JABET
Journal of Advanced Biotechnology and Experimental Therapeutics

ORIGINAL ARTICLE

J Adv Biotechnol Exp Ther. 2025 May; 8(2): 218-231
eISSN: 2616-4760, https://doi.org/10.5455/jabet.2025.18
Published by www.bsmiab.org

# Selection of efficient broiler strain for productive performances and immunity under local farming system in Bangladesh

**Mostafizor Rahman[1, 2, †], Hemayet Hossain[3, †], Milon Mia[4], Md Jamilur Rahman[5], Abu Al Farabi[6], Zhokhar Dudayev[7], Khadiza Akter Brishty[8], Nadia Afrin[9], Md. Arif Ishtiaq Shovon[10], Md. Shahidur Rahman Chowdhury[11], Md. Masudur Rahman[12], Md. Mahfujur Rahman[11, *]**

[1]Department of Dairy & Poultry Science, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh
[2]Faculty of Veterinary and Animal Sciences, Gono Bishwabidyalay, Dhaka, Bangladesh
[3]Department of Anatomy and Histology, Sylhet Agricultural University, Sylhet, Bangladesh
[4]Faculty of Veterinary Medicine, Chattogram Veterinary and Animal Sciences University, Chattogram, Bangladesh
[5]Faculty of Veterinary Science, Bangladesh Agricultural University, Mymensingh, Bangladesh
[6]Department of Microbiology and Veterinary Public Health, Chattogram Veterinary and Animal Sciences University, Chattogram, Bangladesh
[7]Department of Microbiology and Public Health, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh
[8]Department of Zoology (GSSC), University of Dhaka, Dhaka, Bangladesh
[9]Department of Medicine and Surgery, Chattogram Veterinary and Animal Sciences University, Chattogram, Bangladesh
[10]Faculty of Veterinary, Animal and Biomedical Sciences, Sylhet Agricultural University, Sylhet, Bangladesh
[11]Department of Medicine, Sylhet Agricultural University, Sylhet, Bangladesh
[12]Department of Pathology, Sylhet Agricultural University, Sylhet, Bangladesh

***Corresponding author**
Md. Mahfujur Rahman, PhD
Department of Medicine, Sylhet Agricultural University, Sylhet, Bangladesh
Email: mahfuj.vetmed@sau.ac.bd

[†]These authors contributed equally.

**Academic editor**
Md. Abdul Hannan, PhD
Bangladesh Agricultural University, Bangladesh

**Article info**
Received: 05 November 2024
Accepted: 17 February 2025
Published: 02 March 2025

**Keywords**
Broiler, Cobb 500, Ross 308, Growth performance, Immunity

## ABSTRACT

The poultry sector has emerged as an important contributor to the national economy of Bangladesh, meeting essential protein needs with quality products and progressing steadily toward a poultry-sufficient nation. This study investigated the performance of various broiler strains Cobb 500, Indian River (IR), Ross 308, and Efficiency Plus (EP) under the local farming system in Bangladesh, with a focus on growth, carcass characteristics, and immune response. A randomized controlled trial (RCT) was performed using 240 chicks for 42-day experimental trials. Data were collected weekly on body weight, feed intake, carcass yield, and humoral immune responses. These immune responses were evaluated using the hemagglutination inhibition (HI) test and the enzyme-linked immunosorbent assay (ELISA). The key findings indicated that Cobb 500 and Ross 308 exhibited superior growth performance, with Cobb 500 achieving the highest final body weight (2820.67 g) and breast weight (708.00 g). Ross 308 demonstrated a superior feed conversion ratio (FCR) and immune response, exhibiting higher antibody titers against Newcastle Disease and H9N2. Notably, while Ross displayed initially higher antibody levels for Infectious Bursal Disease, Cobb 500 ultimately surpassed it by day 42. Both Cobb 500 and Ross 308 were shown to have strong performance traits, with Cobb 500 leading in body weight and carcass characteristics, while Ross 308 excelled in feed efficiency and immune response. These findings underscored the importance of selecting broiler strains based on comprehensive performance metrics to enhance production efficiency in the poultry sector of Bangladesh.



## INTRODUCTION

Food security for today's global population resides with an efficient and sustainable supply of good protein sources in which poultry holds a pivotal role. Human numbers will expand by another 20%, reaching nearly 10 billion by the year 2050 [1]. The poultry sector in Bangladesh has emerged as an important contributor to the country's economy, delivering essential and quality protein needs and a continuous recursive process toward a poultry-sufficient nation [2]. This sector has experienced significant growth, with an annual increase in commercial poultry farms of about 15%. The industry produces 1.46 million tons of poultry meat annually [3]. This sector has shown remarkable resilience despite facing challenges such as rising feed prices and climate

impacts. On a global scale, the Middle East poultry meat market is estimated to reach USD 16.25 billion in 2025, with a projected growth rate of 1.87% CAGR from 2025 to 2030 [4]. The region has experienced a significant influx of expatriates, resulting in a higher demand for poultry meat. Similarly, China's poultry meat imports are projected to rise, with chicken meat imports (excluding paws) expected to reach 930,000 metric tons in 2022 [5]. The demand for poultry meat in China remains strong despite challenges such as import constraints and avian influenza-related issues [1]. These data points highlight the optimism of Bangladeshi entrepreneurs in exporting poultry meat by 2024, driven by profitable and high-demand markets in the Middle East and China, despite potential challenges [5].

With the rise and trends in protein consumption in the entire world, it has become important to find affordable strategies for producing animal protein in a more cost-effective pattern. In Bangladesh, per capita animal protein consumption has increased from 79.1 g in 2010 to 88 g in 2017 and 201.9 g per head in 2022 [1]. This rise is not just because of an improved understanding of nutrition but also due to transformative changes in the economic base management. Today, poultry farming has become a significant part of the agricultural sector in Bangladesh [6].

These changes in domestic demand and export potential make it crucial to identify higher-performance broiler strains that can maximize productivity and support the economic growth of Bangladeshi farmers. Advancements in growth performance, carcass yield, and composition have been closely linked to the prosperity of poultry production [6]. Broiler strains are developed through a selective breeding process where specific genes governing traits like rapid growth, feed efficiency, and meat yield are targeted and emphasized. Different broiler strains are developed through selective breeding to emphasize traits such as rapid growth, feed efficiency, and meat yield, optimizing them for specific industry needs. Genetic selection aims to create strains with distinct characteristics, optimizing them for desired attributes such as accelerated growth and high meat production within the poultry industry [7]. When selecting the appropriate broiler strain, it is essential to consider the growth rate, which ensures rapid body growth to reach market weight quickly. Feed efficiency is another critical factor, as it determines the ability to convert feed into body weight effectively, thus impacting cost-efficiency [6,7]. Additionally, meat yield with desirable carcass quality is important for profitability, and strains that demonstrate strong resistance to common poultry diseases help reduce mortality and veterinary costs [7].

Broiler production in Bangladesh is influenced by several factors, including economic, environmental, and management practices. Financial aspects play a significant role, as the cost of feed, chicks, and medication represents major expenses [8]. Environmental factors such as temperature and rainfall also impact production, with cold winters and heavy rains posing significant challenges [9]. Management practices, including farmers' education, experience, and access to training and resources, as well as housing patterns, significantly affect broiler performance. Additionally, the availability of credit and the quality of feed and chicks are crucial determinants [10]. Addressing these factors can help to improve broiler production efficiency and profitability in Bangladesh. In the case of the rearing pattern, semi-intensive farming allows chickens access to outdoor areas for foraging, improving their health and welfare while reducing costs and environmental impact compared to intensive farming, which confines birds to limited spaces with higher disease and stress risks [8, 9].

Previous studies have reported differences in the diversity of chicken productivity depending on strain and gender [11]. In recent years, studies have focused on optimizing poultry production through strain selection, advanced nutrition, and the

integration of cutting-edge technology [12]. However, as the demand of the consumer changes, it is also important to find ways of changing production that can enhance the efficiency of the broiler. Various broiler strains have different growth rates and market ages in overall yield, and that is why it is important for both the researchers and the farmers to have accurate statistics for the purpose of the decision-making process [13]. Previous data revealed that the standard weight at 42 days for Cobb 500, Ross 308, Efficiency Plus (EP), and Indian River (IR) was 2952 g, 2809 g, 3028 g & 2915 g, respectively [14-17].

The purpose of this study was to investigate the comparative growth performance and characteristics of four commercially available broiler strains Cobb 500, Ross 308, Efficiency Plus (EP), and Indian River (IR) of Bangladesh. The parameters used to assess growth performance included several key indicators. First, body weight gain was measured to track the increase in weight over time. Second, the feed conversion ratio (FCR) was calculated to determine the efficiency of feed utilization. Third, the specific growth rate (SGR) was analyzed to evaluate the relative growth rate over a specific period. Additionally, the average daily gain (ADG) was recorded to measure the daily weight increase. The broiler production efficiency factor was used to assess overall production efficiency. Finally, the overall performance index was calculated to provide a comprehensive evaluation of growth performance. This study also investigated the immune (Humoral) response against Newcastle Disease (ND), H5N1, H9N2, and Infectious Bursal Disease (IBD) of the four commercially available broiler strains.

## MATERIALS AND METHODS

### Ethical statement

This experiment holds an approved Animal Use Protocol #AUP2023048 from the Animal Experimentation and Ethics Committee (AEEC) at Sylhet Agricultural University, Bangladesh.

### Experimental design and duration

A randomized controlled trial was conducted involving 240 chicks (Day old), which were divided into four groups: Cobb 500, IR, Ross 308, and EP. Each group comprised 60 chicks, further subdivided into three replications, with each replication containing 20 chicks. The study was conducted under farm conditions at Mahbub Poultry Farm in Kuliarchor, Kishoreganj, over a 42-day period.

### Feeding and management

All chicks were provided with commercially available feed from Nourish Poultry and Hatchery Limited, Bangladesh. The chemical composition of the feed ingredients used in formulating the commercial diet is presented in Table 1. Chicks in all treatment groups had unrestricted access to feed and water throughout the 42-day experimental period.

The birds were vaccinated against ND and Infectious Bronchitis (IB) using RaniVax Plus Vet (Incepta Pharmaceuticals Ltd., Bangladesh). The initial dose was administered as an eye drop on day 3, followed by a booster on day 21. RaniVax Plus Vet is a live, freeze-dried vaccine containing the NDV F strain and IBV Massachusetts strain, formulated to provide protection against ND and IB. Additionally, the IBD vaccine,

GumboMed Plus Vet (Incepta Pharmaceuticals Ltd., Bangladesh), was administered via drinking water on day 10, with a booster dose given on day 17. This live, freeze-dried vaccine contains an Intermediate Plus strain of the IBD virus to ensure effective protection against IBD (Gumboro disease).

The chicks were housed in twelve clean and disinfected pens, all of equal size, with floors covered by approximately 6 cm of fresh and dried rice husk. Each bird was allocated a floor space of 1 square foot. A 100-watt electric bulb was used to maintain warmth during the first week, achieving a temperature of 95°F. The temperature gradually decreased by 5°F each week until it reached the ambient conditions of the house. The electric bulb was used for lighting until the end of the study period to facilitate feeding and drinking for the chicks.

**Table 1.** Nutrient Composition of supplied feed up to 42 days.

| Nutrient | Pre-Starter (1-11 days) | Starter (12-21 days) | Grower (22-28 days) | Finisher (29-up to 42 days) |
|---|---|---|---|---|
| Moisture (%) | 12 | 12 | 12 | 12 |
| CP (%) | 21 | 20 | 19 | 18 |
| CF (%) | 5 | 5 | 5 | 5 |
| Ca (%) | 1 | 0.95 | 0.95 | 0.90 |
| P (%) | 0.45 | 0.45 | 0.45 | 0.42 |
| Methionine % | 0.48 | 0.45 | 0.45 | 0.42 |
| Lysine % | 1.15 | 1.05 | 1.05 | 1 |
| ME (Kcal) | 2950 | 3000 | 3050 | 3100 |

CP: Crude protein, CF: Crude fibre, Ca: Calcium, P: Phosphorus, ME: Metabolizable energy

### Data collection

The initial weights of the chicks were measured at the start of the experiment and subsequently recorded weekly until the end of the 42-day period. The birds were weighed prior to the morning feeding sessions on a weighing scale (ACI-Weight scale, ACS-796, Dhaka-1208, Bangladesh). The average live weight for each treatment group (Cobb 500, Indian River, Efficiency Plus, and Ross 308) was documented weekly. The feed intake (FI) of the experimental birds from different replications within each treatment group was weighed at the end of each week, and weekly feed refusals were also recorded. The liveability of the broiler chicks was monitored, and differences in liveability were calculated for each treatment group. Additionally, the feed cost per kilogram of live broiler was calculated based on the market prices of feed ingredients during the experimental period.

### Methods of determining the performance parameters

After the calculation of the liveability percentage (%) and FCR, the Broiler performance efficiency factor (BPEF) and Broiler farm economy index were used to evaluate the growing performance of broilers as suggested by Murugan and Ragavan [18].

$$\text{Liveability (\%)} = \frac{\text{Number of birds at the end}}{\text{Numbers of birds at the beginning}} \times 100$$

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Total quantity of feed consumed per bird in Kg}}{\text{Mean body weight gain Kg}}$$

$$\text{Average Daily Gain (ADG)} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Days}}$$

$$\text{Broiler Performance Efficiency Factor (BPEF)} = \frac{Viability\ (\%) \times BW\ (kg)}{Age\ (d) \times FCR} \times 100$$

$$\text{Broiler Farm Economy Index (BFEI)} = \frac{\text{Average live weight (Kg)} \times \text{Percent livability}}{\text{Feed Efficiency} \times \text{Growing period (days)}}$$

### Carcass characteristics

Prior to slaughter, all birds from each treatment group were withheld from feed and water for 12 hours. After complete bleeding, the birds were individually weighed. To facilitate defeathering, the carcasses were immersed in hot water of 51–55°C for 2 minutes. Final processing involved the removal of the head, shank, viscera, oil gland, kidney, and lungs. The heart and liver were extracted from the remaining viscera, with the gall bladder removed from the liver and the pericardial sac and arteries cut from the heart. The gizzard was separated from the intestine and cleaned with a knife, and the lining was removed by hand. During processing, the following parameters were recorded: live weight, carcass characteristics, giblet weight, and dressing percentages.

### Hemagglutination and hemagglutination inhibition tests

All birds were given vaccines for IBD and ND for commercial broilers in Bangladesh. All the strains received vaccine against ND, while no vaccine was administered for H5N1 and H9N2. The Hemagglutination (HA) test was conducted following the protocol given by OIE. A 96-well V-bottom microtiter plate was prepared, with 50 µl of PBS added to each well in row 1. Equal amounts of ND viral antigen were mixed with PBS in the first well, and subsequent two-fold serial dilutions were performed across the remaining wells in row 1. After each dilution, the solution was thoroughly mixed. From the 11th well onward, 50 µl of the mixture was discarded, leaving 50 µl in each well. To facilitate hemagglutination, 50 µl of 1% chicken red blood cells (cRBC) were added to each well, and a control row containing only PBS and cRBC was included. The plate was incubated at room temperature for 30 minutes to allow the virus to agglutinate the cRBCs. The presence of agglutination was indicated by the formation of a hazy film in wells with sufficient antigen concentration, while wells with lower antigen levels or negative control wells exhibited a distinct button at the bottom. The plate was tilted to confirm buttoning, with the appearance of a teardrop shape indicating a negative result. The last well showing complete agglutination was considered one HA unit, and the HA titer was determined as the reciprocal value of the dilution that gave one HA unit.

For the hemagglutination inhibition (HI) test, the serum samples were first serially diluted in a 96-well V-bottom microtiter plate, starting with a 1:2 dilution in PBS. A fixed volume (50 µl) of each diluted serum was mixed with an equal volume of the appropriate viral antigen (H9N2, H5N1, or ND) at a standardized concentration. The antigen-serum mixture was incubated for 30 minutes at room temperature to allow the serum antibodies to neutralize the viral antigen. Following incubation, 50 µl of 1% cRBC were added to each well, and the plate was again incubated at room temperature for an additional 30 minutes. The presence of hemagglutination was observed in each well, and inhibition of agglutination was recorded when antibodies in the serum neutralized the virus, preventing the cRBCs from agglutinating. The last serum dilution that fully inhibited hemagglutination was considered the HI titer, representing the highest concentration of antibodies capable of neutralizing the virus. The HI titer was calculated as the reciprocal of the highest dilution at which hemagglutination was inhibited, thus indicating the specific antibody concentration against H9N2, H5N1, or ND viruses in the sera samples.

### Enzyme-linked immunosorbent assay

For IBD antibody detection, samples were prepared on a 96-well plate (Catalogue number; CK113 IBD, BioChek, Reeuwijk, Netherlands) to ensure uniform incubation times, with test and control samples transferred to an enzyme-linked immunosorbent assay (ELISA) microplate using a multichannel pipette (Catalog No. 3125000010, Eppendorf, Hamburg, Germany). The Wash Solution was prepared by diluting Wash Concentrate (20x) to 1x with distilled water. The testing procedure involved the addition of samples and controls to designated wells, followed by incubation for 30 minutes at 21°C. A diluted conjugate was added, another incubation was performed, and the wells were washed three times. Finally, a substrate solution was added, incubated in the dark for 15 minutes, and the reaction was stopped with a stop solution before the optical density was measured at 450 nm.

### Statistical analysis

All recorded and calculated data were analyzed using SPSS program (IBM SPSS statistics Version 26). Analysis of variance (ANOVA) was performed, and least significant differences (LSD) were calculated for significant differences to compare parameters between the strains. Origin 2024b and GraphPad Prism 8.4 were used to make the graph based on the data.

## RESULTS

### Effect of strains on body weight and growth dynamics

The initial body weight of day-old chicks (DOC) across different strains was comparable. However, weekly body weight gains varied among the strains. After the first week, Cobb-500 exhibited a significantly higher body weight of 155.27 g and a corresponding body weight gain of 112.93 g, surpassing the other strains significantly ($p$<0.001). Both Cobb-500 and Ross showed a significant increase in body weight at the 5th and 6th weeks. In 42 days, Cobb 500 (2825.33 g) and Ross 308 (2725 g) strains gained more weight by feeding with commercial broiler feed (Nourish feed), which were significantly higher than those of EP and IR (Table 2).

**Table 2.** The body weight and FCR of different broiler strains for 42 42-day period.

| Parameters | Week | Cobb 500 | Ross | IR | EP | $p$-value |
|---|---|---|---|---|---|---|
| Body weight | Initial | 42.33±0.33 | 42.83±0.17 | 42.67±0.33 | 42.67±0.33 | 0.10 |
| | 1st Week | 155.27$^{a}$±1.79 | 152.33$^{ab}$±0.33 | 146.73$^{b}$±2.90 | 136.60$^{c}$±0.42 | <0.001 |
| | 2nd Week | 476.67$^{a}$±7.54 | 471.33$^{a}$±1.86 | 451.00$^{b}$±4.58 | 441.67$^{b}$±4.41 | 0.003 |
| | 3rd Week | 956.33±2.40 | 944.33±8.09 | 965.33±69.84 | 909.00±6.66 | 0.699 |
| | 4th Week | 1577.80±49.36 | 1446.33±28.81 | 1540.00±85.05 | 1433.00±9.07 | 0.209 |
| | 5th Week | 2218.60$^{a}$±43.60 | 2074.17$^{ab}$±34.60 | 2116.00$^{b}$±51.39 | 1990.33$^{b}$±5.49 | 0.017 |
| | 6th Week | 2825.33$^{a}$±22.36 | 2725.00$^{b}$±17.56 | 2641.67$^{c}$±19.22 | 2566.67$^{d}$±8.82 | <0.001 |
| FCR | 1st Week | 0.99$^{c}$±0.02 | 1.06$^{b}$±0.00 | 1.08$^{b}$±0.04 | 1.24$^{a}$±0.01 | <0.001 |
| | 2nd Week | 1.01$^{c}$±0.01 | 1.11$^{bc}$±0.01 | 1.17$^{b}$±0.08 | 1.30$^{a}$±0.02 | 0.005 |
| | 3rd Week | 1.09$^{b}$±0.01 | 1.13$^{b}$±0.02 | 1.21$^{ab}$±0.09 | 1.32$^{a}$±0.01 | 0.025 |
| | 4th Week | 1.16$^{c}$ ±0.04 | 1.41$^{ab}$±0.07 | 1.28$^{bc}$±0.06 | 1.52$^{a}$±0.01 | 0.005 |
| | 5th Week | 1.48±0.07 | 1.47±0.04 | 1.69±0.14 | 1.77±0.02 | 0.061 |
| | 6th Week | 1.77$^{c}$±0.07 | 1.55$^{b}$±0.03 | 1.89$^{ab}$±0.06 | 1.96$^{a}$±0.02 | 0.002 |
| | Final FCR | 1.33$^{c}$±0.96 | 1.36$^{c}$±1.31 | 1.45$^{b}$±0.74 | 1.60$^{a}$±1.47 | 0.023 |

One-way ANOVA with Duncan multiple range test (DMRT); $^{abc}$Superscripts indicate significant variation among the group. Significance level $p$<0.05

While EP and Ross strains demonstrated a gradual increase in weight gain, IR and Cobb-500 exhibited an irregular pattern. The BWG steadily increased until the 5th week but decreased in the 6th week. The highest weight gains were observed in Cobb-500 (640.8 g), Ross (650.83 g), IR (576.0 g), and EP (576.33 g), respectively. The final weight gain was significantly higher in Cobb 500 (2783 g) and Ross (2682 g) (Supplementary Table 1).

### Impact of strains on FI and FCR

The initial range of weekly feed intake was 111.33 to 116.52 g/bird, as shown in Supplementary Table 2. As age increased, there was a gradual rise in feed intake by all strains. The FCR differed among the strains and displayed an ascending trend with increasing age. Notably, the EP strain exhibited the highest feed intake at 1131.83 g/bird/week, coupled with a relatively higher FCR of 1.96 at six weeks of age. Cobb-500, at the 6$^{th}$ week, had a feed intake of 1070 g/bird/week, accompanied by an FCR of 1.77. Conversely, the Ross strain demonstrated superior performance with a lower FCR of 1.55. However, the final FCR was 1.33 and 1.36 in Cobb 500 and Ross, respectively, at the end of 42 days (Table 2).

### Impact on Growth Performance Efficiency Indicators

Various performance indicators, including ADG, BFEI, and BPEF, were presented in Figure 1. Cobb-500 exhibited the highest ADG at 67.27 g, followed closely by Ross with 64.88 g. The indicators of overall farm efficiency, BFEI and BPEF, were notably higher in the Ross strain. Specifically, Ross showed a BFEI of 3.98% and a BPEF of 175.81%. On the other hand, the EP strain displayed the lowest BFEI at 2.65% and the lowest BPEF at 130.65%. The performance parameters indicate the comparative strengths and weaknesses of each strain, with Cobb-500 excelling in ADG, while Ross demonstrated superior efficiency indices, particularly in BFEI and BPEF.

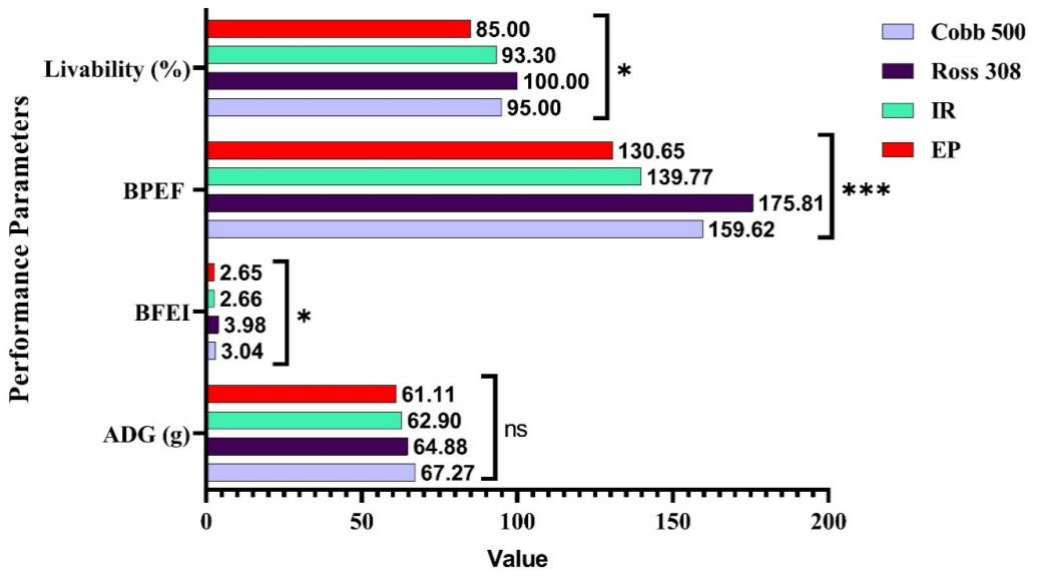


**Figure 1.** Comparative analysis of different performance parameters among different broiler strain. Broiler Performance Efficiency Factor (BPEF); Broiler Farm Economy Index (BFEI).

### Carcass characteristics and yield differences among strains

The carcass characteristics of four broiler strains, including Cobb 500, Ross, IR, and EP, were systematically assessed, and the findings are presented in Table 3. Significant differences were found in both live weight and carcass weight among the various strains. Specifically, Cobb 500 demonstrated the highest values, registering a live weight of 2820.67 g and a carcass weight of 1688.67 g. Significant differences were also evident in drumstick and wing weights, underscoring distinct strain-specific variations. While the thigh weight exhibited numerical distinctions, statistical significance was not established ($p$=0.075), which emphasizes its advantage over the other strains in this specific parameter. The dressing % was found to be higher in Cobb 500 (59.87%) following EP strain (57.45%).

**Table 3.** Carcass characteristics and organ weights of different broiler strains after 42 days trial.

| Attributes | Parameter | Cobb 500 | Ross | IR | EP | *p*-value |
|---|---|---|---|---|---|---|
| Carcass traits | Live wt (g) | 2820.67$^{a}$±49.18 | 2623.00$^{b}$±59.57 | 2475.33$^{b}$±69.68 | 2137.33$^{c}$±40.34 | <0.001 |
| | Carcass wt (g) | 1688.67$^{a}$±8.51 | 1470.00$^{b}$±13.32 | 1421.00$^{b}$±59.15 | 1228.00$^{c}$±26.15 | <0.001 |
| | Dressing % | 59.87±7.30 | 56.04±6.36 | 57.41±8.89 | 57.45±6.82 | 0.065 |
| | Thigh wt (g) | 144.67±26.77 | 105.67±2.33 | 91.00±6.08 | 90.67±2.91 | 0.075 |
| | Drumstic wt (g) | 128.00$^{a}$±7.57 | 108.00$^{b}$±6.43 | 98.00$^{b}$±4.62 | 96.00$^{b}$±2.31 | 0.013 |
| | Wings wt (g) | 82.67$^{a}$±4.37 | 73.00$^{a}$±1.53 | 76.67$^{a}$±3.33 | 62.00$^{b}$±3.06 | 0.012 |
| | Breast wt (g) | 708.00$^{a}$±21.20 | 593.33$^{b}$±9.61 | 612.67$^{b}$±20.08 | 511.33$^{c}$±16.59 | <0.001 |
| | Shank wt (g) | 118.67$^{a}$±4.81 | 100.67$^{ab}$±13.48 | 93.00$^{ab}$±4.93 | 80.67$^{b}$±4.06 | 0.048 |
| | Head wt (g) | 56.67$^{a}$±0.67 | 47.67$^{b}$±1.45 | 47.33$^{b}$±1.76 | 40.00$^{c}$±2.00 | 0.001 |
| | Neck wt (g) | 60.67±7.06 | 56.67±0.67 | 47.67±7.22 | 44.67±0.67 | 0.167 |
| Organ Weight | Liver wt (g) | 70.67±7.69 | 76.00±4.00 | 58.00±6.43 | 54.00±3.46 | 0.076 |
| | Heart wt (g) | 12.00±0.00 | 12.50±1.76 | 10.00±2.31 | 8.00±0.00 | 0.191 |
| | Spleen wt (g) | 2.57±0.72 | 3.60±0.67 | 2.17±0.12 | 1.83±0.17 | 0.150 |
| | Gizzard wt (g) | 34.67±4.67 | 30.67±3.53 | 37.67±1.45 | 26.67±1.76 | 0.151 |
| | Lungs wt (g) | 13.00±3.00 | 12.33±1.67 | 11.00±1.00 | 15.00±1.53 | 0.560 |
| | Bursa wt (g) | 1.53±0.17 | 1.40±0.15 | 1.30±0.25 | 1.40±0.20 | 0.868 |
| | Thymus wt (g) | 10.33±0.33 | 7.17±0.73 | 7.33±0.67 | 7.40±1.40 | 0.093 |

One-way ANOVA with Duncan multiple range test (DMRT); $^{abc}$Superscripts indicate significant variation among the group. Significance level $p$<0.05

### Comparison of organ weights across different strains

The weights of various organs in broilers from different strains Cobb 500, Ross, IR, and EP were measured and presented in Table 3. While there were some differences in the numbers, not all of them were statistically significant. For instance, liver weights showed a trend, being highest in Ross and lowest in EP, but the difference was not significant ($p$-value: 0.076). Similar non-significant trends were observed in the heart, spleen, gizzard, lungs, bursa, and thymus weights.

### Strain-specific antibody response to Newcastle disease, H5N1, and H9N2

The comparative evaluation of humoral immune responses among different broiler strains revealed notable differences in antibody titers over the trial period (Figure 2 and Supplementary Table 3-5). In terms of ND maternal derived antibody (MDA), the Ross strain exhibited the highest levels, though the differences were not statistically significant compared to Cobb 500, IR, and EP. This pattern continued through the various weeks of the trial, with Ross consistently maintaining the highest antibody titers, yet without significant statistical differences across the strains. For H5N1 antibody titers, Ross again showed the highest MDA, but the differences remained non-significant until the fifth and sixth weeks, where significant differences were noted

($p$<0.05) between the strains, with Cobb showing a notable decrease in titers. In contrast, for H9N2, the Ross strain significantly outperformed the others across all weeks, with the highest MDA observed at the beginning of the trial and consistently higher titers throughout the subsequent weeks. Statistical significance was achieved at $p$<0.05, indicating a clear distinction in the humoral response of the Ross strain compared to Cobb, IR, and EP.

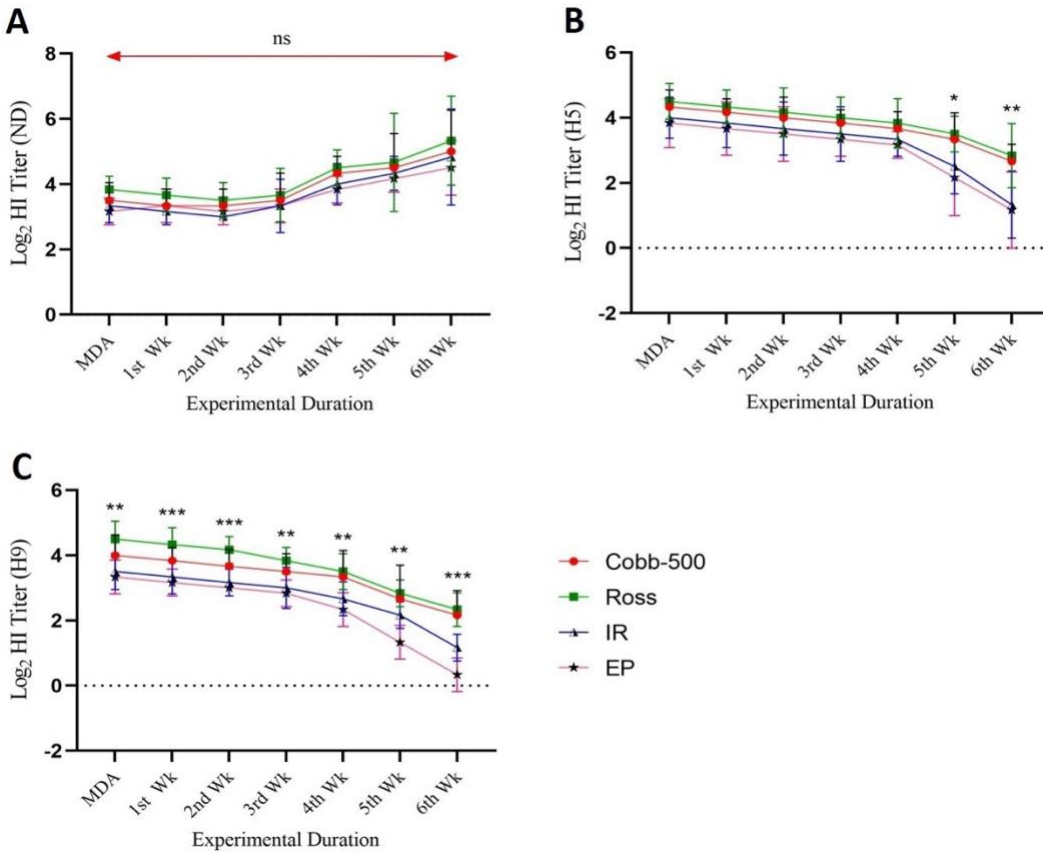


**Figure 2.** Comparative evaluation of immune (Humoral) response against NDV and avian influenza virus (AIV) among the different strains. A) Evaluation of immune titer against ND vaccine, B) Evaluation of immune titer against H5N1, C) Evaluation of immune titer against H9N2; (ANOVA, *$p$<0.05, **$p$<0.01, ***$p$<0.001; ns: non-significant)

### Immune response to infectious bursal disease among strains

The evaluation of humoral immune responses against IBD demonstrated distinct differences among various broiler strains (Table 4). Initially, the Ross strain exhibited significantly elevated MDA levels, followed by Cobb 500, EP, and IR, with statistical significance established ($p$<0.001). By the 21st day, Cobb 500 showed the highest antibody titers, measured at 8575.33, followed by Ross at 7992.50, IR at 7772.50, and EP at 6476.33, all of which were statistically significant. By the 42nd day, Cobb 500 maintained the highest immunity levels at 9930, surpassing Ross at 8794.17, IR at 7972.17, and EP at 7453.50, with all differences remaining statistically significant. Overall, while Ross initially demonstrated higher MDA levels, Cobb 500 ultimately achieved the highest titers by the end of the evaluation period, indicating a notable shift in the immune response dynamics among the strains.

**Table 4.** IBD antibody titer among the different broiler strains.

| | Cobb 500 | Ross | IR | EP | *p*-value |
|---|---|---|---|---|---|
| MDA | 6184.50$^{c}$±3.63 | 6801.67$^{b}$±2.39 | 7519.67$^{a}$±4.20 | 5680.83$^{d}$±2.76 | <0.001 |
| 21 days | 8575.33$^{a}$±2.54 | 7992.50$^{b}$±1.26 | 7772.50$^{c}$±1.26 | 6476.33$^{d}$±8.56 | <0.001 |
| 42 days | 9930.00$^{a}$±2.18 | 8794.17$^{b}$±17.03 | 7972.17$^{c}$±16.61 | 7453.50$^{d}$±4.04 | <0.001 |

One-way ANOVA with Duncan multiple range test (DMRT); $^{abc}$Superscripts indicate significant variation among the group. Significance level $p<0.05$.

## DISCUSSION

The findings of the current study confirmed that the Ross strain following Cobb-500 would be better to select for commercial production in Bangladesh under the local farming system. A similar type of work has been done, mainly focusing on growth performance and FCR in several studies [19-22]. The current findings align with those of Husna *et al.* [19], who similarly noted superior performance in growth and FCR parameters for both the Cobb-500 and Ross strains compared to four different strains. While previous research commonly identified the Cobb-500 as the top performer across various performance metrics in Bangladesh [12, 19, 22], the current study found the recent effectiveness of Ross in commercial broiler farming under an open-house management system. However, a study indicated that Hubbard Classic exhibited superior performance compared to Lohman, Ross, and Hubbard JV strain in Jordan at the 42-day trial, which contradicts the current findings [23]. These variations could have arisen from differences in geographical environments, trial durations, housing systems, management practices, biosecurity measures, and the immune status of the birds.

The researchers in previous studies primarily concentrated on growth performance and FCR, often omitting the inclusion of the Ross strain in their analyses, which could have influenced their conclusions. However, the current study takes a comprehensive approach by evaluating the best performer based not only on performance parameters but also on carcass characteristics and immunity against IBD, ND, and Avian Influenza (H5N1, H9N2) through ELISA and HI tests, respectively.

Husna *et al.* [19] found that during a 30-day trial period, the Cobb-500 strain recorded its highest weight gain of 1553.67 g, accompanied by a FCR of 1.39. Conversely, Hossain *et al.* [12] reported a weight gain of 1385.3 g for Cobb-500 with an FCR of 2.06 over 35 days. In contrast, the current investigation revealed that Cobb-500 attained a maximum weight gain of 2825.33 g, surpassing Ross 2725 g, after a 42-day experimental trial. The current results are consistent with previous reports [12, 19]. The prolonged trial duration in the current study contributed to higher weight gain. However, there was variability in FCR, with Cobb-500 exhibiting an FCR of 1.77 and Ross showing an FCR of 1.55.

Seasonal fluctuations, housing techniques, and variations in feed composition are recognized as influential factors affecting the performance of different broiler strains [12, 19, 21, 22]. The current study demonstrated that the highest weight gain was observed in Cobb-500 and Ross strains under an open housing management system, consistent with previous findings [12, 19]. Another study conducted in Pakistan found that Cobb-500 and Ross strains performed comparably under an open house management system, which fully aligns with the current study findings [24]. Conversely, an optimal performance for Cobb-500 in a closed housing system was with an FCR of 1.38, whereas under an open housing system in Indonesia, the FCR was 1.83 [21]. Ross strain performs better in different performance parameters like BEFI (%),

BPEF (%), and liveability (%). As the growth performance was high in Cobb-500, the ADG was also high, but the BFEI was 3.04 in Cobb-500 and 3.98 in Ross. The BPEF was relatively higher in Ross (175.81), whereas the lower EP (130.65). Recently, BPEF (%) has been a comprehensive indicator for assessing the performance of broilers [18]. The higher BPEF reflects a more efficient and productive broiler production system, while a lower BPEF suggests areas where improvements could be made to enhance efficiency [25]. The liveability was also higher in Ross (100%) than in others.

Carcass characteristics showed that the Cobb-500 had significantly higher carcass weight, dressing percentage, thigh and drumstick weight, and breast muscle weight compared to the Ross, EP, and IR strains. However, no significant differences were noted in the dressing percentage without edible organs. The higher body weight of Cobb-500 contributed to these enhanced carcass characteristics. Conversely, there were no significant variations observed in organ weight among the different strains. The current results align with the observations made by Sarker *et al*. [26], indicating a significant disparity in live weight while observing no noteworthy variations in organ weight and overall dressing percentage. The differences in overall growth performance among the broiler strains, despite the non-significant variation in ADG, could be attributed to variations in genetic potential, feed efficiency, and immune response. Factors such as differences in nutrient utilization, metabolic rate, and adaptability to local farming conditions may have influenced final body weight and carcass characteristics. Additionally, variations in immune resilience and stress tolerance among strains could have contributed to differences in overall productive performance.

MDA plays a crucial role in protecting day-old chicks from infectious diseases, including the ND, IBD, H5, and H9 viruses in poultry chickens. These antibodies are passively transferred from the hen to the chick through the egg yolk during embryonic development [27]. This transfer provides temporary immune protection to the chick during its early stages of life, typically lasting several weeks to a few months, depending on the specific antibodies and their levels [28]. This helps in preventing or reducing the severity of infections caused by these viruses during the critical early stages of the chick's life. However, as the chicks grow older, the levels of maternal antibodies gradually decline due to metabolic processes and dilution as the chicks' immune system starts to develop and produce their own antibodies.

Immunologically, no significant variations were observed among the different strains of broiler chickens. The humoral immune titers, primarily the MDA titers of ND in day-old chicks, indicated that Cobb-500 and Ross exhibited higher antibody titers, ranging from Log2 (3.67 to 3.83), compared to IR and EP. However, it is challenging to determine which strain performed better immunologically solely based on MDA observations. MDA levels are largely dependent on the immune titer status of the parent stock [29, 30]. If the titer is high during production, chicks from that batch inherit higher MDA levels from their parents. Gharaibeh *et al*. reported that approximately 30-40% of MDA is transferred from parent to chicks in cases of ND [29].

Following vaccination with a live vaccine, the titers gradually increased in the flock, reaching 5.33 for Ross and 5.00 for Cobb after 42 days, which was higher than IR and EP. Similar results for antibody levels against NDV were reported by Hossain *et al*. [31] in indigenous Naked Neck chickens raised under local farming conditions in Bangladesh. It was evident that Ross exhibited a superior immune response against ND compared to the others. Additionally, the maternal-derived antibody titers for high pathogenic avian influenza (H5N1) were slightly higher in Ross. Since the chicks were not vaccinated, the titers gradually decreased over time, with a stable trend observed for H5 and H9. MDA HI titers ranged from 3.83 to 4.50 for H5 and 3.33 to 4.50 for H9,

which is consistent with the findings of Gharaibeh *et al*. [29]. The antibody levels against IBD were higher in the IR strain compared to Ross and Cobb-500. The maternal antibody levels against IBD ranged from 5667 to 7532, which aligns closely with findings by Alam *et al*. [28]. By the end of the experimental trial, the antibody titers ranged from 7439 to 9943, as the birds were vaccinated against IBDV. Notably, Cobb-500 demonstrated a robust response with higher titers at the end of the trial. Therefore, determining which strain performs better immunologically under open-house management in Bangladesh proved challenging.

To gain a proper understanding of immunological performance, it is recommended to source chicks from non-vaccinated parent stock to eliminate maternal antibody transfer. Additionally, evaluating different strains' antibody responses during experimental infection can provide valuable insights. Despite addressing various aspects, the study had limitations. Notably, it did not conduct qualitative tests on meat, nor did it assess hematological and biochemical parameters, which could have provided further insights.

The study was conducted at a single farm location, which could affect the generalizability of the results to other regions or farm conditions. The seasonal variation was not considered, which may influence the overall findings. Future research should incorporate seasonal effects to provide a more comprehensive understanding of the results. The use of only four commercial broiler strains may limit the scope for broader comparison with other strains or genetic lines. Environmental factors such as temperature, humidity, and stocking density were controlled, but they may have varied outside the experimental parameters, influencing the results. Additionally, the study focused mainly on growth performance and immunity, with limited assessment of other health parameters or welfare aspects. Finally, while performance indicators were based on standard protocols, factors like variations in feed quality or small measurement errors could have impacted the precision of the results.

## CONCLUSIONS

The current evaluation of broiler strains Cobb-500, Ross 308, IR, and EP in Bangladesh revealed significant differences in production performance, carcass characteristics, and immune responses. The Ross strain demonstrated superior production metrics, including body weight gain and feed conversion ratio, while Cobb-500 excelled in carcass weight and dressing percentage. Both strains showed strong overall efficiency, with Ross leading in immune response to ND, evidenced by higher antibody titers. Although IR had higher maternal antibodies against Infectious Bursal Disease, Cobb-500 exhibited robust post-vaccination responses. This study underscores the need to consider environmental and management factors when selecting broiler strains. Ultimately, the Ross strain stands out as the optimal choice for production and economic viability in Bangladesh's poultry sector.

## ACKNOWLEDGEMENTS

The authors wish to express their gratitude to the Department of Dairy & Poultry Science, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh. Furthermore, our sincere appreciation goes to the Department of Medicine, Sylhet Agricultural University, Sylhet, Bangladesh, for their support and collaboration in the successful completion of this research.

## AUTHOR CONTRIBUTIONS

MR and HH – Conceptualization, Methodology, Data Curation, Software, Formal Analysis, Investigation, Writing – Original Draft, Writing – Review and Editing; MAIS, NA, MM, MJR, AAF, ZD, KAB and MSRC – Data Curation, Investigation, Laboratory work, Formal Analysis, Writing – Original Draft; Writing-reviewing and editing; $MMR^{12}$ and $MMR^{11}$ – Conceptualization, Methodology, Data Curation, Software, Validation, Visualization, Resources, Project Administration, Supervision, Writing – Original Draft, Writing – Review and Editing.

## CONFLICTS OF INTEREST

There is no conflict of interest among the authors.

## SUPPLEMENTARY MATERIALS

Supplementary Table 1. The body weight gain of different strains of broiler chicken up to 6 weeks; Supplementary Table 2. The average feed intake per bird per week; Supplementary Table 3. ND Titre among the different broiler strains; Supplementary Table 4. H5N1 Titre among the different broiler strains; and Supplementary Table 5. H9N2 Titre among the different broiler strains (Supplementary materials).

## REFERENCES


[1] Food and Agriculture Organization of the United Nations (2023). Meat Market Review: Emerging trends and outlook.

[2] Tanni FY, Chowdhury MSR, et al. Prevalence and antimicrobial resistance of extended spectrum beta-lactamase (ESBL) producing Klebsiella spp. in poultry meat. Heliyon. 2025;11: e41748.

[3] LightCastle Partners (2024). Bangladesh Poultry Sector: Efficiency & Growth Opportunities.

[4] Mordor Intelligence (2024). Middle East Poultry Meat Market: Opportunity Analysis & Industry.

[5] USDA Foreign Agricultural Service (2024). China: Poultry and Products Annual.

[6] Torrey S, Mohammadigheisar M, et al. In pursuit of a better broiler: growth, efficiency, and mortality of 16 strains of broiler chickens. Poult Sci. 2021 Mar 1;100:100955.

[7] Neeteson A-M, Avendaño S, et al. Evolutions in commercial meat poultry breeding. Animals. 2023;13:3150.

[8] Ali MS, Hossain MM. Factors influencing the performance of farmers in broiler production of Faridpur District in Bangladesh. World's Poult Sci J. 2010; 66:123-31.

[9] Kamruzzaman M, Islam S et al. Financial and factor demand analysis of broiler production in Bangladesh. Heliyon. 2021; 7: e07152.

[10] Chowdhury SD. Family poultry production in Bangladesh: is it meaningful or an aimless journey? World's Poult Sci J. 2013; 69:649-65.

[11] Broadbent LA, Wilson BJ, et al. The composition of the broiler chicken at 56 days of age: Output, components and chemical composition. Br Poult Sci. 1981;22:385-90.

[12] Hossain M, Suvo K, et al. Performance and economic suitability of three fast-growing broiler strains raised under farming condition in bangladesh. Int J Agri Res Innov Tech. 2011;1:37-43.

[13] Mehaffey JM, Pradhan SP, et al. Meat quality evaluation of minimally aged broiler breast fillets from five commercial genetic strains. Poult Sci. 2006;85:902-8.

[14] Cobb500 broiler performance & nutrition supplement. 2022.

[15] Ross broiler pocket guide. 2018.

[16] Parent stock guide and nutrient specifications. 2022.

[17] Indian river broiler pocket guide. 2018.

[18] Murugan M, Ragavan A. Broiler performance efficiency factor (BPEF) in commercial broiler production facilities with special reference to climate. Indian Vet J. 2017; 94:11-14.

[19] Husna A, Badruzzaman A, et al. Evaluation of productive performance of selected broiler strains under field condition at sylhet district of bangladesh. Ann Vet Anim Sci. 2017;4:104-10.

[20] Iqbal J, Mian AA, et al. Comparative performance of different economic traits of four imported broiler strains under local conditions of pakistan. Pakistan J Agric Res Vol. 2012; 25:76-82.

[21] Muharlien M, Sudjarwo E, et al. Comparative production performance of broiler under opened house and closed house system. J Ilmu-Ilmu Peternak. 2020;30:86-91.

[22] Rokonuzzaman M, Jahan SS, et al. Growth performance of three broiler strains in winter seasons in bangladesh. Int J Agric Polic Res. 2015;3:308-13.

[23] Abdullah AY, Al-Beitawi NA, et al. Growth performance, carcass and meat quality characteristics of different commercial crosses of broiler strains of chicken. J Poult Sci. 2010;47:13-21.

[24] Khalid N, Ali MM, et al. Comparative productive performance of two broiler strains in open housing system. Adv Life Sci. 2021;8:124-7.

[25] Kawathe SS, Gadegaonkar G, et al. Effect of dietary supplementation of creatine monohydrate powder on performance of broiler chicken. Indian J Anim Nutri. 2023;40:174-80.

[26] Sarker M, Islam M, et al. Profitability and meat yield traits of different fast growing broiler strains in winter. J Biol Sci. 2002; 2:361-363.

[27] Ali MZ, Hasan B. Follow up of maternally derived antibodies titer against economically important viral diseases of chicken. Polut Sci J. 2018; 6:149-154.

[28] Alam J, Rahman M, et al. Giasuddin, and msk sarker. Effect of maternally derived antibody on vaccination against infectious bursal disease (gumboro) with live vaccine in broiler. Int J Poult Sci. 2002;1:98-102.

[29] Gharaibeh S, Mahmoud K, et al. Field evaluation of maternal antibody transfer to a group of pathogens in meat-type chickens. Poult Sci. 2008;87:1550-5.

[30] Kowalczyk J, Śmiałek M, et al. Field evaluation of maternal antibody transfer from breeder turkey hens to egg yolks, egg whites, and poults. Poult Sci. 2019;98:3150-7.

[31] Hossain H, Nuradji H,et al. Impact of synbiotic on growth performance, histo-architectural modulation of lymphoid organ, hematology, blood biochemistry and humoral immune response in naked neck chicken. Trop Anim Health Prod. 2024; 57:39704773.