Research Article

Performance and Antibody-Mediated Response to Post-Hatch Feed and Water Deprivation of Chicken Broilers

Soshe Ahmed[1*], Mst. Ishrat Zerin Moni[1], Maksuda Begum[2], Md. Jafar Eqbal[3], Md. Shahidul Islam[4], Mst. Samira Tanjim[1], Mst. Rokeya Sultana[1]

[1]Department of Veterinary and Animal Sciences, University of Rajshahi, Rajshahi-6205, Bangladesh; [2]Department of Poultry Science, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh; [3]Palli Karma Sahayak Foundation (PKSF), Dhaka, Bangladesh; [4]Department of Livestock Services, Ministry of Fisheries and Livestock, Bangladesh.

Abstract | The study assessed the effect of post-hatch feed and water deprivation of broilers reared in a hot-humid environment. A total of three hundred forty-five one-day-old Ross-308 broiler chicks were randomly allotted into five treatment groups as T1, T2, T3, T4 & T5 (6 hrs, 12 hrs, 24 hrs, 48 hrs, and 60 hrs of post-hatch feed and water deprivation). Birds were allowed a two-phase feeding system, such as starter and finisher, where appropriate. Performance parameters include feed intake (g/birds), body weight gain, average daily gain, feed conversion ratio, and viability% for growth periods (1 d to 7 d, 1 d to 14 d, 1 d to 21 d, 1 d to 28 d) were calculated. All chicks were vaccinated with live attenuated Newcastle Disease Virus LaSota strain on day 2 via eye drop vaccination, along with other basic immunization schemes. After 14 days of ND vaccination, post-vaccination sera samples were collected and subjected to an HI test to determine antibody titers. The Haemagglutination inhibition test was done using Newcastle Disease Virus LaSota strain NLT 106.0 EID50 antigen. Post-hatch feed and water deprivation durations significantly affect the production parameters. Feed intake, body weight gain and average daily gain were significantly ($p<0.01$) lower in the T5 group. Significantly ($p<0.01$), a poor feed conversion ratio was observed in the T5 group. The lowest (91.66%) survivability ($p<0.01$) was found in the T5 group compared to other groups. There was a significant ($p<0.01$) difference in European Broiler Index for growth periods. Post-hatch feed and water deprivations did not influence ($p>0.05$) the antibody titer level against the Newcastle disease virus. Increasing post-hatch feed and water deprivation leads to lower feed intake, body weight gains, poor feed conversions, and lesser livability of broilers. Therefore, early access to feed and water after hatching is recommended to achieve better production performance of broilers.

Keywords | Feed and water deprivation; Broiler, Production, Performance; Immune response

Received | December 03, 2022; **Accepted** | December 20, 2022; **Published** | January 10, 2023
***Correspondence** | Soshe Ahmed, Department of Veterinary and Animal Sciences, University of Rajshahi, Rajshahi-6205, Bangladesh; **Email:** soshe.ahmed@gmail.com
Citation | Ahmed S, Moni MIZ, Begum M, Eqbal MJ, Islam MS, Tanjim MS, Sultana MR (2023). Performance and antibody-mediated response to post-hatch feed and water deprivation of chicken broilers. Adv. Anim. Vet. Sci. 11(2): 196-202.
DOI | http://dx.doi.org/10.17582/journal.aavs/2023/11.2.196.202
ISSN (Online) | 2307-8316

INTRODUCTION

The brooding phase is the crucial stage of a fast-growing broiler chicken. Early growth is focused on developing the digestive system, heat-regulating mechanism, and rapidly growing muscles and bones. Newly hatched chicks undergo hatchery treatments, such as grading of chicks, vaccination, sex determination, and sorting. After that, the chickens are transported to the farm, which involves a further feed and water withdrawal period. The time between hatching and post-hatch food and water intake at the farm depends on earlier factors (Van de Ven et al., 2009; Willemsen et al., 2010; Lourens and Leenstra, 2013). The first feed and water intake of broilers may take up to 50 hours or more; even up to 72 hours may require long transportation (Van de Ven et al., 2009; Willemsen et al., 2010). A delay in post-hatch feed and water intake may lead to depletion of a reserved portion of yolk, dehydration, distress growth, and mortality of birds (Dibner et al., 1998). Commercial broiler chicks are often subjected to numerous stressors after hatching in the first 72 hours. Stressors during the critical early hours following hatch can be detrimental, influencing the final performance of birds. These early stressors can lead to declines in final body weights, poor feed conversions, and cost per unit of meat production. Chicks can survive withheld water and feed for 72 hours, receiving total nutrients from their yolk sac residue (Lourens and Leenstra, 2013). However, this does not suggest a post-hatch feed, and water intake should purposely be restricted. The performance of birds is negatively affected by increasing the duration of feed and water intake compared to shorter deprivation (Vieira and Morgan, 1998; Careghi, 2005). Post-hatch feed and water deprivation of chicks have long-term negative consequences for the welfare and performance of chickens (Wakker_Dier, 2013). Broiler chickens' post-hatch feed and water deprivation could lead to poor livability, feed conversion, and depressed body weight gain (Juul-Madsen et al., 2004).

The proper growth and development of the immune system in the early stage of birds is crucial, as the chick initially relies entirely on maternal antibodies. The early brooding period of chicks is also essential for appropriate development and protection from conquering organisms (Davison, 2014). Post-hatch feeding may initiate beneficial microbial colonization and therefore occurs in immune maturation of the gut (Friedman, 2003). Rearing of broilers in sub-optimal conditions may impair their production performance, cause deviation in physiological responses, cause immune suppression, and increase their susceptibility to diseases (Afolayan and Afolayan, 2008). Immune stress occurs due to the loss of immune homeostasis induced by external forces (Yang et al., 2011). Many studies suggest that immediate post-hatch feeding compared to 72h post-hatch feed deprivation of chicks resulted in bursa development, consequently enhancing humoral immunity (Dibner et al., 1998; Bar-Shira et al., 2005; Ao et al., 2012). Antibody titers and antibody response are widely used to assess poultry's immune status or competence against a foreign antigen (Gross and Siegel, 1980). However, it is not clearly documented whether or not post-hatch feed and water deprivation of broilers reared in a traditional hot-humid condition adversely affect performance. The research work aimed to investigate the effect of post-hatch feed and water deprivation on the performance and immune response of broilers reared in a conventional commercial setting.

MATERIALS AND METHODS

Birds, treatment, and management

The experiment was conducted in the Animal Experimental Station, Department of Veterinary and Animal Science, University of Rajshahi, Bangladesh, from Mid-March to Mid-April in a hot-humid climate (Average temperature 31.3^0 and average RH 61%). Three hundred forty-five (345) one-day-old Ross-308 broiler chicks with an average initial weight of 44.49 g ± 3.23 were randomly allotted into five treatment groups such as T1, T2, T3, T4 & T5 (6 hrs, 12 hrs, 24 hrs, 48 hrs, and 60 hrs of post-hatch feed and water deprivation) with three replications having 23 chicks in each. One-day-old baby chicks were placed in their respective pens and intentionally deprived of feed and water according to treatments of the experimental design. Birds were allowed ad libitum access to feed and water after the feed and water deprivation period considering the experimental design under a two-phase feeding system where appropriate, such as starter pellet (0–10 days) with 23.0% crude protein (CP); 12.55 MJ/kg and grower pellet (11–24 days) containing 21.5.0% CP; 12.97 MJ/kg. Nutrient calculations for feed formulations confirmed the Aviagen Ross Broiler recommendation (ROSS 2019). Birds were managed in a deep litter system in a conventional open-sided broiler house similar to commercial settings.

Production parameter measurements

Performance traits such as feed intake (g/birds), body weight gain (BWG), together an average daily gain (ADG), feed conversion ratio (FCR), and viability% for each growth period (1 d to 7 d, 1 d to 14 d, 1 d to 21 d, 1 d to 28 d) were estimated. For the analysis of broiler performance indicators, the following formulas were used:
Feed intake (g/bird) = Amount of feed (g) provided at the beginning of a growth period – leftover feed (g) at the end of that growth period
BWG (grams on a period) = BW (g) at the end of a period – BW (g) on the first day;
ADG (g/chick/d) = BWG/number of days of a growth period;
FCR (kg feed/kg gain) = cumulative feed intake (kg)/total weight gain (kg)
Viability (%) = Number of birds remaining at the end of the period (%)
European Broiler Index (EBI) (Van et al., 2003)

All chicks were vaccinated with live attenuated Newcastle Disease (ND) Virus LaSota strain on day 2 via eye drop vaccination; basic immunization schemes for other vaccines were performed following the standard vaccination schedule for broiler chickens. HI test is commonly used to test titer levels following ND vaccination in poultry flocks since it is fast and cost-effective (Grimes, 2002; Swayne,

Table 1: Response of post-hatch feed and water deprivation on production parameters of broiler

Parameter	Growth Period (days)	Experimental group					*p*-value	LSD
		T1	T2	T3	T4	T5		
Feed Intake (g/bird)	1-7	236.67^{a}±8.82	235.00^{a}±11.55	216.67^{a}±15.89	207.33^{ab}±6.74	179.67^{b}±10.98	0.028	4.32
	1-14	601.33^{a}±10.17	568.33 ^{ab} ±16.91	617.67 ^{a} ±4.33	569.33 ^{ab}±14.85	528.67^{b}±17.70	0.009	6.25
	1-21	1304.33^{a}± 24.74	1278.33^{a}±18.78	1264.67^{a}±17.79	1206.33^{ab} ±14.84	1174.00^{b} ±23.75	0.006	7.02
	1-28	2335±34.44	2307.00±45.92	2363.00±44.52	2291.00±10.69	2280.00±23.79	0.471	0.95
Bodyweight gain (g)	1-7	188.28^{a}±3.80	185.54^{a}±0.58	167.49^{b}±9.45	156.48^{b}±2.31	133.93^{c}±5.50	0.001	17.84
	1-14	467.80^{a}±3.94	471.17^{a}±3.52	453.67^{a}±9.64	418.73^{b}±9.11	396.17^{c}±7.17	0.001	20.99
	1-21	950.47^{a}±14.01	935.22^{a}±6.50	929.10^{a}±13.38	852.83^{b}±10.59	836.27^{b}±18.91	0.001	15.37
	1-28	1572.66^{a}± 43.89	1535.67^{b}±23.35	1528.0^{b}±30.55	1441.00^{c}±16.86	1409.33^{c}± 21.67	0.012	5.71
Average daily gain (g/chick/d)	1-7	26.89^{a} ± 0.54	26.50^{a} ±0.08	23.92^{b} ±1.35	22.35^{b} ±0.33	19.14^{c} ±0.79	0.001	17.80
	1-14	33.40^{a}±0.28	33.65^{a} ±0.25	32.40^{a} ±0.68	29.90^{b}±0.65	28.29^{c} ±0.51	0.001	20.93
	1-21	45.26^{a}±0.66	44.53^{a} ±0.31	44.24^{a} ± 0.63	40.61^{b}±0.50	39.82^{b} ± 0.89	0.001	15.36
	1-28	56.16^{a}±1.56	54.84^{b}± 0.83	54.57^{b} ±1.09	51.46^{c}±0.60	50.33^{c} ± 0.77	0.012	5.71
Feed Conversion Ratio (FCR) (kg feed/kg gain)	1-7	1.25±0.02	1.26±0.06	1.28±0.02	1.32±0.02	1.33 ± 0.05	0.472	0.95
	1-14	1.28^{a} ±0.02	1.20^{b}±0.03	1.35^{a}±0.02	1.35^{a}±0.008	1.33^{a} ± 0.02	0.006	0.85
	1-21	1.37±0.005	1.36±0.02	1.34±0.01	1.39±0.021	1.40 ±0.01	0.236	0.67
	1-28	1.48^{c}±0.02	1.50^{c}±0.00	1.54^{b}±0.005	1.59^{b}±0.01	1.61^{a} ± 0.01	0.001	0.45
Survival of birds (%)	1-7	100.00^{a}±0.00	100.00^{a}±0.00	100.00^{a}±0.00	100.00^{a}±0.00	96.66^{b}±1.66	0.034	4.00
	1-14	100.00^{a}±0.00	100.00^{a}±0.00	100.00^{a}±0.00	100.00^{a}±0.00	96.66^{b}±1.66	0.034	4.00
	1-21	98.33±1.66	100.00±0.00	96.66±1.66	95.00±0.00	95.00±2.88	0.226	1.70
	1-28	95.00^{a}±0.00	95.00^{a}±0.00	95.00^{a}±0.00	95.00^{a}±0.00	91.66^{b}±1.66	0.034	4.00
European Broiler Index (EBI)	1-7	215.14^{b}±0.83	211.48^{b}±11.34	185.73^{a}±7.50	169.36^{a}±1.95	138.59^{c}±2.56	0.001	25.50
	1-14	261.28 ^{b}±7.28	280.69^{b} ±5.89	239.25 ^{a}±10.11	220.39 ^{ac}±3.44	205.58 ^{c} ±0.48	0.001	22.67
	1-21	324.83 ^{a} ±7.30	326.96 ^{a} ±8.58	318.61^{a}±11.38	277.09 ^{b} ±7.62	270.92 ^{b} ±11.51	0.003	8.36
	1-28	360.92 ^{a}±15.14	348.05 ^{a} ±3.28	336.63 ^{a} ±7.11	304.62 ^{b} ±9.31	285.84 ^{b} ±3.29	0.001	12.49

^{a,b,c} Means with different lowercase superscript letters in a row indicate significant differences among treatment groups. T1: 6-hrs of post-hatch feed and water deprivation; T2: 12-hrs of post-hatch feed and water deprivation; T3: 24-hrs of post-hatch feed and water deprivation; T4: 48-hrs of post-hatch feed and water deprivation; T5: 60-hrs of post-hatch feed and water deprivation

Table 2: Antibody titer against NDV

Variable	Experimental group					*p*-value	LSD
	T1	**T2**	**T3**	**T4**	**T5**		
Initial (Day2) (Mean; Log2)	3.33^{a}±0.19	3.33^{a}±0.19	3.44^{a}±0.22	3.44^{a}±0.11	3.44^{a}±0.11	0.97	0.125
Post Vaccination (Day16) (Mean; Log2)	4.66^{a}±0.19	4.44^{a}±0.11	4.66^{a}±0.19	4.66^{a}±0.19	4.44^{a}±0.11	0.705	0.458

^{a} Means with a similar lowercase superscript letter in a row indicate non-significant differences among treatment groups. T1: 6-hrs of post-hatch feed and water deprivation; T2: 12-hrs of post-hatch feed and water deprivation; T3: 24-hrs of post-hatch feed and water deprivation; T4: 48-hrs of post-hatch feed and water deprivation; T5: 60-hrs of post-hatch feed and water deprivation

2013). Forty-five (45) serum samples were collected randomly from 45 birds, nine from each treatment just before vaccination, to determine the level of maternal antibodies against Newcastle disease (ND). Post-vaccination sera samples were collected after 14 days of ND vaccination on day 16 and subjected to an HI test to determine antibody titers. The samples were taken via the Vena ulnaris and collected in 3 ml microcentrifuge tubes (Carl Roth GmbH). The blood serum was then separated from the blood clot and stored. The serum was centrifuged (5,000 x g) for 10 min at 4o C and held at -20°C until further use. The Haemagglutination inhibition (HI) test was done according to OIE (2013) test protocol using Newcastle Disease (ND) Virus LaSota strain NLT 106.0 EID50 antigen. Two-fold serial dilutions of the collected test samples were mixed with an equal volume of NDV LaSota antigen. Chicken red blood cell (CRBC) suspension was added and settled down. Furthermore, the dilutions were subsequently used for complete inhibition of the hemagglutination.

Statistical analysis

The experimental data were analyzed with one-way ANOVA using SPSS 22.0 (IBM, Chicago, IL, USA). Tukey's post hoc comparison test verified the statistical differences between group means. Broiler performance parameters were based on replication per the experimental unit, while antibody titers against NDV were analyzed on individual data from broilers. Study results were expressed as mean ± pooled SEM. A level of 95% ($P<0.05$) and 99% ($p<0.01$) were considered to analyze the data set.

Ethical issue

The study adhered to the Bangladesh law (Animal Welfare Act, 2019) on the production of domestic and farm animals, which relates to the protection of animals. In brief, the activities of the study were not detrimental to the birds relative to the abovementioned law. Furthermore, no cruelty or unjust treatment was shown to the birds; hence, ethical approval was not required.

RESULTS

Effects on production parameters

The data referring to the performance parameters of broilers among the different post-hatch feed and water deprivation groups is presented in Table 1. The feed intake of birds significantly differed among the experimental groups up to 21 days of growth periods. The lowest feed intake was observed in the T5 group. However, a non-significant ($p=0.471$) difference was found for broilers' 1-28 days growth period. The changes in body weight gain of birds showed significant differences among the treatment groups. The highest gain was observed in the T1 group, and the lowest gain was found in the T5 group. Likewise, bodyweight gains and the average daily weight gains significantly ($p<0.01$) differed among the treatment groups. The highest daily gain was observed in the T1 (6-hrs of post-hatch feed and water deprivation), and the lowest was found in the T5 (60-hrs of post-hatch feed and water deprivation) group. There was a significant difference in FCR among the treatment groups. However, the best FCR was observed in the T1, followed by T2, T3, T4, and T5 for the 1-28 growth period. The result indicates the significantly ($p<0.05$) lowest survivability in the T5 (60-hrs of post-hatch feed and water deprivation) group for most of the growth periods compared to other groups. Data for BWG, ADG, FCR, and viability were used to calculate the economic efficiency of broilers through the calculation of EBI. The differences in post-hatch feed and water deprivation significantly ($p<0.01$) affected the EBI for all growth periods of boilers. However, the highest EBI was calculated for T1, followed by T2, T3, T4, and T5.

Response of post-hatch feed and water deprivation on antibody titer level against NDV

The mean antibody titer against NDV is summarized in Table 2. The study also tended to estimate the effect of immune response broiler due to different post-hatch feed and water deprivations. The treatment groups showed no significant difference in antibody titer levels against NDV assessed through the HI test. However, antibody tier levels were higher in the T1 group than in the T5 group.

DISCUSSION

Determination of broilers' post-hatch feed and water deprivation effect at various points in time is essential. A good start with proper management will lead to early development and maximize the overall performance of broilers at slaughter age. The present study examined the effect of post-hatch feed and water deprivation of birds on the subsequent performance of broilers, including the production and immune performance of broilers reared in a hot-humid environment. Increasing the duration of post-hatch feed and water deprivation resulted in significantly lower feed intake, body weight gains, and FCR than early-fed chickens grown up to 28 days of age. Similar findings were reported by others who noted that delayed placement or pre-placement holding time of chicks negatively affects the subsequent post-hatch performance of broilers (Fanguy et al., 1980; Stamps and Andrews, 1995). The result showed that body weight and feed intake are negatively associated with post-hatch feed and water deprivation durations. These reductions persisted for all growth periods, which was supported by earlier studies (Fanguy et al., 1980; Stamps and Andrews, 1995). The time elapsed from hatching until feed and water availability for chicks had a noticeable body weight depression (Juul-Madsen et al., 2004; Careghi et al., 2005). In their investigation, Vieira and Moran (1999) showed that chicks subjected to delayed post-hatch access to feed had lower weight gain than those fed early after hatching. They concluded that post-hatch feed and water deprivations might be associated with a consequent decrease in overall food consumption by the birds. Earlier studies reported that an increased holding period of access to feed and water after hatching causes weight loss in chickens, mainly due to dehydration and pectoral muscle utilization (Vieira and Morgan, 1998; Careghi, 2005). Boersma et al. (2003) summarized that chicks subjected to delayed post-hatch feed and water access could be stressful due to possible dehydration and energy depletion. The result indicated that post-hatch feed and water deprivation significantly affected the survivability of birds on days 1-28. Also, the higher mortality of chicks within the first two weeks of age was found in 60-hrs of post-hatch feed and water-deprivation birds. Similar results were reported in earlier studies, which found that chicks had longer pre-placement holding time led to increased mortality (Fanguy et al., 1980; Stamps and Andrews, 1995; Vieira and Moran, 1999). Early gut development and proper functioning are essential in confirming broiler chickens' overall health and performance. Many studies reported that delayed post-hatch feeding of birds had been shown to negatively affect the development and proper function of the gastrointestinal tract of chicks (Dibner et al., 1998; Yang et al., 2009; Lilburn and Loeffler, 2015). Yegani and Korver (2008) also reported that a delay in the intestinal development of birds could have enduring adverse effects on performance as it can affect the digestion and absorption of nutrients. Hence, immediate post-hatch access to feed and water chicks are essential to maximizing broilers' gastrointestinal development and performance. Earlier, several studies addressed the effects of birds' post-hatch feed and water deprivation on the immune system development and the response to vaccine and disease challenges (Dibner et al., 1998; Juul-Madsen et al., 2004; Bar-Shira et al., 2005; Nnadi et al., 2010; Ao et al., 2012; Hayashi et al., 2013; Price et al., 2015; Simon et al., 2015). The current investigation indicated that post-hatch feed and water deprivation did not significantly affect the antibody titer level against NDV. However, a higher level was found in early-fed birds (6-hrs of feed and water deprivation group) than in 60-hrs of feed and water deprivation birds. Nnadi et al. (2010) indicated a higher antibody response to Newcastle disease vaccination at 21 and 42 days of age in immediately post-hatch-fed chickens compared to 72h post-hatch feed and water-deprived chickens. Dibner et al. (1998) reported that early feeding was positively associated with coccidiosis vaccine challenge at 14 days of age compared to 72h post-hatch feed and water deprivation. Juul-Madsen et al. (2004) observed a lower level and a delayed tendency of specific antibody production in broilers against the IBDV vaccine subjected to 48-hrs of post-hatch feed deprivation compared to immediately fed chicks after hatching or 24-hrs of feed deprivation. From many infectious disease challenges, post-hatch feed deprivation is reported to negatively affect the immune response (Juul-Madsen et al., 2004; Ao et al., 2012; Simon et al., 2015). The rapid development of the gut-associated lymphoid tissue (GALT) occurs after hatching. Studies on GALT development suggested that chickens might be more susceptible to environmental pathogens with delayed access to feed than immediately post-hatch-fed chickens (Dibner et al., 1998; Bar-Shira et al., 2005). Many studies reported that early feeding after hatching is crucial for developing the immune system and protecting chicks from invading pathogens (Davison et al., 2008). Early post-hatch feeding seems to initiate microbial colonization and cause the gut's immune maturation (Friedman et al., 2003). Dawkins (1990) stated that animal demand for feed and water is rigid, and any restriction could be stressful. It is agreed that post-hatch feed and water deprivation harm immune system development and the response to challenges. These may include delayed development of cellular immunity (Hayashi et al., 2013), smaller bursal weight Simon et al. (2014), and decreased weight of both primary and secondary lymphoid organs (Heckert et al., 2002). The abnormal circulating leukocyte changes include reduced lymphocyte numbers, increased heterophil numbers, and a high H:L ratio resulting in high glucocorticoid levels (Gross and Siegel, 1983; Patterson and Siegel, 1998). The discussion above shows that the delay in post-hatch feed and water provision negatively affects the broilers' performance.

CONCLUSION

Post-hatch feed and water deprivation significantly influenced production measures and the survivability of broilers. Post-hatch holding of feed and water leads to lower body weight gains, lower feed intake, poor feed conversions, and poor livability of broilers. As expected, antibody titer worsened as feed and water deprivation prolonged. Therefore, we suggest immediate access to feed and water for birds after hatching to maximize subsequent broiler performance.

CONFLICT OF INTEREST

Authors declare no conflict of interest

NOVELTY STATEMENT

Various studies have shown that delayed post-hatch feed and water deprivation negatively affects the chickens' immunity. However, the published documents still need to include data on the effects on production parameters. Moreover, the environmental rearing conditions could be more precise in the earlier publications. The present study provides quantitative data relating to the impact of post-hatch feed and water deprivation of broilers reared in the hot-humid environmental condition. As such, it may guide poultry practitioners, farmers, and breeder companies to run poultry operations conveniently to reduce the adverse effects of delayed post-hatch feed and water provision.

AUTHORS' CONTRIBUTIONS

SA conceptualized and designed the research. All authors equally contributed to data analysis, drafting, and approving the final manuscript.

FUNDING ACKNOWLEDGEMENT STATEMENT

Supported by the University of Rajshahi, Rajshahi, Bangladesh, Project No. A-64-5/52/RU/Agriculture/2018-19

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