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Evaluation of a Commercially Available Organic Acid Blend and Sanitizer Products on Broiler Breeders' Performance and Economics

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ABSTRACT

Background: The limited information on the use of organic acid products in the poultry farming through drinking water as compared to diet along with water sanitizer and though in broiler breeder performance is inadequate. This makes sense of present study to evaluate the impact of commercially available products that combine acidifiers and sanitizers with those of individual products on the sustainability of commercial broiler breeding operations and production efficiency.

Methods: The study involved 22,000 female and 2,160 male birds of Cobb 430 breeders, equally divided into four sheds. One shed was allotted for treatment (T1) with blended organic acids cum sanitizer (BOA) products, while three sheds were allotted for control (T2, T3 and T4) with mixed organic acids (MOA) and organic chlorine (OC) products. During 13 consecutive weeks of study, daily feed intake, egg weight, hen-day egg production, hatching eggs, broken eggs, rejected eggs, cumulative mortality and economics in broiler breeder supplementation were evaluated.

Result: No significant ($P \geq 0.05$) differences were observed between treated groups in most zootechnical parameters except broken eggs. The T1 treatment birds showed a significant ($P \leq 0.05$) reduction in broken eggs and numerical improvement in all other parameters. The greatest economic efficiency was obtained at a CBR of $21.59 followed by $17.60 and USD 14.58 in favor of the T1 group compared with T2, T4 and T3 group birds respectively. The comparative trials show that producers can recover an average of 17.93 U.S. dollars for every U.S. dollar spent on a T1 product program. The blend of organic acids cum quaternary ammonium compound (T1) used in the study may improve economics by increasing hatching egg numbers, reducing mortality and saving on water treatment costs.

Key words: Broiler breeders, Cost-benefit ratio, Eggshell deformity, Livability, Production performance, Sanitizer, Water acidifier.

INTRODUCTION

Poultry producers in India are exploring green supplements as a substitute for antibiotic growth promoters to improve production performance and intestinal health. The frequent use of antibiotics leads to the selection of resistant bacteria, increasing the incidence of infectious diseases and mortality with negative impacts on production parameters (Bouassi *et al.,* 2016; Ngwenya *et al.,* 2023). Several countries like the European Union (Union, 2006), Sweden, South Korea, Bangladesh, the United States (Editors, 2017), China (Echemi, 2020) and India, under the World Health Organization's direction, have issued regulations banning and restricting the use of antibiotic growth promoters (AGPs) in poultry and human medicine until risk assessments are conducted (Salim *et al.,* 2018). However, antibiotic removal has affected poultry performance, increased feed conversion and increased the incidence of certain animal diseases, ultimately affecting farm economic viability (Dibner and Richards, 2005).

Organic acid, a green, safe and pollution-free antibiotic alternative after researchers and European Union approval, has been preferred by enterprises due to its three-free characteristics: pollution-free, drug resistance-free and residual-free (Adil *et al.,* 2010; Dittoe *et al.,* 2018; Makofane *et al.,* 2022). It has been well-documented that polluted drinking water in poultry farms is particularly susceptible to the growth and spread of water-borne diseases (Chaveerach *et al.,* 2004; Fadeyibi *et al.,* 2018). Organic acid treatments, composed of individual and blends of several acids, have been found to perform antimicrobial activities like antibiotics (Wang *et al.,* 2009). The use of organic acids is becoming more acceptable to feed manufacturers, producers and consumers, leading to a rising global potential for poultry acidifiers for both feed and water applications (Menconi *et al.,* 2014).

Like organic acids, various disinfectants like quaternary ammonium compounds (QACs), oxidizing agents (*e.g.*,

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hydrogen peroxide) and chlorine compounds are commonly used for water sanitation. Chlorine and hydrogen peroxide are the most popular, but they are only effective at a high dosage and preferably not during production. In contrast, QACs based disinfectants are cationic surface-active detergents that attach to anionic bacterial cell walls, diffuse through the cell wall and bind to the cytoplasmic membrane, leading to membrane disruption, intracellular material leakage and cell death (Ioannou *et al.,* 2007). It is crucial to realize that these are two distinct strategies that complement one another to raise the quality of the water. As a result, acidifiers alone cannot replace sanitizers that effectively reduce the microbial load of highly polluted water sources. Instead, acidifiers should be used to keep the pH of the water between 6 and 7 for successful sanitation (Oviedo, 2006).

However, studies on organic acid products in the poultry industry mostly focus on feed supplementation, with limited information on supplementation through drinking water along with water sanitizer and though in broiler breeder performance is scanty. Although numerous individual alternatives are currently available in the market, a valid alternative with the capability of both acidifier and sanitizer is rarely available. Therefore, the objective of the current study aims to compare such products with individual ones in terms of broiler breeders' efficiency. The goal is to determine the most effective approach for improving broiler breeders' performance.

MATERIALS AND METHODS

Blended organic acids cum sanitizer product (BOA)

A blended combination product of organic acids cum sanitizer (AcidLAC™ W Conc. Liquid, Kemin Industries South Asia Pvt. Ltd. Chennai, India) was used in the drinking water according to the manufacturer's recommended dose (1 mL/4 L of water). This combination product is a synergistic blend of organic acids-Propionic acid, Citric acid, Formic acid and Lactic acid, along with Didecyl-dimethyl-ammonium-chloride (DDAC)-a quaternary ammonium compound (QAC) used as potent antimicrobial and antiviral compound, for providing sanitizer effect.

Mixed organic acids product (MOA)

The MOA product used by broiler breeder customers is also a synergistic blend of free and highly buffered organic acids which is applied in drinking water (1 mL/ 2 L of water). The MOA product mainly consists of Copper, Zinc acetate dihydrate, Formic acid, Acetic acid, Propionic acid, Ammonium formate, Benzoic acid, 1,2-propanediol and Lactulose.

Organic chlorine product (OC)

The OC administered (4 g/1000 L of water) was a commercial water sanitizer product containing a Sodium dichloroisocyanurate, which is the sodium salt of a chlorinated hydroxy triazine, micro pulverized powder (Medical grade) as claimed by the manufacturer. This commercial product oxidizes biomass, iron, magnesium, hydrogen sulfide, *etc.* and increases the oxygen content of water without changing the water's pH.

Experimental design

The study was conducted during the months of May 2022 to August 2022 for a period of 13 weeks at Broiler Breeder Farm, Hyderabad, India. Twenty-two thousand female birds and twenty-one hundred and sixty male birds of Cobb 430 breeders at the age of 25th week were selected for the study from four sheds and each shed having fifty-five hundred females and five hundred and forty males breeder birds, Out of four sheds one shed was allotted for the treatment purpose (T1) with offered product BOA and three sheds were allotted for the control purpose (T2, T3 and T4) with customer present usage products MOA and OC. In this way, the study divided the birds into four treatment groups for water acidification and sanitization: T1, T2, T3 and T4. Given its focus on the client's commercial breeding farm, the study doesn't include a control group lacking acidifiers. The absence of acidifiers could lead to suboptimal performance and health issues in the birds. Additionally, the costs associated with breeder birds and hatching eggs are significantly high and no birds were sacrificed during the study since it was solely a performance trial aimed at assessing product efficacy. The details of the experimental design are given in Table 1. The water was treated with the products throughout the 13-week trial period, except on the day of vaccination through drinking water. Each treatment shed was provided with a separate water tank for mixing the water acidifiers and sanitizers. The daily farm management was followed according to the Cobb Breeder Management Guide. Birds were housed in a battery-type California cage system of rearing.

Parameters evaluated

The study evaluated various parameters, including daily mortality, culls, feed intake, total egg number, hatching egg

Table 1: Details of trial and experimental design.

Groups	Product	Dosage	Total number of birds	
			Female	Male
T1	BOA	1 ml/4 L of drinking water	5500	540
T2	MOA + OC	1ml /2 L of D/W + 4GM/1000 L	5500	540
T3	MOA + OC	1ml /2 L of D/W + 4GM/1000 L	5500	540
T4	MOA + OC	1ml /2 L of D/W + 4GM/1000 L	5500	540

number, egg weight, broken eggs and rejected eggs. Livability was recorded as a percentage of live birds daily and feeding allowance was adjusted considering livability. Egg production performance was expressed as a percentage of hen-day egg production and recorded daily. Hatchable eggs were collected for each group and accepted if not dirty, cracked, broken, excessively small or large, or double-yolked.

Cost benefit ratio economics (CBR)

Money values were obtained in Indian rupees and changed to American dollars according to the dollar change rate of the Reserve Bank of India. The total value in USD of hatched eggs was considered to obtain CBR and the difference between the treated and control groups was compared. The cost of each hatching egg in India is equivalent to $0.25 USD. The live breeder bird and hatched eggs cost calculated based on prevailing market cost.

Value of hatching eggs = Total number of hatched eggs × estimated at $0.25 USD/egg

Comparative difference on increase livability of birds = Value of mortality birds from T2, T3 and T4 groups - Value of mortality birds in T1 group

Comparative difference in hatching egg cost = Value of hatched eggs from T2, T3 and T4 groups - Value of hatched egg in T1 group

Comparative difference on water acidification and sanitization cost = Value of water acidification and sanitization from T2, T3 and T4 group - Value of water acidification and sanitization in T1 group

Total costs of T2, T3 and T4 (MOA + OC) = (cost of T2, T3 and T4 /L) × (L of T2, T3 and T4 used)

Total cost of T1 = (cost of T1/L) × (L of T1 used)

Total savings from the T1 group compared to T2, T3 and T4 groups = Difference in increased livability of birds + difference in hatching egg cost + difference in water acidification and sanitization cost

Net saving from the T1 group = Sum of the total savings from the T1 group over the T2, T3 and T4 groups

$$CBR = \frac{\text{Total savings from T1 group}}{\text{Total treatment cost of T1 group}}$$

Data and statistical analysis

The statistical analysis of data was performed using Stat graphics Centurion XVI.II Software version of Microsoft. One-way ANOVA was used for the differences between groups. The P-value of $P \geq 0.05$ was considered statistically non-significant. The values were expressed as means ± standard error (SE).

RESULTS AND DISCUSSION

The results of the broiler breeder performance parameters with the supplementation of T1, T2, T3 and T4 are summarized in Table 2. These results align with previous research on segment-wise topics.

Production parameters

The average daily feed consumption remained consistent across all experimental groups, with no significant ($P \geq 0.05$) effect on egg production percentages. However, the supplementation of organic acids blend (BOA) in the T1 group improved to the hen day egg production (HDEP) by 1.82, 0.62 and 0.62% compared to the T2, T3 and T4 groups. The results align with Yesilbag and Çolpan (2006) found that dietary supplementation with organic acids and their salts had an encouraging effect on egg production from 85.76% (control) to 91.03%, 90.94% and 91.30% for groups of 0.5%, 1.0% and 1.5% respectively. They concluded that organic acids and their salts in diet could accelerate laying capacity in 24-28 weeks laying hens and extend the period of egg production in 36-38 weeks hens, but the difference was not statistically significant. Moreover, Martinez *et al.* (2004) and Nezhad *et al.* (2008) found that different organic acid mixtures and levels have different effects on laying performance parameters in poultry. The improvement in hen day egg production might be due to better feed conversion by broiler breeder birds of the T1 group compared to all three treatment groups. Although the daily feed distribution is uniform for all birds, the T1 group demonstrates greater total feed consumption (Table 3) due to lower mortality rates. This phenomenon may explain the superior feed conversion and improved egg production rates observed in the T1 group compared to the T2, T3 and T4 groups, likely resulting from the synergistic action of the organic acid blend. This could be due to the recovery of damaged digestive wall cells, preservation of microbial

Table 2: Evaluated production parameters for broiler breeder within treatment and controls[1].

Performance parameters	T1	T2	T3	T4	P-value
Mortality (%)	0.22±0.05	0.27±0.04	0.28±0.05	0.27±0.04	0.769
Hen day egg production (%)	78.01±4.66	76.62±4.62	77.53±4.66	77.54±4.08	0.976
Hatching egg (%)	85.05±4.68	82.33±4.62	82.96±4.68	82.57±4.70	0.976
Rejected eggs (%)	09.69±4.25	10.58±4.32	10.60±4.25	10.98±4.38	0.997
Broken egg (%)	1.30±0.07*	1.49±0.04*	1.75±0.07*	1.70±0.09*	0.000
Egg weight (g)	57.64±1.61	57.67±1.61	57.68±1.61	57.76±1.61	1.000

[1]Data expressed as mean ± standard error.

*Mean values significantly differ between experimental treatments ($P<0.05$).

balance and improved nutrient utilization of hens in the supplemented groups (Rahman *et al.,* 2008). Similarly, the addition of product BOA in the T1 group improved hatching egg percentage with improvement in hen day egg production, which were not statistically significant with respective T2, T3 and T4 groups. The results of the current study for these parameters agree with the findings obtained previously (Michel *et al.,* 2017). These encouraging results imply that the integration of organic acid into drinking water or feed could be advantageous for hens during the egg production phase. The numerical improvements recorded in this study serve as a positive indicator of enhanced performance.

Eggshell deformities

Statistical analysis showed that organic acid and sanitizer supplementation did not significantly ($P \geq 0.05$) affect average egg weight. The result agreed with those obtained by Yesilbag and Colpan (2006), Jensen and Chang (1976); Gama *et al.* (2000); Yalcin *et al.* (2000) and Soltan (2008) indicated that the addition of different organic acids into laying hens' diet has not significantly modified the egg weight. However, the percentage of broken eggs decreased significantly ($P \leq 0.05$) with the addition of organic acids, particularly BOA, in the T1 group, compared to the T2, T3 and T4 groups. The potential reason for the low percentage of broken eggs in the T1 group could be attributed to enhanced modulation of gut pH, which leads to improved absorption of essential nutrients and increased mineral uptake necessary for shell formation compared to other treatment groups. The authors have well-documented these effects, as organic acids are known to lower the pH in the digestive tract, thereby enhancing nutrient digestibility (Dittoe *et al.,* 2018; Scicutella *et al.,* 2021) and enhancing the absorption of amino acids, proteins and minerals (Youn *et al.,* 2005; Liem *et al.,* 2008). By this way, organic acids promote the solubility and digestibility of calcium and phosphorus, which in turn facilitates greater deposition of calcium carbonate in the eggshell, leading to improved shell quality in laying hens (Swiatkiewicz and Arczewska-Wlosek, 2012). The results are well supported by Soltan (2008) and Park *et al.* (2009) who observed a significant decrease in soft-shell plus broken egg production and broken shell percentage with improved eggshell thickness when organic acids were added. On the other hand, the impact of acidifiers on the performance of laying hens is not uniform. Contradictory results were found by Gong *et al.* (2021) who reported organic acid supplementation did not appear to affect the rate of eggshell breakage in laying hens. In another study, Yesilbag and Colpan (2006) reported that improved eggshell quality parameters resulted from increased mineral and protein absorption, leading to reduced shell breaking. The studies found that acidification with weak organic acids can decrease pathogen colonization, improve protein digestibility and digestibility of minerals like Ca, P, Mg and Zn by enhancing

Table 3: Evaluation of cost benefit ratio of treatment groups in broiler breeder production parameters.

Parameters	T1	T2	T1	T3	T1	T4
Number of birds (N)	6040	6040	6040	6040	6040	6040
Trial period (Days)	91	91	91	91	91	91
Average feed intake/Bird/Day	147.13	147.14	147.13	147.13	147.13	147.12
Egg production %	78.01	76.62	78.01	77.53	78.01	77.54
Hatching eggs (HE) %	85.05	82.34	85.05	82.96	85.05	82.56
Mortality %	2.88	3.49	2.88	3.63	2.88	3.53
Mortality birds (N)	174.00	211.00	174.00	219.00	174.00	213.00
Difference in mortality birds	37		45		39	
Value addition by saving mortality	321		390		338	
Birds Only $ 8.67 USD/Bird (USD)						
Total egg production (N)	386048	376883	386048	382105	386048	381874
Total hatching eggs (N)	341084	322258	341084	329611	341084	326332
Difference in hatching eggs (N)	18826		11473		14752	
Value of hatching eggs INR $0.2 USD/Egg (USD)	68216.8	64451.6	68216.8	65922.2	68216.8	65266.4
Difference in hatching egg cost (USD)	3765.2		2294.6		2950.4	
Total feed consumed (Kg)	79955	79511	79955	79662	79955	79623
Total water consumed (L)	239865	238533	239865	238985	239865	238870
Total water treatment cost (USD)	199.89	429.36	199.89	430.17	199.89	429.97
Saving on water treatment cost (USD)	229		230		230	
Total savings from T1 (USD)	4315		2915		3519	
Net benefit from T1 (USD)			10749			
Cost benefit ratio (USD)	21.59		14.58		17.60	
Average cost benefit ratio (USD)			17.93			
Average ROI			18:1			

pepsin activity which serve as substrates in intermediary metabolism (Hajati 2018; Saleem *et al.,* 2019).

Livability

The study found no significant (P≥0.05) differences in mortality patterns between experimental groups in broiler breeders. The average mortality percentage was in the order of T1<T2<T4<T3, indicating that treatment with BOA improved the livability of birds. The results of the current study on mortality agree with the results obtained by Bouassi *et al.* (2016) and Park *et al.* (2009). In correspondence to the above results, Adil *et al.* (2010) reported that a combination of acidifier and sanitizer was found to be highly effective in reducing the caecal coliform count. Studies of Samanta, (2010) and Dehghani and Jahanian (2012) have reported that organic acids (OAs) reduce the production of toxic components produced by bacteria and the colonization of pathogens on the intestinal wall, thus preventing damage to epithelial cells. The better antibacterial activity of acidifiers and sanitizers combination in T1 treatment group could have led to a decrease in mortality percentage.

Cost-benefit ratio (CBR)

The results of the comparative evaluation of the cost-benefit ratio (CBR) of all treatment groups are summarized in Table 3. During the study, the greatest economic efficiency was obtained a CBR of $21.59 USD, represented by $4,315 extra total savings in favor of the T1 group when compared with T2 group. In subsequent comparison, birds in the T1 group had $3,519 and $2,915 extra total savings over the T4 and T3 groups, resulting in a CBR of $17.60 and $14.58 respectively. These results suggest that supplementing the blend of organic acid in T1 over other commercial products could increase economic efficiency and improve water quality in broiler breeders. Michel *et al.* (2017) observed the highest cost benefit ratio of 0.75:1 4.41:1 and 4.40:1 USD in favor of organic acids blend and probiotics treated groups compared to the control non-treated group in all three trials of broiler breeders. Similarly, the results of increased economic efficiency and higher net return on organic acids supplementation were consistent with the findings of Rahman *et al.* (2008) and Soltan (2008).

CONCLUSION

The study found that the addition of comparative commercial organic acids and sanitizer products, with a focus on BOA supplementation during peak laying periods, significantly lowered the rate of broken eggs. Furthermore, it enhanced laying performance, hatching success, reduced the rate of rejected eggs and lowered mortality rates when compared to the supplementation of MOA and OC. This led to increased production performance and economic benefits for broiler breeders. Though, there was no significant difference in health status or numerical improvement in all zootechnical production performance parameters observed between the groups. The cost-benefit ratio (CBR) of the comparative trials indicated that for every U.S. dollar spent on the BOA product, producers could recover an average of 17.93 U.S. dollars. The variations in the results could also be brought on by differences in the concentrations of organic acids and sanitizers, the sources and contents used, the chemical nature of the acids, their acid dissociation constant (pK) value, molecular weight, inclusion level and minimum inhibitory concentration, their sites of action and the microbial ecology of the gastrointestinal tract. Further research is needed to understand the exact effect and maximize the benefits of acidifiers and sanitizers in poultry life.

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Conflict of interest

The authors declare no conflict of interest related to this manuscript.

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