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Effects of Yogurt on Growth Performance, Carcass Traits, Lipid Profile and Fecal Microbial Load of Broiler Chickens

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ABSTRACT

This study explored how yogurt and probiotics affect broiler chicken growth, carcass yield, lipid profile, fecal bacterial load, and profitability. A total of 120 Cobb-500 broiler chicks, aged seven days, were randomly assigned to five treatment groups, each with three replicates. The groups were T0: Control BD (basal diet), T1: 0.5g of a commercial probiotic (Avi-Bac™), T2: BD combined with 3g, T3: BD combined with 5g, and T4: BD combined with 7g of fresh yogurt per liter of drinking water. The findings revealed that yogurt supplementation significantly improved ($P<0.01$) live weight gain (LWG), feed conversion ratio (FCR) and carcass weight (g) and reduced mortality compared to the control (T0) and probiotic-treated (T1) groups. Based on blood lipoprotein metrics, yogurt, and probiotics reduced low-density lipoprotein (LDL) levels compared to the control group. At both 21 and 35 days, there were no significant differences ($P>0.05$) in total bacterial and *Escherichia coli* levels between the yogurt-treated and control groups. However, the cost-effective evaluation indicated a significant ($P<0.01$) increase in group T3 compared to other treatment groups. Instead of commercial probiotics, yogurt supplementation @ 5g/L of drinking water can lower broiler chicken production costs by stimulating development.

Keywords: Broiler, Bacterial count, Yogurt, Growth performance, Lipid parameters.

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INTRODUCTION

Poultry production has emerged as a crucial element of the global meat economy, providing a substantial quantity of dietary protein, with chicken rearing being the highest position (Attia et al. 2022). In Bangladesh, the poultry sector is crucial for employment and supplying protein needs, providing 22-27% of the country's total meat supply (Sultana et al. 2017). Antibiotic growth promoters (AGP) have been widely used in poultry husbandry to meet the increased demand for poultry meat to prevent and treat bacterial infections (Habib et al. 2024). Conversely, antibiotics have the potential to negatively impact meat quality and endanger human health when used as feed additives (Stanton, 2013). Misuse of antibiotics can trigger drug-resistant pathogens and antibiotic residues in the food supply chain (Haque et al. 2024). Prior research has shown that antibiotic residues present in poultry have the potential to penetrate the food pyramid and foster gut microbial resistance. Mortality may result from an overabundance of drug-resistant bacteria, which can cause illnesses affecting the gastrointestinal and nervous systems (Neogi et al. 2020; Neveling and Dicks 2021; Haque et al. 2021; Nupur et al. 2023). In addition to regulations prohibiting the application of AGPs in the poultry sector, numerous stressors continue to induce gut health complications in birds (Liang et al. 2021). Hence, it is crucial to explore adequate substitutes for antibiotics in order to enhance animal well-being and mitigate financial losses in the poultry sector.

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Probiotics consist of a combination of a minimum of one viable microorganism. A positive impact on the host can result when these microorganisms reach a specific degree of colonization of the intestinal wall (Alagawany et al. 2018; Glago et al. 2024). Probiotics fight pathogens for the gut niches, preventing infections and altering metabolism (Haque et al. 2023). Probiotics improve intestinal structure, immunity, metabolic function, and likelihood of infection by decreasing bacterial invasion. They eliminate infective organisms in the digestive tract by competing for resources and preventing harmful microbes from adhering to the gut mucosa (Bogucka et al. 2019; De Cesare et al. 2020; Susalam et al. 2024). Researchers have found that probiotics play an important role in the gastrointestinal microbiota of chickens. These roles include maintaining the immune system (Mindus et al. 2021), supporting growth and evolution (Feng et al. 2021), nutrient assimilation (Shehata et al. 2022) and absorbing substances (Ramírez et al. 2022). Probiotics not only improve intestinal homeostasis but also improve protection (Jiang et al. 2021), reduce surplus lipid levels (Chen et al. 2021), amplify egg traits (Zhan et al. 2019) and enhance chicken output (Zhang et al. 2021). Furthermore, short-chain fatty acids (SCFAs), significant compounds derived from gut microbial fermentation, also influence the direct impacts of probiotics in the intestinal tract of poultry. Researchers have found that these SCFAs promote intestinal health, bolster protection, and maximize bird output (Zhang et al. 2012; Yosi et al. 2022). While several nations are adopting probiotic safety recommendations, the absence of legal regulation or potency standards may represent a threat to animal-used probiotics, raising food safety risk (Haque et al. 2022). Probiotics also affect the immune system differently. Raheem et al. (2021) found that probiotics modulated chick immunological responses, both specific and non-specific. This has proven beneficial in preventing and treating infectious diseases. Numerous studies have demonstrated improved performance in probiotic broiler feeds (Yu et al. 2022). However, in the control group, Abd El-Hack et al. (2020) found no improved broiler productivity from the probiotics. Therefore, we must assess the impact of integrating locally produced probiotics like yogurt and commercial probiotics into drinking water on chicken performance.

Probiotics foster poultry health and efficacy (Al-Khalaifah, 2018; Ahmad et al. 2022). Beneficial bacteria, such as *Lactobacillus acidophilus*, are primarily present in yogurt and associated with potential health benefits (Khan et al. 2011). It significantly influences broiler growth performance and nutrient digestibility (Sultan et al. 2006; Boostani et al. 2013). Still, how well probiotics boost the immune system and gastrointestinal colonization depends on many factors—strain specificity, how often and how much is taken, host-related factors, and stress (Jha et al. 2020; Yousaf et al. 2022). Currently, the market offers a wide range of probiotic preparations. The indiscriminate use of these medications necessitates more rigorous scientific evidence. Opsonin Pharma Limited (Bangladesh) markets Avi-Bac^{TM}, a commercial probiotic preparation that contains a unique blend of dried *Bacillus subtilis*, *Bifidobacterium longun*, and *Lactobacillus acidophilus*. According to the product's manufacturer (Ralco Inc. USA), the product improves broiler performance. Furthermore, there has been limited investigation in Bangladesh into using locally produced yogurt as a substitute for commercial probiotics and growth-promoting agents to improve broiler chicken productivity. Therefore, this study assessed the effects of Avi-Bac^{TM} and yogurt on broiler chicken performance to determine the benefits of commercial probiotics and locally-made yogurt in poultry husbandry.

MATERIALS & METHODS

Ethical Approval

The study plan was reviewed and approved by the Institutional Committee of Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, Bangladesh (Approval code: HSTU/VAS/ASN/EA/2023/0014).

Experimental Design and Birds

The study was done in Dinajpur, Bangladesh, from July to August 2023, with 120 specific pathogen-free (SPF) cobb-500-day-old broiler chicks procured from a commercial breeder (Nourish Poultry and Hatchery Limited, Panchagarh, Bangladesh). The chicks were raised in a brooder for seven days to acclimatize to their environment. Following seven days, the chicks were selected at random to one of five dietary trial groups using a Completely Randomized Design (CRD). Each group was divided into three replications, comprising eight birds. Different concentrations of yogurt (3, 5, and 7g/L drinking water) and 0.5g probiotic (Avi-Bac^{TM})/L drinking water were added to the experimental broiler chicks. The experimental layout is depicted in Table 1.

Collection of Yogurt and Probiotic

Yogurt (81% water, 9% protein, 5% fat, and 4% carbohydrates, including 4% sugars) and the commercial probiotic Avi–Bac^{TM} (Actifibe prebiotic, *Bacillus subtilis*, *Bifidobacterium longun*, *Lactobacillus acidophilus*) were acquired at the local market in Dinajpur Sadar, Bangladesh.

Preparation of the Experimental Diets

The experimental diets were made with formulated feed from Dinajpur town market. Using a digital weighing balance, the recommended feed materials were measured and blended. The experiment had two phases: broiler-starter and broiler-finisher. Between 8 and 21 days old, chicks were fed starter; between 22 and 35 days, finisher. Table 2 shows the estimated broiler (starter and grower) feed ingredient proportions.

Housing and Brooding

The study was conducted at the HSTU Experimental Broiler Farm under strictly controlled environmental conditions. The room was thoroughly cleaned and rinsed with pressure water using a hosepipe. Prior to the arrival of the chicks, the ceiling, walls, and floor were sanitized with a Povisep (Jayson Pharmaceuticals Ltd., Bangladesh) solution @ 4mL/L. Concurrently, all necessary equipment, including

Table 1: Layout showing the distribution of experimental broilers

Dietary Treatment groups		Number of broiler chicks in each replication			Total
		R_1	R_2	R_3	
BD (without yogurt)	T_0	8	8	8	24
Feed+0.5g Avi-Bac^{TM}/L drinking water	T_1	8	8	8	24
Feed + 3g yogurt/L drinking water	T_2	8	8	8	24
Feed+ 5g yogurt/L drinking water	T_3	8	8	8	24
Feed + 7 g yogurt/L drinking water	T_4	8	8	8	24
Total number of broilers		40	40	40	120

BD=Basal diet, T0 was considered as the control group provided water without yogurt and probiotics. T1 was considered as a positive control group provided with 0.5g Avi-BacTM commercial probiotic/L drinking water. T2, T3, and T4 groups were provided with 3, 5, and 7g sweet yogurt/L drinking water once every alternative day.

Table 2: Ingredients and calculated chemical composition of broiler starter and finisher diets

Ingredients (For 100 kg)	Broiler starter (8-21 days)	Broiler finisher (22-35 days)
Maize (kg)	53	50
Soybean Meal (kg)	37	41
De Oiled Rice Bran (kg)	5	4
Soybean oil (kg)	4	3.5
DCP (g)	500	200
Salt (g)	250	200
Solvance binder (g)	200	150
Aciplex (g)	200	250
Biograin (g)	50	50
Lysine (g)	200	150
Methionine (g)	250	200
P-Vaila Z/M (g)	100	100
Choline Chloride (g)	50	50
Emerald (g)	100	100
Anchromix (g)	50	50
Calculated chemical composition		
Metabolizable Energy, ME (kCal/kg)	3000	3050
Protein (%)	22	20
Fat (%)	6.18	6
Fiber (%)	3	3
Lysine (%)	1.9	1.9
Methionine (%)	2	2.45
Ca (%)	0.42	1
P (%)	0.36	0.9
Na (%)	0.78	0.97

feeders, plastic buckets, and drinkers, were meticulously cleaned, washed, and disinfected with a Povisep solution @ 5mL per liter. Following the drying process, these items were left empty for a week before the chicks drove in. For this 35-day trial, 15-floor pens with a 120×76cm poultry shed floor were considered. The shed was allowed to dry for a week after being cleaned and disinfected. All windows were left open for sufficient ventilation. One week later, lime was applied to the shelter floor and area for maximum biosecurity.

The brooding temperature was sustained at 34oC from the initial week of age. Thereafter, this temperature gradually decreased until the brood attained the ambient temperature of the house, which was 28°C post-experiment. A supplementary heat source was provided by placing a 100-watt incandescent light in the pen's center, 12 inches above ground level, away from the 7-day-old. The bulb's height was augmented by progressively raising each bulb to meet temperature specifications. Two sides of the home were papered to guard from cold and tempestuous winds. These sheets were partially or completely removed during the final finishing phase when the ambient temperature was optimal. The room temperature was recorded every six hours using a thermometer. The humidity level remained between 55 and 60% throughout the entire trial.

Feeding and Watering

During the first week, the chicks were fed on chick feeder trays. Round drinkers and linear feeders were used throughout the incubation period. After that, a round plastic feeder replaced the linear feeder. Formulated pellet feed was served three times daily: in the morning, midday, and evening. The T0 group received water without yogurt or probiotics. T1 received 0.5g Avi-Bac^{TM} /L drinking water at 9 a.m. twice weekly for three days. T2, T3, and T4 received 3, 5, and 7g of yogurt/L drinking water, respectively, at 9 am once every alternative day. Feeders were cleaned weekly, and drinkers were daily.

Lighting Management

Throughout the experiment, each bird was subjected to a daily regimen of one hour of darkness followed by 23 hours of continuous illumination. By instituting a dark time, the broilers were acclimatized to the possibility of darkness due to a power outage. We hung an electric bulb at a height of 2.8m as an extra illumination source in the evening to provide the necessary warmth.

Immunization

Immunization for New Castle Disease (ND) was administered on the 4th day and for Infectious Bursal Disease (IBD) on the 10th day. Booster dosages were administered on the 21st and 16th days.

Assessment of Productivity

Live weight and weight gain: The live weights of the chicks were recorded at the outset and subsequently weekly for each replication within each treatment group. The live weight gain was calculated by deducting the initial weight from the final weight.

Feed intake and FCR: The feed intake calculation divided each replication's weekly feed consumption by the number of live birds. The Feed Conversion Ratio (FCR) quantifies the relationship between total feed intake and weight gain.

Monitoring Mortality of the Birds: The mortality rates (%) were determined by counting the number of dead birds for each treatment.

Carcass Characteristics: After 35 days, the birds were dissected to determine the weights of organs like the breast, thigh, liver, and heart using a digital weight balance.

Lipid Profile Parameters

On day 35, a one-cc syringe was utilized to extract 3 ml of blood from the wing vein of two randomly selected birds from each pen, collected in a red tube. The serum in the red tube was isolated via centrifugation at 3,000rpm for 15min after being kept upright in the refrigerator. Total cholesterol, triglycerides, high-density lipoprotein (HDL), and low-density lipoprotein (LDL) levels were measured on the blood using standard kits (BioMereux, France) and an automatic analyzer (Humalyzer 300, Merck®, Germany) as directed by the manufacturer (FVMAAU; Addis Abeba, Ethiopia).

Fecal Bacterial Count

First, using sterilized equipment, a 1g fecal sample was aseptically collected from two broilers in each group. Then, ten-fold serial dilutions were prepared with phosphate-buffered saline (PBS), spread on Plate count agar (PCA), and Eosin methylene blue (EMB) media, and incubated at 37°C for 24 hours. Plates exhibiting 30–300 colonies were counted, while others were discarded. The average count was multiplied by the dilution factor, yielding the total number of organisms.

Cost-effectiveness of Broiler Production

The assessment of broiler production costs included expenses related to acquiring chicks, feed, vaccines, probiotics, yogurt and various extraneous items. The income per kg of live broilers in each treatment group was calculated based on the selling price per kg.

Statistical Analysis

The results were analyzed using the IBM SPSS version 22 program with a one-way ANOVA following the Complete Randomized Design (CRD) methods. Data were expressed as Mean±SEM, and statistically significant differences were judged as P<0.05.

RESULTS

Effect of Yogurt on Live Weight Gain, Mortality, Feed Intake and Feed Conversion Ratio

Fig. 1 illustrates the live weight gain of birds over the five-week study period. The results indicate significant differences in bird body weight gain (P<0.01) among treatment groups from week 2 to week 5, except for the first week. T3 (1547.30±3.20g) group supplemented with 5g yogurt had the highest live weight gain compared to control group T0 (1362.89±0.90g) and probiotic (Avi-BacTM) treated group T1 (1431.20±1.92g) (Fig. 1).

Fig. 2 shows how yogurt affects broiler feed consumption. The feed intake was not significantly (P>0.05) different among treatment groups at the seventh day of age, but substantial differences (P<0.01; P<0.05) were seen at the 14th, 21st, 28th, and 35th days of broiler chickens. The average feed consumption was lowest in dietary group T4 (2236.23±1.31) and greatest in T2 (2293.84±3.15) (Fig. 2).

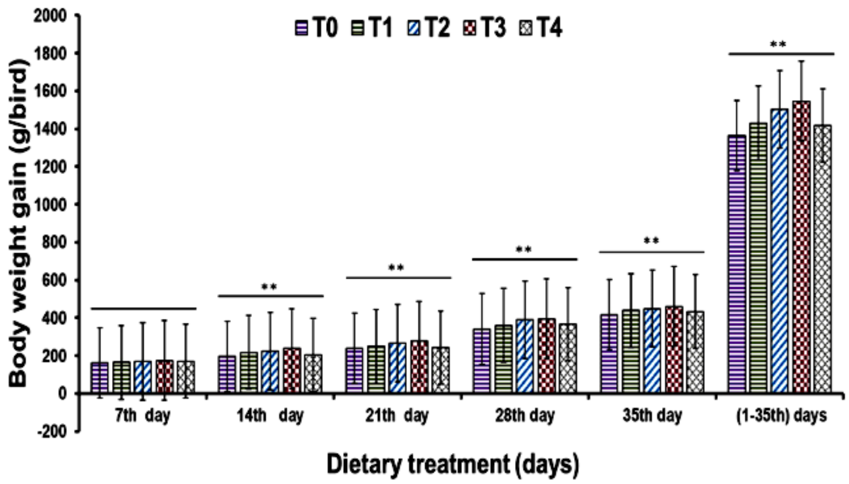

Fig. 1: Effect of yogurt and probiotic (Avi–BacTM) on body weight gain (g) in different dietary treatment groups of broilers.

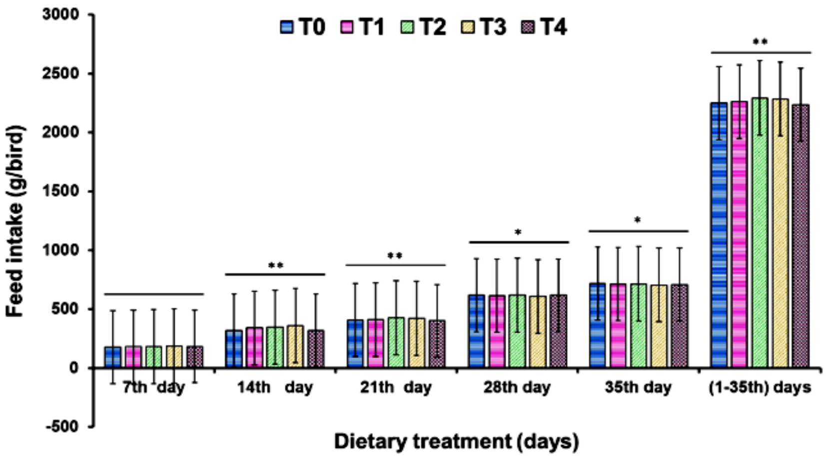

Fig. 2: Effect of yogurt and probiotic (Avi–BacTM) on feed intake (g) in different dietary treatment groups of broilers.

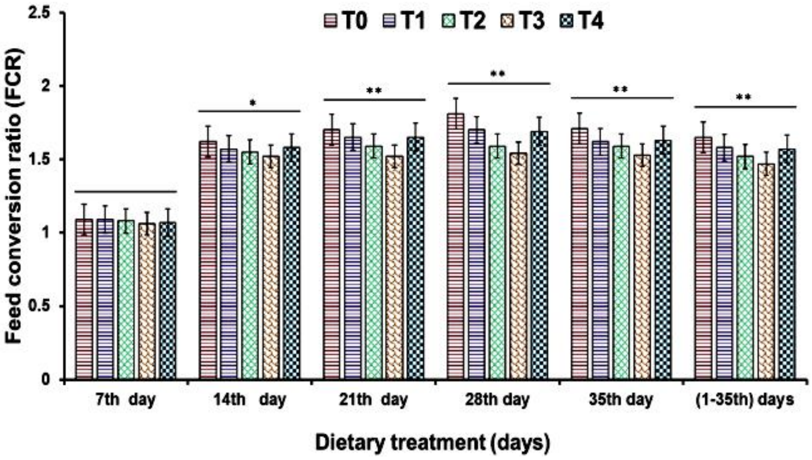

Fig. 3: Effect of yogurt and probiotic (Avi–BacTM) on feed conversion ratio in different dietary treatment groups of broilers.

Fig. 3 represents the experimental birds' Feed Conversion Ratio (FCR). The FCR of broilers varied significantly (P<0.05; P<0.01) among treatment groups at the 14th, 21st, 28th, and 35th days of age. No significant difference (P>0.05) was observed between treatment groups on day seven. The lowest FCR (1-35th days) was recorded in dietary group T3 (1.47±0.01). In contrast, the highest but poorest was in dietary group T0 (1.65±0.03) (Fig. 3). Compared to the other groups, the yogurt-treated groups T2, T3, and T4 had zero mortality (Fig. 4).

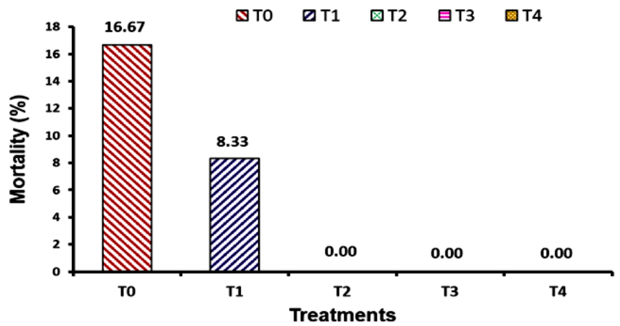

Fig. 4: Effect of yogurt and probiotic (Avi–BacTM) on mortality in different dietary treatment groups of broilers.

Carcass Yield

The results indicate significant differences (P<0.01) in live and carcass weight (g) between treatment groups. T3 had the highest live weight (1586.80±3.20), while T0 had the lowest (1401.10±0.90). Moreover, the T3 (1065.35±3.20) group had considerably more carcass weight (P<0.01) than other treatment groups (Table 3).

The dressing percentages did not differ significantly (P>0.05) among the dietary treatment groups, with T3 having the highest percentage and T0 having the lowest. The study found significant (P<0.05) differences in breast meat weight among treatment groups, with T3 weighing the most (34.60±2.80) and T0 weighing the least (28.22±1.20). The weight of thigh meat differed significantly (P<0.01) among dietary treatment groups, with the 5g yogurt-treated group having the highest weight in T3 (39.10±3.25) and the lowest in T0 (29.93±.85 (Table 3). In addition, liver and heart weight (%) did not differ between trial groups (P>0.05) (Table 3).

Lipid Profile (mg/dL)

The study data indicates significant differences (P<0.01) in total cholesterol and LDL levels among trial groups. Total cholesterol levels (mg/dL) were lowest in T4 (125.57±1.1) and highest in T0 (177.25±3.9). LDL levels (mg/dL) were lowest in T4 (69.79 ±1.1) and highest in T0 (112.12±3.4), with others being T1 (73.16±1.6), T2 (91.26± 2.1), and T3 (102.45±2.7) (Fig. 5). Triglyceride and HDL (mg/dL) levels did not differ significantly (P>0.05) between the trial groups (Fig. 5).

Fecal Bacterial Load (log CFU/g)

At 21 days, there was no significant difference (P>0.05) in the total number of bacteria and *Escherichia coli* (*E. coli*) (log CFU/g) found in feces among the trial groups. The T4 group (5.46±0.50) had the lowest overall bacterial count (log CFU/g), while the T0 group (6.10±3.10) demonstrated the highest level. Conversely, overall fecal bacterial and *E. coli* counts (log CFU/g) were also non-significant (P>0.05) at 35 days across the trial groups. The T3 group exhibited the lowest overall bacterial count (6.10±1.55), whereas the T0 group displayed the highest count (7.05±3.50) (Table 4).

Cost-benefit Analysis of Production

Total production cost/broiler was not significantly different (P>0.05), but net profit/broiler and profit/kg varied significantly (P<0.01), with T_3 having the highest values and T_0 the lowest (Table 5).

Table 3: Effect of yogurt and probiotic (Avi–Bac^{TM}) on carcass yield characteristics of broiler of different dietary treatment groups

Carcass Yield	Dietary treatment groups					Level of Significance
	T_0	T_1	T_2	T_3	T_4	
Live weight (g)	1401.10±0.90^a	1470.20±1.90^c	1540.30±2.70^d	1586.80±3.20^e	1458.20±1.30^b	**
Carcass weight (g)	915.85±0.90^a	970.45±1.50^c	1030.85±2.82^d	1065.35±3.20^e	960.95±1.13^b	**
Dressing %	65.36±1.16	66.0 ±1.97	66.92±2.30	67.05±2.98	65.89±1.50	NS
Breast meat weight (%)	28.22±1.20^{ab}	34.00±1.84^b	32.40±2.15^{ab}	34.60±2.80^b	29.34±0.90^a	*
Thigh meat weight (%)	29.93±0.85^a	37.40±1.90^{ab}	38.50±2.72^b	39.10±3.25^b	32.10±1.20^{ab}	**
Liver weight (%)	2.71±0.20	2.94±0.33	3.23±0.40	2.89±0.35	2.78±0.50	NS
Heart weight (%)	0.50±0.02	0.70±0.06	0.60±0.03	0.60±0.03	0.50±0.02	NS

Legends: Values are expressed as mean ± standard error of means (SEM). NS: Statistically not significant (P>0.05). $^{a\,b\,c\,d\,e}$ means having different superscripts in the same row differed significantly (P<0.05), * indicates a 5% level of significance. **indicates 1% level of significance.

Table 4: Effect of yogurt and probiotic (Avi–Bac™) on fecal microbial load (log CFU/g) of broiler

Bacterial count (log CFU/g)	Dietary treatment groups					Level of Significance
	T_0	T_1	T_2	T_3	T_4	
			Microbial population at 21 days			
Total bacteria	6.10±3.10	5.50±0.09	6.05±2.50	5.90±1.10	5.46±0.50	NS
E. coli	4.04±2.15	3.29±1.20	4.05±2.70	3.33±1.02	3.40±0.80	NS
			Microbial population at 35 days			
Total bacteria	7.05±3.50	6.29±1.91	6.70±2.45	6.10±1.55	6.45±2.42	NS
E. coli	5.95 ±2.10	5.13±1.25	5.90±3.23	4.60± 1.82	5.05 ±1.01	NS

Legends: Values are expressed as mean ± standard error of means (SEM). NS: Statistically not significant (P>0.05).

Table 5: Effect of yogurt and probiotic (Avi–Bac™) on cost analysis of broiler production

Parameters	Dietary treatment groups					Level of significance
	T0 0% yogurt	T1 0.5% Avi-Bac	T2 3 g yogurt	T3 5g yogurt	T4 7 g yogurt	
Chick cost ($)	0.17	0.17	0.17	0.17	0.17	NS
Average feed consumed (Kg)/chicks	2.24±0.58	2.26±0.69	2.29±0.78	2.28±0.67	2.23±0.48	NS
Cost of medicine and vaccine ($/bird)	0.11	0.11	0.11	0.11	0.11	NS
Dietary Treatment cost ($/bird)	0.00±.00a	2.2±1.95d	0.65±0.60b	1.77±1.72c	2.90±2.85[e]	**
Miscellaneous cost ($/bird)	0.14	0.14	0.14	0.14	0.14	NS
Total feed cost/bird ($)	0.84±2.07	0.85±2.15	0.86±2.43	0.86±2.31	0.85±2.16	NS
Total cost/bird ($)	1.26±1.10	1.29±1.16	1.29±1.21	1.29±1.46	1.30 ±1.56	NS
Average live weight (Kg)/bird	1.40±0.02a	1.47±0.06a	1.54±0.07b	1.58±0.08b	1.45±0.04[a]	**
Sale price/kg live weight ($)	1.00	1.00	1.00	1.00	1.00	NS
Sale price /bird ($)	1.40±0.58a	1.47±1.15a	1.54±1.67b	1.58±1.95b	1.45±0.84[a]	**
Net profit/ bird ($)	0.15±1.10a	0.18±1.56a	0.25±2.17b	0.29±2.49b	0.15±1.21[a]	**
Profit / kg ($)	0.10±1.34a	0.12±1.16a	0.16±1.37b	0.18±1.85b	0.10±1.16[a]	**

Legends: Values are expressed as mean±SEM. NS: Non-significant (P>0.05). Mean values having different superscripts in arow differed significantly (P<0.05); **indicates a 1% significance level.

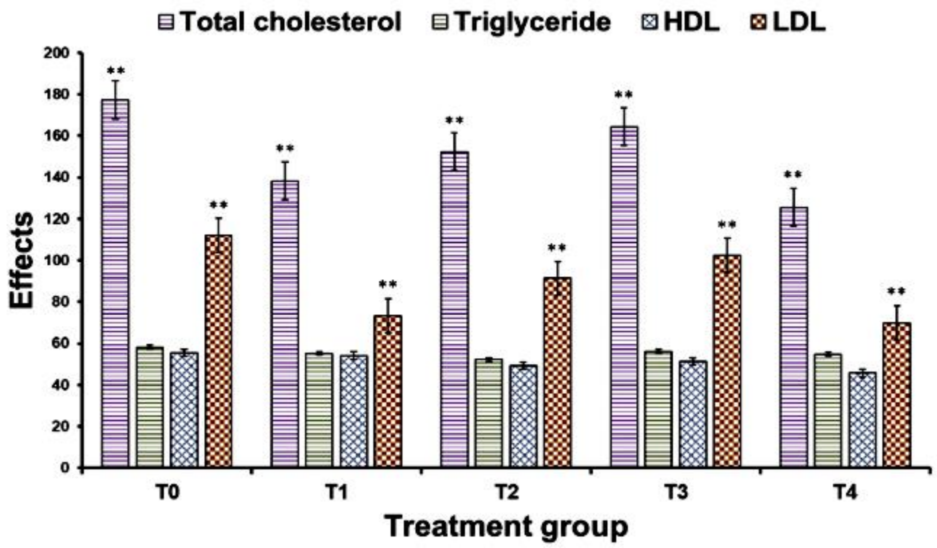

Fig. 5: Effect of yogurt and probiotic (Avi–BacTM) on lipid profile parameters at 35 days of broiler.

DISCUSSION

The current study showed that 5g yogurt-supplemented group T3 had the highest live weight gain (1547.30±3.20), whereas the basal diet (without yogurt) group T0 had the lowest (1362.89±0.90). Our results are consistent with those of Paraskeuas et al. (2023) and Sultan et al. (2006), who found that 5 ml/L yogurt in water boosted live weight gain in contrast to the control group and low yogurt levels. Setyaningrum et al. (2023) and Khan et al. (2011), also found that yogurt in water increased broiler chicken live weight gain, feed intake (FI), and FCR. Our study found that the Avi-BacTM-treated group T1 had a mortality rate of 0.83±0.02%, while the yogurt-treated group T2 had no mortality. This result corroborated the findings of Mahmmod et al. (2014) and Paraskeuas et al. (2023), which demonstrated that dietary supplementation with 1% dried yogurt powder reduced total mortality compared to birds fed a commercial probiotic product and their controls. The present study showed that yogurt significantly affected feed intake in 14th to 35th-day broilers on different diets. Yogurt-treated group T2 had the highest feed intake (2293.84±3.15), supporting findings from Rahmani Alizadeh et al. (2023), Yang et al. (2023) and Chaudhary et al. (2017) that supplementing broilers with 10-20% probiotic product (yogurt fermented maize) improved average daily feed intake (P=0.002). In this study, the effect of yogurt on the FCR of the 14th to 35th days of broiler significantly differed among the dietary groups. The FCR was lower in the 5g yogurt-supplemented group T3 (1.47±0.01), while the basal diet (without yogurt) supplemented group T0 (1.65±0.03) had a higher FCR, consistent with other reports (Unachukwu et al. 2021; Xiang et al. 2022). Yogurt significantly (P<0.05) affected carcass weight and the percentages of breast and thigh muscle among dietary treatment groups, although liver and heart weight exhibited no significant (P>0.05) variations. The results were in strong concordance with the findings of Boostani et al. (2013), Masoumi et al. (2022) and Hossain and Momu (2022), who showed that thepax and yogurt-treated groups presented higher carcass and thigh percentages in contrast to the other groups. The effect of yogurt on total cholesterol (mg/dL) was significantly different (P<0.01), and triglyceride levels varied significantly (P<0.05) among the treatment groups. The T4 group supplemented with yogurt had the lowest cholesterol levels (125.57±1.1mg/dL). Simultaneously, T0 had the highest level at 177.25±3.9mg/dL. T4 had the lowest total cholesterol level at 125.57±1.1mg/dL, whereas T0 recorded the highest at 177.25±3.9mg/dL among the treatment groups, with T4 being supplemented with yogurt. The treatment group T_0 had the highest triglyceride level at 58.18±2.8mg/dL, whereas group T2 had the lowest level at 52.16±1.2mg/dL. Group T3 had the highest HDL level at 55.39±2.2mg/dL, whereas treatment group T_0 recorded the lowest level at 45.62±0.9mg/dL. This result corroborates the findings of Adriani et al. (2020) and Haque et al. (2017), who reported that yogurt supplements significantly impacted blood cholesterol levels. Furthermore, Panda et al. (2003), Tekeli et al. (2006), Singh et al. (2009), Adriani et al. (2020), Alaqil et al. (2020), Fathanah et al. (2024) and Srifani et al. (2024) reported that feeding broiler meals with *Lactobacillus* culture and/or probiotics resulted in a decreased blood cholesterol level which indicated that yogurt also quantitatively decreased cholesterol levels, similar to our findings. There was no statistically significant difference (P>0.05) between the treatment groups at 21 days in terms of total fecal bacteria and *E. coli* counts (log CFU/g). The investigation indicated that a total bacterial count (log CFU/g) of 5.46±0.50 was the lowest in group T4, whereas the maximum count was 6.10±3.10 in group T0. In addition, the lowest count of *E. coli* (log CFU/g) was 3.33±1.02 in group T3, which was treated with 5g of yogurt, compared to the highest count of 4.04±2.15 in group T0. The findings agreed with those of Settles (2021) and Masoumi et al. (2022). Boostani et al. (2013) found that giving broilers yogurt for 21 days dramatically decreased the number of *E. coli* bacteria in their feces (P<0.05). Our study found that treatment group T3 (0.18±1.85) supplemented with 5g yogurt had a higher profit margin per kg of live broiler production than the commercial probiotic-treated group T1 (0.12±1.16) and the control group. The findings were comparable to those of Aftahi et al. (2006) who concluded that the production cost was higher in the 0.1g protein per liter of water treatment group T5 (14.95a). In contrast, the profit per kg of live broiler was best in the 5.0g yogurt-supplemented group T4 (16.00a).

Conclusion

Yogurt supplements improve broiler performance in terms of live weight gain, dietary intake, FCR, livability rate, and carcass yield, and they reduce total cholesterol, triglyceride, and bacterial and *E. coli* counts. However, the best results were obtained by supplementing 5g yogurt/L drinking water. Thus, 5g of yogurt can be used in broiler diets as a growth promoter and an alternative source of commercial probiotics. The study suggests that using yogurt for broiler production might satisfy domestic demand and stimulate the economy.

Conflict of Interest: The author declare that they have no conflict of interest.

Author's Contribution: MAH and MNA conceptualized the research study, designed and implemented the experimental protocols. MAS performed the experiment, sample collections, prepared Fig.s/Tables, and draft preparation; SHS and MDB contributed to the data collection and analysis. ZM and SN interpreted the results and drafted the manuscript. MDAH supervised the project. All authors have reviewed and approved the final manuscript for publication.

REFERENCES

Abd El-Hack, M.E., El-Saadony, M.T., Shafi, M.E., Qattan, S.Y.A., Batiha, G.E., Khafaga, A.F., Abdel-Moneim, A.E. and Alagawany, M. (2020). Probiotics in poultry feed: A comprehensive review. *Journal of Animal Physiology and Animal Nutrition*, 104(6): 1835–1850. https://doi.org/10.1111/jpn.13454

Adriani, L., Joni, I., Kumalasari, C. and Lesmana, R. (2020). The application of simple technology for making yogurt powder to improve biochemical blood profile of broiler. In AIP Conference Proceedings (Vol. 2219, No. 1).

Aftahi, A., Munim, T., Hoque, M.A. and Ashraf, M.A. (2006). Effect of yoghurt and protexin boost on broiler performance. *International Journal of Poultry Science,* 5(7): 651-655. https://doi.org/10.3923/ijps.2006.651.655

Ahmad, R., Yu, Y.H., Hsiao, F.S.H., Dybus, A., Ali, I., Hsu, H.C. and Cheng, Y.H. (2022). Probiotics as a friendly antibiotic alternative: assessment of their effects on the health and productive performance of poultry. *Fermentation,* 8(12): 672. http://doi.org/10.3390/fermentation8120672

Alagawany, M., Abd El-Hack, M.E., Farag, M.R., Sachan, S., Karthik, K. and Dhama, K. (2018). The use of probiotics as eco-friendly alternatives for antibiotics in poultry nutrition. *Environmental Science and Pollution Research,* 25: 10611-10618. http://doi.org/10.1007/s11356-018-1687-x

Alaqil, A.A., Abbas, A.O., El-Beltagi, H.S., El-Atty, H.K.A., Mehaisen, G.M. and Moustafa, E.S. (2020). Dietary supplementation of probiotic *Lactobacillus acidophilus* modulates cholesterol levels, immune response, and productive performance of laying hens. *Animals,* 10(9): 1588. https://doi.org/10.3390/ani10091588

Al-Khalaifah, H.S. (2018). Benefits of probiotics and/or prebiotics for antibiotic-reduced poultry. *Poultry Science,* 97(11): 3807-3815. https://doi.org/10.3382/ps/pey160

Attia, Y.A., Rahman, M.T., Hossain, M.J., Basiouni, S., Khafaga, A.F., Shehata, A.A. and Hafez, H.M. (2022). Poultry production and sustainability in developing countries under the COVID-19 crisis: lessons learned. *Animals,* 12(5): 644. https://doi.org/10.3390 /ani12050644

Bogucka, J., Ribeiro, D.M., Bogusławska-Tryk, M., Dankowiakowska, A., da Costa, R.P.R. and Bednarczyk, M. (2019). Microstructure of the small intestine in broiler chickens fed a diet with probiotic or synbiotic supplementation. *Journal of Animal Physiology and Animal Nutrition,* 103(6): 1785-1791. https://doi.org/10.1111/jpn.13182

Boostani, A., MahmoodiadnFard, H.R., Ashayerizadeh, A. and Aminafshar, M. (2013). Growth performance, carcass yield and intestinal microflora populations of broilers fed diets containing thepax and yogurt. *Brazilian Journal of Poultry Science,* 15(1): 1-6. https://doi.org/10.1590/S1516-635X2013000100001

Chaudhary, N., Saikia, B., Dowarah, R., Tamuly, S. and Sapcota, D. (2017). Effect of feeding curd as a probiotic on growth performance, nutrient utilization, blood biochemical and ceacal microbial profile in broilers. *International Journal of Livestock Research,* 7(12): 165-173. https://doi.org/10.5455/ijlr.20170329100757

Chen, L.W., Chuang, W.Y., Hsieh, Y.C., Lin, H.H., Lin, W.C., Lin, L.J., Chang, S.C. and Lee, T.T. (2021). Effects of dietary supplementation with

Taiwanese tea byproducts and probiotics on growth performance, lipid metabolism, and the immune response in red feather native chickens. *Animal Bioscience,* 34(3): 393–404. https://doi.org/10.5713/ajas.20.0223

De Cesare, A., Sala, C., Castellani, G., Astolfi, A., Indio, V., Giardini, A. and Manfreda, G. (2020). Effect of *Lactobacillus acidophilus* D2/CSL (CECT 4529) supplementation in drinking water on chicken crop and caeca microbiome. *PLoS One,* 15(1): e0228338. https://doi.org/10.1371/journal.pone.0228338

Fathanah, S.Y.E., Rahardja, D.P. and Purwanti, S. (2024). Impacts of probiotic and dietary Lamtoro leaf meal on the growth performance, digestibility and small intestinal morphometry of Kampung chicken. *International Journal of Agriculture and Biosciences,* 13(3): 333-339. https://doi.org/10.47278/journal.ijab/2024.127

Feng, J., Lu, M., Wang, J., Zhang, H., Qiu, K., Qi, G. and Wu, S. (2021). Dietary oregano essential oil supplementation improves intestinal functions and alters gut microbiota in late-phase laying hens. *Journal of Animal Science and Biotechnology,* 12(1): 1-15. https://doi.org/10.1186/s40104-021-00600-3

Glago, J., Tchekessi, C.K.C., Achiamaa, A.A.K., Chabi, N.W., Tona, K. and Gbogbo, K.A. (2024_. Assessment of the impact of temperature and shelf life on the microbiological quality of feed supplements enriched with probiotic bacteria. *International Journal of Veterinary Science,* 13(3): 300-310. https://doi.org/10.47278/journal.ijvs/2023.116

Habib, M.A., Salma, U., Amin, M.N., Rahman, M.G. and Haque, M.A. (2024). The effect of halquinol (HAL) on growth performance, carcass traits, and blood-lipid profile in broiler chickens. *International Journal of Agriculture and Biosciences,* 13(1): 39-45. https://doi.org/10.47278/journal.ijab/2024.001

Haque, M.I., Ahmad, N. and Miah, M.A. (2017). Comparative analysis of body weight and serum biochemistry in broilers supplemented with some selected probiotics and antibiotic growth promoters. *Journal of Advanced Veterinary and Animal Research,* 4(3): 288-294. http://doi.org/10.5455/javar.2017.d226

Haque, M.A., Quan, H., Zuo, Z., Khan, A., Siddique, N. and He, C. (2021). Pathogenicity of feed-borne *Bacillus cereus* and its implication on food safety. *Agrobiological Records* 3: 1-16. https://doi.org/10.47278/journal.abr/2020.015

Haque, M.A., Wang, F., Chen, Y., Hossen, F., Islam, M.A., Hossain, M.A., Siddique, N., He, C. and Ahmed, F. (2022). *Bacillus* spp. contamination: a novel risk originated from animal feed to human food chains in South-Eastern Bangladesh. *Frontiers in Microbiology,* 12:783103. https://doi.org/10.3389/fmicb.2021.783103

Haque, M.A., Zuo, Z. and He, C. (2023). Pathogenesis of gizzard erosion and ulcerations and comprehensive control strategy in poultry. In: Abbas RZ, Saeed NM, Younus M, Aguilar-Marcelino L and Khan A (eds), One Health Triad, Unique Scientific Publishers, Faisalabad, Pakistan, Vol. 2, pp: 129-137. https://doi.org/10.47278/book.oht/2023.52

Haque, M.A., Hu, H., Liu, J., Islam, M.A., Hossen, F., Rahman, M.A., Ahmed, F. and He, C. (2024). Emergence of multidrug-resistant *Bacillus* spp. derived from animal feed, food and human diarrhea in South-Eastern Bangladesh. *BMC Microbiology,* 24: 61. https://doi.org/10.1186/s12866-024-03199-3

Hossain, M.A. and Momu, J.M. (2022). Yogurt as probiotic: comparative effect on growth performance of broiler Japanese quail (*Coturnix japonica*). *Turkish Journal of Agriculture-Food Science and Technology,* 10(6): 987-991. https://doi.org/10.24925/turjaf.v10i6.987-991.4678

Jiang, S., Yan, F.F., Hu, J., Mohammed, A. and Cheng, H.W. (2021). *Bacillus subtilis*-based probiotic improves skeletal health and immunity in broiler chickens exposed to heat stress. *Animals,* 11(6): 1494. https://doi.org/10.3390/ani11061494

Jha, R., Das, R., Oak, S. and Mishra, P. (2020). Probiotics (Direct-Fed Microbials) in poultry nutrition and their effects on nutrient utilization, growth and laying performance, and gut health: a systematic review. *Animals,* 10(10): 1863. https://doi.org/10.3390/ani10101863

Khan, S.H., Yousaf, B., Mian, A.A., Rehman, A. and Farooq, M.S. (2011). Assessing the effect of administering different probiotics in drinking water supplement on broiler performance, blood biochemistry and immune response. *Journal of Applied Animal Research,* 39(4): 418-428. https://doi.org/10.1080/09712119.2012.739092

Liang, W., Li, H., Zhou, H., Wang, M., Zhao, X., Sun, X., Li, C. and Zhang, X. (2021). Effects of Taraxacum and Astragalus extracts combined with probiotic *Bacillus subtilis* and Lactobacillus on Escherichia coli–infected broiler chickens. *Poultry Science,* 100(4): 101007. https://doi.org/10.1016/j.psj.2021.01.030

Mahmmod, Z.A., Abdulrazaq, H.S., Salem, A.S. and Sideq, R.M. (2014). Effects of supplementation probiotic and dried yogurt powder on growth performance, carcass characteristics, intestinal micro flora and immunity of broiler chickens. *Zanco Journal of Pure and Applied Sciences* 26(3): 35-42.

Masoumi, B., Abbasi, A., Mazloomi, S.M. and Shaghaghian, S. (2022). Investigating the effect of probiotics as natural preservatives on the microbial and physicochemical properties of yogurt-marinated chicken fillets. *Journal of Food Quality,* 625114: 1-8. https://doi.org/10.1155/2022/5625114

Mindus, C., van Staaveren, N., Fuchs, D., Gostner, J.M., Kjaer, J.B., Kunze, W., Mian, F.M., Shoveller, A.K., Forsythe, P. and Harlander-Matauschek, A. (2021). *L. rhamnosus* improves the immune response and tryptophan catabolism in laying hen pullets. *Scientific Reports,* 11(1): 19538. https://doi.org/10.1038/s41598-021-98459-x

Neogi, S.B., Islam, M.M., Islam, S.S., Akhter, A.T., Sikder, M.M.H., Yamasaki, S. and Kabir, S.L. (2020). Risk of multi-drug resistant *Campylobacter* spp. and residual antimicrobials at poultry farms and live bird markets in Bangladesh. *BMC Infectious Diseases,* 20: 1-14. https://doi.org/10.1186/s12879-020-05006-6

Neveling, D.P. and Dicks, L.M. (2021). Probiotics: an antibiotic replacement strategy for healthy broilers and productive rearing. *Probiotics and Antimicrobial Proteins* 13: 1-11. https://doi.org/10.1007/s12602-020-09640-z

Nupur, M.N., Afroz, F., Hossain, M.K., Harun-ur-Rashid, S.M., Rahman, M.G., Kamruzzaman, M., Ferdous, K.A. and Haque, M.A. (2023). Prevalence of potential zoonotic bacterial pathogens isolated from household pet birds and their antimicrobial profile in northern Bangladesh. Agrobiological Records 11: 28-38. https://doi.org/10.47278/journal.abr/2023.005

Panda, A.K., Reddy, M.R., Ramarao, S.V. and Praharaj, N.K. (2003). Production Performance, serum/yolk cholesterol and immune competence of white leghorn layers as influenced by dietary supplementation with probiotic. *Tropical Animal Health and Production,* 32(2): 85-94. https://doi.org/10.1023/a:1022036023325

Paraskeuas, V.V., Papadomichelakis, G., Brouklogiannis, I.P., Anagnostopoulos, E.C., Pappas, A.C., Simitzis, P., Theodorou, G., Politis, I. and Mountzouris, K.C. (2023). Dietary inclusion level effects of yoghurt acid whey powder on performance, digestibility of nutrients and meat quality of broilers. *Animals,* 13(19): 3096. https://doi.org/10.3390/ani13193096

Raheem, A., Liang, L., Zhang, G. and Cui, S. (2021). Modulatory effects of probiotics during pathogenic infections with emphasis on immune regulation. *Frontiers in Immunology,* 12: 616713. https://doi.org/10.3389/fimmu.2021.616713

Ramírez, G.A., Keshri, J., Vahrson, I., Garber, A.I., Berrang, M.E., Cox, N.A., González-Cerón, F., Aggrey, S.E. and Oakley, B.B. (2022). Cecal microbial hydrogen cycling potential is linked to feed efficiency phenotypes in chickens. *Frontiers in Veterinary Science,* 9: 904698. https://doi.org/10.3389/fvets.2022.904698

Rahmani Alizadeh, M., Aliakbarpour, H.R. and Hashemi Karouei, S.M. (2023). Effect of dietary supplementation of Iranian multi-strain probiotic or *P. acidilactici* of camel milk isolate on broilers performance, blood parameters, intestinal histology, and microbiota. *Italian Journal of Animal Science,* 22(1): 660-665. https://doi.org/10.1080/1828051X.2023.2234937

Settles, A.L. (2021). Evaluating *Escherichia coli* nissle as a potential probiotic for broiler chickens (Doctoral dissertation, Tennessee State University).

Setyaningrum, S., Siregar, D.J.S. and Pradana, T.G. (2023). Combination of gembili tuber and *Lactobacillus plantarum* on the performance, carcass, hematological parameters, and gut microflora of broiler chickens. *Advances in Animal and Veterinary Sciences,* 11(2): 203-210. http://dx.doi.org/10.17582/journal.aavs/2023/11.2.203.210

Shehata, A.A., Yalçın Latorre, J.D., Basiouni, S., Attia, Y.A., Abd El-Wahab, A., Visscher, C., El-Seedi, H.R., Huber, C., Hafez, H.M., Eisenreich, W. and Tellez-Isaias, G. (2022). Probiotics, prebiotics, and phytogenic substances for optimizing gut health in poultry. *Microorganisms,* 10(2): 395. https://doi.org/10.3390/microorganisms10020395

Singh, S.K., Niranjan, P.S., Singh, U.B., Koley, S. and Verma, D.N. (2009). Effects of dietary supplementation of probiotics on broiler chicken. *Animal Nutrition and Feed Technology,* 9(1): 85-90.

Stanton, T.B. (2013). A call for antibiotic alternatives research. *Trends in Microbiology,* 21(3): 111-113. https://doi.org/10.1016/j.tim.2012.11.002

Srifani, A., Mirnawati, Marlida, Y., Rizal, Y. and Nurmiati (2024). Isolation and characterization of cellulolytic lactic acid bacteria from soymilk waste as probiotic candidates for broiler. *International Journal of Veterinary Science,* 13(1): 108-114. https://doi.org/10.47278/journal.ijvs/2023.067

Sultan, A., Durrani, F.R., Suhail, S.M., Ismail, M., Durrani, Z. and Chand, N. (2006). Comparative effect of yogurt as probiotic on the performance of broiler chicks. *Pakistan Journal of Biological Science,* 9(1):88-92. https://doi.org/10.3923/pjbs.2006.88.92

Sultana, N., Haque, M.A., Rahman, M.M., Akter, M.R., Begum, M.D., Fakruzzaman, M., Akter, Y. and Amin, M.N. (2017). Microbiological quality of commercially available poultry feeds sold in Bangladesh. *Asian Journal of Medical and Biological Research* 3(1): 52-60. https://doi.org/10.3329/ajmbr.v3i1.32036

Susalam, M.K., Harnentis, Marlida, Y., Jamsari, and Ardani, L.R. (2024). The effect of probiotics consortium isolated from fermented fish (Budu) on broiler performances and meat quality. *International Journal of Veterinary Science,* 13(1): 100-107. https://doi.org/10.47278/journal.ijvs/2023.066

Tekeli, A., Celik, L., Kutlu, H.R. and Gorgulu, M. (2006). Effect of dietary supplemental plant extracts on performance, carcass characteristics, digestive system development, intestinal microflora and some blood parameters of broiler chicks. In Proceedings of 12th European Poultry Conference (pp. 10-14).

Unachukwu, M.N., Amobi, O.O., Onyia, F.C., Onwujekwe, E.C. and Eluu, S.C. (2021). A study on the effect of bacteriocin production from lactic acid bacteria in poultry nutrition. *Journal of Applied Biosciences* 162(1): 16754-16763. https://doi.org/10.35759/JABs.162.6

Xiang, L., Ying, Z., Xue, M., Xiaoxian, P., Xiaorong, L., Chunyang, L., Yu, W., Mingcheng, L. and Binxian, L. (2022). A novel Lactobacillus bulgaricus isolate can maintain the intestinal health, improve the growth performance and reduce the colonization of E. coli O157: H7 in broilers. *British Poultry Science* 63(5): 621-632. https://doi.org/10.1080/00071668.2022.2062220

Yang, C., Zhu, X., Liu, W., Huang, J., Xie, Z., Yang, F., Li, Z. and Wei, Y. (2023). Dietary Dried Jujube Fruit Powder (DJFP) supplementation improves growth performance, antioxidant stability, and meat composition in broilers. *Foods,* 12(7): 1463. https://doi.org/10.3390/foods12071463

Yosi, F., Sharma, S., Sener-Aydemir, A., Koger, S., Baskara, A.P. and Metzler-Zebeli, B.U. (2022). Short-chain fatty acids promote jejunal barrier function and caecal muscle contractibility in laying hens ex vivo. *British Poultry Science,* 63(3): 406-413. https://doi.org/10.1080/00071668.2021.2008312

Yousaf, S., Nouman, H.M., Ahmed, I., Husain, S., Waseem, M., Nadeem, S., Tariq, M., Sizmaz, O. and Chudhry, M.F.Z. (2022). A review of probiotic applications in poultry: improving immunity and having beneficial effects on production and health. *Postępy Mikrobiologii-Advancements of Microbiology,* 61(3): 115-123. https://doi.org/10.2478/am-2022-010

Yu, Y., Li, Q., Zeng, X., Xu, Y., Jin, K., Liu, J. and Cao, G. (2022). Effects of probiotics on the growth performance, antioxidant functions, immune responses, and caecal microbiota of broilers challenged by lipopolysaccharide. *Frontiers in Veterinary Science,* 9: 846649. https://doi.org/10.3389/fvets.2022.846649

Zhan, H.Q., Dong, X.Y., Li, L.L., Zheng, Y.X., Gong, Y.J. and Zou, X.T. (2019). Effects of dietary supplementation with *Clostridium butyricum* on laying performance, egg quality, serum parameters, and cecal microflora of laying hens in the late phase of production. *Poultry Science,* 98(2): 896-903. https://doi.org/10.3382/ps/pey436

Zhang, G., Wang, H., Zhang, J., Tang, X., Raheem, A., Wang, M., Lin, W., Liang, L., Qi, Y., Zhu, Y., Jia, Y., Cui, S. and Qin, T. (2021). Modulatory effects of *Bacillus subtilis* on the performance, morphology, cecal microbiota and gut barrier function of laying hens. *Animals,* 11(6): 1523. https://doi.org/10.3390/ani11061523

Zhang, J.L., Xie, Q.M., Ji, J., Yang, W.H., Wu, Y.B., Li, C., Ma, J.Y. and Bi, Y.Z. (2012). Different combinations of probiotics improve the production performance, egg quality, and immune response of layer hens. *Poultry Science*, 91(11): 2755-2760. https://doi.org/10.3382/ps.2012-02339