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The study on the adaptation of light spectrum control in broiler barns

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Abstract

This study examined the effects of light intensity and duration in closed broiler barns, comparing traditional and dimmable lamps on broiler performance. Four groups of Arbor Acres female broilers (n=100,000 per group) were subjected to different lighting conditions for 45 days: (A) traditional lamp, 18-24h; (B) traditional lamp, 18-23h; (C) dimmable LED, 18-24h, fixed 56% intensity; (D) dimmable LED, 18-23h, adjusted 20-80% intensity. Body weight (BW), average daily gain (ADG), feed conversion ratio (FCR), and mortality rate (% Mortality) were evaluated using a randomized complete block design. Group D achieved the lowest FCR (1.6) and highest ADG (69.2 g/day), while group A had the highest final BW (2,823.0 g/bird) and lowest mortality rate (1.2%), though differences were not statistically significant ($p>0.05$). Notably, groups with dimmable LEDs showed higher early-stage mortality. While controlling both light intensity and duration produced the best FCR results, the increased early mortality in these groups necessitates further investigation to optimize lighting programs that balance efficiency and bird welfare, particularly during the critical early growth phase.

Keywords: Broiler chicken, Feed conversion ratio, Light spectrum, Growth performance, Welfare

Introduction

Broilers are economically valuable and widely consumed animals. Due to their versatility in consumption across religions, high yields, and short raising time, they are one of the most important economic animals. Currently, chicken meat consumption in Thailand is on the rise. As a result of the rising demand for chicken meat, the domestic broiler farming industry has expanded rapidly. Furthermore, chicken products are essential to the Thai economy. The annual production of chicken meat in Thailand is 3.3 million tonnes, which represents 3.3% of the global total and ranks the country eighth globally. In addition, Thailand is the world's largest exporter of processed chicken with a market share of 11.9%, ranks sixth in the frozen chicken market with a market share of 2.6%, and is ranked 30th in the world for chilled chicken with a market share of 0.2% (BizVibe, 2020; Sowcharoensuk, 2020; USDA, 2021).

To improve broiler production, there has been an expansion of farming technology, including advancements in lighting systems. The intensity and duration of light can significantly affect broiler growth and behavior. Providing electric light stimulates chickens to see and eat at any time, potentially increasing growth (Deep et al., 2010). However, excessively bright lighting can make chickens more aggressive and active. Moreover, as chickens age, the impact of light intensity on production efficiency may change, suggesting that light intensity should be adjusted to conserve energy and optimize performance (Olanrewaju et al., 2014; Olanrewaju et al., 2016).

The aims of this study were to evaluate the effects of light intensity, duration, and lamp type (traditional vs. dimmable) on broiler performance, with a particular focus on FCR, body weight, average daily gain, and mortality rate. By conducting experiments in large-scale commercial settings, we sought to determine optimal lighting conditions that could be adapted to automatic rearing equipment, potentially improving the efficiency and welfare of broiler production.

Materials and Methods

1. Study area

The study was conducted in broiler barns at Cho-Ti Agricultural Innovation Co., Ltd. (Moo 6, Tambon Bo Kwang Thong, Bo Thong district, Chonburi Province, Thailand) during the third batch of broiler raising from July to September 2022 (Figure 1). It included 2 barns with traditional lamps (without dimmable lamp system) and 2 barns equipped with the Junglite Green model dimmable lamp system (Figure 2). The study was approved by the Institutional Animal Care and Use Committee of Chonburi Province (Approval number: 1261/2022).

2. Experimental methods

A total of 400,000 one-day-old female Arbor Acres broiler chickens were divided into four experimental groups, with 100,000 birds per group. The randomized complete block design (RCBD) was used in this study, with barns serving as blocks to account for potential variations in environmental conditions. Each treatment was replicated twice, with 50,000 birds per replicate. Details of each experimental group are given below and in Figure 3:

Group A = Traditional lamp, using 18-24 lighting hours.

Group B = Traditional lamp, using new program 18-23 lighting hours.

Group C = Barn with dimmable lamp system, supplement lamps Junglite Green model 94 tubes using 18-24 lighting hours and fixed intensity 56%.

Group D = Barn with dimmable lamp system, supplement lamps Junglite Green model 94 tubes using 18-23 lighting hours and adjusted intensity 20-80%.

From one day to forty-five days of age, chicks in all 4 barns were fed according to the standard protocol of the operator's broiler feed, with ample water and food provided throughout the experiment. The following data were recorded for each experimental group: 1. Body weight (BW) of chickens, 2. Mortality rate (%), 3. Average daily gain (ADG: final weight-initial weight divided by days), and 4. Feed conversion ratio (FCR: total feed consumed divided by total weight of product produced).

The dimmable light lamp (ONCE by Signify) added to the barns has the appearance of a long lamp containing red, green, and blue internal pigments. Upon adjusting the spectrum, certain pigments vanish. The light intensity (% dim) was set to a maximum of 80%, then gradually decreased based on the

experimental protocol to 64%, 56%, 48%, 40%, 32%, 24%, and 20% (Modified method of Once Inc., 2020). Statistical analyses of data were performed using one-way Analysis of variance (ANOVA) via Microsoft Excel program. Differences between treatment means were considered statistically significant at $p \leq 0.05$.

Figure 1 Broiler barn at Cho-Ti Agricultural Innovation Co., Ltd.

Figure 2 Inside broiler barn with installed dimmable light system.

	Chicken Age	Group A	Group B	Group C		Group D	
	Day	Lighting hour	Lighting hour	Lighting hour	% dim	Lighting hour	% dim
Week 1	1	24	23	24	56%	23	80%
	2	24	23	24	56%	23	80%
	3	24	22	24	56%	22	80%
	4	24	22	24	56%	22	80%
	5	24	21	24	56%	21	80%
	6	24	21	24	56%	21	80%
	7	24	20	24	56%	20	80%
Week 2	8	22	20	22	56%	20	64%
	9	22	20	22	56%	20	56%
	10	22	20	22	56%	20	48%
	11	22	20	22	56%	20	40%
	12	22	20	22	56%	20	32%
	13	22	20	22	56%	20	24%
	14	22	20	22	56%	20	20%
Week 3	15	20	20	20	56%	20	20%
	16	20	20	20	56%	20	20%
	17	20	20	20	56%	20	20%
	18	20	20	20	56%	20	20%
	19	20	20	20	56%	20	20%
	20	20	20	20	56%	20	20%
	21	20	20	20	56%	20	20%
Week 4	22	18	18	18	56%	18	20%
	23	18	18	18	56%	18	20%
	24	18	18	18	56%	18	20%
	25	18	18	18	56%	18	20%
	26	18	18	18	56%	18	20%
	27	18	18	18	56%	18	20%
	28	18	18	18	56%	18	20%
Week 5	29	18	18	18	56%	18	20%
	30	18	18	18	56%	18	20%
	31	18	18	18	56%	18	20%
	32	18	18	18	56%	18	20%
	33	18	18	18	56%	18	20%
	34	18	18	18	56%	18	20%
	35	18	18	18	56%	18	20%
Week 6	36	24	20	24	56%	20	20%
	37	24	21	24	56%	21	20%
	38	24	22	24	56%	22	20%
	39	24	22	24	56%	22	20%
	40	24	22	24	56%	22	20%
	41	24	22	24	56%	22	20%
	42	24	22	24	56%	22	20%
Week 7	43	24	22	24	56%	22	20%
	44	24	22	24	56%	22	20%
	45	24	22	24	56%	22	20%

Figure 3 Light hours and light intensity in 4 experimental groups.

Results

The results of the study comparing the weight of chickens, the number of dead chickens, ADG and FCR for each week are shown in Figures 4-7, respectively.

I. Hours

When comparing the experimental groups using the same type of lamp (Traditional lamp: Group A & B) but with varying light hours, it was observed that group A had a higher body weight than group B (Figure 4). group B had a higher ADG (Figure 6) and FCR (Figure 7), while group A had a lower mortality rate (Figure 5). However, these differences were not statistically significant ($p>0.05$).

II. Hours, light intensity

Comparing the experimental groups using the dimmable lamp system (Supplement lamps: Group C & D) with varying light hours and light intensity, group D showed higher body weight (Figure 4) and ADG (Figure 6) than group C, resulting in a lower FCR (Figure 7). group C had a higher mortality rate than group D (Figure 5), though these differences were not statistically significant ($p>0.05$).

III. Traditional lamps and dimmable lamp systems

When comparing the experimental groups using different types of lamps (Group A & C, B & D) with fixed light hours, group A had a higher body weight than group C (Figure 4), higher ADG and FCR (Figures 6-7), and a lower mortality rate (Figure 5). Comparing group B & D, group B had a higher body weight than group D

(Figure 4), while group D had a higher ADG and mortality rate (Figures 5-6). However, group B had a higher FCR than group D (Figure 7). These differences were not statistically significant ($p>0.05$).

Comparing group B (Original farm system) & C with fixed intensity 56%, group B showed higher body weight, ADG and FCR (Figures 4, 6-7). However, group D had a lower mortality rate than group C (Figure 5).

When comparing group A (Original farm system) & D with adjusting intensity 20-80%, group A had higher body weight (Figure 4), ADG, and FCR than group D (Figures 6-7). However, group A had a lower mortality rate than group D (Figure 5).

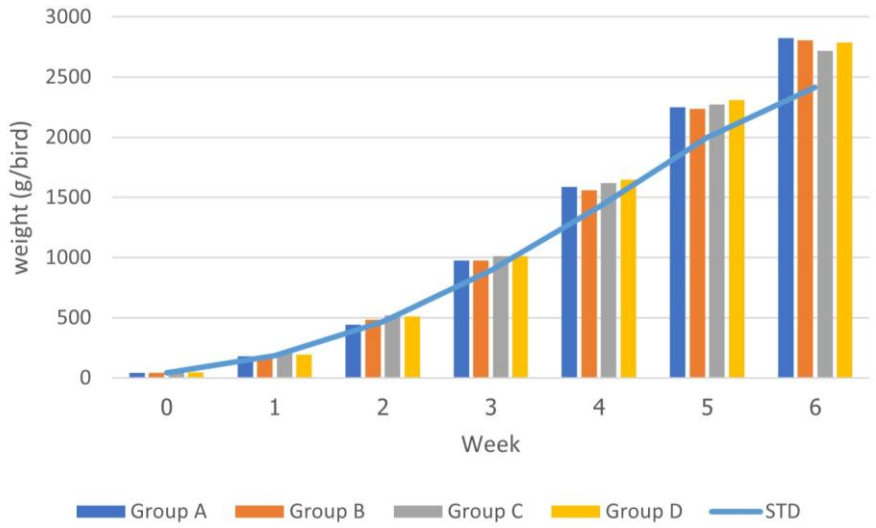

Figure 4 The weight of chicken in each experimental group.

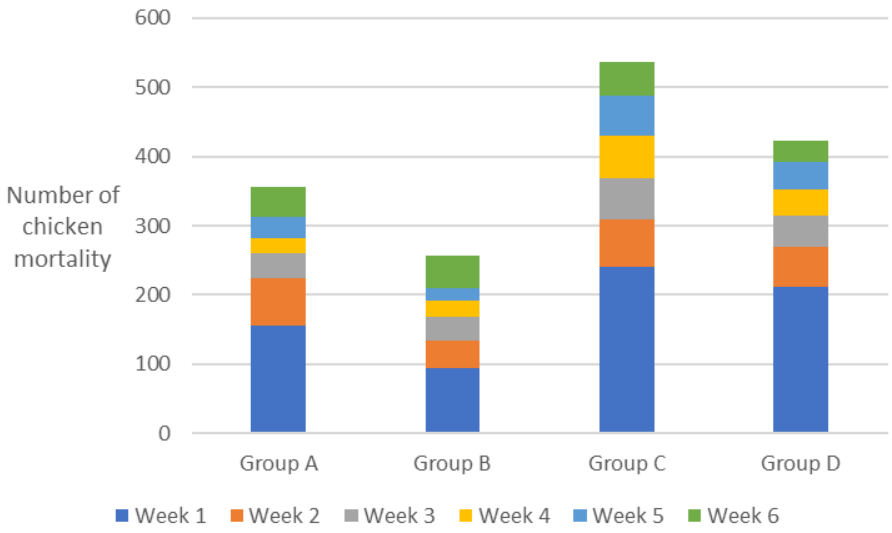

Figure 5 The number of chicken mortality per week of each experimental group.

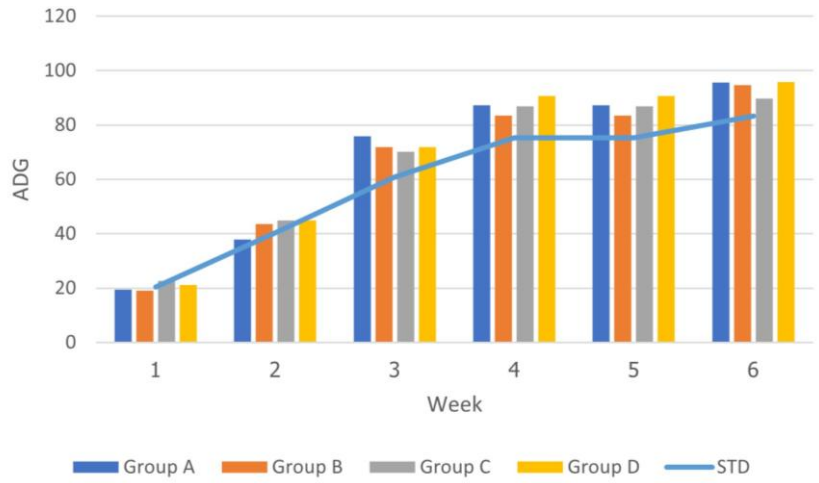

Figure 6 The average daily gain (ADG) of each experimental group.

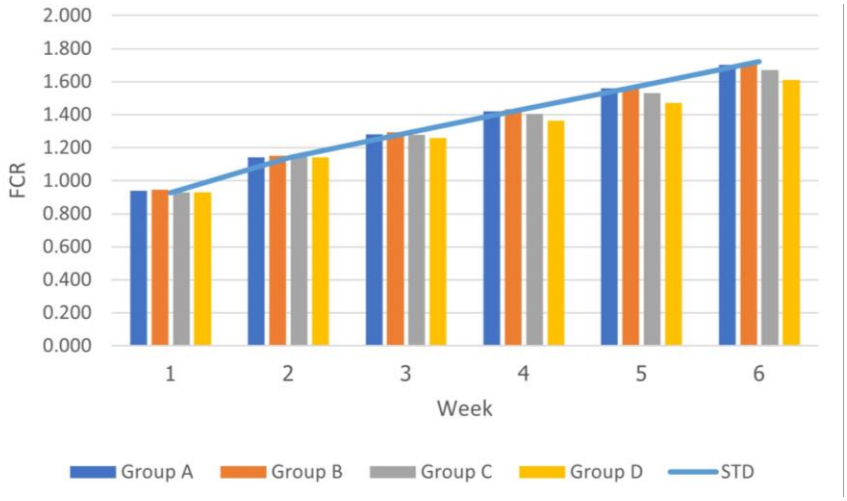

Figure 7 The feed conversion ratio (FCR) of each experimental group.

The treatments had no significant effect on the light intensity, hours and the different types of lamps of body weight, average daily gain, feed conversion ratio and mortality (%) according to the results of the ANOVA (Table 1).

Table 1 Parameters of the treatment groups as evaluated by Analysis of Variance (ANOVA)

Batch	Parameters	Treatment (%)				p-value
		Experiment group A	Experiment group B	Experiment group C	Experiment group D	
Female Arbor Acres broiler chickens	BW (gram)	2823.0±45.2	2805.0±43.8	2719.0±47.1	2789.5±44.6	0.999
	ADG	67.2±1.1	66.0±1.0	66.9±1.2	69.2±1.1	0.998
	FCR	1.7±0.03	1.7±0.03	1.7±0.03	1.6±0.03	0.986
	Mortality (%)	1.2±0.2	0.9±0.1	1.9±0.3	1.5±0.2	0.573

Note: ANOVA single factor's test at a 5% significance level ($p \leq 0.05$). BW, body weight at 48 days; ADG, average daily gain; FCR, feed conversion ratio; Mortality (%), mortality rate calculated based on 28,650 chickens.

Discussion

Our study, focusing on the impact of lighting conditions on broiler farming, particularly comparing traditional lamps versus a dimmable lamp system, provides insights into optimizing growth, feed efficiency, and overall farm performance. While our results did not show statistically significant differences, they suggest potential trends that warrant further investigation.

Lighting and broiler farming efficiency: Our results indicate potential improvements in feed conversion ratio (FCR) under dimmable lighting, particularly in group D (18-23h, adjusted 20-80% intensity), which aligns with the findings of Olanrewaju et al. (2016). They reported that manipulating light intensity can positively affect broiler growth and feed efficiency. The trend towards improved FCR in group D may be attributed to the dynamic light intensity, which could potentially mimic natural light patterns and support the birds' circadian rhythms.

Balancing efficiency and welfare: The higher mortality rate observed in our study under dimmable lighting conditions (Groups C and D) presents a challenge in balancing efficiency with welfare. This echoes the concerns raised by Deep et al. (2010), who found that lighting conditions could significantly impact broiler behavior and welfare. The increased early mortality in the dimmable LED groups might be related to stress responses to changing light conditions. Newborn chicks are particularly sensitive to environmental changes, and their underdeveloped thermoregulatory systems might be affected by variations in light intensity (Olanrewaju et al., 2006).

The physiological basis for these effects may lie in the influence of light on melatonin production and its subsequent impact on growth hormone secretion (Zeman et al., 1999). Melatonin, produced in darkness, plays a crucial role in regulating the growth hormone-insulin-like growth factor-1 axis, which is essential for muscle development in broilers (Zeman et al., 2004). The adjusted light intensity in group D might have optimized this hormonal balance, potentially explaining the trend towards improved growth performance.

Our findings contribute to this ongoing discussion by highlighting the need for optimal lighting that promotes growth without compromising animal health. The potential trade-off between improved FCR and increased mortality underscores the complexity of optimizing lighting conditions in broiler production.

Practical implications and future directions: While our study suggests potential benefits of dimmable LED systems, particularly in terms of FCR, the increased early mortality in these groups necessitates further

investigation. Future research should focus on fine-tuning lighting programs, especially during the critical first week of life. This could involve gradual introduction of varying light intensities or exploring different spectral compositions that might be less stressful for young chicks.

Additionally, future studies could benefit from longer experimental periods and larger sample sizes to detect potential statistical significance in the observed trends. Incorporating physiological measurements, such as plasma corticosterone levels or growth hormone concentrations, could provide deeper insights into the mechanisms underlying the effects of different lighting conditions on broiler performance and welfare.

Conclusion

In conclusion, based on light intensity and hours between traditional lamps and dimmable lamp systems, experiment group D (dimmable LED, 18-23h, 20-80% intensity) resulted in the lowest FCR values among the chickens. However, it should be noted that the groups with dimmable lamps had a higher 1-week mortality rate for chicks than the traditional lamp groups. To implement these findings, further research is necessary to optimize lighting programs, particularly during the critical first week of life. Future studies should investigate the physiological responses of broilers to different lighting conditions, consider longer experimental periods and larger sample sizes, and evaluate the economic implications of implementing dimmable LED systems. Additionally, exploring the interaction between lighting conditions and other environmental factors could provide a more comprehensive understanding of optimal rearing conditions. The ultimate goal is to develop lighting strategies that balance improved feed efficiency and growth with minimized stress and mortality in broiler production.

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