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Environmentally Enriched Lighting Improves Broilers' Welfare and Productivity

Yi Liang
Assoc. Professor - Air Quality
Biological & Agricultural Engineering

Seong Kang
Post Doctoral Fellow
Department of Poultry Science

Karen Christensen
Adjunct Associate Professor
Animal Welfare

Zac Williams
Extension Specialist - Poultry Husbandry and Management
Department of Poultry Science

Lighting in broiler production

Environmental enrichment has been suggested to increase the complexity of broiler houses while benefiting broilers' welfare (Jacobs et al., 2023). Commercial broilers raised in confined spaces rely on artificial light to accomplish their daily activities. It is well established that light influences growth, behavior and reproduction in birds.

Light is typically provided by fluorescent or light-emitting diode (LED) lamps in modern poultry production. Footcandle (fc) is a measure of the light intensity on a surface and helps to standardize the value of light sources. Traditionally in the United States, newly hatched chicks have been given an average light intensity of >2 fc up to 14 days of age, and then 0.5 to 1 fc afterwards. In contrast, the European Union established a minimum light intensity of 2 fc for rearing broiler chickens (European Commission, 2017).

It is generally accepted that chickens exhibit greater activity under bright light than dim light. Dim lighting is linked with impaired well-being indices (e.g., preening, foot lesions) and increased eye abnormalities. However, research on the effect of light intensity in the range of 0.05 to 10 fc in the past decades has reported mixed results in growth performance. Despite considerable research on light intensity, there is still a debate on the optimum brightness for intensively housed broilers.

What do birds like?

Natural behavior is a starting point for assessing animal welfare. In intensive farming systems, natural behavior can help us understand what animals want or like (Dawkins, 2023). Most light intensity research in the past has been conducted to investigate the effect of fixed uniform intensity levels such as 0.1, 1, 2, or 4 fc from a certain age, i.e. seven days, to five or six weeks of age. Fundamentally, much of this research has overlooked that chickens, like other animals, have preferences in their surrounding environment if given choices. For example, when brooding broilers in commercial houses, chickens display individual preferences in air temperature, radiant heat flux and radiant temperature provided by radiant heaters to optimize thermal comfort at different ages (Linhoss, et al., 2018).

With increased attention to animal welfare, researchers have explored behavior patterns when broiler chickens are given choices of brightness (Raccoursier et al., 2019). Raccoursier and colleagues investigated the feeding and resting preference of a group of 38-day-old chickens within three adjoining experimental chambers illuminated with 0.5, 1 or 2 fc light intensities. The three chambers were connected by a dimly lit corridor of 0.1 to 0.2 fc and chickens had free access to any of the chambers or the corridor at any time. More chickens were observed in the 2 fc chambers than the 0.5 fc chambers, with more feed consumed in the 2 fc chambers than in the 0.5 fc chambers.

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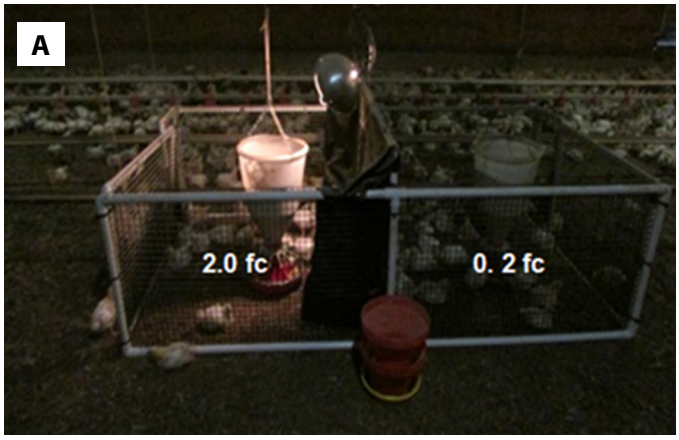

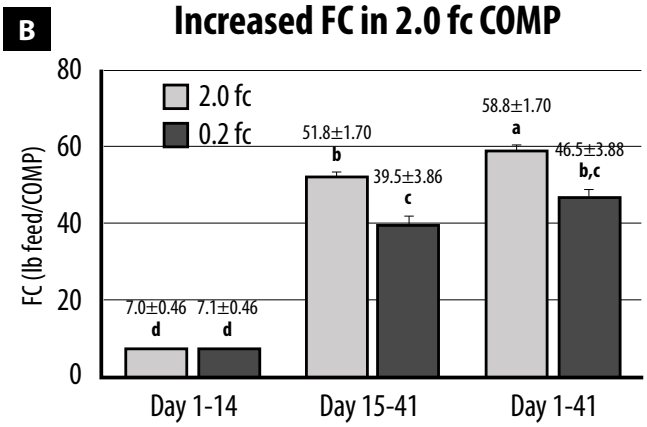

Figure 1. Experiment of the dual light intensity choice (DLIC) program (2.0/0.2 fc) and feed consumptions at Broiler Research Farm at the University of Arkansas. **A.** Pen was divided into two identical compartments (COMP) using a light-blocking divider raised to bird height to allow birds' passage under the divider yet prevent light penetration from the hanging light above. DLIC pen had a light intensity of 2 fc in one compartment and 0.2 fc in the other connecting compartment. **B.** Feed consumptions in each of the connecting compartments (FC: lb feed/COMP) during days 1–14, days 15–41 and days 1–41. Significant differences are denoted by different letters ($p < 0.05$). Fig. 1B adapted from Kang et al. (2020).

Despite the absence of either feed or water, a high density of chickens was observed in the dimly-lit corridor, likely a preferred resting area of broilers. This study suggested that birds will seek out their preferred level of brightness — bright or dark areas — for different activities.

Availability of brightness choices improves feed consumption and mental health

Kang and colleagues (2020) conducted an additional preference study investigating the effect of environments with different light intensities on the feed consumption and welfare, as well as on stress and mental health. Experimental pens, each divided into two compartments (COMP), were placed along the center of commercial production houses. Experimental pens received dual light intensity (DLI) of 0.2 fc in one and 2.0 fc in the other connecting compartment (Fig. 1A). The light-blocking divider inside each pen was raised to bird height to allow birds' passage under the divider yet prevent light penetration from the hanging light above the pen (Fig. 1A). Each compartment had one hanging feeder and nipple drinkers.

Feed consumption (FC) of each compartment under either 2.0 fc or 0.2 fc of DLI pen was calculated during days 1–14, days 15–41 and days 1–41 (Fig. 1B). FC of 2 fc compartments was 31 percent higher than that of 0.2 fc compartments during day 15–41 period ($p < 0.05$), indicating birds' preference of eating in well-illuminated area than dim area. Additionally, we evaluated the effect of providing birds with different light intensities on the negative (stress hormone corticosterone) and positive (serotonin and dopamine) welfare indicators. The availability of dual light intensity of 2.0/0.2 fc attenuated stress hormone levels within a few days of the onset of the lighting program and provided a beneficial effect on mental health by promoting positive emotions in birds.

Figure 2. Tyson Foods' Broiler Welfare Research Farm (BWRF) in Springdale, Ark where enriched lighting research was conducted. **A.** 2-fc lighting intensity program. **B.** Enriched lighting house provided more than 8 fc light intensity around feedlines by lower feedline-mounted LED lamps and 0.2 – 0.5 fc light intensity in the sidewalls and middle of houses.

Implication of enriched lighting program on broiler welfare and production

The preferences of broilers in the enriched lighting (EL) program for different activities were further investigated by comparing the amount of natural behavior and physical activity, brain welfare-indicating gene expression as well as production performance against uniform light intensity in commercial houses over four flocks (Kang et al., 2023). Fixed uniform light intensity was established by traditional ceiling LED light fixtures delivering 0.5 or 2 fc in different production houses. Enriched light intensities were more than 8 fc over feedlines and 0.2-0.5 fc at the sidewalls and middle of the house, delivered by dedicated feedline-mounted LED light fixtures (Fig. 2B), much lower in height than conventional ceiling lights. Both houses had 16 hours of light and 8 hours of darkness. Electricity use by lighting was not measured, but enriched lighting arrangement likely decreased electricity consumption due to lower power drawn by feeder lights.

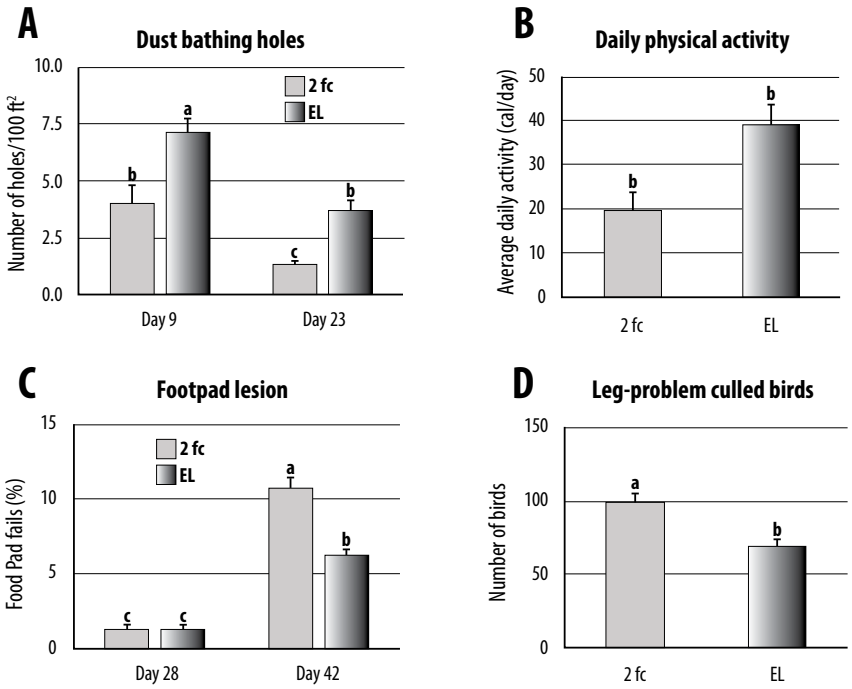

Figure 3. Effects of enriched lighting (EL) program on the natural behavior, physical activity, and leg health compared to 2 fc lighting program. **A.** Dustbathing holes as evidence of dustbathing behavior were counted at 9, and 23 days of age. **B.** average daily activities (energy consumption, calorie/day) measured by an activity tracker for each bird from day 39 to day 42. **C.** Percentage of footpad failed birds at 28 and 42 days of age in 2-fc and EL lighting program. **D.** Accumulated number of birds that were culled by leg problems at 49 days of age in each section (placed 4,800 birds/section). Fig 3 adapted from Kang et al. (2023).

Dustbathing behavior was more prevalent in the enriched lighting program up to 23 days of age compared to other uniform lighting houses (Fig. 3A). Enriched lighting program stimulated voluntary walking behavior of birds (Fig. 3B), resulting in lower footpad lesions at 42 days of age (Fig. 3C) and lower number of leg-problem-induced culling of birds (Fig. 3D), hence lower total mortality. Higher daily weight gain and lower feed conversion ratio (Table 1) were observed under the enriched lighting program compared to the uniform lighting program (Kang et al., 2023). Welfare-indicating gene expression revealed that the enriched lighting program provides a better environment for the homeostatic control of birds' autonomic nervous systems. Birds under their preferred brightness experienced reduced fear response than those under the uniform lighting program, hence promoted safety learning. Enriched lighting within the production space satisfies the physiological needs of seeking a dim area for resting and sleep and a bright area for feeding and drinking, allowing birds choices through natural behavior and locomotion. The combination of physiological satisfaction and voluntary movement likely leads to better growth and production efficiency.

Trial	Treatment	Daily weight gain (lb/day)	Feed conversion ratio (FCR)
Trial 1 (56 days)	2-fc program	0.1461	1.977
	EL program	0.1484	1.932
Trial 2 (51 days)	2-fc program	0.1416	1.842
	EL program	0.1467	1.821
Trial 3 (49 days)	2-fc program	0.1459	1.905
	EL program	0.1461	1.890
Trial 4 (55 days)	2-fc program	0.1506	2.020
	EL program	0.1535	1.949

Table 1. Daily weight gains and feed conversion ratios from four trials under two lighting programs. fc = footcandle; EL=enriched lighting

Summary

Most welfare problems in broilers are the result of a combination of environmental, management and genetic factors (European Commission, 2017). To increase the voluntary natural behavior and activity of broilers in broiler houses lacking complexity, the enriched lighting program was developed by dedicated LED light fixtures mounted on feedlines delivering > 8 fc in feedline area on average, and 0.2-0.5 fc in sidewalls and middle area in commercial broiler houses. The enriched lighting program stimulates birds' voluntary walking and dustbathing, feeding in bright areas, and resting in dim areas, resulting in improved legs, mental health, and production performance.

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DR. YI LIANG is associate professor - air quality, biological & agricultural engineering, **DR. SEONG KANG** is a post doctoral fellow - poultry science, **DR. KAREN CHRISTENSEN** is adjunct associate professor - animal welfare and sr. director of animal welfare of Tyson Foods, and **DR. ZAC WILLIAMS** is extension specialist - poultry husbandry and management. All are with the University of Arkansas System Division of Agriculture in Fayetteville.

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