

Effect of Midnight Feeding on Performance and Production of Layer Hens Raised in Open House

Galy Hardyta^{1*}, Dody Houston Billhaq¹, Rifa Nisfatul Mina¹, Viona Aprilia¹,
Muhammad Alfin Yahya¹

¹Department of Animal Husbandry, Faculty of Agriculture, Tidar University, Magelang, Indonesia.

*Corresponding author: galy@untidar.ac.id

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Abstract

Midnight feeding (MF) has been shown to improve laying performance in closed-house systems; however, evidence under open-house conditions remains limited. This study evaluated the effects of MF on feed intake (FI), body weight (BW), egg production, egg mass, feed conversion ratio (FCR), and egg quality of laying hens reared in an open house. A completely randomized design was used with two treatments: 150 hens without MF (17L:7D; P0) and 150 hens with MF (17L:2.5D :2L:2.5D; P1). Treatments were initiated at week 24, with data collected from weeks 26 to 31. Statistical analysis was performed using an independent two-tailed t-test or Mann–Whitney U test according to data normality ($P \leq 0.05$). Midnight feeding had no significant effect on FI (approximately 118–122 g/day), BW (1705–1801 g), or Haugh unit (70–82) ($P \geq 0.05$). However, P1 showed significantly higher weekly egg production (WEP), reaching 70.93% vs. 56.44% in week 27 ($P \leq 0.05$). Eggshell thickness increased from 0.263–0.297 mm in P0 to 0.382–0.414 mm in P1 during significant weeks ($P \leq 0.05$). Egg mass was significantly higher in P1, for example 38.77 vs. 30.83 g/hen/day in week 27 ($P \leq 0.05$), resulting in improved FCR (3.06 vs. 3.84 in week 27; $P \leq 0.05$). These findings indicate that MF enhanced productive efficiency under open-house conditions without increasing feed intake or altering body weight and internal egg quality. Nevertheless, nocturnal photostimulation may influence circadian regulation, stress responses, and laying hen behaviour, particularly in tropical open-house systems.

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Introduction

Intermittent lighting programs are defined as lighting techniques that consist of two or more light and dark cycles within a 24-hour period (Farghly, 2019). The poultry industry is familiar with a similar program called midnight feeding. A midnight feeding program provides 1 to 2 hours of additional light during the dark period to stimulate feed consumption in the middle of the night (Hy-Line International, 2018; Ito, 2021). Although termed “feeding,” the program primarily operates through nocturnal photostimulation rather than the provision of additional feed. Providing photostimulation to hens can induce various responses such as hormone release, metabolic changes

related to the digestive system and feed intake, egg production rate, egg weight, and Haugh unit (Ma *et al.*, 2013; Geng *et al.*, 2014; Farghly and Makled, 2015).

Light acts as a primary environmental signal regulating the photo-neuroendocrine system in poultry (Yuwanta, 2004). Photoreceptive pathways transmit light signals to the hypothalamus, influencing the secretion of gonadotropin-releasing hormone (GnRH), which subsequently modulates ovarian activity through the hypothalamic–pituitary–gonadal (HPG) axis (Garcia-Fernandez *et al.*, 2015; Cheng *et al.*, 2021). In addition, light exposure during the dark phase may also alter melatonin secretion and circadian regulation, potentially affecting feeding patterns, reproductive performance, and production efficiency (Chowdhury *et al.*, 2010; Kasiyati, 2018; Ferreira *et al.*, 2024).

Research by Zhao *et al.* (2019) showed that broilers receiving an intermittent lighting program identical to midnight feeding (17 light: 3 dark: 1 light: 3 dark) had higher average daily feed intake compared to constant lighting. Leeson *et al.* (2003) reported that midnight feeding can manipulate growth and sexual maturity in pullets, resulting in increased egg production. Clark *et al.* (2025) demonstrated that an interrupted darkness lighting program improved eggshell quality. However, most studies have been conducted in closed-house systems.

Open houses are characterized by greater exposure to natural environmental factors (Lallo *et al.*, 2012), which may influence feeding behaviour, stress responses, and physiological adaptation compared with closed-house systems (Tesakul *et al.*, 2025). The limited availability of scientific data on midnight feeding under open-house conditions represents a significant knowledge gap, particularly in tropical production systems. Therefore, this study aimed to evaluate the effect of midnight feeding on feed intake, body weight, egg production, egg mass, feed conversion ratio, and egg quality in laying hens raised in an open house. It was hypothesized that midnight feeding, implemented through nocturnal photostimulation, would influence performance and production efficiency traits in laying hens reared under open-house conditions.

Materials and Methods

Ethics Approval

The Research Ethics Committee of Institute of Research and Community Service (IRCS), Tidar University, approved this study and gave the Ethical Number B/1143/UN57.L1/PT.01.04/2025. All applicable national and international guidelines for the care and use of animals were followed.

Animals and Experimental Design

A total of 300 Hy-Line Brown laying hens were used in this study. At the beginning of the experiment, hens were 24 weeks of age and were randomly assigned to two treatments (150 hens per treatment). The treatments consisted of:

- P0 (Control): continuous photoperiod of 17 hours light and 7 hours darkness (17L:7D).
- P1 (Midnight feeding): split photoperiod of 19 hours light and 5 hours darkness arranged as 17L:2.5D:2L:2.5D within a 24-hour cycle.

Each hen was housed individually in a cage (45 cm × 40 cm × 45 cm; one hen per cage). Individual hens served as experimental units for individually measured parameters, whereas for population-based production parameters, the treatment group served as the experimental unit.

Study area

The study was conducted in a commercial layer farm in Pringapus, Semarang Regency, Central Java, Indonesia. The housing system used was an open-sided house (open house system) that relied on natural ventilation. No mechanical ventilation system (e.g., exhaust fans or evaporative cooling pads) was used, and air circulation occurred passively through cross-ventilation across the open house structure. The average ambient temperature at the study site was 31 °C with approximately 54% relative humidity during the day, and 27 °C with approximately 68% relative humidity at night. Ambient temperature and relative humidity were measured twice daily, during the daytime and nighttime periods, throughout the experimental phase.

Diet Composition

All hens were fed the same commercial layer diet (PT Japfa Comfeed Indonesia Tbk., Indonesia) in mash form throughout the experimental period. The nutrient composition of the experimental diet, based on the manufacturer's label specifications, is presented in Table 1. All treatments received the same diet throughout the study to minimize potential nutritional confounding effects.

Table 1. Nutrient content of the commercial layer diet used in the experiment (based on manufacturer specifications)

Nutrient	Content
Crude protein (%)	≥ 17
Crude fat (%)	≥ 3
Crude fiber (%)	≤ 8
Calcium (%)	3.8–4.2
Available phosphorus (%)	≥ 0.40

Note: values were obtained from the manufacturer's label specification.

Lighting Program

Lighting was provided through a combination of natural daylight (approximately 12 hours) and supplemental artificial lighting (5 hours) to achieve a continuous 17-hour photoperiod in both treatments. Artificial light from incandescent bulbs was supplied for 1 hour before sunrise (04:00–05:00) and 4 hours after sunset (17:00–21:00) to maintain the targeted daily light duration.

P0 (Control) received 17 consecutive hours of light followed by 7 hours of continuous darkness (17L:7D). P1 (Midnight feeding treatment) received the same 17-hour primary light period, followed by 2.5 hours of darkness, then 2 additional hours of supplemental light during the night (23:30–01:30), and finally 2.5 hours of darkness, resulting in a total daily photoperiod of 19 hours of light and 5 hours of darkness (17L:2.5D:2L:2.5D).

The supplemental midnight lighting in P1 was provided using light-emitting diode (LED) lamps installed above the feeding troughs. LEDs were installed only in the P1 cages. Light intensity at hen level was maintained at approximately 18 lux and measured using a lux meter, with daily monitoring to ensure uniform exposure within treatments.

Feeding Management

Feed was provided twice daily at 07:00 (60 g/bird) and 15:00 (60 g/bird). No additional feed was supplied during the midnight light period in P1. Although no additional feed was provided during the midnight lighting period, the term “midnight feeding” was used following common poultry

management terminology referring to nocturnal light stimulation intended to encourage voluntary feed intake from previously supplied feed.

Experimental Timeline

The lighting treatments were initiated at week 24 of rearing. Weeks 24 and 25 were considered an adaptation period to allow hens to physiologically adjust to the modified photoperiod. Data collected during this adaptation phase were excluded from statistical analysis. Experimental data used for analysis were collected from week 26 to week 31 of rearing.

Measured parameters

Measured parameters were categorized according to the level of observation and experimental unit. For parameters requiring individual handling, including body weight, eggshell thickness, and Haugh unit, 10% of hens per treatment (15 hens per treatment) were selected using a simple random sampling procedure. Each selected hen was identified individually, and the same hens were evaluated throughout the experimental period.

Production-related parameters were calculated using aggregated data from all hens within each treatment group (150 hens per treatment). These included feed intake, Weekly egg production (WEP), egg weight (daily population mean), egg mass, and feed conversion ratio (FCR).

- a. Feed intake (g/hen/day) was determined by recording the amount of feed offered and subtracting the residual feed weighed the following morning (Setiawati *et al.*, 2016). Feed intake was calculated using the following formula (Sung and Adeola, 2022):

$$\text{Feed intake} = \frac{\text{feed given} - \text{feed remaining}}{\text{number of hens}}$$

- b. Body weight (g) was measured weekly using a digital scale.
 c. Weekly egg production (WEP, %) was calculated using the following formula (Ma *et al.*, 2013):

$$\text{WEP (\%)} = \frac{\text{number of weekly eggs}}{\text{number of hens at the beginning of week}} \times 100$$

- d. Eggshell thickness (mm) was measured using a vernier caliper at the sharp end, blunt end, and equatorial region of the egg, and the average value was recorded (Kul and Seker, 2004).
 e. Egg weight (g) was measured daily using a digital scale. Mean egg weight was calculated as the average daily egg weight per treatment across seven consecutive days within each week.
 f. Egg mass (g/hen/day) was calculated weekly using the following formula (Lukanov *et al.*, 2023):

$$\text{Egg mass} = \frac{\text{WEP} \times \text{mean egg weight}}{100}$$

- g. Feed conversion ratio (FCR) was calculated using the following formula (Yuan *et al.*, 2015):

$$\text{FCR} = \frac{\text{feed intake}}{\text{egg mass}}$$

- h. Haugh unit (HU) was determined based on albumen height (H) and egg weight (W) according to Haugh (1937):

$$\text{HU} = 100 \log (H + 7.57 - 1.7W^{0.37})$$

Statistical analysis

The data were first tested for normality using the Shapiro–Wilk test. Data that met the assumption of normal distribution were analyzed using an independent two-tailed t-test, whereas non-normally distributed data were analyzed using the Mann–Whitney U test. Statistical significance was declared at $P \leq 0.05$ ($\alpha = 5\%$). All statistical analyses were performed using SPSS version 25 software (IBM, 2017) .

Results and Discussion

Feed intake

Feed intake of laying hens in treatments P0 and P1 from week 26 to week 31 is presented in Table 2. No significant differences were observed between treatments throughout the observation period ($P \geq 0.05$). Feed intake increased from week 26 to week 28 and then stabilized during weeks 29–31. This pattern was similar in both treatments.

Table 2. Feed intake of laying hens affected by midnight feeding

Week	P0 (g/day)	P1 (g/day)	p-value
26	99.96 ± 7.10	102.74 ± 4.49	0.398
27	118.35 ± 4.32	118.45 ± 2.77	0.961
28	122.87 ± 10.46	118.84 ± 10.82	0.492
29	119.25 ± 2.79	120.06 ± 0.47	0.465
30	120.16 ± 1.15	120.20 ± 1.13	0.947
31	119.85 ± 0.81	119.93 ± 0.69	0.878

Body weight

The average body weight of laying hens in P0 and P1 from week 26 to week 31 is presented in Table 3. Body weight remained relatively stable in both treatments throughout the observation period, ranging from 1705.6 to 1801.0 g in P0 and from 1686.0 to 1783.0 g in P1. No significant differences were detected between treatments ($P \geq 0.05$).

Table 3. Body weight of laying hens affected by midnight feeding

Week	P0 (g)	P1 (g)	p-value
26	1705.6 ± 172.2	1686.0 ± 154.9	0.535
27	1711.0 ± 176.9	1720.7 ± 157.7	0.822
28	1721.7 ± 170.5	1746.8 ± 145.4	0.567
29	1763.5 ± 208.5	1783.0 ± 156.2	0.665
30	1801.0 ± 122.4	1768.8 ± 145.7	0.221
31	1779.2 ± 151.1	1775.8 ± 102.6	0.921

Weekly Egg Production (WEP)

Weekly Egg Production from week 26 to week 31 is shown in Table 4 midnight feeding significantly enhanced WEP during weeks 26–29 ($P \leq 0.05$). The most pronounced difference was observed in week 27 (70.93% in P1 vs. 56.44% in P0). In weeks 30 and 31, production remained numerically higher in P1 but was not statistically different ($P \geq 0.05$).

Table 4. Weekly egg Production (WEP) of laying hens affected by midnight feeding

Week	P0 (%)	P1 (%)	p-value
26	60.50 ± 1.67	64.79 ± 3.74	0.017*
27	56.44 ± 4.50	70.93 ± 3.24	0.000*
28	63.47 ± 3.26	72.13 ± 2.27	0.000*
29	71.01 ± 3.41	78.93 ± 2.87	0.002*
30	72.26 ± 2.88	73.33 ± 4.29	0.593
31	70.64 ± 1.77	72.24 ± 2.93	0.233

*Refers to signification at $p \leq 0.05$.

Eggshell thickness

Eggshell thickness values are presented in Table 5. Eggshell thickness was significantly greater in P1 during weeks 27, 28, 30, and 31 ($P \leq 0.05$). The largest difference occurred in week 27 (0.414 mm in P1 vs. 0.263 mm in P0). In week 29, P1 showed numerically higher values, but the difference was not statistically significant.

Table 5. Eggshell thickness of laying hens affected by midnight feeding

Week	P0 (mm)	P1 (mm)	p-value
26	0.353 ± 0.095	0.369 ± 0.087	0.562
27	0.263 ± 0.111	0.414 ± 0.063	0.0027*
28	0.281 ± 0.093	0.382 ± 0.079	0.0156*
29	0.297 ± 0.090	0.387 ± 0.090	0.0508
30	0.263 ± 0.070	0.400 ± 0.069	0.0007*
31	0.279 ± 0.052	0.382 ± 0.050	0.0006*

*Refers to signification at $p \leq 0.05$.

Egg weight

The results are presented in Table 6. Egg weight did not differ significantly between P0 and P1 in most observation weeks. A significant difference was observed only in week 30 ($P \leq 0.05$), where P0 exhibited slightly higher egg weight than P1. In the remaining weeks (26, 27, 28, 29, and 31), egg weight values were comparable between treatments. Overall, midnight feeding did not consistently alter egg weight under open-house conditions.

Table 6. Eggs weight of laying hens affected by midnight feeding

Week	P0 (g)	P1 (g)	p-value
26	54.90 ± 0.57	55.71 ± 2.64	0.454
27	54.63 ± 0.48	54.66 ± 2.65	0.976
28	54.54 ± 1.02	55.61 ± 1.25	0.105
29	57.86 ± 1.49	57.04 ± 1.70	0.359
30	58.65 ± 1.34	57.14 ± 1.07	0.039*
31	57.21 ± 0.97	57.22 ± 0.61	0.987

*Refers to signification at $p \leq 0.05$.

Egg Mass and Feed Conversion Ratio

Egg mass was significantly higher in hens subjected to midnight feeding during weeks 26–29 and week 31 ($P \leq 0.05$; Table 7). The most pronounced difference was observed in week 27, where egg mass increased from 30.83 to 38.77 g/hen/day. In week 30, no significant difference was detected between treatments.

Table 7. Egg mass and feed conversion ratio of laying hens affected by midnight feeding

Week	Egg mass (g/hen/day)			Feed conversion ratio (FCR)		
	P0	P1	p-value	P0	P1	p-value
26	33.22 ± 0.34	36.10 ± 1.71	0.0039*	3.01 ± 0.03	2.85 ± 0.14	0.014*
27	30.83 ± 0.27	38.77 ± 1.88	0.001*	3.84 ± 0.03	3.06 ± 0.14	0.001*
28	34.62 ± 0.64	40.11 ± 0.90	0.001*	3.55 ± 0.07	2.96 ± 0.07	0.001*
29	41.08 ± 1.06	45.02 ± 1.35	0.001*	2.90 ± 0.08	2.67 ± 0.08	0.001*
30	42.38 ± 0.97	41.90 ± 0.76	0.329	2.84 ± 0.06	2.87 ± 0.05	0.323
31	40.42 ± 0.68	41.34 ± 0.44	0.013*	2.97 ± 0.05	2.90 ± 0.03	0.017*

*Refers to signification at $p \leq 0.05$.

Feed conversion ratio reflected a similar pattern. Hens in P1 exhibited significantly lower FCR values (improved feed efficiency) during weeks 26–29 and week 31 ($P \leq 0.05$ Table 7). The greatest improvement occurred in week 27, where FCR decreased from 3.84 in P0 to 3.06 in P1.

Haugh unit (HU)

HU values are presented in Table 8. No significant differences were observed between P0 and P1 from week 26 to week 31 ($P \geq 0.05$). The average HU ranged from 69.86 to 80.77 in P0 and from 70.57 to 82.36 in P1.

Table 8. Haugh unit (HU) of laying hens affected by midnight feeding

Week	P0	P1	p-value
26	73.87 ± 19.35	70.57 ± 8.05	0.646
27	73.77 ± 23.63	82.36 ± 8.96	0.930
28	80.77 ± 8.36	71.09 ± 18.72	0.251
29	74.93 ± 8.23	74.63 ± 11.74	0.951
30	75.43 ± 8.33	75.32 ± 10.57	1.000
31	69.86 ± 8.41	70.82 ± 5.16	0.860

Previous studies conducted in closed-house systems reported that intermittent lighting, including midnight feeding, significantly altered feed intake (Petek *et al.*, 2005; Zhao *et al.*, 2019). In contrast, the present study conducted under open-house conditions showed no significant difference in feed intake between treatments. The absence of treatment effects may be related to the open-house environment, where hens are exposed to natural dawn and dusk transitions. Natural light gradients structure feeding behavior during daytime periods (Wang *et al.*, 2021; Geng *et al.*, 2022). Consequently, under open-house conditions, nocturnal photostimulation may redistribute feeding time rather than increase total feed intake. Extended nocturnal photostimulation has been associated with alterations in stress physiology in poultry (Olanrewaju *et al.*, 2006; Oke *et al.*, 2024). However, stress-related indicators were not measured in this study. The potential role of stress-related pathways under nocturnal photostimulation warrants further investigation under open-house conditions.

Similarly, body weight remained stable throughout the observation period and did not differ between treatments. The absence of body weight differences suggests that midnight feeding did not adversely affect growth or energy balance. This finding is consistent with the similar feed intake observed between treatments, indicating that extended nocturnal photostimulation did not impose a measurable metabolic burden during the study period.

In contrast to feed intake and body weight, midnight feeding significantly enhanced hen-week production during the early observation weeks. These findings suggest that nocturnal photostimulation may transiently augment reproductive output by modulating photoneuroendocrine signaling. Light exposure during normally dark phases is known to influence hypothalamic sensitivity to photoperiodic signals (Kuenzel *et al.*, 2015), potentially enhancing ovarian responsiveness during the early phase of peak production. The attenuation of statistical differences in later weeks may reflect physiological adaptation or stabilization of the reproductive axis under sustained photoperiod extension (Huang *et al.*, 2025).

Improvement was also observed in shell quality. The present findings are consistent with Clark *et al.* (2025), who reported improved eggshell quality under an interrupted darkness lighting program, and with Mohammed (2016), who demonstrated that variations in photoperiod length can influence eggshell thickness. Because shell calcification primarily occurs during the dark period, when calcium supply depends largely on medullary bone mobilization (Liu *et al.*, 2023), alterations in light–dark schedules may influence calcium availability for shell formation. Nocturnal photostimulation may therefore modify the timing of calcium mobilization and uterine activity, potentially optimizing mineral deposition (Clark *et al.*, 2024). However, because circulating calcium, estrogen, or bone turnover markers were not assessed, these mechanisms remain inferential.

Egg weight did not differ consistently between treatments across most observation weeks, indicating that the enhanced productive output under midnight feeding was primarily driven by increased oviposition frequency rather than sustained enlargement of individual eggs. Photoperiod length is a primary regulator of ovarian follicle hierarchy and ovulatory rhythm (Wolc *et al.*, 2019), and nocturnal photostimulation may amplify neuroendocrine signaling linked to ovulation timing and reproductive axis activation (Derese *et al.*, 2024), thereby increasing egg number rather than egg size.

Importantly, egg mass was significantly increased in hens subjected to midnight feeding during most observation weeks. Because feed intake remained similar between treatments, the higher egg mass resulted in improved feed conversion ratio, indicating enhanced biological efficiency rather than merely increased production output. Previous reviews have suggested that strategic lighting manipulation may improve feed efficiency and metabolic regulation without necessarily increasing total production output (Lee *et al.*, 2025). Variations in eggshell thickness may have contributed marginally to total egg mass, as previous studies have demonstrated a positive correlation between eggshell thickness and egg weight (Ukwu *et al.*, 2017). Despite increased egg mass, Haugh unit values did not differ between treatments, indicating that improved productivity was not accompanied by deterioration of internal egg quality.

A longitudinal mixed-effects analysis may provide further insight into treatment and time interactions and should be considered in future investigations.

Taken together, although midnight feeding did not alter feed intake, body weight, or Haugh unit, it significantly improved hen-week production, eggshell thickness, egg mass, and feed conversion efficiency during most observation weeks. These findings indicate that the midnight feeding program, implemented through nocturnal photostimulation, enhanced productive efficiency under open-house conditions without increasing feed consumption. Thus, the benefits observed appear to be associated primarily with photoperiod manipulation rather than increased nutrient intake.

However, because metabolic and endocrine parameters were not directly measured, this interpretation should be considered cautiously.

Conclusions

Midnight feeding, applied as nocturnal photostimulation in an open-house system, improved hen-week production, eggshell thickness, egg mass, and feed conversion efficiency without increasing feed intake or altering body weight and internal egg quality. These findings suggest that photoperiod manipulation through midnight lighting can enhance production efficiency in laying hens under open-house conditions. Further studies incorporating endocrine and metabolic measurements are warranted to elucidate the physiological mechanisms involved.

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Conflict of interests

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

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Author Contribution

The first and second authors drafted the original manuscript. All authors contributed to reviewing and editing the manuscript and approved the final version for submission.

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