



Impact of *Lactobacillus acidophilus*-Derived Post Biotic Metabolites on Performance and Meat Quality in Broiler Chickens

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ABSTRACT

Background: The rising concerns over antibiotic resistance and the growing demand for antibiotic-free poultry products have driven interest in natural alternatives like postbiotics. These bioactive compounds support gut health, enhance immunity and improve meat quality without compromising production efficiency. By reducing antibiotic dependence, postbiotics contribute to one health initiatives, minimizing antibiotic residues in the food chain and mitigating environmental contamination. This approach promotes sustainable poultry production, enhances food safety and aligns with global efforts to combat antimicrobial resistance. In this context, the present study evaluates the impact of postbiotic supplementation on chicken meat quality parameters.

Methods: Postbiotic metabolites were extracted from *Lactobacillus acidophilus* using MRS broth culture and centrifugation, followed by the collection of cell-free supernatants. These postbiotics were analysed for their physiochemical properties and then mixed with feed daily during the feeding trial. A total of 480, Day old CARI-Bro Dhanraja chicks were randomly assigned to six separate groups i.e. T1-Basal diet (BD) supplemented with 0.2% (v/w) MRS Broth or uninoculated media; T2-BD+Antibiotic (CTC@335 mg/kg); T3-BD+ Probiotic; T4-BD+Post biotics @ 0.2% (v/w); T5-BD+Post biotics @ 0.4% (v/w) and T6-BD+Post biotics @ 0.6% (v/w).

Result: The study demonstrated that post biotic supplementation significantly ($P < 0.001$) improved meat quality indicators in broiler chickens, reducing cooking loss, drip loss and shear force, leading to more tender and juicier meat. Carotenoid deposition significantly improved ($p < 0.001$), enhancing meat appearance. Sensory evaluation showed no significant differences in appearance and colour, but T4 consistently received the highest scores for flavour, odor, juiciness and overall acceptability. The results suggest that postbiotics derived from *Lactobacillus acidophilus* at the dose of 0.2% can enhance meat tenderness, moisture retention and carotenoid deposition, potentially improving the overall quality of broiler meat can be used as a substitute for antibiotics in diets of broiler chickens.

Key words: Antibiotic-free poultry, Broilers, Meat quality, Natural alternatives, Postbiotics.

INTRODUCTION

Chicken meat is a lean protein that boasts with low cholesterol levels, essential vitamins and a higher concentration of polyunsaturated fatty acids (PUFAs), which are vital for human development and energy production (Ajay Kumar *et al.*, 2024). Application of indiscriminate antibiotics as growth promoters in poultry farming have sparked significant concerns regarding the safety of consuming chicken meat and eggs, due to potential negative health implications for humans. In light of this challenge, natural substitutes (probiotics, prebiotics, postbiotics *etc.*) have emerged as promising solutions, targeting the improvement of gut health in birds (Nath *et al.*, 2023). Using Probiotics promote gut integrity is ubiquitous in poultry because of its various favouring mechanisms. However, significant concern is that these live beneficial microbes also potentially transfer virulent genes from pathogenic microbes within the host via lateral gene transfer, contributing to antibiotic resistance (Sugandhi, 2018). To address these issues, products that possess the qualities of probiotics but do not contain live microorganisms can be administered; one such option is postbiotics. Postbiotics, or the metabolic residues of probiotics, are the fermented products derived from lactic

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acid bacteria, can be incorporated into poultry feed as novel additives. Postbiotics are metabolic byproducts generated by lactic acid bacteria and encompass a variety of components, such as bacteriocins, short-chain fatty acids (SCFAs), 2-furan carboxaldehyde, benzeneacetaldehyde and ethanone, among others. These compounds positively

shape the gut microbial community (Kareem *et al.*, 2015), exhibit similar capabilities and biological mechanisms as probiotics but without the presence of live microorganisms.

Meat quality encompasses various indicators that determine the wholesomeness and freshness of a meat product, including its color, texture, flavor, pH and juiciness. Postbiotics have shown potential in enhancing broiler meat quality. Recognizing the significance of meat quality and the necessity of delivering clean, safe meat to consumers, this study seeks to offer a more profound understanding of how different concentrations of postbiotic supplementation influence production performance and meat quality attributes in broiler chickens.

MATERIALS AND METHODS

Ethics declarations

The experimental was conducted at ICAR-Central Avian Research Institute, Bareilly under the project no. P-1/2021/1-IAV/L34/3900/6100, Duration: 01-04-2021 to 31.03.2024). The protocols employed in this investigation received explicit approval from the institute animal ethics committee (IAEC) *i.e.*, 452/GO/S/03/CPCSEA- 25/07/2021.

Harvesting postbiotics at laboratory: Postbiotics were evolved and extracted from *Lactobacillus acidophilus* under controlled laboratory conditions, following the protocol outlined by Kareem *et al.* (2015). Inoculum was reactivated by inoculating with de-Mann Rogosa Sharpe (MRS) broth (Hi Media-M369, granulated) followed by appropriate incubation conditions (30°C for 24 h). After bacterial propagation was further carried out by spread plate inoculation of culture and incubation again at 30°C for 48 h. A single colony was transferred to 10 ml of MRS broth and incubated at 30°C for 24 hours, followed by a sub-culture under the same conditions. From this culture, a 1% (v/v) inoculum was added to the reconstitution medium and incubated at 30°C for 24 hours. The bacterial cells were then harvested by centrifugation at 10,000 × g for 15 minutes and the cell-free supernatant (CFS) was obtained by filtering through a 0.22 µm syringe filter (Millex®). These postbiotics underwent laboratory analyses following Monika *et al.*, (2022). The liquid postbiotics were then mixed daily into the feed according to the birds' intake requirements and provided to the designated treatment groups.

Management, diets and experimental design of birds

A total of 480 Day old CARI-Bro Dhanraja chicks were randomly split up into six groups. Each group was comprised of four replicates and each replicates contained twenty chicks. Six different dietary treatments groups were, T1-Basal diet (BD)+0.2%(v/w) MRS Broth/ uninoculated media; T2-BD+Antibiotic (CTC@335 mg/kg) {The antibiotic (CTC-Chlorotetracycline) was procured from Altron Biotech}; T3 BD+Probiotic (*Lactobacillus acidophilus* -1×10⁹cfu/g); T4-BD+Postbiotics @ 0.2% (v/w); T5-BD+Postbiotics @ 0.4% (v/w) and T6-BD+Postbiotics @ 0.6% (v/w). Birds were fed with three different phases of diet such as pre-starter

(0-14d), starter (15-28d) and finisher (29-42d) according to ICAR (2013) recommendations. The detailed outline of the feed ingredients employed in the study is given in the (Table 1).

Zootechnical performance

The production performance parameters, including body weight, weight gain and feed conversion ratio (FCR), were assessed at various growth stages: pre-starter, starter and finisher phases of the birds.

Meat quality and sensory traits

For meat quality estimation, the birds were slaughtered at the end of the trial, *i.e.*, 42nd day, four birds from each replicate of the treatment group (20 birds/dietary treatment, n=120) were randomly selected. Subsequently, birds were subjected to mechanical stunning and preceded to halal method of slaughter followed by meat sample collection and estimation.

Ultimate pH

Post-slaughter, breast samples (*Pectoralis major*) were collected and divided into two halves and assigned to the physical and sensory analyses. The pHu of 120 half breasts was assessed by inserting a portable pH meter (FG2-Five GoTM Mettler Toledo, Greifensee, Switzerland) probe calibrated at pH 4.0 and 7.0 into breast muscle (*Pectoralis major*).

Drip loss

In this study, the gravimetric method, specifically the Honikel bag method as described by Warner (2014), was employed to determine drip loss in meat samples. A 50 g portion of breast meat was carefully excised and suspended in an inflated bag at 4±0.7°C, ensuring that the sample did not come into contact with the bag's sides. This technique involves weighing the meat at the beginning and end of the storage period, with drip loss calculated as the percentage reduction in weight relative to the initial mass. After the designated storage period, the samples were reweighed to precisely quantify the amount of drip loss.

Shear force value

A total of 120 other half breasts (*Pectoralis major*) were vacuum sealed and cooked in a water bath at 80°C until the core temperature reached 74°C for quantification of shear force and sensory traits. The V-shaped Warner-Bratzler shear blade was used to cut perpendicularly the longitudinal muscle fibres of the meat to determine Warner-Bratzler shear force (WBSF).

Sensory analysis

The samples were kept at room temperature for 20 min then samples were cut into small pieces and randomly served to 20 panellists. The panel received the list of descriptors to score on a numerical scale from 0 (the lowest score for each attribute) to 8 (the highest score for each attribute) as per the method acknowledged by Keeton, 1983.

Estimation of muscle cholesterol and triglycerides

The total lipid was extracted from muscle tissue samples and proceeds as per the method of Folch *et al.* (1957).

The cholesterol (mg/dl) and triglyceride (mg/dl) content of muscle samples were estimated as per the standard procedures of Coral Diagnostic Kits, Tulip diagnostics, Pt., Ltd., Goa.

Estimation of muscle carotenoid

The carotenoid contents of minced meat samples were extracted and quantified following the method described by Okonkwo (2009).

Statistical analysis

The statistical analysis was executed using Statistical Package for Social Sciences (SPSS) version 20.0, software. The data obtained from the conducted experiments underwent rigorous statistical analysis employing a one-way ANOVA framework. The group means were compared using Tukey's multiple range test at a significance level of $P \leq 0.05$ to determine if the differences between them were statistically significant.

RESULTS AND DISCUSSION

Effect of postbiotic on production performance

The impact of postbiotics on production parameters revealed significant ($p < 0.001$) differences among treatment

groups across all three trial phases (Table 2). Results clearly indicate that treatment group T4 achieved a notably higher body weight (1677.52 g), overall weight gain (1636.72 g) and FCR (1.75), comparable to the antibiotic-supplemented group. Conversely, group T1 demonstrated significantly ($p < 0.001$) lower overall body weight (1394.78 g), weight gain (1357.18 g) and FCR (1.94).

Effect of postbiotic on meat quality parameters

The results from the (Table 3) illustrate the effects of postbiotic supplementation on meat quality parameters. The pH values across the groups ranged from 5.71 to 6.11, with no statistically significant ($p > 0.05$) differences between the treatments. Cooking loss was significantly ($p < 0.001$) impacted by postbiotic supplementation. Drip loss significantly ($p < 0.001$) varied across treatments, T1 exhibited the highest drip loss at 3.96%, while T4 had the lowest at 2.24%. The shear force values, a measure of meat tenderness, showed significant ($p < 0.001$) differences among the groups. T1 (1113.0 g) had the highest shear force, indicating tougher meat, whereas T4 (937.36 g) had the lowest value, suggesting the most tender meat. The

Table 1: Ingredient and chemical composition of basal diet. (ICAR-2013).

Ingredients (%)	Pre-starter	Starter	Finisher
Maize	54.60	54.20	57.62
Soybean meal (CP, 44%)	39.58	37.80	32.58
Rice bran oil	02.12	04.24	05.86
Calcite	01.54	01.52	01.73
Di-calcium phosphate	0.90	0.95	1.10
Salt	0.18	0.18	0.18
L-Lysine	0.30	0.15	0.17
DL-Methionine	0.30	0.28	0.27
Phytase	0.015	0.015	0.015
Vitamin AD ₃ EK ^{1*}	0.014	0.014	0.014
B-complex vitamins ^{2*}	0.015	0.015	0.015
Trace minerals ^{3*}	0.010	0.010	0.010
Coccidiostat	0.01	0.01	0.01
Toxin binder	0.05	0.05	0.05
Total	100	100	100
Nutrient composition (%) Calculated			
Crude protein	22.65	21.65	19.70
Metabolizable energy (kcal/kg)	3000	3125	3250
Calcium	0.96	0.95	0.90
Available phosphorus	0.45	0.46	0.46
Lysine	1.42	1.25	1.14
Methionine	0.62	0.59	0.55

ICAR- Indian Council of Agricultural Research; CP- Crude protein; L-lysine: Levo lysine; DL- Methionine: D (dextrogyre) and L (levogyre); %- Percentage; kcal/kg- Kilocalories per kilogram.

*Calculated values.

- 1 One gram of Vitamin AD₃ EK supplement contained 82500 IU of Vitamin-A, 12000 IU of Vitamin-D₃, 80 mg of Vitamin-E and 10 mg of Vitamin-K.
- 2 One gram of B-complex supplement contained 8 mg of Vitamin-B₁, 16 mg of Vitamin-B₆, 80 mcg of Vitamin-B₁₂, 120 mg of Niacin, 8 mg of Folic acid, 80 mg of Calcium -D-pantothenate and 86 mg of Calcium.
- 3 One gram of Trace min. mix. contained 54 mg of Manganese, 52 mg of Zinc, 20 mg of Iron, 2 mg of Iodine and 1 mg of Cobalt. Units: IU- International unit; mcg- microgram; mg- milligram.

trend shows that postbiotic supplementation improves meat tenderness, particularly in T4.

Effect of postbiotics on total cholesterol, triglycerides and carotenoids on meat

The impact of postbiotics on meat total cholesterol, triglycerides and carotenoids deposition were presented in the (Table 3). No significant ($p>0.05$) differences were observed in the total cholesterol and triglyceride levels across the treatment groups. However, carotenoid levels in meat were significantly affected by postbiotic supplementation ($p<0.001$).

Effect of postbiotics on meat sensory parameters

The appearance and color scores showed minimal variation across treatments, with scores ranging from 4.35 to 4.61. Similarly, no statistically significant ($p>0.05$) differences between the treatment groups were observed. Odor scores ranged between 4.34 and 4.64, with T4 receiving the highest score. This indicates that postbiotic supplementation may have a positive, albeit modest, impact on the meat's aroma. Juiciness scores increased across treatments, with T1 having the lowest score (4.76) and T6 the highest (5.08). Overall acceptability scores varied slightly among treatments, with T4 again receiving the highest score (4.70). This indicates that postbiotic supplementation, particularly in T4, may improve overall consumer satisfaction with the meat.

Effect of postbiotic on production performance

Birds' body weight, feed intake, weight gain trends and FCR significantly improved ($P<0.001$), highlighting the benefits of postbiotic treatment. Postbiotics have both

bacteriostatic and bactericidal qualities that block harmful bacteria and reduce the formation of toxins in the gut, in better performance (Monika *et al.*, 2022). Postbiotics improve nutrition absorption of nutrients by lowering subclinical infections, mirroring antibiotics' growth-promoting effects. Additionally, postbiotics include vitamins, teichoic acids, extracellular polysaccharides, cell lysates, microbial cell wall fragments, short-chain fatty acids and other advantageous metabolites that improve nutrient absorption in the jejunal villi. According to Monika *et al.* (2022) postbiotics have an acidic pH of 4 to 5, which is ideal for protein digestion and aids in controlling bacterial populations throughout the gut. When combined, the acidic environment and reduced pathogen load boost feed digestion digestibility leading to increased growth performance in poultry.

Effect of postbiotic on meat quality parameters

The results show that the addition of postbiotics did not have a statistically significant impact on the percentage of pH value of breast meat samples. A similar trend was observed by Kareem *et al.* (2015); Doski (2023) for pH value when they fed broiler with postbiotics. However, Doski *et al.* (2023) not found any significant difference due to postbiotic supplementation in drip loss and cooking percentage, but in the present study for both the parameters significant results were observed. Reduction in cooking loss in this study is a favourable outcome, indicating that postbiotic-treated birds retained more moisture during the cooking process. Postbiotics may enhance gut health and nutrient absorption, leading to better muscle development and increased intramuscular water retention. Additionally, their role

Table 2: Effect of postbiotics on production performance in broiler chickens.

	T1	T2	T3	T4	T5	T6	P- value
Body weight							
Pre starter	216.73 ^d ±1.81	241.30 ^b ±1.79	234.00 ^c ±2.04	253.52 ^a ±1.68	232.52 ^c ±1.72	224.15 ^d ±1.61	0.025
Starter	694.30 ^c ±5.37	728.90 ^{bc} ±4.64	715.80 ^{bc} ±5.52	743.12 ^a ±4.66	714.12 ^b ±4.06	708.15 ^c ±4.96	0.036
Finisher	1394.78 ^e ±10.71	1631.03 ^b ±10.34	1478.65 ^{cd} ±11.43	1677.52 ^a ±10.60	1512.78 ^c ±8.41	1474.48 ^{cd} ±10.35	0.000
Body weight gain							
Pre starter	178.40 ^{cd} ±0.97	200.67 ^b ±0.83	193.85 ^c ±1.21	212.72 ^a ±0.82	192.38 ^{bc} ±0.69	183.82 ^c ±0.91	0.002
Starter	478.33±2.26	487.6±1.92	481.8±2.33	489.6±1.93	481.6±1.64	484±2.11	0.086
Finisher	700.45 ^{cd} ±2.93	902.13 ^b ±3.43	762.85 ^c ±3.15	934.4 ^a ±3.64	798.67 ^{bc} ±2.45	766.33 ^c ±2.85	0.034
Overall	1357.18 ^{de} ±2.93	1590.4 ^b ±4.23	1438.5 ^{cd} ±3.43	1636.72 ^a ±2.15	1472.65 ^{bc} ±2.65	1434.15 ^d ±2.74	0.012
FCR							
Pre starter	1.38 ^a ±0.03	1.26 ^c ±0.01	1.29 ^b ±0.03	1.18 ^d ±0.01	1.26 ^b ±0.04	1.38 ^a ±0.03	0.057
Starter	1.80 ^a ±0.02	1.7 ^b ±0.01	1.72 ^b ±0.02	1.68 ^c ±0.02	1.73 ^b ±0.04	1.83 ^a ±0.02	0.036
Finisher	2.16 ^a ±0.03	1.93 ^{bc} ±0.02	1.98 ^b ±0.03	1.92 ^c ±0.01	1.94 ^b ±0.02	2.15 ^a ±0.03	0.078
Overall	1.94 ^a ±0.04	1.77 ^{bc} ±0.03	1.81 ^b ±0.08	1.75 ^c ±0.04	1.79 ^{bc} ±0.04	1.93 ^a ±0.04	0.057

Means bearing different superscript (a, b, c, d) in rows differ significantly ($p<0.001$); T1= BD+0.2%(v/w) MRS Broth/uninoculated media, T2= BD+CTC @ 335 mg/kg (w/v), T3= BD + Probiotic; T4= BD + Postbiotics @ 0.2% (v/w); T5= BD + Postbiotics @ 0.4% (v/w); T6= BD+Postbiotics @ 0.6% (v/w). MRS- de-Mann Rogosa Sharpe (MRS) broth; CTC- Chlortetracycline.

BD: Basal diet; FCR: Feed conversion ratio; v/w: Volume/weight; % - Percentage.

in modulating oxidative stress and strengthening muscle fiber integrity could contribute to reduced protein denaturation and better moisture retention during cooking (Yang *et al.*, 2012).

In this study, drip loss was significantly ($p < 0.001$) reduced in postbiotic-supplemented groups. This aligns with the findings of Xu *et al.*, 2020, who reported that postbiotics can improve cell membrane integrity, leading to reduced fluid exudation during storage. The reduced drip loss in postbiotic-treated groups, particularly in T4, suggests that postbiotics help maintain meat juiciness and freshness during storage, which is crucial for prolonging shelf life and enhancing consumer satisfaction.

Shear force, a measure of meat tenderness, was significantly reduced ($p < 0.001$) in postbiotic-supplemented groups. These results are consistent with previous studies that have shown the beneficial effects of probiotics and postbiotics on meat tenderness. For example, Zhang *et al.*, 2021 reported that probiotics can enhance meat tenderness by reducing oxidative stress and improving muscle fiber integrity. The lower shear force observed in T4 indicates that postbiotics may help improve meat tenderness by reducing muscle stiffness and promoting better muscle fiber alignment. This improved tenderness is likely due to the antioxidant properties of postbiotics, which mitigate oxidative damage to muscle proteins and contribute to better meat quality (Xiong *et al.*, 2019).

Water-holding capacity (WHC) is a critical factor influencing meat juiciness, texture and overall consumer acceptability. The treatment groups were not statistically

significant ($p > 0.05$), a trend of decreased WHC was observed with increasing postbiotic levels. This finding is in line with earlier research by Owens *et al.*, 2000, who suggested that WHC may be influenced by several factors, including muscle pH, protein denaturation and muscle fibers characteristics. The numerical decrease in WHC observed in this study could be related to the reductions in drip loss and cooking loss, as improved moisture retention during storage and cooking can contribute to better WHC.

Effect of postbiotics on total cholesterol, triglycerides and carotenoids on meat

Although no statistically significant ($p > 0.05$) differences were found in cholesterol and triglyceride levels, the numerical trends observed in the data suggest potential benefits of postbiotics. This trend suggests that postbiotic supplementation may have a cholesterol-lowering effect. Previous studies have reported similar findings, where postbiotics, particularly those derived from *Lactobacillus* strains, were found to modulate lipid metabolism and reduce cholesterol levels in both animal models and humans (Lee *et al.*, 2018). The mechanisms behind this effect are thought to involve the inhibition of cholesterol absorption in the intestines and the deconjugation of bile salts by bile salt hydrolase-active postbiotic components (Lye *et al.*, 2010). Similarly, triglyceride levels also showed no statistically significant differences, but a notable numerical reduction was observed. This observation is supported by findings from studies such as (Zhang *et al.*, 2021),

Table 3: Effect of postbiotics on meat quality parameters in broiler chickens.

	T1	T2	T3	T4	T5	T6	P value
pH	6.11±0.24	6.05±0.18	5.94±0.32	5.81±0.24	5.86±0.12	5.71±0.14	0.217
Cooking loss %	23.5 ^{cd} ±1.24	21.99 ^c ±1.25	21.66 ^{bc} ±1.54	18.18 ^a ±1.32	19.51 ^{ab} ±1.45	19.69 ^b ±1.64	0.009
Drip loss %	3.96 ^d ±0.05	2.95 ^c ±0.01	2.92 ^c ±0.04	2.24 ^a ±0.05	2.36 ^b ±0.02	2.66 ^{bc} ±0.06	0.024
Shear force (g)	1113.08 ^a ±3.65	1037.95 ^b ±7.65	1027.79 ^b ±4.65	937.36 ^a ±6.45	964.39 ^{ab} ±7.99	981.25 ^{ab} ±8.21	0.008
WHC%	63.52±1.63	60.69±1.33	58.42±1.31	57.3±1.74	55.97±1.54	56.74±1.42	0.908
Total cholesterol (mg/dl)	236.79±8.72	230.86±22.17	221.39±7.49	208.37±17.48	201.26±7.96	215.48±9.33	0.802
Triglycerides (mg/dl)	197.33±12.51	174.02±7.03	157.21±34.14	139.86±3.35	144.22±4.71	146.91±14.23	0.312
Carotenoids (µg/g)	4.25 ^c ±0.34	6.46 ^b ±0.36	8.50 ^{bc} ±0.73	11.10 ^a ±0.75	10.09 ^{ab} ±0.81	8.92 ^{bc} ±1.2	0.000
Meat sensory parameters							
Appearance/ Colour	4.38±1.54	4.35±1.64	4.41±1.32	4.61±1.45	4.43±1.25	4.54±1.24	0.446
Flavor/Taste	4.28±0.18	4.42±0.14	4.40±0.24	4.75±0.32	4.59±0.12	4.48±0.24	0.521
Odor	4.34±1.63	4.42±1.54	4.40±1.33	4.64±1.42	4.53±1.74	4.47±1.31	0.159
Juiciness	4.76±0.05	4.71±0.01	4.76±0.06	4.86±0.02	5.02±0.04	5.08±0.05	0.379
Overall acceptability	4.50±3.65	4.59±7.65	4.47±4.65	4.70±7.99	4.62±8.21	4.61±6.45	0.544

Means bearing different superscript (a, b, c, d) in rows differ significantly ($p < 0.001$); T1= BD+0.2%(v/w) MRS Broth/uninoculated media, T2= BD+CTC @ 335 mg/kg (w/v), T3= BD+Probiotic; T4= BD+Postbiotics @ 0.2% (v/w); T5= BD+Postbiotics @ 0.4% (v/w); T6= BD+Postbiotics @ 0.6% (v/w). MRS- de-Mann rogosa ssharpe (MRS) broth; CTC- Chlortetracycline.

BD: Basal diet; v/w: Volume/weight; %-Percentage; g: Gram; mg/dl: milligrams per decilitre; µg/g: micrograms per gram

where postbiotics were shown to positively influence lipid metabolism by enhancing fatty acid oxidation and reducing fat deposition in animal models. Carotenoid levels in the meat were significantly ($p < 0.001$) affected by postbiotic supplementation. These findings suggest that postbiotics significantly enhance the deposition of carotenoids in broiler meat. The increased carotenoid levels observed in the postbiotic-supplemented groups may be attributed to the ability of postbiotics to improve intestinal absorption of nutrients and their role in modulating gut microbiota (Pérez-Rosés *et al.*, 2020). Postbiotics, by improving gut health, could enhance the absorption and bioavailability of carotenoids, leading to greater deposition in the muscle tissues. Therefore, the significant increase in carotenoid content with postbiotic supplementation not only boosts the nutritional value of the meat but also contributes to better preservation and consumer appeal. These findings are consistent with the hypothesis that postbiotics can act as functional feed additives to enhance both the nutritional and sensory qualities of poultry meat.

Effect of postbiotics on meat sensory parameters

Flavour scores demonstrated slight improvement across treatments, with T4 (4.75) achieving the highest score. Although the differences were not statistically significant ($p > 0.05$), this trend suggests that postbiotics may enhance the flavor of broiler meat. Odor scores ranged between 4.34 and 4.64, with T4 receiving the highest score. Although the differences were not statistically significant, the higher odour score in T4 indicates that supplementing with postbiotics might contribute to improved aroma in broiler meat. The enhancement of odor could be related to improved oxidative stability of the meat, as postbiotics have been associated with reductions in lipid oxidation, which can negatively affect meat odour (Surai *et al.*, 2019). Juiciness scores increased across treatments, with T1 having the lowest score (4.76) and T6 achieving the highest (5.08). This trend aligns with the reductions in cooking loss and drip loss observed in the earlier analysis, suggesting that postbiotic supplementation may contribute to a more succulent meat product. Juiciness is directly influenced by the water-holding capacity (WHC) of the meat, as well as the fat content and distribution within the muscle tissue. The improved juiciness in postbiotic-supplemented groups, particularly T6, can be attributed to the enhanced moisture retention properties conferred by postbiotics, which may help reduce water loss during cooking and storage (Hossain *et al.*, 2022). Total satisfaction ratings varied slightly among treatments, with T4 receiving the highest score (4.70). This highlights that postbiotic supplementation, particularly in the concentration used in T4, may improve overall consumer satisfaction with the meat.

CONCLUSION

Postbiotics from *Lactobacillus acidophilus* at a 0.2%(v/w) dose level show potential as a natural alternative to antibiotics in broiler diets, enhancing meat quality through improved tenderness, moisture retention and carotenoid

deposition. Their application as natural growth promoters can serve as a sustainable alternative to antibiotics, addressing concerns over antimicrobial resistance. Future research should focus on optimizing dosage, identifying strain-specific effects and exploring synergistic combinations with other feed additives to maximize their efficacy in commercial poultry production.

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Disclaimers

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Informed consent

All animal procedures for experiments were approved Institute Animal Ethical Committee.

Conflict of interest

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