organic acid supplementation did not adversely influence internal organ development. The observations for weight (%) of intestines, blood, lungs, spleen, pancreas, and proventriculus are in agreement with the findings of Bozkurt *et al*. (2009) [2], Sohail *et al*. (2015) [21], and Adil *et al*. (2020) [4].

3.4 Weight (%) of overall external offal

The weight (%) of external offal components, including feathers, blood, and shanks of broiler birds under organic acid treatments, is presented in Table 1.1. The mean shank weight (%) showed only minor numerical variations among the groups, and statistical analysis indicated no significant differences (p >0.05). Feather weight (%) was numerically highest in T4 (15.77 ± 0.16), followed by T3 (15.40 ± 0.08), T1 (15.28 ± 0.18), and T2 (15.27 ± 0.06); however, these

differences were statistically non-significant (p >0.05), indicating uniform feather development across treatments.
Similarly, the mean blood weight (%) was numerically lower in T2 (4.13 ± 0.22) and T3 (4.21 ± 0.05) compared to the control T1 (4.26 ± 0.04), although the differences were not statistically significant (p >0.05), suggesting that organic acid supplementation did not influence blood yield.
Overall, the weight percentages of blood, shank, and feathers did not differ significantly among treatment groups.
The proportion of feathers, skin, and other inedible components also remained statistically comparable (p >0.05) across treatments, indicating that supplementation of organic acids at the tested levels did not adversely affect the physiological development of external body parts or offal yield. These findings are consistent with Islam *et al*. (2008) [3], who reported lower values for skin, feathers, and inedible parts in organic acid-supplemented groups. In contrast, Mohammed (2018) observed a significant increase in these parameters following supplementation with citric and acetic acids.

Table 1.1: Carcass Characteristic

	Treatments			
	T1	**T2**	**T3**	**T4**
Carcass Characteristic				
Dressed Weight%	74.53a±0.34	74.74a±0.20	74.85a ± 0.18	74.02a ±0.32
Eviscerated Weight%	66.81a±0.32	67.30a±0.22	67.21a±0.22	66.69a±0.36
Carcass cuts				
Head	2.74±0.04	2.67±0.04	2.66±0.01	2.81±0.07
Neck	2.58±0.06	2.58±0.06	2.61±0.04	2.47±0.07
Wing	5.54±0.03	5.54±0.02	5.44±0.05	5.42±0.03
Back	11.85±0.12	11.74±0.07	11.69±0.09	11.76±0.05
Thigh	10.19±0.06	10.27±0.05	10.42±0.13	10.22±0.13
Drumstick	8.75±0.11	8.95±0.09	9.24±0.14	9.20±0.18
Breast	22.70±0.02	22.79±0.03	22.61±0.11	22.51±0.10
Giblets Weight				
Liver	2.37±0.01	2.45±0.04	2.44 ± 0.05	2.37 ± 0.03
Heart	0.54 ± 0.02	0.54 ± 0.02	0.54 ± 0.03	0.58 ± 0.03
Gizzard	2.33 ± 0.10	2.43 ± 0.07	2.46 ± 0.21	2.08 ± 0.20
Total Giblet	5.24 ± 0.11	5.50 ± 0.08	5.43 ± 0.25	5.04 ± 0.25
Visceral Inedible				
Intestines	5.00b±0.03	4.90b ± 0.05	4.85b± 0.09	4.57a ± 0.00
Lungs	0.57 ± 0.01	0.53 ± 0.01	0.58 ± 0.00	0.56 ± 0.01
Pancreas	0.42 ± 0.01	0.35 ± 0.02	0.87± 0.45	0.43 ±0.01
Proventriculus	0.47 ± 0.01	0.45 ± 0.02	0.47± 0.01	0.44 ± 0.01
Kidney	0.51 ±0.01	0.46 ± 0.02	0.49± 0.01	0.51 ± 0.02
Spleen	0.30 ± 0.01	0.31± 0.01	0.34 ± 0.01	0.33 ±0.01
Crop	0.43 ± 0.01	0.42 ±0.01	0.47 ± 0.01	0.46 ± 0.01
Overall External Offal				
Feather	15.28 ± 0.18	15.27± 0.06	15.40 ±0.08	15.77 ± 0.16
Blood	4.26 ± 0.04	4.13 ±0.22	4.21 ± 0.05	4.27 ± 0.10
Shanks	3.17 ± 0.15	3.04 ± 0.12	3.00 ±0.02	3.09 ± 0.18

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