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Effect of organic acid supplementation on performance index, water intake & economics of broiler chickens

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ABSTRACT

This study evaluated the effect of organic acid supplementation, administered through drinking water, on performance index (PI), water intake, and cost economics of broiler chickens. A total of 150 day-old, straight-run broiler chicks were randomly allotted to five treatment groups, each comprising 30 birds for a 35-day trial: T_1 (control, tap water only), T_2 (0.2% acetic acid), T_3 (0.2% propionic acid), T_4 (0.2% citric acid), and T_5 (0.2% mixture of acetic, propionic and citric acid @ 0.067% each). The overall PI was significantly higher ($p < 0.05$) in the group supplemented with mixture of organic acids (T_5), in comparison to the groups supplemented with organic acids individually; which had statistically similar PI, yet in turn also yielded significantly higher ($p < 0.05$) PI in comparison to the control group (T_1). Overall water intake was significantly reduced ($p < 0.05$) in all supplemented groups compared with the control. The economic analysis revealed that organic acid supplementation improved overall profitability over control, with best results from the treatment T_5 . Hence, these findings indicate that supplementing drinking water with a combination of acetic, propionic and citric acids improves overall growth performance and economic returns in broilers more effectively than any single acid, supporting its potential as a practical, antibiotic-free growth promoter for commercial broiler production.

Keywords: Antibiotic Growth Promoters, Broiler, Chicken, Economics, Organic acids, Performance Index

Introduction

A major challenge in broiler production is the impact of clinical and subclinical bacterial and viral infections, which can cause morbidity and mortality. Broilers are highly susceptible to enteric pathogens such as *Escherichia coli*, *Salmonella spp.*, and *Clostridium spp.* from an early age. These pathogens compete for nutrients, impair growth performance, and increase disease susceptibility, leading to the widespread use of antibiotic growth promoters (AGPs) to improve health and productivity.

The European Union phased out and prohibited the use of AGPs in animal feed from 1 January 2006 under Regulation (EC) No. 1831/2003, primarily due to concerns regarding antimicrobial resistance and antibiotic residues in food products (European Parliament and Council, 2003; Castanon, 2007) [1, 2]. In India, according to Rule 97(3A) of the Drugs and Cosmetics Rules, 1954 [3], the withdrawal period for veterinary drugs used in food producing animals shall not be less than 7 days for egg and milk and 28 days for meat obtained from poultry and mammals, before such products are marketed for human consumption (CDSCO, 2016) [3]. Consequently, there is increasing interest in safer alternatives to AGPs, including probiotics, prebiotics, synbiotics, phytobiotics, and organic acids (Adil *et al.*, 2011) [4].

Organic acids are a group of chemicals having organic carboxylic acid, of the general structure $R-COOH$, having antimicrobial activities like those of antibiotics (Wang *et al.*, 2009) [5]. Some examples of such antimicrobial organic acids are acetic, propionic, butyric, citric, lactic, malic, tartaric, sorbic and formic acids, etc (Dibner *et al.*, 2002) [6]. The use of organic acids and their salts in poultry feeding is approved by the European Union as they are generally considered safe (Adil *et al.*, 2010) [7]. They reduce colonization of pathogenic microorganisms, increase the digestibility of proteins and minerals and reduce toxic bacterial metabolites such as ammonia and amines, resulting in improved feed efficiency and growth performance of the host. For this study, Organic acids viz; Acetic, propionic and citric acids were supplemented through drinking water. Acetic acid supplementation in drinking water improves the growth performance of broilers (Hudha *et al.*, 2010) [8]. Propionic acid can inhibit the growth of fungi, increase the growth of good bacteria in the gastrointestinal tract, decrease the pH of the digestive tract thereby stimulating the activity of digestive enzymes, and maintain a healthy condition, and microflora balance in the digestive tract (Lu *et al.*, 2003) [9].

Citric acid was found useful in improving overall health and growth of broilers (Abdelrazek *et al.*, 2016; Islam *et al.*, 2008) [10, 11].

Materials and methods

Ethical approval

This study was approved by the Institutional Animal Ethics Committee (IAEC), CVAS, RAJUVAS, Bikaner, Rajasthan, India, bearing approval notice no. CVAS/IAEC/2023-24/69.

Experimental location and design

The study was conducted at Poultry Unit, Livestock Farm Complex, CVAS, RAJUVAS, Bikaner, Rajasthan. The trial was conducted for 35 days on 150 straight-run, day-old broiler chicks. The chicks were designated to five treatment groups, each containing 30 birds ($n = 30$ chicks/treatment) and each treatment was further divided into 3 replicates with 10 birds each ($n = 10$ chicks/replicate), as presented in Table 1.

Management of experimental birds

All standard and uniform managerial conditions were maintained for all the experimental birds throughout the trial period. Feed and water were offered *ad libitum* to each treatment. The birds were vaccinated against New-castle and Gumboro diseases.

Parameters recorded

1. Performance index

The productive performance of the broilers in terms of performance index for different treatment groups on weekly intervals was estimated as per the equation:

$$PI = \frac{\text{Body weight gain (g)}}{\text{FCR}}$$

2. Water intake

The mean weekly and overall water intake (ml/bird) by birds in each group was recorded in order to find out the acceptance of acidic water, owing to its distinctive change in smell and flavour from the regu-

lar tap water used in the control (T_1) group.

3. Comparative cost economics

The average cost of feed (starter feed- INR 61.500 and finisher feed- INR 60.500) and organic acid per kg body weight gain was calculated from the records of feed consumption, price of readymade feed, the price of organic acid utilized in each treatment and their body weight gain.

4. Overall economics of various treatment groups

Calculated as the difference between the total expenditure during experimental period and the income generated through sale (INR 130.000 per Kg live body weight) of broilers.

Statistical analysis

The data regarding various parameters recorded during this study was subjected to one-way analysis of variance (ANOVA) technique using the statistical package SPSS software version 21 (Snedecor *et al.*, 2004) [12]. The means of different experimental groups were tested for statistical significance ($P < 0.05$) by Duncan's new multiple range test [13].

Results and discussion

Performance index (PI)

As per the data of mean performance index of different treatment groups, summarized in Table 2, the cumulative/overall mean performance index for the group supplemented with the mixture of organic acids (T_5) was found to be statistically higher ($p < 0.05$) than the rest of the groups. Meanwhile, the overall mean performance index of groups supplemented with acetic, propionic and citric acids alone were found to be statistically similar ($p > 0.05$) to one another yet higher ($p < 0.05$) than the control group (T_1). The findings of this study regarding PI of broilers were in accordance to those of Abou-Ashour *et al.* (2021) [14], who observed that supplementing broilers with a blend of citric and acetic acid yielded the highest PI value, followed by acetic and citric acid individually. Additionally, they noted that the enhancement in PI among the different groups supplemented with acetic and citric acid, either alone or in combination, was notably greater than that of the control group.

Table 1. Random distribution of broilers to treatment groups

S. No.	Treatment Groups		No. of chicks per replicate			Total no. of chicks per treatment
			R ₁	R ₂	R ₃	
1	T ₁	Control (Tap water only)	10	10	10	30
2	T ₂	Tap water + 0.2% Acetic acid	10	10	10	30
3	T ₃	Tap water + 0.2% Propionic acid	10	10	10	30
4	T ₄	Tap water + 0.2% Citric acid	10	10	10	30
5	T ₅	Tap water + 0.2% Organic acid mixture (0.067% Acetic, Propionic and Citric acid each)	10	10	10	30

Table 2. Average Performance Index (PI) in different treatment groups

Age (weeks)	Groups				
	T ₁	T ₂	T ₃	T ₄	T ₅
0-I	56.318 ^a ± 1.796	62.112 ^b ± 1.812	61.783 ^b ± 1.238	69.501 ^c ± 2.345	73.127 ^c ± 1.557
I-II	140.496 ^a ± 5.260	153.573 ^b ± 2.232	155.298 ^b ± 0.757	172.858 ^c ± 4.931	186.748 ^d ± 7.332
II-III	183.206 ± 7.377	201.727 ± 9.778	209.194 ± 6.172	197.892 ± 4.799	197.814 ± 4.955
III-IV	187.738 ^a ± 5.607	189.919 ^a ± 5.876	195.173 ^a ± 5.017	200.524 ^a ± 3.610	223.977 ^b ± 9.782
IV-V	184.972 ^a ± 3.546	203.584 ^b ± 5.185	208.703 ^b ± 6.632	201.826 ^{ab} ± 6.094	214.658 ^b ± 0.245
0-V	743.674 ^a ± 8.569	800.858 ^b ± 16.742	822.304 ^b ± 18.625	832.087 ^b ± 4.405	885.415 ^c ± 15.315

Means having different superscript in a row differ significantly ($p < 0.05$) within a column.

Average water intake

As per the data presented in Table 3, a significant reduction ($p < 0.05$) in the overall water intake was observed in the groups supplemented with organic acids, irrespective of the type and combination. The groups supplemented with acetic and citric acid showed the even lower ($p < 0.05$) water intake when compared to the groups supplemented with propionic acid and mixture of all three organic acids.

The outcomes of this study concerning water intake were found to be similar to those of Ali *et al.* (2020) [15], who noted a considerable decrease ($P < 0.05$) in water intake among the groups supplemented with organic acids. Conversely, Sultan *et al.* (2015) [16] observed a non-significant effect throughout their entire trial period.

Means having different superscript in a row differ significantly ($p < 0.05$) within a column.

Table 3. Average Water intake (ml/bird) in different treatment groups

Age (weeks)	Groups				
	T ₁	T ₂	T ₃	T ₄	T ₅
0-I	262.667 ± 4.631	232.667 ± 11.289	221.667 ± 8.110	244.333 ± 8.413	241.667 ± 9.597
I-II	564.667 ± 4.978	497.333 ± 14.970	522.000 ± 27.185	541.333 ± 12.548	526.333 ± 19.785
II-III	1092.333 ± 20.513	1018.333 ± 19.462	1001.000 ± 50.013	989.000 ± 37.233	1048.333 ± 40.916
III-IV	1514.667 ± 31.440	1436.333 ± 55.336	1453.000 ± 28.290	1402.000 ± 35.360	1431.667 ± 63.183
IV-V	2006.667 ± 37.239	1839.333 ± 43.910	1932.333 ± 25.274	1855.333 ± 53.654	1946.000 ± 38.889
0-V	5441.000 ^c ± 62.405	5024.000 ^a ± 50.895	5130.000 ^b ± 109.914	5032.000 ^a ± 65.368	5194.000 ^b ± 79.563

Comparative cost economics

The results of comparative cost economics given in Table 4, indicate that the total cost of feed and organic acid/Kg body weight gain during the entire trial period was lowest for the group supplemented with

the mixture of organic acids, followed by the groups supplemented with citric, propionic and acetic acid, respectively; and highest for the control group.

Table 4. Comparative cost economics

Parameter		Group				
		T ₁	T ₂	T ₃	T ₄	T ₅
Cost of feed/Kg body weight gain (INR)	Starter phase	96.290	93.467	93.491	92.694	91.218
	Finisher phase	114.287	112.473	110.727	110.152	107.560
	Overall	106.052	103.659	102.641	101.870	99.971
Cost of Organic acid/Kg body weight gain (INR)	Starter phase	0.000	0.221	0.351	0.699	0.422
	Finisher phase	0.000	0.359	0.596	1.158	0.680
	Overall	0.000	0.295	0.481	0.941	0.560
Total Cost of feed and organic acid/Kg body weight gain (INR)	Starter phase	96.290	93.688	93.842	93.393	91.640
	Finisher phase	114.287	112.832	111.323	111.310	108.240
	Overall	106.052	103.954	103.123	102.810	100.531

Overall economics of various treatment groups

The overall economics of various groups is represented in Table 5. Maximum return was derived from the group supplemented with the mixture of organic acids, followed by the groups supplemented with

citric, propionic and acetic acids; with the least returns from the control group.

Table 5. Overall economics of various treatment groups

S.No.	Economic Particulars	Group				
		T ₁	T ₂	T ₃	T ₄	T ₅
1	Cost of day-old chick (INR/chick)	28	28	28	28	28
2	Total cost of feed consumed per bird (INR)	137.317	141.221	142.182	141.708	145.208
3	Miscellaneous cost/bird (INR) (medicine, vaccination, etc.)	0.900	0.900	0.900	0.900	0.900
4	Cost of Organic acid/bird (INR)	0.000	0.402	0.667	1.308	0.814
5	Total cost of production (INR)	166.217	170.523	171.749	171.916	174.922
6	Return obtained (INR)/chicken	173.988	182.750	185.800	186.450	194.502
7	Net profit (INR)	7.771	12.227	14.051	14.534	19.580

The results of this study regarding cost economics were consistent with findings from Prasad and Sen (1992) [17], Islam *et al.* (2008) [11], Lokhande (2005) [18], Thirumeignanam *et al.* (2006) [19], Hudha *et al.* (2010) [8], Rout *et al.* (2016) [20], Kamel and Mohammed

(2016) [21], Abou-Ashour *et al.* (2021) [14], and Khenjan and Sanswat (2023) [22]. These studies also reported improved returns and lower costs of production per kilogram of body weight gain.

Conclusion

Supplementation of drinking water with organic acids improved broiler performance in terms of performance index, reduced water intake, and enhanced production economics over the 35-day trial. Performance index (PI) was significantly higher ($p < 0.05$) in all acid-supplemented groups compared to the control, with the group supplemented with mixture of acetic, propionic & citric acid yielding the highest overall PI. The groups supplemented with acetic, propionic, and citric acid individually produced statistically similar PI. Organic acid treatment also reduced overall water intake significantly ($p < 0.05$), most notably in the groups supplemented with acetic and citric acid, without any adverse effect on growth. These physiological gains translated directly into economic benefit: the group supplemented with mixture of organic acids recorded the lowest total feed-plus-acid cost per kilogram body weight gain and the highest net profit. These findings indicate that a combination of acetic, propionic, and citric acids in drinking water is a more effective and economically viable strategy than single-acid supplementation for improving growth performance and reducing production costs, supporting its use as a practical, antibiotic-free alternative in commercial broiler production.

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