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Effect of Application Different Lighting Programs on Some Productive Performance of Broiler (ROSS 308)

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Abstract:

This study was conducted from September 10, 2023, to November 13, 2023, at the poultry farm of the Animal Production Department of the College of Agriculture, University of Basrah. The objective was to compare the effects of continuous lighting systems with various intermittent lighting regimes on the productive performance of broilers. A total of 216 one-day-old unsexed ROSS308 chicks were randomly assigned to six experimental treatments, with three replicates each consisting of 12 chicks. Each treatment was reared in a separate section. From hatching to four days old, chicks received 23 hours of light per day. The lighting programs started on the fifth day and lasted until the end of the 35-day trial. The experiment parameters were as follows: T1: continuous lighting (22 L, 2 D); T2: intermittent lighting (11 L: 1 D) twice a day; T3: continuous lighting (20 L: 4 D); T4: intermittent lighting (5 L: 1D) four times a day; T5: continuous lighting (18 L: 6 D) daily; T6: intermittent lighting (3 L: 1D) six times a day. The results showed a significant increase ($P \leq 0.05$) in live body weight, cumulative weight gain, and cumulative feed intake up to 35 days of age in birds increase under the T1 and T2 programs. Significant improvements ($P \leq 0.05$) were observed in feed conversion rate, economic index, and livability ratio for birds under T4, T5, and T6 programs in the study.

Keywords: Lighting programs, production performance, economic indicator, broiler.

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تأثير تطبيق برامج الإضاءة المختلفة على بعض الأداء الإنتاجي لدجاج اللحم (ROSS 308)

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الخلاصة:

أجريت هذه الدراسة من 10 سبتمبر 2023 إلى 13 نوفمبر 2023 في مزرعة الدواجن التابعة لقسم الإنتاج الحيواني بكلية الزراعة بجامعة البصرة. وكان الهدف هو مقارنة آثار أنظمة الإضاءة المستمرة مع أنظمة الإضاءة المتقطعة المختلفة على الأداء الإنتاجي للدجاج اللحم. تم توزيع إجمالي 216 ROSS308 غير محدد الجنس بعمر يوم واحد بشكل عشوائي على ست معاملات تجريبية، مع ثلاث مكررات تتكون كل منها من 12 كوكبًا. تم تربيتها كل معاملة في قسم منفصل من الفقس إلى عمر أربعة أيام، تلقت الكتاكيت 23 ساعة من الضوء يوميًا. بدأت برامج الإضاءة في اليوم الخامس واستمرت حتى نهاية التجربة التي استمرت 35 يومًا. كانت معلمات التجربة كما يلي: T1: إضاءة مستمرة (22 لترًا، 2 يوم)؛ T2: إضاءة متقطعة (11 لترًا، 1 يوم) مرتين في اليوم T3: إضاءة مستمرة (20 لترًا، 4 أيام)؛ T4: إضاءة متقطعة (5 لترًا، 1 يوم) أربع مرات يوميًا؛ T5: إضاءة مستمرة (18 لترًا، 6 أيام) يوميًا؛ T6: إضاءة متقطعة (3 لترًا، 1 يوم) ست مرات يوميًا.

إضاءة متقطعة (3 لترات: يوم واحد) ست مرات يوميًا. أظهرت النتائج زيادة معنوية ($P \leq 0.05$) في وزن الجسم الحي، وزيادة الوزن التراكمية، وكمية العلف المستهلكة حتى عمر 35 يومًا في الطيور المرباة ضمن برنامجي T1 و T2. كما لوحظ تحسن ملحوظ ($P \leq 0.05$) في معدل التحويل الغذائي، والمؤشر الاقتصادي، ونسبة قابلية الحياة للطيور المرباة ضمن برامج T4 و T5 و T6 في الدراسة.

الكلمات المفتاحية: برامج الإضاءة، أداء الإنتاج، المؤشر الاقتصادي، دجاج التسمين.

Introduction

The broiler chicken industry is a critical source of animal protein that is crucial for the fast-growing global population. Genetic advancements have made significant improvements in broiler feed conversion ratios and growth performance to meet this demand. Broiler production has recently received significant attention from environmental factors, including lighting (Al-Samrai et al., 2023). The performance of poultry is determined by its genetic potential and environmental interactions, with light being a crucial factor (Al-hummed, 2020). By understanding and managing light properly in poultry production, producers can implement optimal lighting programs, improve performance standards, and lower production costs (Saad et al., 2024). Broiler life weight and disease resistance can be affected by different lighting systems, as studies have shown. For instance, researchers have used continuous or near-continuous lighting regimes to increase feed consumption and maximize growth rates. Continuous lighting can increase feed intake and growth in broilers, but it may not always result in better feed conversion ratios or economic returns (Abo Ghanima et al., 2021).

Some studies have indicated that continuous lighting can hinder growth and cause physiological stress in birds (Alaasam et al., 2021). Therefore, varying lighting periods have gained interest as a means to improve broiler productivity and health. Helmy et al. (2023) highlight the need for research on lighting systems, noting that physical activity and energy consumption decrease significantly during dark periods. As a result, intermittent lighting may improve the productivity of birds. Manfio et al. (2019) reported that an intermittent lighting system (1 hour light, 2 hours dark) was more effective at improving broiler performance than continuous lighting. Their findings revealed that intermittent lighting resulted in higher productivity, reduced leg deformities and sudden death syndrome, and improved bird vitality and metabolic processes. Research evaluating the performance of broilers under lighting systems found that while feed consumption was lower in broilers under intermittent lighting compared to continuous lighting, this difference was not statistically significant. The average live weight and feed conversion ratios were significantly improved by intermittent lighting. Compared to continuous lighting, shorter lighting periods resulted in a reduction in feed consumption (Onbasilar et al., 2018). Providing birds with adequate darkness periods resulted in fewer health issues compared to continuous or near-continuous lighting, with no adverse effects on hematological and biochemical blood parameters (Farghly and Makled, 2015). The purpose of this research is to compare continuous lighting systems with various intermittent lighting systems and evaluate their effects on broiler productive performance, carcass traits, and blood parameters.

Materials and Methods

This study was conducted at the College of Agriculture, University of Basrah, from October 9, 2023, to November 13, 2023. A total of 216 one-day-old, unsexed broiler chicks of the Ross 308 strain, with an average weight of 42 grams, were used. The chicks were randomly assigned to six experimental treatments, with three replicates per treatment (12 chicks per replicate). The birds were housed in separate sections, each dedicated to a specific treatment. The experimental treatments were as follows: T1: Continuous lighting (22 hours light: 2 hours dark) daily. T2: Intermittent lighting (11 hours light and 1 hour dark) twice daily. T3: Continuous lighting (20 hours light: 4 hours dark) daily. T4: Intermittent lighting (5 hours light and 1 hour dark) four times daily. T5: Continuous lighting (18 hours light: 6 hours dark) daily. T6: Intermittent lighting (3 hours light and 1 hour dark) six times daily.

Each replicate was equipped with 5-watt light bulbs. Two types of commercial diets were used: a starter diet (23.04% crude protein and 2945 kcal/kg metabolizable energy) from days 1 to 20, and a finisher diet (19.14% crude protein and 3170 kcal/kg metabolizable energy) from days 21 to 35 (Table 1). The necessary administrative measures were taken to ensure optimal rearing conditions. This included maintaining appropriate temperature and humidity levels throughout the entire experimental period.

The productive traits studied included live body weight, weight gain, feed consumption, feed conversion ratio, mortality rate, and economic index, as described by Al-Fayadh *et al.* (2011). The study was designed according to a completely randomized design (CRD). The collected data were statistically analyzed using the SPSS software (2019). The significance of differences between means was tested using Duncan's multiple range test (1955) at a significance level of $P \leq 0.05$.

Table 1: Nutritional Composition of Diets

Forage	Starter (1-21 day)	Growth (22-35 day) %
Wheat bran	16	20
Yellow corn	44.2	48.7
Concentrated Protein ⁽¹⁾	4	1
The soybean gain is 44% protein	32	22
Soy oil	0.5	2.5
Vitamin and mineral mixture	1	1
Salt	0.3	0.3
limestone	2	1.5
Computerized chemical composition (2)		
Crude protein (%)	23.04	19.14
Metabolic energy (kilograms / kg)	2945	3170

(1) The Concentrated Protein imported from Jordan. Company of FAPCO. Containing 2200 kcal / kg, 50% crude protein, 2.5% methionine + cysteine, 3% lysine, 3% phosphorous and 8% calcium

(2) The chemical composition wear reported according to the NRC (1994) analysis of feed stuffs mentioned.

Results and Discussion

Table (2) indicates the effect of applying lighting programs on the body weight (g) of broiler chickens during the experimental period. The table shows no significant effect ($p \leq 0.05$) of the lighting programs on the live body weight rates of birds in different experimental treatments in the first week of the birds' age. However, in the second week, birds raised under intermittent lighting T2 (11 hours light, 1 hour dark) twice daily showed a significant increase ($p \geq 0.05$) in live body weight rates, recording the highest rate and not differing significantly from the control treatment T1 (22 hours light, 2 hours dark). The lowest rates were recorded in birds raised under the lighting program T5 (18 hours light, 6 hours dark), which did not differ significantly from treatment T6 (3 hours light, 1 hour dark, 6 times daily) and treatment T4 (5 hours light, 1 hour dark, 4 times daily). In the third, fourth, and fifth weeks, the

significant superiority ($p \geq 0.05$) of the T2 and T1 treatments in body weight continued over the other treatments, while the birds raised under the lighting programs T6 and T5 recorded the lowest rates.

Table 3 shows the effect of applying lighting programs on the weekly weight gain rates (g) and the cumulative period (0–5 weeks) for broiler chickens. The results showed no significant differences ($p \leq 0.05$) between the different experimental treatments. However, in the second week, the T2 treatment group showed significant superiority ($p \geq 0.05$), which did not differ significantly from the T1 (control) treatment, while the T5 treatment recorded the lowest weight gain rate, which did not differ significantly from the T3, T4, and T6 treatments. In the third week, the T4 treatment demonstrated a significant superiority ($p \geq 0.05$) in weight gain rate over the rest of the experimental treatments, except for the T2 treatment, which did not differ significantly from it. The T3 treatment recorded the lowest weight gain rate, with no significant difference from the T5 treatment. In the fourth and fifth weeks, the T2 and T1 treatments recorded the highest rates, while the T5 treatment recorded the lowest rates, not differing significantly from the T6 and T4 treatments in both weeks. When looking at the cumulative weight gain (0–5 weeks), Table 3 shows that the T2 treatment was significantly better ($p \geq 0.05$) than the T1 (control) treatment. On the other hand, the birds raised under the T5 lighting programs had the lowest rates, which were not significantly different from the T6 treatment.

Table 2: The effect of applying lighting programs on the body weight rate (g) of broiler chickens at different ages (mean $\pm$ standard error)

Treatments	First week	Second week	Third week	Fourth week	Fifth week
T1	208.08 $\pm$ 5.50	503.33 $\pm$ 6.12 ^{ab}	992.49 $\pm$ 9.32 ^a	1513.38 $\pm$ 10.68 ^a	2132.24 $\pm$ 13.85 ^a
T2	203.94 $\pm$ 8.69	512.47 $\pm$ 5.20 ^a	1005.72 $\pm$ 8.24 ^a	1519.38 $\pm$ 10.44 ^a	2146.82 $\pm$ 10.16 ^a
T3	206.44 $\pm$ 3.85	484.30 $\pm$ 8.07 ^{bc}	944.66 $\pm$ 6.98 ^{bc}	1451.77 $\pm$ 4.44 ^b	2041.72 $\pm$ 11.42 ^{bc}
T4	203.66 $\pm$ 8.53	465.44 $\pm$ 5.98 ^{cd}	965.77 $\pm$ 7.10 ^b	1462.86 $\pm$ 9.42 ^b	2056.31 $\pm$ 11.34 ^b
T5	205.99 $\pm$ 10.06	455.55 $\pm$ 7.58 ^d	918.96 $\pm$ 5.26 ^d	1409.30 $\pm$ 10.17 ^c	2001.52 $\pm$ 8.18 ^d
T6	205.27 $\pm$ 5.15	461.08 $\pm$ 5.76 ^d	932.13 $\pm$ 4.98 ^{cd}	1425.15 $\pm$ 3.19 ^c	2019.48 $\pm$ 5.30 ^{cd}
Sig. Level	NS	*	*	*	*

Different letters within each column indicate significant differences between the treatment means.* Indicates a significant difference at a significance level of 0.05. N.S indicates no significant difference. Treatments: T1: Continuous lighting (22 hours light: 2 hours dark) daily. T2: Intermittent lighting (11 hours light and 1 hour dark) twice daily. T3: Continuous lighting (20 hours light: 4 hours dark) daily. T4: Intermittent lighting (5 hours light and 1 hour dark) four times daily. T5: Continuous lighting (18 hours light: 6 hours dark) daily. T6: Intermittent lighting (3 hours light and 1 hour dark) six times daily.

The role of lighting programs (light periods), whether continuous or intermittent, in affecting feeding times may account for the reduction in live body weight and weight gain rates in the T6 and T5 treatments compared to the other study treatments. Longer dark periods prevent birds from accessing feed, thus reducing feed intake (Table 4), which in turn affects growth (Kim et al., 2022). This result is consistent with Abo Ghanima et al. (2021), who found that birds raised under continuous lighting (22 hours light and 2 hours dark) twice daily had superior live body weight and weight gain compared to other treatments. Lighting programs that increase dark periods during the final stages of growth and provide long feeding periods during light periods enable birds to meet their nutritional needs, thereby positively influencing their growth (Yang et al. 2015). Birds exposed to short light periods exhibit decreased growth performance due to the deficiency of some essential nutrients, particularly protein, which plays an important structural role in the body (Kim et al., 2022).

In Table 4, the feed consumption rate (g) of broiler chickens at different ages is shown to be affected by lighting programs. No significant differences ($p \geq 0.05$) were observed between the different experimental treatments in feed consumption rates during the first week as indicated by the table. However, in the second week, significant differences ($p \geq 0.05$) were observed between the different treatments. The T1 control program had the highest rates, while the T6 program had the lowest rates, which were not significantly different from treatments T5 and T4. In terms of cumulative feed consumption, the T6 treatment recorded the lowest rates, not significantly different from those of treatments T4 and T5, while the T1 treatment recorded the highest rate. The reason for this may be that birds raised under the T1 lighting program consumed more feed due to its availability. Rodrigues and Chout (2019) found that raising Cobb 500 broiler chickens under a continuous long lighting system significantly increased their feed consumption compared to those raised under an intermittent lighting system. Birds raised under different lighting systems had a gradual increase in food consumption as light hours increased (ShynKaruk et al., 2022).

Table 3: The effect of applying lighting programs on the weight gain rate (g) of broiler chickens at different ages (Mean $\pm$ SE)

Treatments	First week	Second week	Third week	Fourth week	Fifth week	Cumulative weight
T1	166.07 $\pm$ 5.50 ^a	295.25 $\pm$ 2.28 ^a	489.16 $\pm$ 3.56 ^b	520.89 $\pm$ 4.22 ^a	618.86 $\pm$ 3.17 ^a	2090.24 $\pm$ 13.85 ^a
T2	161.94 $\pm$ 8.69 ^a	308.52 $\pm$ 8.52 ^a	493.25 $\pm$ 3.04 ^{ab}	513.66 $\pm$ 3.21 ^{ab}	627.44 $\pm$ 1.08 ^a	2104.83 $\pm$ 10.16 ^a
T3	164.44 $\pm$ 3.85 ^{ab}	277.86 $\pm$ 11.87	460.36 $\pm$ 1.11 ^d	507.11 $\pm$ 2.60 ^{bc}	589.95 $\pm$ 7.29 ^b	1999.73 $\pm$ 11.42 ^{bc}
T4	161.66 $\pm$ 8.53 ^b	261.78 $\pm$ 9.81 ^{cd}	500.33 $\pm$ 5.04 ^a	497.09 $\pm$ 3.51 ^{cd}	593.45 $\pm$ 3.23 ^b	2014.31 $\pm$ 11.34 ^b
T5	163.99 $\pm$ 10.06 ^b	249.55 $\pm$ 13.65	463.41 $\pm$ 2.75 ^{cd}	490.34 $\pm$ 5.58 ^d	592.22 $\pm$ 2.53 ^b	1959.52 $\pm$ 8.18 ^d
T6	163.27 $\pm$ 5.15 ^b	255.81 $\pm$ 10.73	471.06 $\pm$ 1.89 ^c	493.02 $\pm$ 1.79 ^d	594.33 $\pm$ 2.62 ^b	1977.48 $\pm$ 5.30 ^{cd}
Sig. Level	NS	*	*	*	*	*

Different letters within each column indicate significant differences between the treatment means.* Indicates a significant difference at a significance level of 0.05. N.S indicates no significant difference. Treatments: T1: Continuous lighting (22 hours light: 2 hours dark) daily. T2: Intermittent lighting (11 hours light and 1 hour dark) twice daily. T3: Continuous lighting (20 hours light: 4 hours dark) daily. T4: Intermittent lighting (5 hours light and 1 hour dark) four times daily. T5: Continuous lighting (18 hours light: 6 hours dark) daily. T6: Intermittent lighting (3 hours light and 1 hour dark) six times daily.

The table (5) indicates no significant effect ($p \leq 0.05$) of the lighting programs on the feed conversion ratio rates for birds in the different experimental treatments in the first week of the birds' age. In the second week, the T2 treatment showed a significant improvement ($p \geq 0.05$) compared to the rest of the treatments, and it did not significantly differ from treatments T1, T3, and T4. Treatments T5 and T6 had the highest rates, but there was no significant difference between them and treatments T1 and T4. In the third week, treatment T4 showed a significant improvement ($p \geq 0.05$) compared to the other treatments and did not significantly differ from treatment T6, whereas treatments T1 and T3 recorded the highest rate. Treatments T2 and T5 showed a significant improvement compared to treatments T1 and T3 in the fourth week. The feed conversion ratio of birds raised under the T6 lighting program was the best, but it was not significantly different from those raised under treatments T3 and T5. The highest feed conversion ratio was recorded by birds under treatment T1, but it was not significantly different from treatments T2, T3, T4, and T5. Compared to the other treatments, birds under the T6 lighting program showed a significant improvement in the fifth week. Birds in treatment T1.

Table (4): The effect of applying lighting programs on the feed consumption rate (g) of broiler chickens at different ages (Mean $\pm$ SE)

Treatments	First week	Second week	Third week	Fourth week	Fifth week	Cumulative consumption

T1	169.30 ±3.05 ^a	379.16 ±4.17 ^a	680.30 ±5.29 ^a	908.96 ±7.53 ^a	1130.61 ±5.95 ^a	3268.34 ±25.42 ^a
T2	169.39 ±4.99 ^a	358.25 ±4.81 ^b	648.55 ±5.18 ^b	885.63 ±4.41 ^b	1106.47 ±5.68 ^b	3168.29 ±24.67 ^b
T3	161.75 ±6.83 ^{bc}	348.05 ±3.68 ^{bc}	638.77 ±3.37 ^{bc}	871.23 ±6.11 ^b	1076.09 ±9.52 ^c	3095.89 ±24.54 ^{bc}
T4	167.08 ±4.99 ^c	339.02 ±6.44 ^{cd}	628.50 ±4.24 ^{cd}	858.47 ±4.78 ^c	1042.85 ±6.26 ^d	3035.91 ±17.67 ^{cd}
T5	167.16 ±7.63 ^c	339.08 ±3.54 ^d	623.72 ±4.14 ^d	834.03 ±7.83 ^d	1002.23 ±7.63 ^e	2966.22 ±30.62 ^d
T6	169.16 ±5.95 ^c	336.19 ±3.83 ^e	604.86 ±4.78 ^d	822.58 ±6.65 ^d	973.85 ±6.13 ^f	2906.63 ±27.06 ^d
Sig. Level	NS	*	*	*	*	*

Different letters within each column indicate significant differences between the treatment means.* Indicates a significant difference at a significance level of 0.05. N.S indicates no significant difference. Treatments: T1: Continuous lighting (22 hours light: 2 hours dark) daily. T2: Intermittent lighting (11 hours light and 1 hour dark) twice daily. T3: Continuous lighting (20 hours light: 4 hours dark) daily. T4: Intermittent lighting (5 hours light and 1 hour dark) four times daily. T5: Continuous lighting (18 hours light: 6 hours dark) daily. T6: Intermittent lighting (3 hours light and 1 hour dark) six times daily.

Table (5): The effect of applying lighting programs on the feed conversion ratio (g feed/g weight gain) of broiler chickens at different ages (Mean± SE)

Treatments	First week	Second week	Third week	Fourth week	Fifth week	Cumulative conversion ratio
T1	1.02 ±0.02	1.28 ±0.02 ^{ab}	1.39 ±0.004 ^a	1.75 ±0.02 ^a	1.83 ±0.001 ^a	1.56 ±0.003 ^a
T2	1.05 ±0.80	1.16 ±0.04 ^b	1.31 ±0.02 ^{cd}	1.72 ±0.02 ^a	1.76 ±0.01 ^b	1.50 ±0.02 ^{cd}
T3	0.98 ±0.06	1.26 ±0.05 ^{ab}	1.39 ±0.01 ^{ab}	1.71 ±0.02 ^{ab}	1.82 ±0.02 ^a	1.55 ±0.01 ^{ab}
T4	1.04 ±0.04	1.30 ±0.03 ^{ab}	1.26 ±0.01 ^e	1.73 ±0.01 ^a	1.76 ±0.01 ^b	1.51 ±0.003 ^{cd}
T5	1.03 ±0.10	1.36 ±0.06 ^a	1.35 ±0.02 ^{bc}	1.70 ±0.02 ^{ab}	1.69 ±0.02 ^c	1.51 ±0.01 ^{bc}
T6	1.04 ±0.06	1.32 ±0.05 ^a	1.28 ±0.01 ^{de}	1.67 ±0.02 ^b	1.64 ±0.01 ^d	1.47 ±0.01 ^d
Sig. Level	NS	*	*	*	*	*

Different letters within each column indicate significant differences between the treatment means.* Indicates a significant difference at a significance level of 0.05. N.S indicates no significant difference. Treatments: T1: Continuous lighting (22 hours light: 2 hours dark) daily. T2: Intermittent lighting (11 hours light and 1 hour dark) twice daily. T3: Continuous lighting (20 hours light: 4 hours dark) daily. T4: Intermittent lighting (5 hours light and 1 hour dark) four times daily. T5: Continuous lighting (18 hours light: 6 hours dark) daily. T6: Intermittent lighting (3 hours light and 1 hour dark) six times daily.

Recorded the highest feed conversion ratio, but it was not significantly different from treatment T3. Treatments T2 and T4 showed a significant improvement compared to treatments T1 and T3, and treatment T5 showed a significant improvement ($p \geq 0.05$) compared to treatments T1, T2, T3, and T4. Notably, birds under treatment T6 achieved the best cumulative feed conversion ratio for the period of 1-5 weeks, while birds under treatment T1 recorded the lowest rate, which was not significantly different from treatment T3. Treatments T2, T4, and T5 showed significant improvement ($p \geq 0.05$) compared to treatment T1.

Reduced energy expenditure due to less movement during the dark period and slower food passage through the digestive tract, which provides more extended time for digestive enzymes to act on the food, improves digestion, and allows more prolonged absorption of digested nutrients, is responsible for the weekly and cumulative improvement in the feed conversion ratio under the T6 lighting program (Charles et al. 1992). The results of the current study align with Al-Samrai et al. (2023), who found that birds raised under intermittent lighting programs (4 hours light and 2 hours dark) four times daily recorded the best feed conversion ratio compared to the control birds raised under continuous lighting (24 hours light daily). The higher feed conversion ratio in birds raised under long light periods may be due to the higher feed consumption (Table 4), as there is a negative correlation between feed consumption and feed conversion ratio (Quintana-Ospina et al., 2023).

The table shows that the lighting programs have a significant effect ($p \geq 0.05$) on the total mortality rate in the different experimental treatments, with the lowest rate recorded in treatments T4 and T6, which is not significantly different from treatment T5. On the other hand, treatments T1 and T3 recorded the highest rates, which did not significantly differ from those of T2. The lower mortality rate in treatments T4 and T6 and the higher rate in treatments T1 and T3 may be due to metabolic disorders resulting from continuous feeding, especially in the early ages, given the high growth rate of the Ross 308 strain used in the study, which is associated with a high metabolic rate requiring high concentrations of thyroxine hormone secreted by the thyroid gland, leading to thyroid hormone disturbances and increased mortality rates linked to metabolic diseases such as ascites and sudden death syndrome (Buys et al. 1998). This result agrees with Hassanzadeh et al. (2005), Abo Ghanima et al. (2021), and Dhumal et al. (2022), who noted a significant decrease in total mortality rates with reduced light hours and intermittent lighting programs compared to continuous and nearly continuous lighting programs.

Production costs and economic returns are significantly influenced by livability and mortality rates (Table 6). The livability percentage went up significantly ($p \geq 0.05$) for treatments T4 and T6, which had the highest values but were not significantly different from treatment T. In contrast, treatments T1 and T3 recorded the lowest rates, which did not significantly differ from treatment T2. These results are directly influenced by the mortality rate, which is an indicator of flock livability. Table (6) shows significant differences ($p \geq 0.05$) in the economic index values for different treatments, with treatments T4 and T6 recording the highest values, but not significantly different from treatment T. On the other hand, birds under treatment T3 recorded the lowest economic index values, which were not significantly different from those under treatments T1 and T5. Given that this index considers all economic traits of broiler chickens, the significant improvement in the feed conversion ratio and the lower total mortality rate in these treatments compared to continuous lighting treatments may account for the significant increase in the economic index values for treatments using intermittent lighting programs. This result is in line with the findings of Kalaba et al. (2016), who observed that raising birds under intermittent lighting resulted in a significant increase in the economic index compared to continuous lighting.

Table (6): The effect of applying lighting programs on the total mortality rate, livability rate, and economic index score of broiler chickens at 35 days of age (Mean $\pm$ SE)

Treatments	Total Mortality Rate (%)	Livability Rate (%)	Economic Index Score
T1	8.33 $\pm$ 0.00 ^a	91.67 $\pm$ 0.00 ^c	357.15 $\pm$ 2.10 ^{bc}
T2	5.55 $\pm$ 2.78 ^{ab}	94.44 $\pm$ 2.78 ^{bc}	384.64 $\pm$ 6.35 ^{ab}
T3	8.33 $\pm$ 0.00 ^a	91.67 $\pm$ 0.00 ^c	345.43 $\pm$ 3.29 ^c
T4	0.00 $\pm$ 0.00 ^c	100.00 $\pm$ 0.00 ^a	389.82 $\pm$ 2.36 ^a
T5	2.78 $\pm$ 2.78 ^{bc}	97.22 $\pm$ 2.78 ^{ab}	357.51 $\pm$ 13.46 ^{bc}
T6	0.00 $\pm$ 0.00 ^c	100.00 $\pm$ 0.00 ^a	392.61 $\pm$ 6.24 ^a

Sig. Level	*	*	*
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Different letters within each column indicate significant differences between the treatment means.* Indicates a significant difference at a significance level of 0.05. N.S indicates no significant difference. Treatments: T1: Continuous lighting (22 hours light: 2 hours dark) daily. T2: Intermittent lighting (11 hours light and 1 hour dark) twice daily. T3: Continuous lighting (20 hours light: 4 hours dark) daily. T4: Intermittent lighting (5 hours light and 1 hour dark) four times daily. T5: Continuous lighting (18 hours light: 6 hours dark) daily. T6: Intermittent lighting (3 hours light and 1 hour dark) six times daily

Conclusions

According to our findings, the lighting programs used during the rearing period of broiler chickens have a significant impact on production performance. The use of intermittent lighting with a dark period of no less than 4 hours daily resulted in an improved feed conversion ratio and economic index, as well as a reduced total mortality rate. Also, it led to lower production costs by decreasing feed consumption and utilizing less electrical energy.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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