



Effects of lighting program at different periods on broiler chicken performance

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Received: Aug. 17, 2025	Abstract Researchers have not yet definitively established the optimal lighting program and dark period initiation for improving the welfare, health, and performance of commercial broilers. Therefore, this study aims to examine how different lighting schedules at various ages affect key factors, including growth performance and mortality rates, in broiler chickens. 400-day-old Ross chicks were assigned to four experimental groups using a completely randomized design. Each group consisted of five replicates with 20 chicks in each. The experimental groups were as follows: T1 was exposed to 24 hours of continuous light, while the other three groups experienced a daily dark period of five hours. Specifically, T2 began its dark period after the first week, T3 after the second week, and T4 after the third week. The broiler chickens in the T2 experimental group showed significantly better performance compared to the other groups ($P < 0.05$). Furthermore, all experimental groups that experienced 5 hours of darkness demonstrated an improved feed conversion ratio ($P < 0.05$), with no significant changes observed in feed intake or mortality rates ($P > 0.05$) over the 42 days. In conclusion, providing 5 hours of darkness after the first week of age significantly improved the feed conversion ratio without decreasing feed intake. Chickens subjected to this lighting regimen also showed better weight gain compared to those kept under continuous lighting programs. Therefore, it is recommended to raise broiler chickens on a 19-hour light and 5-hour dark (19L:5D) schedule following the first week of age to promote optimal growth and health.
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Introduction

The high production of white meat, particularly chicken, in the Kurdistan Region is attributed to the growing number of poultry projects and an increased demand for broiler meat. Over the past five years, the region has experienced a 50% rise in broiler meat production [1]. In recent years, there has been a heightened focus on how lighting management impacts the growth performance, immune status, and overall welfare of broilers [2]. While significant advancements have been made in understanding the

effects of photoperiod on broiler production, health, and welfare, the results have been inconsistent. Researchers have observed increases, decreases, or no change at all, with these variations influenced by multiple factors that remain not fully understood [3].

There are three types of lighting programs for broilers: continuous, intermittent, and increasing [4]. It is essential to implement these lighting programs effectively. They should focus on optimizing bird performance while also reducing farm costs [5]. Due to recent findings, continuous lighting programs in broiler production have been banned in several regions. For instance, the United Kingdom mandates at least 8 hours of darkness (DEERA, 2018), while the European Union requires a minimum of 6 hours of total darkness, with at least four uninterrupted hours (2007). Aviagen [6] recommends providing 23 hours of light from days 0 to 7 of age. After day 7, an optimal lighting schedule may include around 5 hours of darkness, with the total darkness duration ranging from 4 to 6 hours .

The sleep requirements of birds may exceed current recommendations during specific growth stages [7]. Additionally, longer daylight hours (23 hours of light compared to 20, 17, and 14 hours) can lead to sleep fragmentation, negatively impacting the welfare of the birds [8]. Therefore, it is crucial to develop an optimal lighting program to enhance the health and welfare of broilers [9].

Currently, there are no lighting programs in use in the Kurdistan region of Iraq that align with the guidelines advised by companies. Many poultry operations continue to provide light for 23 or even 24 hours a day. This study aims to investigate the effects of photoperiods, as recommended by Aviagen [6], on broiler performance over a 42-day experimental period.

Materials and Methods

This study was conducted at the Department of Animal Science, College of Agricultural Engineering Sciences, University of Sulaimani Iraq. All materials and methods were reviewed and approved by the College's ethics committee, following the guidelines of the FAO [10]. All materials and methods were reviewed and approved by the College's ethics committee, in accordance with the guidelines of the FAO [10]. All materials and methods were reviewed and approved by the College's ethics committee, following the guidelines of the FAO [10].

Bird Housing and Experimental Design

A total of 400-day-old Ross chicks were randomly allocated into four experimental groups, each consisting of five replicates of 20 chicks. The groups included T1, which experienced 24 hours of continuous lighting, and three additional groups that underwent a daily dark period of five hours. Specifically, T2 began the dark period after the first week of age, T3 started it after the second week, and T4 implemented it after the third week. All experimental groups were provided with a pelleted diet during different growth phases: a starter phase with 3031 kcal/kg and 23% protein, a grower phase with 3100 kcal/kg and 21.5% protein, and a finisher phase with 3200 kcal/kg and 20% protein. These diets, outlined in Table 1, followed the guidelines established by Aviagen

(2022) for their respective strains. Additionally, the chicks had ad libitum access to both feed and water and were reared under 20 lux light intensity.

Performance Measurement

At the end of each week, several key performance indicators for the birds were measured, including average body weight (ABW), average feed intake (AFI), average weight gain (AWG), feed conversion ratio (FCR), and mortality percentage. These measurements were adjusted to account for the weight of any deceased broiler chickens that were present.

Table (1): Diet rations for broiler chickens

Ingredients	Starter (1-11 Days)	Grower (12-25 Days)	Finisher (26-42 Days)
Corn grain	53.735	57.192	59.632
Soybean meal 46%	39.726	35.942	32.445
Sunflower oil	0.00	0.899	2.481
Dicalcium phosphate	0.850	0.459	0.175
CaCO ₃	0.860	0.693	0.567
Vit-Min premix ¹	4.500	4.500	4.500
L-Methionine	0.329	0.315	0.200
Chemical composition			
M. Energy kcal/kg	3031	3100	3.200
Crude protein %	23.00	21.500	20.000
Linoleic acid %	1.341	1.861	2.707
Crude fiber %	1.886	1.879	1.859
Calcium %	1.055	0.895	0.775
Available phosphate %	0.500	0.420	0.360
Potassium %	0.957	0.891	0.828
Sodium %	0.218	0.218	0.218
Lysine %	1.420	1.322	1.229
Methionine %	0.746	0.713	0.581
Methionine + cysteine %	1.09	1.04	0.89
Threonine %	0.912	0.854	0.799

Abbreviations: Vit-Min premix; Vitamin-Mineral premix, OGM; Onion and Garlic Mixture, M. Energy; Metabolizable Energy.

¹ Provided per kg of diet: Protein, 18%; CaCO₃, 19%; Monocalcium phosphate, 7%; NaCl, 4.5%; Methionine, 2%; Lysine, 4%; Threonine, 1%; Choline chloride, 1%; Iron (sulphate), 2800mg; Zinc (oxide), 2480mg; Manganese (oxide), 3600mg; Copper (sulphate), 240mg; Iodine (IK), 60mg; Selenium (SeNa), 14mg; Cobalt (sulphate), 14mg; Magnesium (oxide), 800mg; Antioxidant (BHT), 32mg; Vitamin A, 420000 IU; Vitamin D3, 80000 IU; Vitamin E, 800mg; Vitamin C, 40mg; Vitamin K3, 80mg; Vitamin B1, 80mg; Vitamin B2, 200mg; Vitamin B6, 80mg; Vitamin B12, 0.6 mcg; Biotin, 10.4mg; Folic acid, 20mg; Nicotinic acid, 400mg; Pantothenic acid, 160mg.

Statistical Analysis

The collected data were analyzed using the General Linear Model procedures from the SAS Institute (SAS 9.1, Cary, NC) [11]. When the model results were significant, Tukey's test was applied to compare the means, using a significance level of $P < 0.05$.

Results and Discussion

Performance

Feed Intake

The impact of various lighting programs on chicken feed intake is presented in **Table 2**. Throughout the entire rearing period (from 1 to 42 days), there were no significant differences in average feed intake among the different lighting programs, except for the fourth week. During this particular week, the feed intake of birds in the T2 experimental group was significantly higher than that of the other groups, demonstrating a notable difference when compared to T1 ($P < 0.05$). This observation may be attributed to the implementation of appropriate light-dark ratios at an earlier stage of development. Furthermore, similar findings were reported by Rahimi et al. [12], who also noted no significant differences in feed intake across all age phases.

In specific experiments, the feed intake of chickens subjected to intermittent lighting conditions was observed to be higher than that of chickens maintained under continuous light during the 3- to 6-week age period [13]. These findings align with previous research, which indicates that the strategic manipulation of lighting regimens for broilers can effectively stimulate feed intake [4, 9], modulate the systemic immune response [14], and reduce aggressive physiological behaviors in broilers [15]. Furthermore, light is recognized as a crucial element of the feeding environment [4, 7, 16, 17].

Table (2): Effects of lighting program on chickens' feed intake at different ages.

Treatments	Average Feed Intake (g)						
	1 st week	2 nd week	3 rd week	4 th week	5 th week	6 th week	1-42 day
T1	100.2	241	372	505 ^b	1556	762	3593
T2	109.7	239	393	576 ^a	1584	750	3676
T3	104.5	234	381	515 ^{ab}	1479	743	3456
T4	105.8	240	362	526 ^{ab}	1571	813	3618
-----Provability-----							
P value	0.7349	0.9189	0.1299	0.0291	0.0544	0.1728	0.0790
MSE	2.85	3.69	4.83	9.62	16.0	12.6	31.6
Abbreviations: T1; 24h Lighting, T2; at 1 st week 5h darkness initiated, T3; at 2 nd week 5h darkness initiated, T4; at 3 rd week 5h darkness initiated, MSE; mean of standard errors. ^{a-b} means with difference letters in the same column are significantly different ($P < 0.05$).							

Appropriate lighting conditions can significantly enhance the dietary intake of broilers, as indicated by the findings of Gomes de Oliveira and José Camargos Lara [4] and Wu et al. [2]. Furthermore, the onset of the dark period has been shown to stimulate

feeding behaviors in both broilers and laying hens, thereby reducing the likelihood of food shortages during nighttime [18]. Moreover, different lighting programs have been found to have a statistically significant effect ($p < 0.01$) on total feed consumption across all experimental groups. Research by Ghanima et al. [19] indicated that broilers raised under Continuous Lighting (CL) programs (CL22, CL20, and CL18) consumed significantly more feed compared to those exposed to Intermittent Lighting (IL) programs (IL22, IL20, and IL18). However, findings from Gratta et al. [20] showed a lower daily feed intake throughout the entire experimental period ($P < 0.001$). There was a reported decrease in feed intake when the light hours were less than 18, without differences in feed conversion ratio (FCR) among the chickens maintained under 24L:0D, 18L:6D, 8L:16D, and 4L:20D lighting conditions [8, 9, 21].

Live body weight

Table 3 illustrates the effects of different lighting programs on broiler body weight throughout a 6-week experiment. During the first three weeks, the various lighting programs had no significant impact on the chicks' body weight. However, in the final three weeks, the lighting programs had a significant impact on body weight ($P < 0.05$). Specifically, during the fourth and fifth weeks, the T2 group, which implemented a 5-hour dark period starting in the second week, recorded the highest body weight compared to the other experimental groups ($P < 0.05$). During the last week of the experiment (6th week), both the T2 and T4 lighting programs demonstrated superior performance in terms of chicken body weight compared to the other groups ($P < 0.05$). Consequently, the birds in the T2 experimental group, exposed to the dark photoperiod starting in the second week, achieved the highest live body weight among all experimental groups ($P < 0.05$).

Table (3): Effects of lighting program on chickens' live body weight at different ages

Treatments	Average Live Body Weight (g)						
	1-day-old	1 st week	2 nd week	3 rd week	4 th week	5 th week	6 th Week
T1	37	102.2	239	405	735 ^{ab}	1377 ^b	1595 ^b
T2	37	108.7	243	450	813 ^a	1572 ^a	1896 ^a
T3	37	107.0	215	410	722 ^b	1413 ^b	1672 ^b
T4	37	111.2	237	415	725 ^b	1459 ^b	1804 ^a
-----Provability-----							
P value		0.3928	0.2697	0.2447	0.0197	0.0012	0.0001
MSE		1.84	5.41	8.52	13.1	20.6	30.4
Abbreviations: T1; 24h Lighting, T2; at 1 st week 5h darkness initiated, T3; at 2 nd week 5h darkness initiated, T4; at 3 rd week 5h darkness initiated, MSE; mean of standard errors. a-b means with difference letters in the same column are significantly different ($P < 0.05$).							

The results observed may be attributed to the effects of the lighting program, as indicated by previous studies. These studies demonstrate that lighting affects birds' metabolism [8, 19, 22, 23]. This metabolic influence is crucial for maximizing growth

performance and maintaining normal physiological processes and functions [16,24]. Implementing a dark period during the second stage of broiler rearing can positively impact performance by encouraging activity during the light period, which may enhance feed conversion and reduce inactivity [25].

The results of the current study showed no significant differences in the first week; this contrasts with the findings of Ashabranner et al. [26], who reported that control birds reared under continuous light during brooding initially exhibited higher body weights during the first week ($P \leq 0.05$). Additionally, treatment birds that experienced dark periods during brooding showed greater body weights than the control group on days 10 and 14. At 31 days, regression analyses indicated no significant effect on body weight [27]. In contrast to the current findings, Rahimi et al. [12] and Gratta et al. [20] found no significant differences in body weight at 42 days between treatments. Trocino et al. [28] reported that chickens subjected to early light-restricted conditions had lower final weights compared to those fed ad libitum (2%), despite experiencing compensatory growth. Furthermore, Simões et al. [29] noted that an increase in feed restriction from 21 to 49 days of age was associated with a linear decrease in the occurrence of woodpecker beak (WB). Wu et al. [2] also found that long photoperiod programs negatively impacted body weights at younger marketing ages, while Ingram et al. [30] documented a reduction in live body weight.

Table 4 presents the effects of various lighting programs on weight gain in chickens. Similar to feed intake and live body weight, there were no significant impacts on weight gain during the first, second, and third weeks of age, as well as at six weeks. However, during the fourth and fifth weeks, the T2 lighting program significantly enhanced weight gain compared to T1, and also showed numerical advantages over the other experimental groups. Throughout the entire rearing period (from 1 to 42 days), T2 exhibited the highest weight gain among the different groups, with significant differences observed ($P < 0.05$). It is worth noting that there was no significant difference between T2 and T4 ($P > 0.05$). The results indicated that as body weight increased, weight gain also increased, reflecting a positive relationship between body weight and feed intake due to the lighting program. This program demonstrated higher weight gain in the study. The findings can be attributed to the alternating periods of darkness and short periods of light, which would enable the birds to meet their nutritional needs during the light periods. During the dark periods, they expend less energy, resulting in greater weight gain.

The uniformity and growth rate of the broilers may be comparable to, or even better than, those of birds raised under continuous lighting, mainly when compensatory gain is achieved [5]. Similarly, Magee et al. [31] observed no performance differences between birds subjected to different light schedules (23L:1D vs. 20L:4D) on either Day 7 or 14. Ashabranner et al. [26] reported that by Day 14, the treatment group continued to outperform the control group, showing significantly higher body weight gain (BWG). They also noted significant differences in feed-to-gain ratios throughout the experiment. Research by Kim et al. [9] and Ghanima et al. [19] identified increased total body weight gain. However, studies by Gratta et al. [20], Olanrewaju et al. [21],

and Ingram et al. [30] reported a reduction in weight gain. Additionally, Rahimi et al. [12] found no significant difference in body weight gain between treatments by day 42.

Table (4): Effects of lighting program on chickens' weight gain at different ages

Treatments	Average Weight Gain (g)						
	1 st week	2 nd week	3 rd week	4 th week	5 th week	6 th week	1-42 Day
T1	65.2	137	166	299 ^b	673 ^b	218	1558 ^b
T2	71.7	135	206	363 ^a	797 ^a	286	1859 ^a
T3	70.0	108	195	312 ^{ab}	691 ^{ab}	260	1636 ^b
T4	74.2	126	178	311 ^{ab}	734 ^{ab}	320	1767 ^a
	-----Provability-----						

P value	0.3928	0.0737	0.0969	0.0170	0.0194	0.3038	0.0001
MSE	1.84	4.41	6.25	8.40	16.4	18.7	30.4
Abbreviations: T1; 24h Lighting, T2; at 1 st week 5h darkness initiated, T3; at 2 nd week 5h darkness initiated, T4; at 3 rd week 5h darkness initiated, MSE; mean of standard errors.							
a-b means with difference letters in the same column are significantly different (P<0.05).							

Feed conversion ratio

Table 5 illustrates the effects of different lighting programs on the feed conversion ratio of chickens. In the first week of age, all chickens showed nearly the same feed conversion ratio. However, in the second week, T3 showed a significant improvement in feed conversion ratio compared to T1 and T2 (P<0.05). In the third, fourth, and sixth weeks of age, no significant difference in feed conversion ratio was observed between different lightning programs (P > 0.05). Otherwise, all experimental groups that had a 5-hour dark period experienced a significantly better feed conversion ratio compared to the continuous lighting program (T1) (P < 0.05) in both the fifth week of age and the entire rearing period (1-42 days).

The feed conversion ratio of broiler chickens improved with a daily five-hour darkness period at different ages, compared to a continuous lighting program, especially for those chickens provided with a dark period earlier in their development. This result is in agreement with Schwean-Lardner and Classen [32], who reported that the day length had a significant effect on the broilers' feed conversion ratio, which had a positive correlation with day length. Additionally, Mahmud et al. [33] assessed the effects of various lighting programs on broiler chickens. They found that chickens raised under a higher daylength period had a better feed conversion ratio compared to those under continuous lighting programs.

The improvement of the feed conversion ratio may be related to an increase in melatonin levels and a decrease in corticosterone levels during periods of darkness.

The release of melatonin and the regulation of the circadian rhythm are influenced by exposure to light [34,35]. Darkness appears to enhance the welfare of chickens and reduce their stress during production, resulting in better feed conversion [36]. Previous studies have reported improvements in feed conversion ratios resulting from various lighting programs [2, 5, 30, 37, 38]. However, some studies found no significant differences in feed-to-gain ratios throughout the experiments [9,26]. Additionally, Magee et al. [31] reported no performance differences between birds subjected to different light schedules (23L:1D vs. 20L:4D) on either Day 7 or Day 14. Ghanima et al. [19] noted that reducing lighting hours significantly decreased the feed conversion ratio.

Table (5): Effects of lighting program on chickens’ feed conversion ratio at different ages

Treatments	feed conversion ratio (g/g)						
	1 st week	2 nd week	3 rd week	4 th week	5 th week	6 th week	1-42 Day
T1	1.533	1.770 ^b	2.116	1.651	2.409 ^a	3.960	2.308 ^a
T2	1.522	1.803 ^b	1.918	1.591	2.127 ^b	2.543	2.004 ^b
T3	1.500	2.176 ^a	1.970	1.655	2.147 ^b	3.232	2.115 ^b
T4	1.449	1.926 ^{ab}	2.053	1.693	2.142 ^b	2.460	2.049 ^b
-----Provability-----							
P value	0.8701	0.0234	0.4573	0.4110	0.0122	0.1262	0.0004
MSE	0.04	0.05	0.04	0.02	0.04	0.26	0.03
Abbreviations: T1; 24h Lighting, T2; at 1 st week 5h darkness initiated, T3; at 2 nd week 5h darkness initiated, T4; at 3 rd week 5h darkness initiated, MSE; mean of standard errors. ^{a-b} means with difference letters in the same column are significantly different (P<0.05).							

Mortality

As shown in Table 6, the mortality rate across all experimental groups was comparable, with no significant changes observed when a dark period was initiated at different ages throughout the weeks, except in the sixth week. In that particular week, the T4 group, which had started its dark period in the third week of age, exhibited a significantly higher mortality rate compared to the T1 group. Conversely, the T3 experimental group recorded the lowest mortality rate for the overall period (1-42 days) among all groups. In contrast, the T2 group had the highest mortality rate, though this difference was not statistically significant. However, as indicated, the overall mortality was neither significantly higher nor lower; this is illustrated by the compensatory growth observed in birds that were subjected to increased lighting during the final phase of their growth period.

Classen et al. [39] explained that the increased lighting led to the synthesis of steroidal anabolic hormones, which in turn facilitated compensatory growth. Furthermore, Abreu et al. [40] found that a continuous lighting program enhances the performance of broilers. They reported that while this program leads to greater energy expenditure, it also increases the mortality rate. Ingram et al. [30] noted that although prolonged

light exposure may result in a slight rise in mortality, the effect is not significant; however, they observed improved feed efficiency during dark periods. In contrast, studies by Manfio et al. [37], Wu et al. [2], and Liboni et al. [5] reported lower mortality rates. Additionally, Rahimi et al. [12] found no significant differences in mortality between treatments.

Table (6): Effects of lighting program on chickens' mortality at different ages

Treatments	Mortality (%)						
	1 st week	2 nd week	3 rd week	4 th week	5 th week	6 th week	1-42 Day
T1	4	0	2.05	1.053	2.632	0.00 ^b	12
T2	2	0	6.00	4.020	4.444	4.107 ^{ab}	22
T3	1	0	2.00	0.000	1.316	3.500 ^{ab}	10
T4	4	0	1.00	2.053	4.269	9.020 ^a	19
	-----Provability-----						

P value	0.4411	----	0.0897	0.0935	0.6076	0.0415	0.1754
MSE	0.77	0.00	0.77	0.58	0.89	1.18	2.21
Abbreviations: T1; 24h Lighting, T2; at 1 st week 5h darkness initiated, T3; at 2 nd week 5h darkness initiated, T4; at 3 rd week 5h darkness initiated, MSE; mean of standard errors.							
a-b means with difference letters in the same column are significantly different (P<0.05).							

In conclusion, providing 5 hours of darkness after the first week of age significantly improved the feed conversion ratio without decreasing feed intake. Chickens subjected to this lighting regimen also showed better weight gain compared to those kept under continuous lighting programs. Therefore, it is recommended to raise broiler chickens on a 19-hour light and 5-hour dark (19L:5D) schedule following the first week of age to promote optimal growth and health.

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