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Research Article

The LED wavelength, lighting intensity, feather coverage, and novelty inclusion in turkey hens

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Abstract

Light-emitting diodes (LED) have been gaining acceptance in agriculture applications as alternatives to incandescent light sources. Daylength intensity and spectral wavelength are important in poultry production and also, in some cases, serve as the only mean of light in some facilities. Therefore, Large White turkey hens of the same strain were reared to market weights using two different housing facilities in combination with different LED light treatments. Each treatment within the environmentally controlled facility (ECF) consisted of four replicate rooms, 16 rooms total in the facility. LED bulbs consisted of 5,000 Kelvin (K) or 2,700K LED in conjunction with a high or low foot-candle (FC) intensity level. Daylength was fixed at 14L:10D. Additionally, birds were reared in a natural curtain-sided facility (6 replicate pens) with exposure to natural light with a 75W incandescent bulb to maintain daylength consistency with the ECF. Performance parameters were measured at 0, 5^{th}, 9^{th}, and 12^{th} week (wk) of age. Serum triiodothyronine (T3) and right eye measurements were taken at the 5^{th} and 9^{th} wk of age. Feather coverage was assessed at the 9^{th} and 12^{th} wk old as indicators of bird wellbeing. Novelty interactions for visual or nutritional items were recorded at 7^{th} wk old. Spectral output within the same Kelvin temperature was significantly altered during dimming to achieve intensity levels. There were mixed performance results; however, cumulatively, birds reared under LED lighting, regardless of LED type or intensity level, had consistently increased body weight. Bird wellbeing was altered under 5,000K LED in combination with 2 FC as measured by a significant elongation of the anterior-posterior distance. However, the same effect was not measured in the 5,000K, 10 FC treatment, or in the 2,700K treatments, regardless of FC measurement. There were no differences among treatments for T3, feather coverage, or latency to approach or interact with novel items. When LED lights are used in environmentally controlled facilities, coupled with novelty interactions, birds maintained and excelled in performance parameters when compared to birds reared with natural light and ventilation conditions.

Keywords: Turkey, LED lighting, Intensity, Fear response, Kelvin temperature

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Introduction

Poultry species are affected through interactions between behavioral and physiological responses to lighting environments, including day length, illuminance, and wavelength of light (Kristensen et al., 2007). The retina of the eye is stimulated by light which results in behavioral changes affecting growth and development (Li et al., 2015). In addition, the proportion of each wavelength emitted by different lighting systems and bulb types may influence the physiology of birds (Retes et al., 2017). Therefore, there may be an interaction between spectral output in combination with light intensity. Also, it has been documented that spectral intensity is not even across the visual spectrum for birds (Huth and Archer, 2015).

Birds are able perceive light into portions of the ultraviolet spectrum (Huth and Archer, 2015) and have four cone sensitive droplets residing at the 415, 460, 510, and 580 nanometer (nm) wavelengths which differ from human cone sensitivity (Lewis and Morris, 2000). Therefore, the type of bulbs used for poultry applications may impact the physiology and wellbeing of birds reared for commercial applications. Blue and green monochromatic light has been used in broiler and quail rearing resulting in an increased body weight gain (Rozenboim et al., 2004; Retes et al., 2017). Additionally, blue, green, and yellow LEDs have affected meat quality in broilers with improved meat characteristics

(Parvin et al., 2014).

The introduction of open field testing involves added social isolation which may also elicit a fear response (Forkman et al., 2007). Commercially reared poultry can be considered prey animals in which there is a fear of predation leading to predator avoidance (Huth and Archer, 2015). In addition, fear has been associated with different spectral outputs impacting fear responses differently (Sultana et al., 2013). Light intensity preference behavior has been suggested to be involved in the welfare of birds (Kang et al., 2020) with increased activity and aggressive behaviors recorded in chickens and turkeys reared under red lights (Manser, 1996; Lewis et al., 2007). However, it has been documented that using LED bulbs in poultry applications results in positive, calming behaviors of birds in which they were less prone to feather pecking and aggressive acts towards conspecifics (Hunt, 2009). However, these positive interactions have yet to be studied in commercial turkey applications.

Physiological responses in poultry species to novelty have been analyzed through open field testing, tonic immobility (Forkman et al., 2007), and elicited fear response towards a stationary person (de Haas et al., 2013). Fear responses have been accompanied by behaviors such as remaining motionless, flee, or flight (Huth and Archer, 2015). Additionally, how a bird responds to novelty can be associated with tolerance to social isolation, exploration level, and other coping mechanisms, such as feather pecking (de Haas et al., 2010).

Brightly lit environments have been beneficial for bird eyesight (Blatchford et al., 2012) which has been further enforced as dim conditions that lead to an increased incidence of buphthalmia, choroiditis, glaucoma, and lens distortion (Deep et al., 2010). Long periods of darkness or dim light can cause decreased corneal thickness in chickens (Blatchford et al., 2009). However, when taking into consideration other aspects of poultry management, low light intensity environments have been speculated to have reduced activity in chickens which may lead to an improvement in feed efficiency and a reduction in sudden death and carcass damage (Deep et al., 2010).

Therefore, there is speculation that similar results may be obtained in turkeys and these increased production parameters could be beneficial in commercial settings. Although chickens and turkeys vary greatly in their response to lighting programs (Schwean-Lardner et al., 2016), management practices in turkeys are often derived from broiler studies. Therefore, this study aimed to study the spectral output of LED bulbs at low and high intensity levels in interaction with bird performance.

Material and methods

Animal care

All animal handling procedures used in this study were based on the guidelines described in the Ag Guide 3rd Edition (2010) and were approved by the Institutional Animal Care and Use Committee at North Carolina State University (protocol 18-155-A). All husbandry and euthanasia procedures were implemented by trained individuals with full consideration for animal welfare. All mortalities and culls were observed for cause including potential injuries (pecking and cannibalism).

Housing systems

Two different housing facilities were used to accommodate Large White female turkeys (Nicholas Select, Aviagen Turkeys, Inc., Lewisburg WV, USA), reared to 12 th wks of age, and consisted of five different lighting treatments. One of the facilities was a natural curtain-sided facility and was fitted with 75W incandescent bulbs. The daylength was maintained at a fixed 14h daylength with a resulting natural flux in light intensity. The birds were reared using natural ventilation by curtain adjustment as needed (NAT) with 6 replicate pens (n=24 birds/pen).

The other facility had solid sidewalls and was environmentally controlled. There were 16 rooms individually controlled for heat, ventilation, and light and were used for the LED lighting treatments, four replicate rooms per treatment (n= 58 birds/room). Each room was fitted with a dimmer control which allowed light intensity of either high (10 footcandles, FC) or low (2 FC) intensity to be achieved and was verified by averaging 5 measurements throughout each room. The LED light treatments included: 5,000 Kelvin (K) LED, 10 FC (5KH); 5,000K LED, 2 FC (5KL); 2,700K LED, 10 FC (2KH); and 2,700K LED, 2 FC (2KL) (n = 58birds/pen). All treatments were maintained at a 14hL:10hD daylength with time clocks fitted to each room.

The LED spectroradiometer (UPRtek MK350S Premium, Gamma Scientific, San Diego, CA, USA) was used to determine spectral wavelength output between 380 nm and 780 nm in addition to measured intensity levels. Brooding stocking density was based on breeder suggested industry standards and was fixed by placing a divider in each pen to accommodate a 0.11 m^2/birds stocking density for the LED treatments and 0.12 m^2/birds for the NAT treatments until the 5^{th} wk of age. At the 5^{th} wk, the divider was removed, and grow-out stocking density was increased to 0.23 m^2/birds for all treatments.

Performance measurements

Corn, wheat, and soybean meal-based diet formulated for turkeys and milled by the North Carolina State University Feed Mill Education Unit (Raleigh, NC) and was fed on a kg/bird basis in four phases (Bartz and Grimes, 2021). Spectral output was assessed by averaging spectrum outputs by treatment and quantifying each individual nanometer wavelength between 380 and 780 nm. Bird body weight (BW) at placement was measured by pen. Additional performance data for individual BW and feed intake (FI), by pen, were collected at 5^{th}, 9^{th}, and 12^{th} wk of age.

The FI per bird and feed conversion ratio (FCR) were calculated and BW of mortalities and culls were included in the FCR calculation. Right eye samples were taken for eye weight (EW), cornea diameter (CD), averaged medial-lateral dorsal-ventral diameter (MLDV), and anterior-posterior diameter (APD) using a digital caliper (±0.01mm) at 5 and 9 wks of age (n=2). Blood serum was collected from the brachial vein (n=2) at the 5^{th} and 9^{th} wks which was analyzed using a commercially available radioactive immunoassay kit for triiodothyronine (T3) hormone for each treatment (MP Biomedical, Solon, OH, 06B2542-CF).

Feather coverage was assessed using a previously described method (Bartz and Grimes, 2021) by allowing birds to freely hang by the shanks on a stationary shackle. Briefly, a total of two birds per pen were weighed and analyzed for feather coverage in which infrared images were obtained for the breast area to be quantified in imageJ software using the area measurement tool. Area measurements were taken at locations on the breast appearing red in color and analyzed as areas of low feather coverage. Once the area was measured, it was then divided by the total number of pixels in the image and multiplied by 100 to obtain a pixel percentage for feather coverage.

General behavior and novelty

Using a procedure modified from de Haas et al. (2013), fear of a new object and novelty behavioral measurements were conducted for 1 hour, between 8am–10am at the 7^{th} wk of age using two different objects: one selected for visual cues with no nutritional benefits, and the other for nutritional benefits but not visually stimulating (lacked novel coloration). The visual object (VO) was an orange plastic playground safety cone (16.5cm tall by 12.7cm wide at the base; Dollar Tree, 2pc. SKU 242398), with four colored (green, yellow, blue, red) (5.1cm L x 5.1cm W x 2.5cm H) hollow plastic Lego boxes (Dollar Tree, 4pc. SKU 269635) bolted to each corner of the safety cone. When struck or pecked, these colored boxes would emit a sound that can be captured by the video recording, allowing for proper measurements for time to interaction. Video recordings (GoPro Hero 7 Black) were completed in each room using a randomized treatment filming schedule. Each treatment was represented on each day of filming and randomly assigned throughout the building.

Filming was conducted over four consecutive days (Tue – Fri). The nutritional novelty object (NO) (Big & J, "The Cube", BB2C2580; 11.3kg, 21.59cm L x 21.59cm W x 22.86cm H) and the VO (modified safety cone) were randomly placed in one of the replicates each day, with each item placed between a different feeder and drinker. In each replicate, the items were placed in the same location and the VO was always oriented the same way. Enough space was allotted between any walls or other items in the pen for at least a one bird width around each object. Video footage was recorded a half hour before placement of the novelty and captured the first half hour of novelty which was a limitation due to the battery life of the camera. After one hour, the novelty was removed from the pen and the difference in weight for the nutritional block was recorded. Solomon Coder Software was used to quantify video footage including the latency to approach each item by defining a circular area around each item within the software (one bird width around each item), the amount of time to the first peck of each object, and number of successful perches on the NO.

Statistical analysis

Data were analyzed using JMP13 as a one-way ANOVA and LS means were separated using Tukey's HSD procedure at a significance of P0.05. In addition, performance measurements were evaluated by Student-t test at a significance level of P0.05 for type of LED used (5,000K and 2,700K) and intensity level (2 FC and 10 FC) fitted separately for each parameter.

Results

Spectral output

The LED spectroradiometer spectral output results by light treatment are summarized in Figure 1. Noted differences occurred at the cone sensitive droplet areas for birds, with significant differences in spectral output for the 5,000K LED near the 580 nm wavelength and at the 415 nm, 460 nm, and 510 nm wavelengths for the 2,700K LED when comparing 10 FC and 2 FC intensity levels within the same Kelvin temperature bulbs (data not shown). There were significant differences between 2,700K LED 2 FC and 10 FC treatments for all wavelengths measured between 380 and 780 nm except for 482 nm, 506 nm, and 549-650 nm wavelengths. There were fewer differences between 5,000K LED 2 FC and 10 FC treatments with differences recorded at 440-453 nm, 457-459 nm, 526-528 nm, 539-540 nm, 549-569 nm, 572-578 nm, and 589 nm. These results further validate that light intensity is related closely to light spectrum which was previously reported by Huth and Archer (2015).

Performance

Performance results for the current study are presented in Table 1. Birds brooded under NAT lighting had a significant increase in FI at 5 wks ($P<0.0001$) resulting in a poorer FCR ($P<0.0001$) when compared to all LED treatments; however, there were no differences in BW at 5 wks ($P>0.05$). At the 9^{th} wk, there were no differences in FI or FCR due to treatments regardless of facility or light treatment type ($P>0.05$). However, birds residing in the 2KH treatment were significantly heavier than the NAT birds ($P=0.023$). At the 12^{th} wk, there was no difference in FI or BW regardless of facility or light type; however, FCR was improved in all LED treatment birds regardless of light treatment type or intensity level when compared to the NAT treatment birds ($P=0.001$).

From 5^{th}–9^{th} wks, BW was significantly higher for the 5KL, 2KL, and 2KH treatment birds when compared to the NAT treatment birds ($P=0.0004$). From 9^{th}–12^{th} wks, 5KH birds had a higher BW compared to NAT birds ($P=0.046$) and from 5^{th}–12^{th} wks, all birds

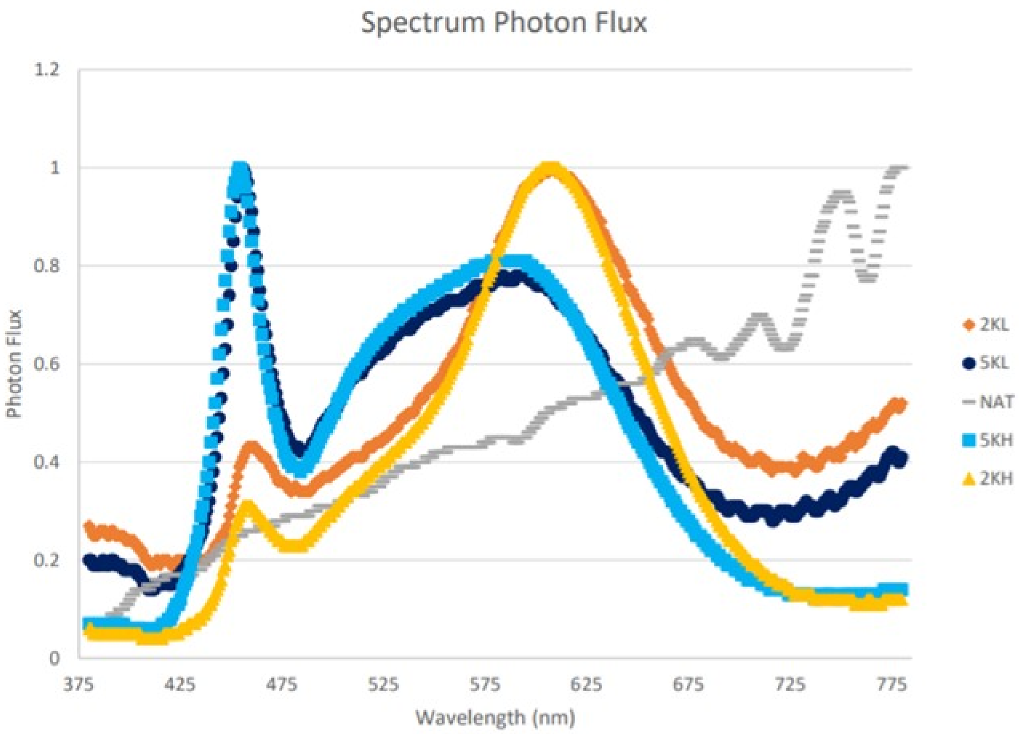

Figure 1: Spectral emittance after altering to 2 FC and 10 FC in the lighting-controlled facility.

Table 1: Lighting program intensity effects on turkey hen performance grown till the 12th week.

Age		Light Treatment					SEM	P-value
		NAT	5KL	5KH	2KL	2KH		
	Intensity	NAT	2 FC	10 FC	2 FC	10 FC		
	LED Light Type	NONE	5,000K	5,000K	2,700K	2,700K		
0–5 weeks performance	Feed Intake[1]	2.64[a]	2.01[b]	2.03[b]	2.04[b]	2.06[b]	0.057	<0.0001
	BW[2]	1.20	1.20	1.24	1.21	1.23	0.047	0.962
	FCR[3]	2.11[a]	1.61[b]	1.62[b]	1.62[b]	1.61[b]	0.046	<0.0001
5-9 weeks performance	Feed Intake	4.86	5.25	5.24	5.19	5.21	0.119	0.126
	BW	2.64[b]	3.03[a]	2.82[ab]	2.89[a]	3.01[a]	0.053	0.0004
	FCR	1.74	1.72	1.78	1.74	1.68	0.031	0.339
0-9 weeks performance	Feed Intake	7.96	7.39	7.40	7.33	7.40	0.213	0.157
	BW	3.95[b]	4.21[ab]	4.14[ab]	4.16[ab]	4.30[a]	0.072	0.023
	FCR	1.87[a]	1.69[b]	1.71[b]	1.70[b]	1.66[b]	0.022	<0.0001
9-12 weeks performance	Feed Intake	6.50	6.77	6.75	6.71	6.64	0.147	0.624
	BW	2.63[b]	2.79[ab]	2.99[a]	2.87[ab]	2.78[ab]	0.077	0.046
	FCR	2.09	2.16	2.07	2.14	2.18	0.107	0.341
5-12 weeks performance	Feed Intake	11.93	12.37	12.26	12.15	12.10	0.233	0.691
	BW	5.46[b]	5.93[a]	5.98[a]	5.89[a]	5.92[a]	0.100	0.005
	FCR	1.92	1.93	1.94	1.94	1.94	0.024	0.981
0-12 weeks performance	Feed Intake	15.31	14.66	14.52	14.53	14.39	0.333	0.252
	BW	7.00	7.29	7.36	7.29	7.29	0.103	0.097
	FCR	1.96[a]	1.87[b]	1.87[b]	1.88[b]	1.88[b]	0.015	0.001

[1]Feed Intake, kg/bird.

[2]Body weight, kg/bird.

[3]Feed Conversion, kg/bird.

[a,b]Means within the same row with different superscripts are considered significant (P<0.05).

Table 2: Performance summary based on LED Kelvin temperature and intensity levels in turkey hens fitted as Student-T test.

Age	LED Kelvin temperature	5,000K	2,700K	SEM	P-Value
5 weeks performance	Feed Intake[1]	2.02	2.05	0.038	0.544
	BW[2]	1.22	1.22	0.031	0.934
	FCR[3]	1.59	1.62	0.034	0.614
9 weeks performance	Feed Intake	7.39	7.37	0.080	0.803
	BW	4.17	4.23	0.052	0.440
	FCR	1.70	1.68	0.016	0.451
12 weeks performance	Feed Intake	14.59	14.46	0.132	0.503
	BW	7.32	7.29	0.062	0.705
	FCR	1.87	1.88	0.009	0.458
	Intensity	**2 FC**	**10 FC**	**SEM**	**P-Value**
5 weeks performance	Feed Intake	2.03	2.04	0.039	0.771
	BW	1.20	1.23	0.031	0.521
	FCR	1.62	1.59	0.034	0.614
9 weeks performance	Feed Intake	7.36	7.40	0.080	0.721
	BW	4.18	4.22	0.053	0613
	FCR	1.69	1.68	0.016	0.669
12 weeks performance	Feed Intake	14.59	14.46	0.132	0.478
	BW	7.29	7.32	0.062	0.705
	FCR	1.88	1.87	0.009	0.713

[1]Feed Intake, kg/bird.

[2]Body weight, kg/bird.

[3]Feed Conversion, kg/bird.

reared under LED, regardless of bulb type or intensity level, were heavier than NAT birds (P=0.005). In the current study, LED Kelvin temperature and high/low FC intensity level were compared by student-t tests on turkey hen performance parameters (Table 2). There were no differences due to LED bulb type or intensity level on performance at the 5th, 9th or 12th wk.

Eye development

Eye measurements from the current study are presented in Table 3. At the 5th wk, there were no differences in eye weight, anterior-posterior distance (APD), average medial-lateral dorsal-ventral distance, or cornea diameter regardless of light regimen (P=0.628, 0.306, 0.174, and 0.660, respectfully). However, at the 9th wk, there was a significant interaction in spectrum by intensity level in which birds exposed to low light intensity with a 5,000 kelvin LED (5KL) having a significantly longer APD compared to birds reared under the same bulb at 10 FC (5KH) (P=0.049). Furthermore, this elongation was not observed in the low intensity 2,700K LED (2KL) treatment, indicating the importance of combining spectrum and intensity level.

IR feather coverage

Ventral imaging of red pixels located on the breast as an indicator of feather coverage were analyzed and are presented in Table 4. There were no differences in feather coverage due to light treatment effects at the 9th or 12th weeks of age (P>0.05).

Triiodothyronine hormone analysis

Light intensity treatment effects on T3 hormone levels, measured in ng/mL are presented in Table 5. There were no differences in T3 hormone levels at the 5th or 9th wk of age, regardless of bulb type or intensity level.

Novelty inclusion

Latency to approach novelty items and interaction with novelty items from the current study are presented in Table 6. There were no differences in the latency to approach objects or interact with objects indicating no apparent difference in fear responses or vision impairments between treatment groups.

Discussion

Performance

Low light intensities have been documented to decrease sudden death and carcass damage in association with a reduction in activity and aggression levels, leading to improved feed efficiency in broilers (Deep et al., 2010). Although the FI and FCR performance results were statistically significant at the 5th week of age in the study herein, it was also observed that there was more feed wastage by birds in the NAT treatment; however, this wastage was not measured. Therefore, this observation should be taken into consideration for the

Table 3: LED lighting intensity effects on the eye development in turkey hens at the 5th and 9th weeks of age.

Age		Light Treatment					SEM	P-value
		NAT	5KL	5KH	2KL	2KH		
	Intensity	NAT	2 FC	10 FC	2 FC	10 FC		
	LED Light Type	NONE	5,000K	5,000K	2,700K	2,700K		
5 weeks	Eye Wt. (g)	3.13	3.21	3.17	3.10	3.17	0.048	0.628
	AP Distance (mm)[1]	13.80	13.50	13.38	13.03	13.34	0.264	0.306
	MLDV Distance (mm)[2]	18.12	18.82	18.52	18.22	18.41	0.216	0.174
	Cornea Diameter (mm)	8.64	8.65	8.57	8.56	8.44	0.107	0.660
9 weeks	Eye Wt. (g)	4.99	5.02	4.89	5.00	4.97	0.095	0.888
	AP Distance (mm)	16.94[ab]	17.24[a]	16.65[b]	16.74[b]	17.01[ab]	0.137	0.049
	MLDV Distance (mm)	21.78	21.87	21.70	21.80	22.10	0.126	0.268
	Cornea Diameter (mm)	10.48	10.60	10.59	10.57	10.58	0.084	0.779

[1]Anterior–posterior distance.

[2]Medial–lateral dorsal–ventral averaged distance.

[a,b]Means within the same row with different superscripts are considered significant ($P<0.05$).

Table 4: LED light intensity treatment effects on the breast feather coverage (% red pixels).

Treatment	Intensity	IR of Feather Coverage		
		LED Type	9 Weeks	12 Weeks
NAT	NAT	NONE	1.99	3.08
5KL	2 FC	5,000K	1.81	3.09
5KH	10 FC	5,000K	1.64	3.15
2KL	2 FC	2,700K	1.68	3.57
2KH	10 FC	2,7000K	2.02	3.00
		SEM	0.195	0.239
		P-value	0.556	0.503

Table 5: LED light intensity treatment effects on the triiodothyronine (T3) hormone levels (ng/mL) at 5 and 9 weeks of age.

Treatment	Intensity	T3 measured by RIA (ng/mL)		
		LED Type	9 Weeks	12 Weeks
NAT	NAT	NONE	1.27	2.35
5KL	2 FC	5,000K	1.60	2.00
5KH	10 FC	5,000K	1.56	2.42
2KL	2 FC	2,700K	2.31	2.21
2KH	10 FC	2,7000K	1.14	2.38
		SEM	0.306	0.218
		P-value	0.091	0.668

interpretation of the 5th wk results when comparing the birds in the NAT treatment to birds in the LED treatments. Based on the results obtained at the 9th wk and 12th wk, birds reared in an environmentally controlled facility, regardless of light treatment, had increased feed efficiency compared to natural light and natural ventilation. This contrasts with previous results obtained by Bartz and Grimes (2021) and results suggested by Blatchford et al. (2012) in which natural conditions had compensatory gains with no significant differences in feed efficiency.

Monochromatic light in chicken production has been reported to be beneficial as measured by the increase in layer egg production with red light (Olanrewaju et al., 2015) and increased growth in broilers under green and blue light (Rozenboim et al., 2004).

Table 6: LED light intensity treatment effects on the time to interact with novel items (sec) at 7 weeks of age.

Treatment	Intensity	LED type	Approach nutrition	Peck nutrition	Perch nutrition	Approach visual	Peck visual
NAT	NAT	NONE	496	1091	1193	73	869
5KL	2 FC	5,000K	193	1026	1194	0.5	617
5KH	10 FC	5,000K	296	1041	1072	5	344
2KL	2 FC	2,700K	310 805	600	6 926		
2KH	10 FC	2,7000K	352	990	1018	14	683
		SEM	185	401	402	44	311
		P-value	0.796	0.988	0.831	0.671	0.704

When similar monochromatic wavelengths (450 nm – blue and 650 nm – red) were used in turkey production, 16 wks toms and 18 wks hens had significantly faster growth, in addition to earlier sexual maturation, under red light in combination with a high intensity level (Lewis et al., 2007). In the study herein, similar increases in BW were measured with birds reared under 2,700K LEDs at 10 FC having an increased BW at the 9th wk.

Eye development

The eyes are the most developed sensory organs of poultry, which makes them susceptible to changes in lighting programs (Bartz and Grimes, 2021). Light and dark phases are responsible for the synchronization of rhythmic activities and induces hormone production (Grimes and Siopes, 1999). Eyes have greater growth during periods of light and reduced growth during periods of darkness (Deep et al., 2010). The effect of light intensity on the synchrony of resting behavior has been reported by Alvino et al. (2009). Sleep deprivation in birds can have a negative impact on welfare (Schwean-Lardner et al., 2016). Under low intensity lighting, negative impacts in turkeys have been measured in eye development and health as decreased blood flow to the eye and an elongation in the anterior-posterior distance causing myopia (Vermette et al., 2016). These results are similar in the current study in which the anterior-posterior distance was elongated at the 9th wk of age under dim conditions. However, this elongation was only observed under the 5,000K LED treatment further indicating that spectral output interacts with eye development.

IR feather coverage and triiodothyronine hormone analysis

Environmental effects may include type of lighting which have led to a reduction in feather pecking behaviors and aggressive acts with the use of LED lighting systems (Hunt, 2009). These same effects, in combination with an increase in foraging behavior, have been observed in broilers reared under warm-white compact fluorescent bulbs in low light intensities (Kristensen et al., 2007). Furthermore, Denbow et al. (1990) reported that the type of light significantly affects the degree to which turkeys peck and pull feathers. Since feather development and regeneration includes genetic, hormone, nutritional, physiological, and environmental controls (Bartz and Grimes, 2021), the study herein used a non-invasive measurement of feather coverage by IR imaging, using techniques published by Zhao et al. (2013) in layers and adapted by Bartz and Grimes (2021) for turkeys. In the study herein, there were no significant differences in feather coverage regardless of facility type or light treatment.

Changes in light intensity, daylength, or red-light spectrum have been associated with stimulation of the hypothalamic extra-retinal photoreceptors, Lien and Siopes (1993) measured a high correlation between the timing of annual cycle, thyroid hormones with feather regeneration. In the study herein, T3 hormone levels (ng/mL) were trending lower in birds exposed to 2,700K, 10 FC treatment and natural light treatment (P=0.09). Since changes in light intensity, daylength, or red-light spectrum have been associated with stimulation of the hypothalamic extra-retinal photoreceptors and stimulate the reproductive axis by controlling the secretion of gonadotrophin releasing hormone (GnRH), the hormone responsible for stimulating the release of luteinizing hormone and follicle stimulating hormone (Liu et al., 2018), this may have impacted the results herein.

Novelty

Lighting type and color (wavelength) have the potential to alter bird behavior by increasing activity (Blatchford et al., 2009) and there has been a positive correlation between light intensity and activity levels in broilers reared under incandescent lights (Blatchford et al., 2012). The analysis of the novelty behavior measurements in the study herein indicated no significant differences between lighting treatments to approach, peck, or perch on objects. In spite of the novelty possibly causing an altered response, the full extent of this effect is yet to be determined, as birds approached the visual object faster than the nutritional object. Although this is a statistically significant finding, it may not be biologically significant since there are several confounding factors such as color, size, and the shape of the objects.

Furthermore, it is important to note that feather coverage measured by IR imaging was improved in this study overall by 4% when compared to the results reported by Bartz and Grimes (2021). This alteration could be due to natural variation between flocks, LED Kelvin temperature or daylength. The addition of novel items in each pen may have redirected aggressive feather pecking acts towards interacting with the novel items. However, since this improvement in feather coverage was assessed at the end of the trial from video data collected at the 7th wk, it can only be suggested as a possible reason for improved feather coverage and would need to be investigated further. Overall, investigation of the novelty interaction will be necessary to determine if there is a link to feather coverage based on altering coping mechanisms and diverting attention away from feather pecking is warranted.

Conclusion

Dimming LED lights significantly altered the spectral output within the same Kelvin temperature light type. There were significant differences in the violet, blue, and green wavelengths for the 2,700K LED lights and differences in the yellow-orange wavelength for the 5,000K LED lights which are biologically significant since these are the photo-areas sensitive in poultry. Therefore, LED light output should be measured directly with the proper instrumentation to ascertain the actual illuminance directed to the birds. There were mixed performance results throughout this trial with no difference in FCR during production periods (excluding brooding phase/potential feed wastage); however, BW was consistently lower for birds in the NAT treatment and was trending lower (P=0.097) for the cumulative 12 wks performance. Overall, there were no significant differences in performance between LED treatments, regardless of Kelvin temperature or intensity level and were improved compared to NAT treatment. However, there was a significant interaction between intensity level and bulb color temperature as measured by the elongation of the eye under low intensity, i.e., 5,000 kelvin, LED lights at the 9th wk. Further research on feather development and coverage as affected by the light type and density is warranted. There were no differences in the amount of time for birds to approach novel items between lighting treatments. However, it was noted that birds approached the visual item faster than the nutritional item.

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