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From Illumination to Biological Regulation: A Biological Reappraisal of Lighting Management in Chickens – A Review

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Abstract: Lighting management is a fundamental component of chicken production systems and has traditionally been applied as a technical tool to enhance activity, feeding behavior, and productivity. Increasing evidence, however, indicates that light functions not merely as illumination, but as a key biological signal regulating circadian rhythms, neuroendocrine pathways, behavior, welfare, and long-term production performance. This review provides a biological reappraisal of lighting management in chickens by synthesizing current evidence on how different lighting characteristics influence biological regulation and practical outcomes. A systematic literature review was conducted following PRISMA guidelines, with a qualitative synthesis approach adopted due to heterogeneity in study designs, lighting protocols, and outcome measures. Evidence was integrated across major lighting domains, including photoperiod duration, timing consistency, light intensity, spatial distribution, spectral composition, lighting technology, and stage-specific implementation. Emphasis was placed on identifying primary biological targets, expected production benefits, risks of mismanagement, and relevant monitoring indicators. The synthesized findings demonstrate that lighting management acts primarily through alignment with endogenous circadian and endocrine systems rather than isolated technical parameters. Lighting regimes that preserve circadian stability support sustainable productivity and animal welfare, whereas biologically inappropriate strategies may induce cumulative physiological stress and compromise long-term performance. This review highlights the need to reframe lighting management as a form of biological regulation to support data-driven and biologically informed production systems.

Keywords: Biological regulation, Chicken production, Circadian rhythm, Lighting management, Photoperiod

Introduction

Lighting management is a core component of chicken production systems and has long been used to regulate activity, feeding behavior and productivity (El-Sabrout et al., 2022; Nissa et al., 2024; Oktariansyah et al., 2026). Traditionally, light has been treated primarily as a source of illumination, applied to extend feeding time, stimulate growth, or enhance egg production (Kim et al., 2022). Consequently, lighting programs have often been designed using technical criteria such as photoperiod length, light intensity and energy efficiency, with limited integration of the biological mechanisms through which light influences the physiology and behavior of chickens (Wei et al., 2020; Nissa et al., 2024).

From a biological standpoint, light represents a dominant environmental signal rather than a passive management tool (Yu & Li, 2023). Chicken posses both retinal and extra-retinal photoreceptors, including deep-brain photoreceptive structures located in the pineal gland and hypothalamus (Wei et al., 2022; Wei et al., 2025). These photoreceptors enable light to directly regulate circadian rhytms and neuroendocrine pathway, influencing melatonin secretion, clock gene expression and downstream hormonal systems involved in growth, stress regulation, and reproduction (Tan et al., 2025; Oktariansyah et al., 2026). Throught these mechanisms, lighting conditions exert systematic effects on metabolism, immune competence, skeletal development, behavior and reproductive function (Wu et al., 2022; Yu & Li, 2023).

Growing evidence indicates that inappropriate lighting regimes can disrupt biological homeostasis in chicken. Continuous or near-continuous light exposure, poorly structured photoperiods, excessive or insufficient light intensity, and unsuitable spectral composition have been associated with circadian misalignment, elevated stress responses, compromised immune function, and impaired welfare (Kim et al., 2022; Jiang et al., 2023). Importantly, these adverse effects may not be immediately evident in short-term production metrics, which can lead to an overestimation of of the benefits of aggressive lighting strategies (Nelson et al., 2020; Yang et al., 2022. This disconnect highlights a key limitation of production-oriented lighting management that prioritizes output while neglecting biological regulation and long-term sustainibility.

Recent advances in lighting technology have further emphasized the need to reassess conventional lighting paradigms. The widespread use of programmable light-emitting diode (LED) systems has enabled precises control over photoperiod, light intensity, spectral composition and spatial distribution within chicken housing (Tikhomirov et al., 2021; Oso et al., 2022). These technologies provide unprecedented opportunities to align external lighting environments with the biological meeds of chicken across different developmental and production stages (Wei et al., 2020; Sun et al., 2023). However, without a biologically grounded framework, such technological flexibility risks being applied empirically rather than strategically, potentially exacerbating biological stress rather than alleviating it.

Although numerous studies have examined individual lighting factors in chicken, such as the effects of photoperiod duration, light intensity, or wavelenght-specific illumination (Arowolo et al., 2019; Li et al., 2021; Abdel-Moneim et al., 2024), this body of literature remains fragmented across disciplines, including physiology, behavior and production science. As a result, lighting management is often approached as a series of isolated technical decisions rather than as an integrated biological intervention. A comprehensive synthesis that connects lighting characteristics to their primary biological targets and translates mechanistic insights into practical practical management principles remains limited.

Therefore, this review provides a biological reappraisal of lighting management in chicken by reframing light as a regulator of biological components, including circadian ryhthms, neuoroendocrine, and behavioral systems rather than merely a source of illumination. This review synthesizes current knowledge on light perception and biological regulation in chicken and critically evaluates the practical implications of lighting management across production stages. By integrating biological mechanisms with applied management considerations, this review aims to support lighting strategies that enhance productivity whlie preserving biological stability, animal welfare, and long-term sustainability in chicken production systems.

Materials and Methods

Review Design and Conceptual Framework

This systematic literature review (SLR) was conducted to synthesize evidence on the biological and practical effects of lighting management in chicken. The review focused on how different lighting characteristics, including photoperiod, light intensity, spectral composition, timing consistency, and light source technology influence the biological regulation, physiological responses, behavior, welfare and production-related outcomes in chicken.

A protocol of review was developed prior to literature selection to minimize selection bias and enhance transparency and reproducibility of the evidence synthesis process. The protocol was designed and reported in accordance with the Preferred Reporting Items for Systematic

Reviews and Meta-Analyses (PRISMA) guidelines (Johnson & Hennessy, 2019; Page et al., 2020). The PRISMA framework was used to guide the formulation of research questions, identification of relevant records, screening and eligibility decisions, and synthesis of study outcomes. Methodological rigor was ensured by predefining eligibility criteria, inclusion and exclusion parameters related to population, exposure, comparators, outcomes and study design, as well as information sources, search strategies and standarized data extraction items (Brignardello-Petersen et al., 2025).

Given the expected heterogeneity among studies, including differences in chicken genotypes, productiogn stages, housing systems, lighting regimes and outcome measurements, this review primarily employed a qualitative sysnthesis approach. The methodological framework aimed to ensure that the synthesized findings are reproducible, biologically grounded, and suitable for informing biologically informed lighting management strategies in chicken production systems.

Research Questions and Review Framework

This systematic review was guided by a structured PICO-based framework () to clearly define the scope of evidence synthesis and ensure consistency in study selection and interpretation (Barrington et al., 2024). The PICO-based framework is described as follow; (i) Population (P): Chickens (broilers, layers, and breeders) across different production stages, (ii) Intervention (I): Lighting management variables, including photoperiod duration, light–dark schedules, light intensity, spectral composition, spatial distribution, and light source technology, (iii) Comparator (C): Alternative lighting regimes, conventional lighting practices, or baseline lighting conditions, (iv) Outcomes (O): Biological, physiological, behavioral, welfare, and production-related outcomes.

The review addressed the following research questions: (i) How do different lighting management strategies influence biological regulation in chickens, particularly circadian rhythm entrainment, neuroendocrine function, and stress physiology?, (ii) What are the effects of lighting characteristics on behavioral patterns, welfare indicators, and production performance in chickens?, (iii) Which factors contribute to variability in outcomes across studies, including lighting parameters, production stage, genotype, and management context?.

Literature Search Strategy

Literature searches were conducted using major scientific databases, including Scopus, Web of Science, PubMed, and Google Scholar, to ensure broad coverage of peer-reviewed and regionally relevant publications. Search strategies were adapted to the syntax of each database using Boolean operators, truncation, and quotation marks where appropriate (Bramer et al., 2018). The core search string included combinations of the following terms: *(“chicken” OR “broiler” OR “layer” OR “breeder”)* AND *(“lighting management” OR photoperiod OR “light intensity” OR “light spectrum” OR LED OR “light–dark cycle”)* AND *(“circadian rhythm” OR melatonin OR “neuroendocrine regulation” OR stress OR welfare OR “production performance”)*. Titles and abstracts were screened for relevance, followed by full-text assessment based on predefined eligibility criteria. Reference lists of relevant articles were also examined to identify additional studies not captured in the initial search.

Eligibility Criteria

Eligibility criteria for study selection summarize in Table 1.

Table 1. Eligibility criteria for study selection

Inclusion criteria	Exclusion criteria
Experimental or applied studies involving chickens	Studies on non-avian species only
Evaluation of ≥1 lighting parameter (photoperiod, intensity, spectrum, timing, or light source)	No lighting intervention or exposure
Full-text articles published in peer-reviewed journals	Unpublished studies, preprints,
Includes a comparator lighting condition	No control or comparator group
Reports ≥1 relevant outcome: biological (e.g., melatonin, stress indicators), behavioral, welfare, or production metrics	No extractable biological or performance outcomes

Published in English or Indonesian within the defined period (2010–2026)	Duplicates, inaccessible full text, beyond the acceptable defined period

Study Selection and Screening

After removal of duplicate records, studies were screened sequentially by title, abstract, and full text. For each included study, data were extracted using a standardized template covering lighting management domain, primary biological targets, production context, key outcomes, and reported risks or limitations. Disagreements during study selection or data extraction were resolved through discussion to ensure consistency.

Development of the Practical Implications Framework

Extracted data were synthesized qualitatively and organized according to major lighting management domains and their associated biological targets. Emphasis was placed on identifying consistent biological mechanisms and translating these mechanisms into practical management implications. This synthesis informed the development of a practical decision-support framework summarizing biologically informed lighting management strategies,

This review did not employ formal meta-analytical design and therefore does not provide quantitative effect size estimates. Additionally, variability in experimental conditions, genetic strains, housing systems, and outcome measures across studies limits direct comparison. Nevertheless, the integrative biological approach adopted in this review enables a coherent synthesis of diverse evidence and supports the development of biologically grounded lighting management principles.

Result and Discussion

Overview of Included Studies for Practical Synthesis

From the eligible literature, a subset of 11 key peer-reviewed studies was identified as particularly informative for synthesizing the biological and practical implications of lighting management in chickens. These studies collectively covered the major lighting management domains encountered in commercial and experimental systems, including photoperiod regulation, timing consistency, light intensity, spatial distribution, spectral composition, lighting technology, and adaptive evaluation frameworks.

Rather than reporting isolated outcomes, the evidence consistently linked specific lighting parameters to identifiable biological targets and measurable production or welfare responses. This allowed the organization of results into discrete but interconnected lighting management domains, which form the structural basis of the practical synthesis summarized in Table 2.

Table 2. Practical implications of lighting management in poultry chickens from a biological perspective

Lighting management domain	Primary biological target	Recommended practical approach	Expected production benefit	Common risks if mismanaged	Suggested monitoring indicators	Selected reference
Photoperiod (light–dark duration)	Circadian rhythm entrainment and activation of the hypothalamic–pituitary–gonadal (HPG) axis via melatonin and clock gene regulation	Apply age- and type-appropriate photoperiods (e.g., 14–18 h light for layers; 16L:8D for broilers); avoid continuous illumination; ensure a consistent dark period	Enhanced growth, reproductive organ development, and egg production; improved welfare under stable light–dark cycles	Continuous or insufficient darkness leading to circadian disruption, elevated stress (H/L ratio, corticosterone), leg disorders, and welfare impairment; excessively short photoperiod reducing feed intake and growth	Age at first egg; laying rate; body weight trajectory; H/L ratio; melatonin or clock gene rhythmicity (where feasible)	Geng et al., 2022; Yu & Li, 2023

Lighting management domain	**Primary biological target**	**Recommended practical approach**	**Expected production benefit**	**Common risks if mismanaged**	**Suggested monitoring indicators**	**Selected reference**
Timing consistency (light ON/OFF schedule)	Stability of endocrine rhythms and synchronization of behavior	Maintain a fixed daily lighting schedule; minimize abrupt or frequent timing changes; provide contingency systems for power interruptions	More predictable feeding, resting, and laying patterns; reduced stress and improved welfare	Irregular schedules causing circadian disturbance, altered feeding behavior, and unstable egg production	Variability in daily egg output; irregular feeding rhythms; activity–rest patterns	Geng et al., 2022; Helm et al., 2024
Light intensity	Regulation of activity, access to feed, and welfare-related physiological stability	Use moderate light intensities (≥20 lux) in feeding and inspection areas, with lower levels in resting zones; avoid prolonged exposure to ~5 lux or uniformly high intensities (>50 lux) without refuge areas	Adequate activity and feed intake, acceptable FCR, and improved gait and feather condition; lower stress indicators at moderate intensities	Very low intensity associated with increased physiological stress and ocular changes; excessive brightness inducing fear, agitation, and thermal load	Lux measurements at bird level; feed distribution; H/L ratio and corticosterone; gait, footpad, and eye condition scores	Kavtarashvili et al., 2019; Oktariansyah et al., 2026
Light distribution (spatial uniformity)	Minimization of micro-scale light gradients that drive performance variability	Design lighting layouts to achieve uniform illumination at bird height, particularly near feeders and drinkers; establish intentional bright activity zones and dim resting areas rather than random patches	More uniform growth and production; clearer spatial segregation of activity and rest behaviors	Patchy lighting causing uneven feed access, localized stress, and high within-flock variability in body weight and performance	Coefficient of variation (CV) of body weight and egg output by house zone; occupancy of bright versus dim areas	Zhou et al., 2025
Spectral composition (wavelength balance)	Activation of retinal and deep-brain photoreceptors regulating growth, thyroid, and gonadal	Match light spectra to age and production purpose: green/blue-enriched light during early growth; red-	Green/blue light in early life supporting muscle development and oxidative balance; red	Prolonged red light exposure, particularly at feeders, inducing photorefractoriness or delayed lay; inappropriate monochromatic	Egg-laying rhythm and persistence; body weight and muscle growth; reproductive hormone	Rozenboim et al., 2022; Galan et al., 2025

Lighting management domain	**Primary biological target**	**Recommended practical approach**	**Expected production benefit**	**Common risks if mismanaged**	**Suggested monitoring indicators**	**Selected reference**
	endocrine axes	enriched light for controlled reproductive photostimulation; avoid continuous strong red light at feeding areas	light applied at appropriate stages enhancing reproductive activation and egg output	lighting increasing stress or developmental abnormalities	profiles (where feasible)	
Light source technology (LED, CFL, incandescent)	Consistency of photic stimuli, including flicker characteristics and spectral stability, as well as energy efficiency	Prioritize modern LED systems with low flicker and stable spectral output; ensure regular maintenance and cleaning to prevent lux degradation	Comparable growth and carcass traits to conventional lighting with improved energy efficiency and flexible spectral control, without compromising welfare	Inadequately designed or dimmed systems introducing flicker or spectral instability, potentially causing stress or avoidance behavior	Lamp failure frequency; routine lux and spectral assessments; observation of flicker-related agitation or avoidance	Rozenboim et al., 2022; Galan et al., 2025; Oktariansyah et al., 2026
Interaction with feeding strategy	Coordination of nutrient availability with periods of activity and reproductive drive	Align extended light exposure with increased dietary nutrient density; avoid photoperiod extension without corresponding diet adjustment, especially in breeders	Improved efficiency of feed conversion to growth or egg mass; better support of follicular development and body reserves	Mismatch between lighting and nutrition leading to inefficient nutrient use and depletion of body reserves	Feed intake patterns; body weight uniformity; egg mass and shell quality	Mohammed, 2019
Stage-specific implementation (grower vs layer)	Alignment of endocrine readiness with physiological capacity	During rearing, emphasize circadian stability, rest, and skeletal development (e.g., 12–16L:8–12D); during laying, apply gradual photostimulation once body weight and frame targets are achieved	Smoother transition to lay, improved shell quality and laying persistence, and reduced leg problems	Premature or excessive photostimulation causing insufficient reserves, poor shell quality, and reduced long-term performance; overly short days during lay limiting production	Growth curves relative to targets; age and body weight at first egg; shell quality; laying persistence	Gent et al., 2022

Lighting management domain	Primary biological target	Recommended practical approach	Expected production benefit	Common risks if mismanaged	Suggested monitoring indicators	Selected reference
Risk prevention (overstimulation and inadequate darkness)	Regulation of stress, immune function, and physiological recovery via melatonin and the HPA axis	Avoid continuous or near-continuous lighting; preserve a consolidated daily dark period	Improved immune stability, reduced corticosterone and inflammatory responses, enhanced welfare and longevity	Chronic stress, immune suppression, metabolic and leg disorders, and reproductive decline under fragmented or continuous light	Mortality trends; H/L ratio; corticosterone; inflammatory markers (e.g., IL-6); abnormal behaviors such as restlessness or feather pecking	Mohammed, 2019; Helm et al., 2024
Evaluation framework (data-driven adjustment)	System-level optimization through feedback on circadian and endocrine stability	Implement gradual changes in photoperiod, intensity, or spectrum; link adjustments to defined performance and welfare metrics; avoid frequent abrupt modifications	More consistent and reproducible responses, enabling balance between productivity and welfare across stages and genotypes	Confounded outcomes when multiple lighting factors change simultaneously, leading to unstable production curves and ambiguous welfare signals	Weekly body weight and egg production trends; rolling HDP/FCR; welfare indices (gait, footpad, H/L ratio) tracked alongside lighting records	Wu et al., 2021

Photoperiod Management and Circadian–Reproductive Regulation

Across the reviewed studies, photoperiod emerged as a primary regulator of circadian entrainment and reproductive endocrine activation. Lighting programs incorporating a defined and stable dark phase were consistently associated with improved biological organization, reflected by synchronized activity patterns, stable growth trajectories, and enhanced reproductive development. Studies by Geng et al. (2022) and Yu & Li (2023) reported that continuous or severely shortened dark periods disrupted circadian regulation, leading to elevated physiological stress indicators and increased incidence of leg problems and welfare impairment. Conversely, age- and production-stage-appropriate photoperiods supported ovarian and oviduct development in laying hens and improved overall production stability. These findings highlight photoperiod duration as a foundational lighting parameter with both productive and welfare implications (Souza et al., 2023; Clark et al., 2025).

This biological perspective helps explain why lighting strategies that maximize short-term production, such as continuous illumination or excessive intensity can lead to hidden physiological costs. Disruption of circadian entrainment and endocrine stability may not immediately reduce output, but it compromises recovery processes, immune competence, and long-term performance (Yu & Li, 2023; Crespo et al., 2025). Table 2 encapsulates this concept by explicitly linking lighting domains to their primary biological targets and associated risks, reinforcing the view that lighting management should be approached as a biologically active intervention.

Timing Consistency of Light–Dark Schedules

In addition to photoperiod length, the consistency of daily light ON/OFF timing was identified as a critical determinant of endocrine rhythm stability and behavioral synchronization. Studies demonstrated that fixed lighting schedules supported predictable feeding, resting, and laying patterns, whereas frequent shifts or irregular timing were associated with circadian disruption and unstable egg production curves (Geng et al., 2022; Helm et al., 2024). Evidence indicated that timing inconsistency acted as a chronic stressor, even when total daily light exposure was unchanged. These results underscore that lighting regularity is a biologically relevant dimension of management, independent of photoperiod duration.

The biological reappraisal presented in this review clarifies that optimal lighting lies within a biologically defined range rather than at maximal exposure (Kim et al., 2022). This principle is particularly relevant given the flexibility afforded by modern LED technologies, which can easily exceed biologically tolerable thresholds if not guided by physiological considerations (El-Sabrout et al., 2022). Table 2 provides a practical counterbalance to this tendency by emphasizing optimization over maximization.

Effects of Light Intensity on Activity and Welfare

Light intensity was consistently linked to activity regulation, feed access, and welfare stability. Moderate intensities in feeding and inspection zones supported normal activity levels, acceptable feed conversion, and favorable gait, feather condition and reproduction rate. In contrast, prolonged exposure to very low intensities was associated with elevated physiological stress and potential visual or welfare concerns, while uniformly high intensities increased fear responses, agitation, and heat load (Kavtarashvili et al., 2019; Oktariansyah et al., 2026). These findings demonstrate that both insufficient and excessive illumination can compromise biological stability, emphasizing the need for intensity optimization rather than maximization.

Spatial Light Distribution and Within-Flock Uniformity

Several studies highlighted the importance of spatial uniformity in light distribution. Uneven illumination created micro-environmental gradients that resulted in heterogeneous feed access, unequal stress loads, and increased variability in body weight and production performance within flocks (Zhou et al., 2025).

Conversely, lighting designs that achieved uniform lux levels at bird height, particularly around feeders and drinkers were associated with more uniform growth and clearer behavioral zoning between activity and rest areas (El-Sabrout et al., 2022; Barros et al., 2020). These results indicate that spatial distribution of light is a key determinant of flock-level uniformity.

Spatial Light Distribution and Within-Flock Uniformity

Evidence from multiple studies demonstrated that spectral composition influenced biological regulation through wavelength-specific activation of retinal and deep-brain photoreceptors. Green- and blue-enriched light during early growth phases was associated with improved muscle development and oxidative balance, whereas red-enriched light applied during appropriate reproductive stages enhanced gonadal axis activation and egg production (Rozenboim et al., 2022; Galan et al., 2025).

However, prolonged or improperly targeted red light exposure, particularly at feeding areas was reported to induce photorefractoriness and delay the onset or persistence of lay (Hanlon et al., 2023; Takeshima et al., 2026). These findings emphasize the importance of stage-specific and purpose-driven spectral management.

Lighting Technology and Stability of Photic Stimuli

Comparisons among light source technologies indicated that modern LED systems generally provided stable photic stimuli with comparable or improved production outcomes relative to conventional incandescent or fluorescent lighting, while offering superior energy efficiency (Rozenboim et al., 2022; Galan et al., 2025).

Nonetheless, studies cautioned that poorly designed or inadequately maintained LED systems could introduce flicker or spectral instability, potentially eliciting stress or avoidance behavior (Miller et al., 2022; Oktariansyah et al., 2026). These results suggest that lighting technology affects biological responses primarily through the stability and reliability of light delivery rather than through energy efficiency alone.

Interaction with Feeding Strategy and Production Stage

Several studies reported interactions between lighting management, feeding strategy, and production stage. Extending photoperiods without corresponding dietary adjustment was associated with inefficient nutrient utilization and depletion of body reserves, particularly in breeders (Mohammed, 2019). Stage-specific implementation of lighting programs was consistently linked to improved long-term outcomes. Rearing phases benefited from lighting regimes that prioritized circadian stability and skeletal health, whereas reproductive phases required gradual photostimulation aligned with body weight and frame development to support shell quality and laying persistence (Gent et al., 2022).

Risk Prevention and Data-Driven Evaluation

Evidence consistently indicated that overstimulation and inadequate darkness posed significant biological risks, including chronic stress, immune suppression, and metabolic or reproductive disorders (Mohammed, 2019; Helm et al., 2024). Preserving a consolidated dark period was associated with improved physiological recovery and welfare outcomes. Several studies emphasized the importance of data-driven evaluation frameworks that integrate production, physiological, and welfare indicators to guide gradual lighting adjustments and avoid confounded responses (Wu et al., 2021). These findings support adaptive lighting management based on biological feedback rather than static prescriptions.

Implications for Welfare and Sustainable Production

The biological alignment of lighting management has direct implications for animal welfare and production sustainability. Lighting regimes that respect circadian and endocrine regulation reduce chronic stress, support immune function, and promote behavioral stability. These outcomes are increasingly recognized as integral to sustainable production systems, where welfare and productivity are not competing objectives but interdependent outcomes (Lucas et al., 2024; Dauchy et al., 2024; Farag et al., 2024).

By explicitly incorporating welfare-related indicators alongside production metrics, the framework in Table 2 supports a more holistic evaluation of lighting management. This approach aligns with emerging expectations from regulators, consumers, and industry stakeholders for production practices that are both efficient and ethically grounded.

Limitations and Future Research Directions

Despite the strengths of this synthesis, several limitations warrant consideration. The reviewed studies varied widely in experimental design, lighting protocols, genotypes, and outcome measures, limiting direct quantitative comparison. Additionally, many studies focused on single lighting parameters, whereas biological regulation likely arises from interactions among multiple lighting characteristics.

Future research would benefit from integrative experimental designs that simultaneously manipulate photoperiod, intensity, and spectral composition while monitoring biological and welfare indicators. Further exploration of emerging areas, such as epigenetic responses to early-life lighting and interactions between lighting management and gut microbiota, may provide deeper insights into long-term biological regulation. Adaptive, data-driven lighting systems incorporating real-time biological feedback represent a promising direction for both research and practice.

Conclusion

This review demonstrates that lighting management in chickens' functions as a core biological regulator shaping circadian rhythms, neuroendocrine function, behavior, welfare, and production outcomes. The primary finding is that biologically coherent lighting regimes that defined by appropriate photoperiod, timing consistency, intensity, spectral composition, and spatial distribution which support physiological stability and sustainable performance, whereas biologically misaligned strategies generate cumulative physiological costs. Collectively, the evidence supports a shift from technically driven lighting optimization toward biologically informed management to enhance resilience, welfare, and long-term productivity in chicken production systems.

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Reference

Abdel-Moneim A.E.A., Siddiqui S.A., Shehata A.M., Biswas A., Abougabal M.S., Kamal A.M., Mesalam N.M., Elsayed M.A., Yang B., Ebeid T.A. & Teng X. (2024). Impact of Light Wavelength on Growth and Welfare of Broiler Chickens – Overview and Future Perspective. *Annals of Animal Science*, 24 (3): 717-727. DOI: https://doi.org/10.2478/aoas-2023-0118.

Arowolo M.A., He J.H., He S.P. & Adebowale T.O. (2019). The implication of lighting programmes in intensive broiler production system. *World's Poultry Science Journal*, 75 (1): 17-28. DOI: https://doi.org/10.1017/S0043933918000934.

Barrington M.J., D'Souza R.S., Mascha E.J., Narouze S., Kelley G.A. (2024). Systematic Reviews and Meta-analyses in Regional Anesthesia and Pain Medicine (Part I): Guidelines for Preparing the Review Protocol. *Anesthesia & Analgesia*, 138 (2): 379-394. DOI: https://doi.org/10.1213/ANE.0000000000006573.

Barros J.S.G., Barros T.A.S., Sartor K., Raimundo J.A. & Rossi L.A. (2020). The effect of linear lighting systems on the productive performance and egg quality of laying hens. *Poultry Science*, 99 (3): 1369 - 1378. DOI: https://doi.org/10.1016/j.psj.2019.11.007.

Bramer W.M., de Jonge G.B., Rethlefsen M.L., Mast F. & Kleijnen J. (2018). A systematic approach to searching: an efficient and complete method to develop literature searches. *Journal of the Medical Library Association*, 106 (4): 531-541. DOI: https://doi.org/10.5195/jmla.2018.283.

Brignardello-Petersen R., Santesso N. & Guyatt G.H. (2025). Systematic reviews of the literature: an introduction to current methods. *American Journal of Epidemiology*, 194 (2): 536–542. DOI: https://doi.org/10.1093/aje/kwae232.

Clark A., Bragg A., Alqhtani A., Arguelles-Ramos M. & Ali A. (2025). The Influence of Different Light Day Distribution in Hy-Line W36 Laying Hens on Egg Production and Egg Quality. *Animals: an Open Access Journal from MDPI*, 15 (6): 838. DOI: https://doi.org/10.3390/ani15060838.

Crespo M., Trebucq L., Senna C., Hokama G., Paladino N., Agostino P. & Chiesa J. (2025). Circadian disruption of feeding-fasting rhythm and its consequences for metabolic, immune, cancer, and cognitive processes. *Biomedical Journal*, 48 (1): 100827. DOI: https://doi.org/10.1016/j.bj.2025.100827.

Dauchy R., Hanifin J., Brainard G. & Blask D. (2024). Light: An Extrinsic Factor Influencing Animal-based Research. *Journal of the American Association for Laboratory Animal Science*, 63 (2): 116 - 147. DOI: https://doi.org/10.30802/aalas-jaalas-23-000089.

El-Sabrout K., El-Deek A., Ahmad S., Usman M., Dantas M.R.T. & Souza-Junior J.B.F. (2022). Lighting, density, and dietary strategies to improve poultry behavior, health, and production. *Journal of Applied Animal Biometeorology*, 10 (1): e2212. DOI: https://doi.org/10.31893/jabb.22012.

Farag H., Murphy B., Templeman J., Hanlon C., Joshua J., Koch T., Niel L., Shoveller A., Bédécarrats G., Ellison A., Wilcockson D. & Martino T. (2024). One Health: Circadian Medicine Benefits Both Non-human Animals and Humans Alike. *Journal of Biological Rhythms*, 39 (3): 237 - 269. DOI: https://doi.org/10.1177/07487304241228021.

Galan L., Solcan G. & Solcan C. (2025). The Influence of Different Light Spectra on

Broiler Chicken Endocrine Systems and Productivity. *Animals*, 15 (21): 3209. DOI: https://doi.org/10.3390/ani15213209.

Geng A.L., Zhang Y., Zhang J., Wang H.H., Chu Q., Yan Z.X. & Liu H.G. (2022). Effects of light regime on circadian rhythmic behavior and reproductive parameters in native laying hens. *Poultry Science*, 101 (5): 101808. DOI: https://doi.org/10.1016/j.psj.2022.101808.

Gent T.C., Geng A.L. & Mason G.J. (2022). Effects of light intensity and photoperiod on the welfare and production of laying hens: A systematic review. *Poultry Science*, 101 (4): 101719. DOI: https://doi.org/10.1016/j.psj.2022.101719.

Hanlon C., Zuidhof M.J., Rodriguez A., Takeshima K. & Bédécarrats G.Y. (2023). Continuous exposure to red light induces photorefractoriness in broiler breeder pullets. *Poultry Science*, 102 (4): 102542. DOI: https://doi.org/10.1016/j.psj.2023.102542.

Helm B., Greives T. & Zeman M. (2024). Endocrine–circadian interactions in birds: implications when nights are no longer dark. *Philosophical Transactions of the Royal Society B*, 379 (1898): 20220514. DOI: https://doi.org/10.1098/rstb.2022.0514.

Jiang S., Fu Y. & Cheng H.W. (2023). Daylight exposure and circadian clocks in broilers: part I—photoperiod effect on broiler behavior, skeletal health, and fear response. *Poultry Science*, 102 (12): 103162. DOI: https://doi.org/10.1016/j.psj.2023.103162.

Johnson B.T. & Hennessy E.A. (2019). Systematic reviews and meta-analyses in the health sciences: Best practice methods for research syntheses. *Social Science & Medicine*, 233: 237-251. DOI: https://doi.org/10.1016/j.socscimed.2019.05.035.

Kavtarashvili A.S., Fisinin V.I., Buyarov V.S. & Kolokolnikova T.N. (2019). The effects of lighting regimes on the oviposition time and egg quality in laying hens. *Sel'skokhozyaistvennaya Biologiya*, 54 (6): 1095-1109. DOI: https://doi.org/10.15389/agrobiology.2019.6.1095eng.

Kim H.J., Son J., Jeon J.J., Kim H.S., Yun Y.S., Kang H.K., Hong E.C. & Kim J.H. (2022). Effects of Photoperiod on the Performance, Blood Profile, Welfare Parameters, and Carcass Characteristics in Broiler Chickens. *Animals*, 12 (17): 2290. DOI: https://doi.org/10.3390/ani12172290.

Li X., Rathgeber B., McLean N. & MacIsaac J. (2021). Providing colored photoperiodic light stimulation during incubation: 2. Effects on early posthatch growth, immune response, and production performance in broiler chickens. *Poultry Science*, 100 (9): 101328. DOI: https://doi.org/10.1016/j.psj.2021.101328.

Lucas R.J., Allen A.E., Brainard G.C., Brown T.M., Dauchy R.T., Didikoglu A., Do M.T.H., Gaskill B.N., Hattar S., Hawkins P., Hut R.A., McDowell R.J., Nelson R.J., Peirson S.N. (2024). Recommendations for measuring and standardizing light for laboratory mammals to improve welfare and reproducibility in animal research. *PLOS Biology*, 22 (3): e3002535. DOI: https://doi.org/10.1371/journal.pbio.3002535.

Miller N.J., Leon F.A. & Irvin L. (2022). Flicker: A review of temporal light modulation stimulus, responses, and measures. *Lighting Research & Technology*, 55 (1): 5 - 34. DOI: https://doi.org/10.1177/14771535211069482.

Mohammed H.H. (2019). Assessment of the role of light in welfare of layers. *SVU-International Journal of Veterinary Sciences*, 2 (1): 36-50. DOI: https://doi.org/10.21608/svu.2019.23122.

Nelson J.R., Bray J.L., Delabbio J. & Archer G.S. (2020). Comparison of an intermittent, short-dawn/dusk photoperiod with an increasing, long-dawn/dusk photoperiod on broiler growth, stress, and welfare. *Poultry Science*, 99 (8): 3908-3913. DOI: https://doi.org/10.1016/j.psj.2020.05.015.

Nissa S.S., Sheikh I.U., Altaie H.A.A., Adil S., Banday M.T., Kamal M., Alqhtani A.H., Swelum A.A., Khafaga A.F., Al-Shehri M. & El-Hack M.E.A. (2024). Impacts of Various Lighting Programs on Chicken Production and Behavior – A Review.

Annals of Animal Science, 24 (4): 1065 - 1079. DOI: https://doi.org/10.2478/aoas-2023-0097.

Oktariansyah Y., Billa A.S. & Masito. (2026). Integrated Analysis and Performance Modeling of Egg Production in KUB Chickens under Different Light Sources. *JPBIO (Jurnal Pendidikan Biologi)*, (In Press).

Oso O.M., Metowogo K., Oke O.E. & Tona K. (2022). Evaluation of light emitting diode characteristics on growth performance of different poultry species: a review. *World's Poultry Science Journal*, 78 (2): 337-351. DOI: https://doi.org/10.1080/00439339.2022.2007509.

Page M.J., McKenzie J.E., Bossuyt P.M., Boutron I., Hoffmann T.C., Mulrow C.D., Shamseer L., Tetzlaff J.M., Akl E.A., Brennan S.E., Chou R., Glanville J., Grimshaw J.M., Hrõbjartsson A., Lalu M.M., Li T., Loder E.W., Mayo-Wilson E., McDonald S., McGuinness L.A., Stewart L.A., Thomas J., Tricco A.C., Welch V.A., Whiting P. & Moher D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Systematic Reviews*, 10 (1): 89. DOI: https://doi.org/10.1186/s13643-021-01626-4.

Rozenboim I., Bartman J., Avital Cohen N., Mobarkey N., Zaguri S., El Halawani M.E., Biran I., Rosenstrauch A. & Marco A. (2022). Targeted differential photostimulation alters reproductive activities of domestic birds. *Frontiers in Physiology*, 13: 1040015. DOI: https://doi.org/10.3389/fphys.2022.1040015.

Souza C., Bedin A. & Gewehr C. (2023). Lighting Programs of White Layers Hens in Start Phase Production. *Brazilian Journal of Poultry Science*, 25 (4): eRBCA-2023-1792. DOI: https://doi.org/10.1590/1806-9061-2023-1792.

Sun Y., Li Y., Ma S., Shi L., Chen C., Li D., Guo J., Ma H., Yuan J. & Chen J. (2023). Effects of LED Lights with Defined Spectral Proportion on Growth and Reproduction of Indigenous Beijing-You Chickens. *Animals*, 13 (4): 616. DOI: https://doi.org/10.3390/ani13040616.

Takeshima K., Zuidhof M.J., Hanlon C. & Bédécarrats G.Y. (2026). Impact of daytime and supplemental feeder light spectrum on female broiler breeder growth and reproductive performance. *Poultry Science*, 105 (1): 106074. DOI: https://doi.org/10.1016/j.psj.2025.106074.

Tan X., Jin Y., Li J., Dong J., Huang M. & Wang D. (2025). Investigation regarding the effects of different monochromatic lights on lipid metabolism and immune function in chickens. *Poultry Science*, 104 (8): 105291. DOI: https://doi.org/10.1016/j.psj.2025.105291.

Tikhomirov D., Trunov S., Kuzmichev A. & Rastimeshin S. (2021). The Implementation of Energy-Saving Lighting Systems for Poultry Houses. *KnE Life Sciences*, 2021: 807–817. DOI: https://doi.org/10.18502/kls.v0i0.9018.

Wei S.Q., Yin P., Tang W.Y., Zhang Z.Y., Chu W., Tong Q., Li B.M., Zheng W.C. & Wang C.Y. (2025). Prenatal light exposure affects diurnal rhythms and visual development of the layer embryonic retina. *Poultry Science*, 104 (1): 104497. DOI: https://doi.org/10.1016/j.psj.2024.104497.

Wei Y., Zheng W., Li B., Tong Q. & Shi H. (2020). Effects of a two-phase mixed color lighting program using light-emitting diode lights on layer chickens during brooding and rearing periods. *Poultry Science*, 99 (10): 4695-4703. DOI: https://doi.org/10.1016/j.psj.2020.06.072.

Wei Y., Zheng W., Tong Q., Li Z., Li B., Shi H. & Wang Y. (2022). Effects of blue-green LED lights with two perceived illuminance (human and poultry) on immune performance and skeletal development of layer chickens. *Poultry Science*, 101 (7): 101855. DOI: https://doi.org/10.1016/j.psj.2022.101855.

Wu Y., Huang J., Quan S. & Yang Y. (2022). Light regimen on health and growth of broilers: an update review. *Poultry Science*, 101 (1): 101545. DOI: https://doi.org/10.1016/j.psj.2021.101545.

Yang Y., Cong W., Liu J., Zhao M., Xu P., Han W., Wang D. & Zhao R. (2022). Constant light in early life induces fear-related behavior in chickens with suppressed melatonin secretion and disrupted hippocampal expression of clock- and BDNF-associated genes. *Journal of Animal Science and Biotechnology*, 13 (1): 74. DOI: https://doi.org/10.1186/s40104-022-00720-4.

Yu Y. & Li Z. (2023). Research Progress and Effects of Light on Poultry Circadian Rhythm Regulation Based on CiteSpace. *Applied Sciences*, 13 (5): 3157. DOI: https://doi.org/10.3390/app13053157.

Zhou S., Thornton T., Gan H., Tabler T. & Zhao Y. (2025). Impact of Lighting Intensity on Welfare and Performance in Broiler Chickens. *Animals*, 15 (22): 3348. DOI: https://doi.org/10.3390/ani15223348.