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Research Article
Effects of Sweet and Sour Yogurt Supplementation in Drinking Water on Antibiotics Free Commercial Broiler Production

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Abstract
Objective: The present study aimed to investigate the effects of useful bacteria isolated from sweet and sour yogurt on the overall performance of antibiotic-free commercial broiler production. **Materials and Methods:** A total of 128 mixed-sex broiler chicks were randomly divided into 4 groups with 4 replicates where T1, T2 and T3 was treated with a bacterial solution (5 mL L^{-1}) isolated from sweet yogurt, sour yogurt and their combination, respectively and T4 was considered as the control. The experiment was conducted for 34 days and the supplements were added to the drinking water. The data were statistically analyzed using a Completely Randomized Design (CRD). **Results:** A non-significant effect of yogurt supplementation on feed intake was observed in this study. Yogurt supplementation significantly increased ($p<0.05$) body weight gain. A highly significant ($p<0.01$) improvement in body weight gain was recorded for T2. The yogurt supplementation significantly ($p<0.01$) improved the FCR. The dressing weight was significantly ($p<0.05$) increased by the supplementation. The difference in survivability among the treatments was non-significant. Further, the highest profit was obtained from T2 (27.17 Tk kg^{-1}), followed by T3 (22.31 Tk kg^{-1}) and T1 (21.00 Tk kg^{-1}). In contrast, the lowest profit was recorded for the T4 (17.08 Tk kg^{-1}). **Conclusion:** The present study showed promising effects of yogurt supplementation on commercial broiler production without antibiotics, especially sour yogurt, which significantly improved the production performance and net profit. Therefore, it is suggested that sour yogurt could be a safe alternative to antibiotics for commercial broiler production.

Key word: Yogurt, poultry diet, antibiotic-free broiler, broiler meat, probiotics

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Broiler farming plays an important role to improve livelihood, food security and poverty alleviation in rural and semi-urban communities in developing countries including Bangladesh. For the last two decades, the poultry sector has been vigorously contributing to the economy of Bangladesh. The poultry industry has changed the livelihood and food habits, reduced the dependence on beef and mutton as animal protein sources as well as improved the food security[1]. Further, it has been engaging supply of quality protein to the Bangladesh population at the lowest price in the world. Presently, the poultry sector has employed huge manpower (approximately 0.6 million) of both technical and non-technical background workers and expected to make more rooms for employment in the future[2]. In Bangladesh, commercial poultry farmers extensively utilize antibiotics without any veterinary advice, even without ensuing the consecutive withdrawal period[3]. Antibiotics are widely used in the poultry diet as a growth promoter and to treat infections. However, the consumer market and public agencies have been continuously indicating the adverse effect of antibiotics on human health due to its overuse as a growth promoter in animal feed[4]. For many years, antibiotics have been used as growth promoters in the poultry industry but recently these compounds have been prohibited due to their adverse effects on human and animal health conditions. Therefore, in many countries, the prescription of antibiotics for animal diets has been prohibited[5,6]. Hence, the probiotics can decrease the use of antibiotics in ruminant and poultry diets[7]. Probiotics are live microbial feed supplement that benefits the host by the intestinal microbial balance. The utilization of probiotics in animal nutrition can also provide healthy foods for humans[8]. Similarly, researchers have defined probiotics as an alternative to antibiotics in animal diets[7]. Probiotics are increasingly adopted as an alternative to antibiotic growth promoters in poultry diets[8]. In recent years, several studies have been conducted on the use of probiotics in broiler chickens and the majority of researchers reported that the use of probiotics improved the performance of broiler chicks[9-12]. The previous studies reported that the use of probiotics has beneficial effects on poultry performance. For example, Khaliq and Ebrahimnezhad[13] concluded that the use of probiotics from 1-42 days in diet improved the performance of broiler chicks. Another study demonstrated that the use of probiotic (1.5 g kg^{-1}) in water or diet, improved live weight, feed consumption and feed conversion efficiency of Japanese quail[14].

Yogurt is one of the best sources of probiotics, which are friendly bacteria that can improve bird health and can elevate the immune system of the host. Yogurt is a milk product obtained by fermentation of milk-specific microorganisms, which shall be viable, active and abundant in the product *Lactobacillus delbrueckii* subsp. bulgaricus and *Streptococcus thermophilus*[15].

Therefore, it can be used as an effective probiotic in broiler chicken's nutrition[16,17]. Yogurt also contains 10^8 CFU mL^{-1} *Streptococcus thermophilus*, *Lactobacillus delbrueckii* [17], 3.7% protein, 3.4% fat and 4.7% lactose[18]. Consequently, it has a direct impact on the health of the digestive tract by preventing the growth of pathogenic bacteria and maintaining the balance of beneficial bacteria[16]. Further, a comparative study on probiotics, yogurt and antibiotics was conducted and it was reported that the use of yogurt-like probiotics had a significant effect on the performance of broiler chickens[19]. It has also been reported, that *L. acidophilus* can absorb cholesterol from in vitro system and this phenomenon can decrease the cholesterol level of the medium[20]. In addition, *Lactobacillus* bacteria can increase the protein digestibility and availability of minerals for its host like Cu, Mn, Ca, Fe, P, etc.[21].

Sweet and sour yogurt are two forms of yogurt containing different bacteria. Sour yogurt is produced from the fermentation of the lactose in milk by the rod-shaped bacteria (*Lactobacillus delbrueckii* subsp. *Bulgaricus*), these bacteria produce lactic acid which acts on milk protein to give yogurt its texture and its sour taste[17]. Other bacteria found in yogurt (sweet and sour) act as probiotics and increase feed intake and digestion. A study showed that the use of sweet and sour yogurt at the recommended level in water improved body weight gain, feed intake and feed conversion ratio compared to the other groups. The results indicated that treatment had a significant effect on the carcass yield, intestinal length, thigh meat yield and abdominal fat in male and female chickens. There were no effects on the total bacterial population[22].

It was reported that the use of sweet and sour yogurt in drinking water successfully improved the overall performance and gross return of the experimental birds[21]. The main probiotics in yogurt are lactic acid bacteria, which can elevate the immune system of the host. No previous study has been carried out on the utilization of yogurt in antibiotic-free sustainable broiler production in Bangladesh. Therefore, the present study was undertaken to determine the effect of sweet, sour and mixed yogurt as alternative to antibiotic growth promoter on commercial broiler production.

MATERIALS AND METHODS

Design, layout and duration of the experiment: A total of 128 mixed-sex day-old broiler chicks (DOC) of the Lohman Meat strain were randomly divided in a completely randomized design (CRD) into 4 groups with 4 treatments and 4 replicates. The treatments were: T1 [birds treated with isolated bacteria from sweet yogurt (5 mL L^{-1})], T2 [birds treated with isolated bacteria from sour yogurt (5 mL L^{-1})], T3 [birds treated with a combination of a bacterial solution of sweet and sour yogurt (2.5 and 2.5 mL L^{-1}, respectively)] and T4 [birds without any supplementation (control birds)]. The experiment was conducted for 34 days (7-40 days of age).

Collection of raw materials preparation and isolation of probiotic bacteria: Sweet and sour yogurt were selected as a growth promoter for antimicrobial activity in commercial broilers. Yogurt samples were purchased from a local market. Samples were collected in a sterile plastic container and transported to the Laboratory of Microbiology, Department of Genetic Engineering and Biotechnology, University of Rajshahi, Rajshahi, Bangladesh, in an insulated box with ice to maintain a temperature ranging from 4-6°C. All the samples were processed within 6 hours of their collection. The collected yogurt samples were filtered by filter paper in a beaker and 5 mL of each filtered yogurt sample was added to 100 mL Luria Broth (LB) liquid medium for enrichment as well as the selection. The incubation was done for 48-72 h at 37°C. Then the bacterial isolates were screened on nutrient agar (NA) plates. Again, the plates were incubated at 37°C for 24 h and colonies differing in morphological characteristics were selected and used for further studies. The single colony from mixed bacterial culture was isolated by this plating method. The individual bacterial population was isolated from the above-mentioned enrichment cultures by plating out on LB agar. The single colonies from these plates were sub-cultured onto replicate plates and colonies from these eventually transferred into LB liquid medium. Pure strains were maintained by the weekly passage in LB liquid medium and also by weekly subculture onto the LB agar medium. From all mixed bacterial culture plates, two colonies were isolated and identified. One was identified as isolate A (white colony-forming) from sour yogurt [Fig. 1(a)] and another was isolate B (yellow colony-forming) from sweet yogurt sample [Fig. 1(b)]. Those colonies were isolated by sub-culturing onto fresh LB plates and purified by restreaking further on nutrient agar medium [Figure 1(c and d)] and incubated for 18-24 h at 37°C. Following overnight incubation, the isolates were preserved in 30% glycerol at -20°C [Fig. 1(e and f)] for further use.

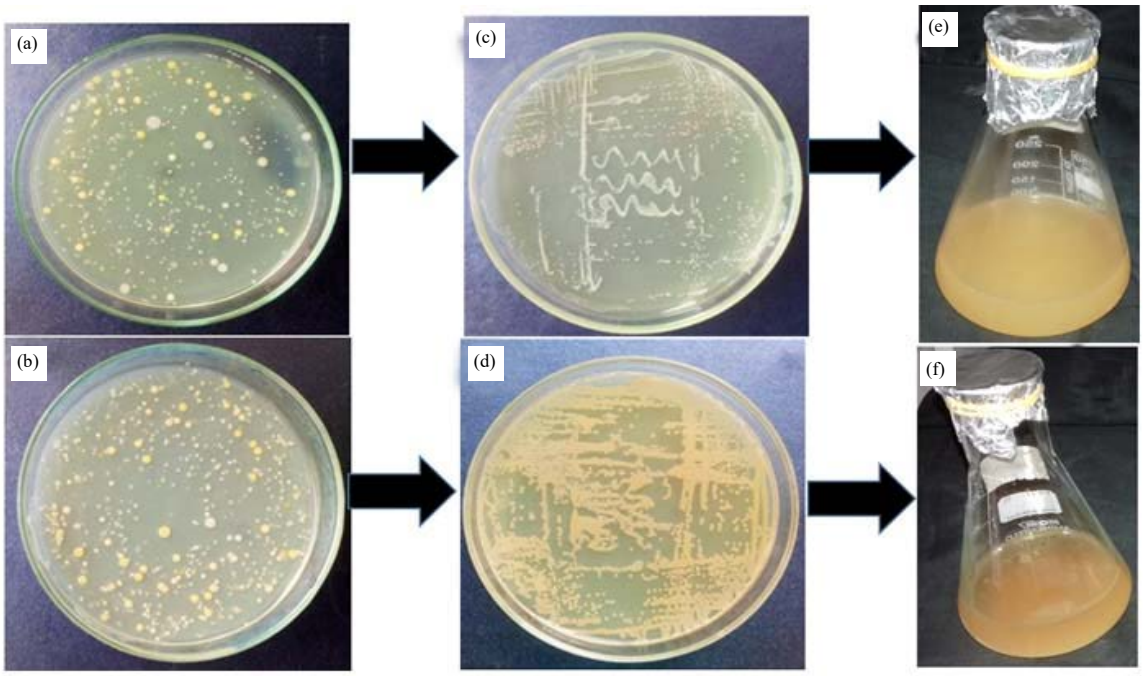

Fig. 1(a-f): Isolated probiotic bacteria from sweet and sour yogurt.
Here, plate (a) and (b) represent the mixed culture bacteria from sour and sweet yogurt, respectively. Plate (c) and (d) indicate the isolated pure bacteria from sour and sweet yogurt, respectively and (e) and (f) imply purified bacterial solution from sour and sweet yogurt, respectively

Management procedure: The brooder house was scrubbed and cleaned at least one week before the arrival of chicks in the brooder house. At first, the old litter was removed and cleans all the required equipment with a disinfected solution. After properly cleaned, the house was allowed to dry out thoroughly. Rice husk was used as litter material and 2.5 cm depth was maintained. The wet portion of the litter including dropping materials was removed and disposed of, when necessary, on regular basis. The new litter was added to maintain the normal depth of litter whenever required and was stirred normally 2 times a day. For the first 3 days, a simple paper or newspaper was spread over litter materials along with sprinkle feed. After 3 days the paper was removed and the feeder and waterers were evenly distributed around the brooder. The electric brooder was adjusted for 24 h before the arrival of chicks and the temperature was adjusted at 95°F (35°C) at the edge of the brooder 2 inches (5 cm) above the litter during the first week. The temperature was decreased by 5°F (2.8°C) each week until it reaches 70°F. The perfect temperature was monitored carefully.

All the DOCs were brooded together for the first 7 days to adjust and cope with the experimental environment. Then the birds were distributed according to the design of the experiment. The experimental birds were fed *ad libitum* from day old to 40 days of age. The broiler chicks were supplied with different diets (pellet) according to their age (Nilsagor Agro Industries Ltd). Clean, cool, normal and fresh pure drinking water was always provided *ad libitum* to the experimental birds to fulfill their requirements. Round hanging drinkers were used for drinking purposes. The drinking water was supplemented with the isolated bacterial solution of sweet, sour and mixed yogurt according to the design of our experiment. Strict biosecurity measures were followed during the experiment. The equipment was cleaned and disinfected regularly. The entrance of people was restricted except for relevant personnel. Before entrance hands were washed with soap and separate shoes were used. Virocid (combination of quaternary ammonium compounds, glutaraldehyde and alcohol) spray was used for disinfection. Adequate precautions were followed in case of vaccination. Dead birds were buried away from the farm and sick birds were isolated immediately to a separate place from the experimental pens. The farm was kept free from rats, cats, dogs and wild animals.

Data collection: The body weights of birds under each replicate were recorded at three days of interval and cumulative body weight was determined at the end of the experiment. The average body weight gain was calculated by subtracting the initial body weight from the final body weight, where body weight at 7 days was considered initial body weight. Feed consumption of each replicate was recorded at weekly intervals, on a cumulative basis and final feed consumption per bird was determined at the end of the experiment. The FCR was calculated as feed intake per unit body weight gain from 7-40 days of age using equation No. 1:

$$\text{FCR} = \frac{\text{Total amount of feed consumed}}{\text{Final live weight gain}} \quad (1)$$

The survivability of birds from every individual treatment was recorded until the end of the experiment (34 days). It was calculated by using equation No. 2:

$$\text{Survivability} = \frac{\text{Total survived birds}}{\text{Total birds housed}} \times 100 \quad (2)$$

At the end of the experimental period (34 days), four birds from each dietary group (one bird/replicate) were sacrificed and dressing yield was estimated by using equation No. 3:

$$\text{Dressing (\%)} = \frac{\text{Carcass weight of birds}}{\text{Live weight of birds}} \times 100 \quad (3)$$

At the end of the experiment, the total cost of production and total return was calculated. The major cost was considered for chick, feed, labor, litter, electricity and miscellaneous. Birds were sold at local market price and finally, the net income from the individual bird was estimated.

Data analysis: The data obtained were subjected to one-way analysis of variance (ANOVA). All data were presented as Means±standard deviation (SD). The significant differences were analyzed by Fischer's LSD comparison test, in which any difference was considered statistically significant when the p-value was smaller than 0.05 and 0.01.

RESULTS AND DISCUSSION

Feed consumption: The average feed consumption of experimental birds from 7-40 days of age (34 days) was recorded under four treatments. The average feed consumption for the four groups was 3982.5±23.62, 3972.5±15.54, 3988.8±70.99, 3995.0±42.03 g for T1, T2, T3 and T4, respectively (Table 1). The results revealed the non-significant effect of supplementation on the average total feed intake during the finisher phase under four treatments. Similarly, a non-significant effect of probiotics supplementation on feed intake of broiler chicks was observed

Table 1: Effects of supplementation of bacterial isolates on the performance of experimental birds

Variables	T1	T2	T3	T4	p-value
Feed intake (g)	3982.50±23.62	3972.50±15.54	3988.80±70.99	3995.00±42.03	0.8987
Body weight (g)	2351.25±23.23^{a}	2515.00±59.72^{b}	2385.25±54.62^{a}	2263.75±14.93^{c}	0.0001
Body weight gain (g)	2165.00±19.647^{a}	2322.70±66.073^{b}	2201.00±55.857^{a}	2075.20±13.817^{c}	0.0001
FCR	1.69±0.01^{a}	1.58±0.04^{b}	1.67±0.02^{c}	1.76±0.02^{d}	0.0001

Means in the same row with different superscripts are significantly different (P<0.01)

in a previous study[23]. Sultan *et al.*[21] also observed non-significant difference in feed intake of all the three groups of birds during the starter phase. In a previous study[24], an increase was observed in feed intake of broiler chicks treated with sweet yogurt as compared to control. The results of the present study are not supported by the previous research findings where the authors claimed low feed intake in the chicks fed on probiotic as compared to the control group[25]. Results of the present study are similar to a previous study conducted by Hatab *et al.*[26] who reported that supplementation of *B. subtilis* and *E. faecium* attributed to the maintenance of beneficial microbial population that improved feed intake[26]. However, the average feed intakes were increased from the beginning to the end under all treatments because of the increased requirement of growing birds.

Body weight and body weight gain: The recorded average live weights of the experimental birds under T1, T2, T3 and T4 were 2351.25, 2515.00, 2385.25 and 2263.75 g, respectively (Table 1). The highest body weight was recorded for T2, followed by T3 and T1, whereas the lowest body weight was recorded under T4 (control). The statistical analysis indicated that the average live weights significantly differ from each other. The average live weight of birds treated with bacteria isolated from sour yogurt (T2) was the highest (p<0.01) among other treatment groups, whereas the body weight of birds in other supplemented groups were also significantly different (p<0.05) from control group (Table 1).

In the current study, the average final body weight gains of birds at different treatments were recorded and analyzed. The results indicated that the average body weight gain of experimental birds under T2 at 40 days of age was the highest (2322.70 g) followed by T3 (2201.00 g) and T1 (2165.00 g). On the other hand, the lowest average body weight gain was recorded for T4 (2075.20 g) (Table 1). The difference among the means under all the treatments was found to be statistically highly significant (p<0.01) at all stages of growth. The results of the present study are supported by the findings of Hatab *et al.*[26] and Mansoub[27] who reported significant increase in final body weight and body weight gain in the supplemental group. The results of the present study are also in agreement with Asgar *et al.*[28] who reported significantly higher body weight gain with supplementation of probiotic compared with the control group. It is reported that supplementation of probiotics (Biogen, up to 1 kg t^{-1}) improved the growth performance of the broiler chicken[29]. Furthermore, Panda *et al.*[30] observed significantly ($p \leq 0.05$) higher body weight gain in probiotics supplemented broilers (1508.0 g) compared to control (1398.0 g) during the overall experimental period (0-6 weeks.). Similar results were also obtained by Anjum *et al.*[23] and Singh *et al.*[31]. A previous study showed that the live weight gains were significantly higher in experimental birds as compared to control ones at all levels during the 2nd, 4th, 5th and 6th weeks of age, both in vaccinated and non-vaccinated birds[32]. It was observed that probiotics and enzymes supplementation enhanced the growth rate. At the final day of experiment, the body weight was significantly higher (p<0.01) in the treated groups than that of the control group[33].

FCR: The computed FCR during the entire period of the experiment for T1, T2, T3 and T4 were 1.69, 1.58 1.67 and 1.76, respectively (Table 1). The results indicated that the supplementation of bacteria isolated from sweet or sour yogurt had a very significant (p<0.01) effect on the FCR of the experimental broilers. The superior FCR (1.58±0.04) was recorded for T2 (birds treated with isolated bacteria from sour yogurt). On the other hand, the worst FCR (1.76±0.02) in this study was recorded for T4 (without any supplementation). Yogurt, as a probiotic, has progressive effects on broiler's productive performances. There are numerous researches on it. However, a significantly lower FCR was found in birds treated with sour yogurt compare to the other treatment groups[34]. Sultan *et al.*[21] also reported lower FCR in sour yogurt-treated birds. Khan *et al.*[35] reported that probiotic treatments decreased feed to gain ratios (FCRs) by 0.194 or 0.166 units (p<0.05) at 28 and 39 days of age, respectively. Mansoub[27] reported that the average feed conversion ratios (FCR) were significantly higher in the probiotic supplemental group than that of the control group. Again, it was reported that feed conversion ratio was significantly ($p \leq 0.01$) improved with probiotics supplementation @100 g t^{-1} of feed compared to control[36]. On the other hand, non-significant results for FCR in all treated groups of birds were reported by Shivani *et al.*[37]. However, several other factors also influence the FCR of broilers.

Table 2: Effects of supplementation in various treatments on dressing percent and meat yields of the experimental birds

Variables	T1	T2	T3	T4	p-value
Dressing wt. (g)	1658.80±17.01[a]	1767.00±19.54[b]	1653.50±27.34[ac]	1609.00±31.86[d]	<0.0001
Dressing (%)	70.54±0.39	70.27±1.2771	69.33±0.49	71.08±1.80	0.23248
Breast meat (g)	692.50±66.64	757.50±22.54[a]	682.50±75.77[b]	621.25±43.66[b]	0.03577
Thigh meat (g)	332.50±12.58[a]	388.75±49.72[b]	322.50±29.86[acd]	272.50±35.95[c]	0.00424
Drumstick (g)	292.50±17.07[a]	323.75±7.50[b]	252.50±15.00[c]	270.00±37.41[acd]	0.00399

Data represent the Means±SD of 4 replicates of each treatment (8 birds/replicate). Data with different letters within the same row differ significantly ($p<0.05$, $p<0.01$). SD: Standard deviation

Dressing percentage and meat yield: The effect of supplementation of isolated bacteria from sweet and sour yogurt and their combination on dressing weight and dressing percentage is shown in Table 2. The dressing weight (1767.00±19.54 g) was the highest in T2 whereas the lowest dressing weight (1609.00±31.86) was recorded in the control group (T4). The supplementation of bacterial solution isolated from sweet and sour yogurt alone and in combination significantly ($p<0.05$) influenced the dressing weight (Table 2). The dressing percentage was the highest (71.08±1.80) in T4 whereas the lowest dressing percentage (69.33±0.49) was recorded in T3 group. Non-significant difference was observed in average dressing percentage among the treatment groups (Table 2). The results of the present study are different from those of Chiang and Hsieh[38] who noted a higher dressing percentage for chicks fed on probiotic containing *Lactobacilli* spp. It was also reported that probiotics supplementation at the rate of 100 g/ton of feed did not affect dressing percentage and organ weights (% body weight) which remained statistically ($p\geq0.05$) similar[37]. The highest breast meat yield (757.50±22.54) was obtained in T2 whereas the lowest breast meat yield (621.25±43.66) was recorded for the birds of T4 (control) group. There was a significant difference ($p<0.05$) in breast meat yield among T2, T3 and T4 treatment (Table 2). A previous study reported that adding 2 g probiotic per liter water increased thigh and breast meat yield of broiler chickens compared to the control treatment[11]. Further, several beneficial effects of probiotics on carcass characteristics of broiler chickens have been reported by other researchers[39,21]. It was reported that, differences between results could be related to the mode of action of those feed additives, which may be quite different, particularly regarding their antimicrobial activity[17]. However, they may exert similar physiological effects by modifying intestinal pH, altering the composition and balance of intestinal flora, enhancing nutrient digestibility and improving growth rate and carcass characteristics. The highest thigh meat yield (388.75±49.72) was observed in T2 whereas the lowest thigh meat yield (272.5±35.95) was recorded in T4 (control) group. It was observed that supplementation of bacteria isolated from sweet and sour yogurt alone and in combination significantly ($p<0.05$) influenced the thigh meat yield in all treatment groups (Table 2). The comparison test indicated a significant difference among T2, T3 and T4 but a non-significant difference was obtained between T1 and T3 and T4. Almost similar opinion was expressed by Ghasemi-Sadabadi *et al.*[22] who stated that supplementation of kefir, yogurt and probiotic up to 42 days significantly ($p<0.05$) improved the carcass yield, thigh meat yield and intestine length of male and female broiler chickens. Table 2 shows the effect of supplementation of isolated bacteria from sweet and sour yogurt on drumstick meat yield. The results revealed that supplementation significantly ($p<0.05$) influenced the drumstick meat yield. The highest drumstick meat yield (323.75±7.50) was observed in T2 whereas the lowest drumstick meat yield (270.00±37.42) was recorded for birds of T4 (control) group. A significant difference was noticed among T2, T3 and T4 but a non-significant difference was observed between T1 and T4, T3 and T4. A previous study conducted by Eltrefi[30] reported that adding the probiotic did not affect either breast, thigh and drum sticks meat: bone ratios or the wholesale cuts percentages at any level of supplementation. Ghasemi-Sadabadi *et al.*[22] reported that use of kefir, yogurt and probiotic in water up to 42 days at the recommended level improved body weight gain, feed intake and feed conversion ratio of male and female broiler compared to other groups ($p<0.05$).

Survivability: Survivability was recorded during the experimental period and expressed in terms of percentages for each group. The recorded survivability of experimental birds from 7-40 days of age is presented in Fig. 2. These results indicated that percent survivability was the lowest in T4 (90.63%±11.01) (control group, without any supplement). On the other hand, 100% survivability was recorded for T1 and T2 group as well as 93.75% survivability was found in T3. However, the difference in survivability among the treatments was non-significant. Yogurt supplementation in the broiler diet enhanced gut health and the environment. Therefore, the survivability rate of the flock increases. However, no mortality

Table 3: Cost-benefit analysis and profit margin per bird or per kg under different treatment

Variables	T1	T2	T3	T4
Cost/chick (BDT)	27	27	27	27
Average feed intake (kg) chicks^{-1}	3.98	3.97	3.99	4
Feed price kg^{-1} (BDT)	42	42	42	42
Average feed cost (BDT)	168.00	167.16	165.90	168.00
Electricity cost	3	3	3	3
Labor cost (BDT)	5	5	5	5
Miscellaneous (BDT)	7	7	7	7
Total cost/broiler (BDT)	209.16	208.74	209.58	210.00
Average live weight (Kg)	2.35	2.52	2.39	2.26
Selling price kg^{-1} live wt. (BDT)	110	110	110	110
Selling price broiler^{-1} (BDT)	258.5	277.2	262.9	248.6
Net profit broiler^{-1} (BDT)	49.34	68.46	53.32	38.6
Profit kg^{-1} broiler (BDT)	21.00	27.17	22.31	17.08

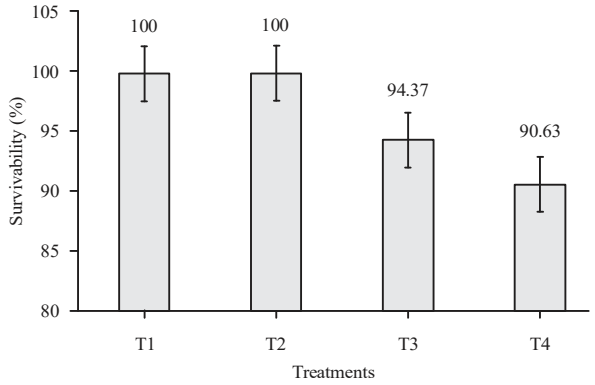

Fig. 2: Variation in survivability (%) after supplementation of bacterial isolates in different treatments.
Here, the vertical bar indicated the error and n = 32

was found in the group treated with sour yogurt and in sweet yogurt treated birds mortality was lower than those of the control birds[21]. Moreover, Eltrefi *et al.*[29] reported that mortality rate was low in broilers fed on diets supplemented with Biogen. Therefore, due to the lack of enough immunity birds in the control group died frequently whereas birds treated with bacteria isolated from yogurt showed better survivability (0% mortality) even without antibiotics. Patel *et al.*[36] reported that mortality (%) for T3 (1.25) was lower than that of T2 (3.75) and T1 (control) (5.00) but differences were non-significant. The reduction in mortality rate in probiotic treated birds might be due to the presence of surface adhesions (mucus-binding proteins) on the surface of probiotic bacteria which mediate the attachment of probiotics with intestinal epithelial cells (IECs) and this interaction between probiotic bacteria and IECs may inhibit the colonization of pathogenic bacteria in the intestinal mucosa[40,41].

Cost-benefit analysis: One of the objectives of the present study was to determine the feasibility of using yogurt in antibiotic-free broiler production in terms of economics. The total cost of production per bird was 209, 208, 209 and 210TK for T1, T2, T3 and T4, respectively where the major cost for chick, feed, labor, litter, electricity and the miscellaneous was included. The selling price per bird was 258.5, 277.2, 274.3, 262.9 and 248.6 TK for group T1, T2, T3 and T4, respectively and net profit was 49.34, 68.46, 53.32 and 38.6 TK for T1, T2, T3 and T4, respectively (Table 3). It was revealed from the cost-benefit analysis that the highest profit was obtained from T2 (sour yogurt) (27.17 Tk kg^{-1}), followed by T3 (mixed yogurt) (22.31 Tk kg^{-1}) and T1 (sweet yogurt) (21.00 Tk kg^{-1}). In contrast, the lowest profit was recorded for the T4 or control group (17.08 Tk kg^{-1}). Therefore, it may be concluded that profitable broiler meat production is possible without antibiotics. It was assumed that yogurt supplementation in the diet enhances the production performances of birds by better utilization of feeds. Therefore, it hikes profitability by maximum net return. A previous study revealed that feed cost was significantly lower for the sour yogurt treated group and no significant difference was found in another group[21]. Further, another study reported that the dietary supplementation of probiotics (100 g t^{-1} of feed) significantly enhanced body weight gain along with better feed conversion ratio and profit without any adverse effect on feed intake, mortality and carcass characteristics[36]. Khan *et al.*[35] reported that the birds supplemented with probiotics generated more profit than those of the control birds (without probiotic). The net income per bird was US$0.33, 0.49, 0.54 and 0.55 for control, protexin, biovet and yoghurt group, respectively. Among probiotics, yogurt was more economical than biovet and protexin because it was locally prepared. The supplementation of isolated bacteria from sweet or sour yogurt through drinking water had a significant ($p<0.05$) effect on the body weight, body weight gain, FCR, dressing weight, meat yield and profitability of the experimental broilers. Therefore, isolated bacteria from sweet or sour yogurt could be used as an alternative to the antibiotic for safe broiler production.

CONCLUSION AND RECOMMENDATION

The supplementation of bacterial isolates from yogurt had promising effects on profitable broiler production without antibiotics, especially sour yogurt exerted significant beneficial effects on the production performance of broiler. Therefore, isolated bacteria from sweet and sour yogurt could be effectively used in fresh drinking water as a potential natural growth promoter contributing to better body weight gain, FCR and survivability in an antibiotic-free broiler production system. Finally, it is suggested that sour yogurt could be used as an alternative to antibiotics in commercial broiler production.

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