International Journal of Bio-resource and Stress Management https://ojs.pphouse.org/index.php/IJBSM

Crossref

IJBSM July 2025, 16(7): 01-08 **Article** AR6082

Research Article *Natural Resource Management*

DOI: HTTPS://DOI.ORG/10.23910/1.2025.6082

Effect of Early Post-hatch Feeding on Nutrient Digestibility, Carcass Characteristics, Gut Morphology and Livability of Commercial Broiler Chicken

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Open Access

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0009-0002-4844-0761

ABSTRACT

The experiment was conducted from February to March, 2024 at the Poultry Research Station, VASREU, Kamdhenu University, Anand, India to study the effect of early post-hatch feeding on commercial broiler chicken performance. A total of 144 days-old broiler chicks were assigned to four groups based on body weight, with 36 chicks in each group. The control group received water and pre-starter feed immediately upon arrival, while T_1, T_2 and T_3 groups received feed and water 12, 24, and 0 hours post-arrival, respectively. A metabolic trial was conducted at 6 weeks of age. Gut morphology was assessed on days 7, 21, and 42, and carcass characteristics were evaluated on day 42. Nitrogen balance was significantly higher in the OF, D12, and C groups than in D24 (p<0.05), with early feeding improving nitrogen retention. Nutrient retention of calcium, phosphorus, dry matter, crude fat, and crude fiber showed no significant differences across treatments. Dressing percentage was similar for all treatments, but abdominal fat was highest in D24 and lowest in C, with intermediate levels in D12 and OF. Delayed feeding reduced villi height, width, and crypt depth in the duodenum but did not affect the villi-to-crypt depth ratio. In the jejunum, delayed feeding decreased villi width and crypt depth, but increased the villi-to-crypt depth ratio. Liveability remained unaffected by the feeding and watering schedule.

KEYWORDS: Early feeding, nutrient digestibility, carcass characteristics, gut morphology

***Citation* (VANCOUVER):** Desai et al., Effect of Early Post-hatch Feeding on Nutrient Digestibility, Carcass Characteristics, Gut Morphology and Livability of Commercial Broiler Chicken. *International Journal of Bio-resource and Stress Management,* 2025; 16(7), 01-08. HTTPS://DOI.ORG/10.23910/1.2025.6082.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 12th January 2025 RECEIVED in revised form on 25th June 2025 ACCEPTED in final form on 09th July 2025 PUBLISHED on 17th July 2025

1. INTRODUCTION

The early post-hatch period plays a crucial role in poultry production, as it is a critical phase for chick development (Prabakar et al., 2016). A major challenge in modern broiler production is the delayed provision of feed and water to hatchlings, caused by hatchery protocols and transportation logistics, which can extend up to 48–72 hours post-hatch (Dieryck et al., 2022). However, the industrialization of the hatching process, aimed at reducing costs and increasing scale, leads to several negative outcomes (Madej et al., 2024). This is mainly due to the practice of withholding water and feed from newly hatched chicks for extended periods while they remain in the hatching chambers. Factors such as strain, parental age, egg size, storage duration, and eggshell temperature (both before and during incubation) primarily influence the incubation time (Avsar et al., 2022). In commercial hatcheries, chicks hatch over a 24 to 48-hour window, often referred to as the "hatching window" (Willemsen et al., 2010). This results in some chicks being delayed as they wait for others to hatch. If chicks are collected too early, the percentage of second-quality chicks with unhealed navels increases. On the other hand, delaying chick collection often results in a higher percentage of dehydrated chicks. After hatching, chicks undergo hatchery procedures before being transported to broiler farms, which can lead to delays of up to 72 hours before they are given their first feed and water (Willemsen et al., 2010). This prolonged fasting period can severely affect growth patterns and may jeopardize bird health and performance. A delay of 36 to 48 hours in feed access has been linked to higher mortality rates, stunted growth, and an unfavorable feed-to-gain ratio (Juul-Madsen et al., 2004, Careghi et al., 2005; Shira et al., 2005; de Jong et al., 2017). Additionally, it adversely impacts gastrointestinal development by delaying the structural and functional maturation of the intestine, reducing nutrient absorption, and impairing gut health by disrupting gut barrier function and immune system development (Panda et al., 2015; Liu et al., 2020; Proszkowiec-Weglarz et al., 2020).

During the early post-hatch phase, the yolk sac provides essential energy and proteins for growth and survival. Chicks with immediate feed access deplete the yolk sac faster than those deprived of food for 48 hours, limiting growth, weight gain, and increasing pathogen susceptibility (Henderson et al., 2008; Noy and Sklan, 1999).

Newly hatched chicks face the challenge of transitioning quickly from relying on the yolk to utilizing external nutrients (Sklan, 2001). At the time of hatching, their digestive organs are not fully developed. Therefore, providing early nutrients supports the development of their digestive system, promoting intestinal growth and improving nutrient intake (Wang et al., 2020, Noy and Sklan 2001). Early feeding is critical for setting the foundation for optimal growth in broiler chicks (Proszkowiec-Weglarz et al., 2019; Wang et al., 2020). Offering nutrients shortly after hatching enhances intestinal activity, accelerates intestinal development, and improves feed absorption, thereby boosting immunity and promoting overall growth. However, in today's intensive farming systems, the growth potential of chicks is compromised when feed is not provided immediately after hatching. Delayed feeding can result in underdeveloped intestines, which further exacerbates nutrient absorption inefficiencies.

Early post-hatch nutrition involves providing chicks with easily digestible proteins, carbohydrates, and fats during the first few hours of life. The experiment aimed to assess how different feeding schedules post-hatch affect the growth performance, intestinal health, and overall livability of broiler chicks.

2. MATERIALS AND METHODS

The experiment was conducted from February to March, 2024 at the Poultry Research Station, VASREU, Kamdhenu University, Anand. The experiment was conducted with prior approval from the Institutional Animal Ethics Committee (Approval No. 416/AN/23). A total of 144 broiler chickens were used, divided into four treatment groups, each comprising four replicates with nine chicks replicate^{-1}.

2.1. Treatment groups

The experimental phase to evaluate performance was carried out at the Poultry Research Station, Veterinary Animal Science Research and Extension Unit, Kamdhenu University, Anand. A total of 144 day-old broiler chicks were utilized for the study, of which 108 chicks were procured from "Akashganga Hatcheries Pvt. Ltd." in Anand, Gujarat, while the remaining 36 chicks were hatched on-farm. For on-farm hatching, 50 fertilized eggs from the same parent stock were collected on the 19th day of incubation. These eggs were incubated under controlled artificial conditions simulating commercial hatchery settings for temperature and humidity (T_3 experimental group: early nutrition, on-farm hatched). From the 18th day of incubation, incubation conditions were maintained at an air temperature of 37.5°C, floor temperature of 34°C and relative humidity of 60–65%, following protocols described by Lourens et al. (2006) and Molenaar et al. (2010). Hatching occurred between the evening of the 19th day and the morning of the 20th day, allowing the chicks immediate access to feed and water within 27–36 hours of hatching, provided directly in the egg trays. Post-hatch, the 36 chicks were transferred to a designated pen within the broiler house for the T_3 group,

where feed and water were readily accessible. On day 21, chicks from the commercial hatchery were wing-banded, individually weighed and randomly assigned to treatment groups. These procedures were completed within two hours.

A uniform experimental feed was formulated for all groups following Anonymous (2007) standards for broiler nutrition. The diet comprised pre-starter (0–7 days), starter (8–21 days) and finisher (22–42 days) rations, provided according to daily nutritional requirements. In the control group, chicks received water and pre-starter feed immediately upon arrival at the experimental station. In contrast, chicks in T_1 received feed and water 12 hours after arrival, while those in T_2 were provided access 24 hours post-arrival. In the T_3 group, feed and water were administered immediately after hatching on the farm.

Initial body weights of the day-old chicks in the control, T_1 and T_2 groups did not differ significantly (p<0.05), whereas the T_3 group exhibited significantly (p<0.05) higher initial weights (Table 1). This difference was attributed to the early provision of feed and water, which mitigated dehydration and energy depletion (Table 2). All groups were reared in a deep litter housing system, with each replicate housed in a separate pen containing nine birds. Vaccination protocols included administration of Ranikhet Disease vaccine (B1 strain) on day 7, Infectious Bursal Disease vaccine on day 14 and a booster for Ranikhet Disease on day 21.

The phase-specific feed formulations for the experimental groups are presented in Table 3. These formulations were meticulously designed to meet the calculated crude protein (CP) and metabolizable energy (ME) requirements, adhering to the Anonymous (2007) standards for broilers.

The broiler house, along with all equipment utilized

Table 1: Mean body weight (g) of day-old experimental broiler chicks under feeding experiment

Replicate	Control	T_1	T_2	T_3
R_1	45.39	43.77	44.46	52.71
R_2	46.95	44.11	45.33	53.64
R_3	45.73	45.52	44.28	55.32
R_4	45.73	45.16	46.16	56.14
Average	45.95^{b}± 0.34	44.64^{b}± 0.42	45.06^{b}± 0.43	54.45^{a}± 0.78

Table 2: Average body weight (g) and feed offered (g) to a day-old experimental broiler chick in T_3 (on farm hatching) from day 19th to 21st

Replicate	Control	T_1	T_2	T_3	Avg.
Day 19/20 weight	48.32	50.12	49.81	51.20	49.86
Day 21 weight	52.71	53.64	55.32	56.14	54.45
Weight gain	4.38	3.53	5.53	4.94	4.60
Feed offer	270.00	270.00	270.00	270.00	270.00
Feed left over	213.75	229.65	224.56	230.65	224.65
Feed consumption	56.25	40.35	45.44	39.35	45.35
F.C bird^{-1}	6.25	4.48	5.05	4.37	5.04

Table 3: Proportion of feed ingredients (%) used in pre-starter, starter and finisher diets

Sl. No.	Ingredients	Name of mash		
		Pre-starter	Starter	Finisher
		Qunt. (kg)	Qunt. (kg)	Qunt. (kg)
1.	Maize	56.00	57.00	60.00
2.	Soyabean DOC	37.60	35.50	30.00
3.	Deoiled rice bran	1.50	1.19	2.19
4.	Calcite powder	1.37	1.36	1.36
5.	DCP	0.96	1.00	1.00
6.	Vitamins	0.05	0.05	0.05
7.	Vitamin-B12	0.01	0.01	0.01
8.	Trace minerals	0.10	0.10	0.10
9.	Choline chloride-60%	0.10	0.10	0.10
10.	Lysine	0.05	0.05	0.05
11.	Methionine	0.15	0.13	0.13
12.	Phytase-5000	0.01	0.01	0.01
13.	Enzymes	0.05	0.05	0.05
14.	Salt	0.25	0.25	0.25
15.	Sodium bicarbonate	0.10	0.10	0.10
16.	Livertonic	0.10	0.10	0.10
17.	Immunomodulator	0.05	0.05	0.05
18.	Toxin binder	0.10	0.10	0.10
19.	Emulsifier	0.05	0.05	0.05
20.	Probiotic	0.05	0.05	0.05
21.	Anticoccidial	0.05	0.05	0.05
22.	Oil	1.30	2.70	4.20
	Total	100.00	100.00	100.00
	Calculated crude protein	23.50	22.45	20.28
	Calculated (ME kcal kg feed^{-1})	2986.67	3098.76	3199.88

for brooding and rearing, was thoroughly cleaned and disinfected prior to the commencement of the experiment. Brooder bulbs were activated 12 hours before chick placement to establish an initial temperature of 95°F, which was systematically reduced by 5°F each week until a final temperature of 75°F was achieved. The chicks' behaviour under the brooder was closely observed and adjustments to the temperature were made as necessary to ensure optimal comfort and well-being.

2.2. Metabolic trial and proximate analysis

A metabolic trial was conducted during the 6th week on one bird replicate^{-1}, with a 2-day adaptation and 3-day collection period. Birds were moved to individual partition in pen systems for precise feeding and watering. Feed intake, refusal and excreta output were recorded to evaluate nutrient utilization. Excreta samples were collected using plastic sheets, with a portion preserved in concentrated H_2SO_4 for nitrogen analysis and the rest oven-dried for dry matter estimation. Pooled samples were analyzed for proximate composition and nitrogen content was determined using the Kjeldahl method. Proximate analysis and calcium and phosphorus estimation were conducted at the Animal Nutrition Research Station. Samples were ground to 1 mm using a cyclone mill. Proximate analysis of feed, leftovers and dried excreta. Calcium estimation was conducted as per Anonymous (1962) and phosphorus was measured using a BIOMATE 3S spectrophotometer (Thermo Fisher) as per Anonymous, 2000.

2.3. Carcass characteristics

At 42 days of the experiment, one bird from each replicate was randomly selected, fasted for 12 hours and slaughtered using standardized methods. Pre-slaughter weight was recorded. After complete bleeding, the carcass was processed by removing feathers, skin and eviscerating the bird. Organs, including the liver (excluding the gall bladder), heart (excluding the pericardium) and gizzard, were separately collected and weighed. The dressed carcass and abdominal fat were also weighed. Giblet weight was determined by summing the weights of the liver, heart and gizzard. Dressing % was calculated based on pre-slaughter weight, while giblet and abdominal fat %s were calculated relative to the dressed weight.

2.4. Histomorphological study of small intestine

On the 7th, 21st and 42nd days of the experiment, one bird replicate^{-1} from each treatment was sacrificed. Duodenum and jejunum segments were collected to measure villi height, width, crypt depth and the villus height to crypt depth ratio. Samples were preserved in 10% formalin and processed for histology using paraffin embedding. Sections were cut at 4–5 microns, stained with H&E and analyzed under a light microscope using ImageJ software. Villus height was measured from the villus-crypt junction to the tip, crypt depth from the base to the invagination and villus width as the average of apical and basal widths.

2.5. Livability

The % of livability was calculated by determining the proportion of birds that survived, after accounting for mortality, in each treatment group throughout the experimental period.

2.6. Statistical analysis

The data obtained from the completely randomized design were analyzed according to Snedecor and Cochran (2014). The means of replicates within each treatment were used for analysis and statistical computations were performed using SPSS software (version 20).

3. RESULTS AND DISCUSSION

3.1. Nutrient digestibility (retention) and balance studies

Nitrogen balance was positive and they were significantly (p<0.05) higher in the C, OF and D12 groups, attributed to early access to feed and water, compared to the delayed access in the D24 group (Table 4). The calcium, phosphorus

Table 4: Means of nitrogen, calcium and phosphorus balance (g day^{-1} h^{-1}) during metabolic trial

	Control	T_1	T_2	T_3
Nitrogen				
Total intake	7.50^{a}± 0.49	5.35^{c}± 0.19	4.30^{d}± 0.22	6.41^{b}± 0.25
Excreted in faeces	1.13± 0.07	0.97± 0.04	1.07± 0.13	1.28± 0.11
Balance	6.36^{a}± 0.47	4.38^{b}± 0.22	3.23^{c}± 0.15	5.13^{b}± 0.16
Calcium				
Total intake	1.82± 0.25	1.24± 0.09	1.36± 0.10	1.30± 0.12
Excreted in faeces	0.95^{a}± 0.13	0.57^{b}± 0.03	0.57^{b}± 0.07	0.55^{b}± 0.10
Balance	0.87± 0.26	0.67± 0.12	0.78± 0.03	0.75± 0.12
Phosphorus				
Total intake	0.91± 0.12	0.62± 0.05	0.68± 0.05	0.65± 0.06
Excreted in faeces	0.44± 0.03	0.30± 0.04	0.38± 0.02	0.32± 0.07
Balance	0.47± 0.15	0.32± 0.03	0.30± 0.04	0.33± 0.11

The means bearing different superscripts in the same row differ significantly (p<0.05)

balance was statistically similar across all treatments. Obun and Osaguona (2013) reported a reduction in ileal crude protein digestibility due to delayed access to feed and water in broilers, which aligns with the significant (p<0.05) decrease in nitrogen balance observed in the D24 group. Dry matter, organic matter, crude fat and crude fiber retention was numerically higher with early access to feed and water, specifically in the OF group, compared to the D12 and D24 groups (Table 5). However, the results of this study regarding the 24-hour delay in feed and water access (D24) contradict the findings of Ojebiyi et al. (2022), who observed no significant effect on crude protein availability with delayed feed and water access. These findings align with those of Ojebiyi et al. (2022), who also observed no significant impact of immediate feed and water supply on dry matter retention. However, the present study disagreed the results of Obun and Osaguona (2013), who found a significant (p<0.05) increase in dry matter retention in 12, 24 and 36-hour fasting groups compared to those with 48, 60 and 72 hours of fasting.

Table 5: Average nutrient retention (%) of experimental broilers during metabolic trial

Replicate	Control	T_1	T_2	T_3
Dry matter	70.72± 7.12	69.11± 2.79	70.65± 0.68	70.98± 4.96
Organic matter	72.89± 7.00	72.64± 3.26	74.68± 0.87	80.01± 2.91
Crude fat	81.51± 4.26	80.26± 1.50	80.72± 1.00	82.05± 2.24
Crude fiber	40.47± 2.27	39.93± 3.43	37.71± 3.64	43.78± 3.31

3.2. Carcass characteristics

Birds provided with early access to feed and water (OF group) demonstrated a significantly increase (p<0.05) in dressed weight and small intestine weight compared to those with delayed access to feed and water (D24 group) post-hatching (Table 6). Early feeding reduced both abdominal fat weight and abdominal fat %. The findings align with El Rammouz et al. (2011), who reported no significant difference in dressing % when feed access was delayed by 12 hours post-hatch. Similarly, Abousekken et al. (2017) noted a significant (p<0.05) increase in dressing % with early dietary supplementation compared to fasting groups. Kadam et al. (2009) reported significantly higher (p<0.05) dressing %s with immediate post-hatch nutritional polyherbal supplementation compared to chicks deprived of feed and water during a 48-hour transport period. Shafey et al. (2011) demonstrated significantly higher (p<0.05) abdominal fat %s in chicks provided with early feed and water access compared to those deprived for 48 to 72 hours.

Table 6: Carcass characteristics of experimental broilers at the end of experiment

Replicate	Control	T_1	T_2	T_3
Pre-slaughter wt. (g)	2325.75^{a} ±35.69	1906.00^{b} ±100.27	2227.50^{a} ±55.47	2405.00^{a} ±86.34
Dressed wt. (g)	1439.13^{ab} ±31.33	1224.73^{c} ±70.32	1342.20^{bc} ±34.13	1504.82^{a} ±47.62
Dressing %	61.87 ±0.69	64.27 ±1.87	60.26 ±0.42	62.60 ±0.38
Liver wt. (g)	50.63^{a} ±2.50	39.88^{b} ±2.34	43.08^{b} ±1.19	44.50^{ab} ±2.71
Heart wt. (g)	9.90 ±0.10	8.05 ±0.78	10.28 ±1.14	10.05 ±0.64
Gizzard wt. (g)	43.93 ±0.80	40.73 ±3.28	43.80 ±2.11	45.40 ±1.19
Giblet wt. (g)	104.45 ±3.22	88.65 ±5.01	97.15 ±3.34	99.95 ±4.21
Giblet %	7.28 ±0.37	7.28 ±0.43	7.25 ±0.27	6.68 ±0.45
Abdominal fat wt. (g)	26.58^{b} ±2.49	38.30^{b} ±5.86	51.63^{a} ±3.65	38.18^{b} ±4.41
Abdominal fat %	1.84^{c} ±0.16	3.13^{ab} ±0.42	3.86^{a} ±0.33	2.53^{bc} ±0.28
Small intestine wt. (g)	67.39^{a} ±3.08	68.01^{a} ±2.72	55.14^{b} ±2.63	76.84^{a} ±4.61
Small intestine length (cm)	165.25 ±6.97	172.25 ±7.61	168.25 ±10.66	168.50 ±4.03
Large intestine wt. (g)	8.11 ±1.04	8.51 ±0.47	7.77 ±0.63	8.42 ±0.19

The means bearing different superscripts in the same row differ significantly (p<0.05)

Abousekken et al. (2017) also recorded significantly (p<0.05) longer gastrointestinal tract lengths in pre-starter-fed chicks versus fasting groups, which contradicts the present findings. However, Maiorka et al. (2003) reported a non-significant effect on duodenum, jejunum and ileum lengths, consistent with the results of this study.

3.3. Histomorphological study of small intestine

The histomorphological data for days 7, 21 and 42 are presented in Tables 7, 8 and 9, respectively. At the age of 42nd day it was observed that the duodenal villus height was significantly higher (p<0.05) in the OF group than in the D12 and D24 groups, with the C group showing comparable values to the OF group. Villus width followed a similar trend. The D12 and D24 groups exhibited the lowest villus height and significantly (p<0.05) lower crypt depth compared to the C and OF groups. No significant

Table 7: Histomorphological observations of duodenum and jejunum (µm) of experimental broilers under experiment at the age of 7th day

	Particulars	Control	T_1	T_2	T_3
Duodenum	Villi height	591.09±8.03	556.03±25.20	536.62±9.67	564.50±16.90
	Villi width	73.77±3.24	73.46±1.65	71.43±2.54	79.28±3.16
	Crypt depth	112.67±3.92	112.97±3.92	112.72±5.64	116.02±2.70
	Villi height: crypt depth	5.26±0.14	4.94±0.28	4.79±0.21	4.86±0.07
Jejunum	Villi height	460.37±22.93	472.03±27.88	464.80±25.78	444.94±13.71
	Villi width	85.94±0.71	87.72±1.31	85.94±2.43	89.22±0.85
	Crypt depth	91.18±3.46	89.54±2.05	87.58±1.73	90.37±2.25
	Villi height: crypt depth	5.04±0.08	5.27±0.27	5.30±0.26	4.93±0.18

Table 8: Histomorphological observations of duodenum and jejunum (µm) of experimental broilers under experiment at the age of 21st day

	Particulars	Control	T_1	T_2	T_3
Duodenum	Villi height	1386.16±19.27	1436.72±30.43	1464.16±27.82	1445.93±42.97
	Villi width	223.63±6.46	225.78±9.33	224.46±8.66	226.91±12.46
	Crypt depth	222.70±6.87	221.26±8.84	225.29±10.93	228.46±6.32
	Villi height: crypt depth	6.24±0.23	6.52±0.25	6.53±0.25	6.34±0.23
Jejunum	Villi height	1281.10±85.17	1344.84±27.82	1271.98±39.91	1245.90±45.86
	Villi width	168.97±3.47	169.31±6.83	167.51±4.76	164.15±3.62
	Crypt depth	204.60±11.69	206.94±13.17	215.47±6.14	218.43±7.88
	Villi height: crypt depth	6.30±0.45	6.59±0.51	5.93±0.32	5.71±0.16

Table 9: Histomorphological observations of duodenum and jejunum (µm) of experimental broilers under experiment at the age of 42nd day

	Particulars	Control	T_1	T_2	T_3
Duodenum	Villi height	2528.85^{ab}±59.44	2326.17^{bc}±115.28	2233.69^{c}±75.45	2761.78^{a}±83.85
	Villi width	380.61^{ab}±8.51	333.05^{bc}±30.72	328.07^{c}±3.18	388.12^{a}±3.39
	Crypt depth	459.44^{a}±6.33	365.20^{c}±13.52	360.55^{c}±5.40	407.64^{b}±14.54
	Villi height: crypt depth	5.50±0.06	6.42±0.48	6.19±0.16	6.82±0.45
Jejunum	Villi height	2836.48±65.03	2550.76±153.05	2447.07±130.83	2723.74±55.94
	Villi width	343.04^{a}±3.24	293.11^{b}±3.32	359.10^{a}±22.99	363.21^{a}±3.17
	Crypt depth	392.77^{a}±9.26	320.41^{c}±4.52	274.29^{d}±4.28	359.53^{b}±4.29
	Villi height: crypt depth	7.22^{b}±0.09	7.99^{ab}±0.59	8.91^{a}±0.35	7.58^{b}±0.24

The means bearing different superscripts in the same row differ significantly (p<0.05)

differences were observed in the villus height-to-crypt depth ratio among the treatment groups. Li et al. (2022) reported similar findings, with immediate post-hatch feeding. They observed significantly (p<0.05) increased duodenal villus height compared to delayed feeding. However, their results for the villus height-to-crypt depth ratio differed.

The jejunal villus height was unaffected by immediate post-hatch feeding. Villus width was significantly lower (p<0.05) in the D12 group compared to C, D24 and OF groups. Crypt depth was lowest in the D24 group, followed by D12, OF and C groups. The villus height-to-crypt depth ratio was highest (p<0.05) in the D24 group, with the D12 group being comparable to D24 and OF groups. The villus height and width data correlated with improved performance during the 6th week of the study on early feed and water access. This may be attributed to enhanced

nutrient utilization (Noy et al., 2001). Reduced villus height could lead to poor nutrient absorption and compromised performance (Yegani and Korver, 2008).

3.4. Livability

The values obtained across all treatments were statistically similar and are presented in Table 10.

Table 10: Livability of experimental broilers under experiment

Particulars	Control	T_1	T_2	T_3
Livability %	97.22	97.22	86.11	97.22

Post-mortem examination of all deceased birds revealed no pathological changes. These results aligned with the findings of Elibol et al. (2023), where the duration of incubation had no effect on mortality rates at 7 and 35 days post-placement. Hassan et al. (2023) also observed no significant difference in livability due to delayed feeding. Mustafa (2021) found no significant difference in livability due to a 24-hour delayed feeding. The study by Sarlak et al. (2016) also aligns with our findings, as they found no significant effect on mortality after up to 48 hours of fasting. Obun and Osaguona (2013) also found that withdrawing feed and water for the first 72 hours did not negatively impact livability.

4. CONCLUSION

Early access to feed and water post-hatch significantly (p<0.05) improved nitrogen balance, small intestine weight, abdominal fat percent, duodenal villi height, villi width and jejunal villi width at the age of 42 days.

5. ACKNOWLEDGEMENT

We sincerely acknowledge the support and facilities provided by the Research Scientist and Head, Animal Nutrition Research Station, Veterinary & Animal Science Research & Extension Unit, Kamdhenu University, Anand, Gujarat.

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