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Influence of Photoperiod, Light Intensity and Their Interaction on Growth Performance and Carcass Characteristics of Broilers Grown to Heavy Weights

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Abstract: The effects of photoperiod, light intensity and their interaction on growth performance and carcass characteristics of broilers were investigated in 2 trials. The experiment was consisted of a factorial arrangement of treatments in a randomized complete block design. In each trial, all treatment groups were provided 23L:1D with 20 lx of intensity from placement to 7 d and then subjected to the treatments. The 9 treatments consisted of 3 photoperiods [long/continuous (23L:1D) from d 8-d 56; regular/intermittent (2L:2D) and short/non-intermittent (8L:16D) from d 8-d 48 and 23L:1D from d 49-d 56, respectively] and exposure to 3 light intensities (10, 5.0 and 0.5 lx) from d 8 through d 56 at 50% RH. Birds were provided a four phase-feeding program and water was provided *ad libitum*. Birds and feed were weighed on 0, 14, 28, 42 and 56 d of age for growth performance evaluation. At 56 d of age, 20 (10 males and 10 females) birds from each room were randomly selected, slaughtered and processed to determine weights and yields. Broilers subjected to a short/non-intermittent photoperiod showed the significantly ($P<0.05$) lowest BW, BW gain, feed intake, carcass weight and pectoralis major and minor weights as compared with broilers reared under long/continuous and regular/intermittent photoperiods. Feed conversion and mortality were not affected by treatments. There was no effect of light-intensity or photoperiod x light intensity interactions on all examined variables. Corticosterone concentrations were not affected by treatments, suggesting an absence of physiological stress. These results indicate that long/continuous and regular/intermittent photoperiods equally improved broiler performance as compared with a short/non-intermittent photoperiod with no significant effect due to light intensity treatments.

Key words: Photoperiod, light-intensity, stress, meat yield, broiler

INTRODUCTION

Research development in poultry production has been shown by improving breeds for high productivity. However, this genetic potentiality of poultry will not be fully utilized due to environmental (temperature, humidity, lighting, air velocity, etc.) factors. These factors are known to affect production, health and welfare of poultry (Donkoh, 1989; Moller *et al*., 1995; Chen *et al*., 2002; Olanrewaju *et al*., 2010a,b). It has been documented that exposure of poultry to inadequate micro environmental factors during the course of the production period adversely impacts production efficiency (BW, BW gain (BWG), FCR), meat yield, immune response and mortality (Howlinder and Rose, 1989; Olanrewaju *et al*., 2010b). Therefore, it is important to determine the adequate poultry housing environmental factors on broilers grown to heavy weights in order to maximize their genetic potential for economic sustainability to producers without any negative impact on the welfare of broilers.

Light is one of the most important environmental factors in broiler chickens production, as it greatly influences broiler growth development and physiological functioning (Olanrewaju *et al*., 2006b). Light consists of three different aspects: Intensity, photoperiod (duration) and wavelength (color) and both photoperiod and light intensity are important among environmental factors. Light intensity, color and the photoperiodic regime can affect the physical activity of broiler chickens. Manipulation of lighting programs is a strategy used to reduce the incidence of metabolic and skeletal disorders in broiler chickens. Lighting programs have a central purpose of slowing the early growth rate of broilers which allows birds to achieve physiological maturity prior to maximal rate of muscle mass accretion. Light allows the bird to establish rhythmicity and synchronizes many essential functions, including body temperature and various metabolic processes that facilitate feeding and digestion. Broilers are commonly provided with continuous or near continuous illumination because most of the early photoperiodic studies have showed that such regimens maximized feed intake and body weight gain, especially during the phase of the growing period (Lewis *et al*., 2009). High light intensity will increase activity, while lower intensities are effective in improving production parameters. Low light intensity

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reduces hyperactivity, minimizes skin scratches and limits early rapid growth resulting in decreased mortality, feed consumption and improved feed conversion (Gordon, 1994; Buyse *et al.*, 1996; Manser, 1996). A lighting pattern (less than 5 lx) is necessary that includes at least 8 hours of near-darkness over the final weeks of grow-out, when the lighting intensity is usually increased to encourage normal diurnal rhythms (Alvino *et al.*, 2009).

Most research involving light management on poultry production has focused on photoperiods (Lewis *et al.*, 2009; Schwean-Lardner *et al.*, 2012), light-intensity (Lien *et al.*, 2008; Deep *et al.*, 2010; Olanrewaju *et al.*, 2011b) or light-intensity in combination with other environmental factors (Lien *et al.*, 2007; Olanrewaju *et al.*, 2008; 2010a,b). In two separate studies, we have reported the effects of varying light intensities in the presence of inhalation of elevated ammonia concentrations and in the presence of varying levels of ambient temperature along with their interaction on growth performance, welfare and blood physiological variables in broiler chickens under environmentally controlled conditions (Olanrewaju *et al.*, 2007, 2010a,b, 2011a,b). Although, most of the research involving light management has focused on photoperiods, light-intensity, or each in combination with other environmental factors, more studies are still necessary to examine the effects of photoperiods in combination with gradient levels of light intensity at ranges typically used in commercial practice to understand the adequate light program (photoperiod, light-intensity) that can maximize growth performances of broilers grown to heavy weights without any negative impact on poultry welfare. This information is needed for a better understanding of the metabolic mechanism of how photoperiod, light intensity and their interactions affect broiler chickens grown to heavy weights to maximize productive efficiency and to establish proper broiler chicken health practice that are important to consumers and enable the poultry industry to compete globally. To address this knowledge gap, the present study examined the effects of photoperiod, varying light intensity and their interaction on growth performance and carcass characteristics of broilers grown to heavy weights.

MATERIALS AND METHODS

Bird husbandry: All procedures relating to the use of live birds in this study were approved by a USDA-ARS Animal Care and Use Committee at the Mississippi State location. In each of the 2 trials, each lasting 8 wk, a total of 540 one-day-old Ross x Ross 708 (Aviagen Inc., Huntsville, AL) chicks were purchased from a commercial hatchery. On arrival, the chicks were sexed and then group weighed. Chicks were randomly distributed into 9 environmentally-controlled rooms (30 males and 30 females chicks/room). Each environmentally-controlled room had a floor area of 6 m^2 (2.3 m width x 2.6 m depth) with a room volume of 15.3 m^3 (2.5 m height). Chicks were vaccinated for Marek's, Newcastle and infectious bronchitis diseases at the hatchery. At 12 d of age, birds received a Gumboro vaccination via water administration. Each room contained fresh pine shavings at a depth of 10 cm, tube feeders and a 7-nipple drinker system. Birds were provided a 4-phase feeding program (starter: 1 to 14 d; grower: 15 to 28 d; finisher: 29 to 42 d; withdrawal: 43 to 56 d of age). Diets were formulated to meet or exceed NRC (1994) nutrient recommendations. Starter feed was provided as crumbles and subsequent feeds were provided as whole pellets. Feed and water were offered for *ad libitum* consumption. Ambient temperature was maintained at 33°C at the beginning of experimentation and was reduced as the chickens progressed in age until d 42, when temperature reached 15.6°C.

Experimental treatments: Photoperiod consisted of continuous lighting (24L:0D) with 20 lx of intensity from placement to 7 d of age for all treatment groups and then subjected to the following treatments. The treatments consisted of 3 photoperiods (long/continuous (23L:1D) from d 8-d 56; regular/intermittent (2L:2D) and short/non-intermittent (8L:16D) from d 8-d 48 and (23L:1D) from d 49-d 56, respectively) and exposure to 3 light intensities (10, 5.0 and 0.5 lx) from d 8 through d 56. There were 3 different rooms for each photoperiod treatment along with 3 different rooms for each light intensity treatment, for a total of 9 rooms. Each of the 3 photoperiod treatments was paired with 1 of the 3 light intensity treatments so that each room represented a particular photoperiod:light intensity level combination. Each room was equipped with incandescent lighting, typical of that used in commercial housing. Light intensity settings were verified from the center and four corners of each room at bird height (30 cm) using a photometric sensor with National Institute of Standards and Technology-Traceable calibration (403125, Extech Instruments, Waltham, MA) for each intensity adjustment. The light fittings and tubes were dusted weekly to minimize dust buildup which would otherwise reduce the intensity.

Measurements: Chickens and feed were weighed on 0, 14, 28, 42 and 56 d of age for the computation of growth rate and feed consumption. The incidence of mortality was recorded daily and feed conversion was corrected for mortality. Necropsies were performed and cause of death was determined by a veterinarian on all birds that died during the trials.

Blood collections and chemical analyses: On d 55 (d before processing) of each trial, blood samples were collected between 0800 and 0900 h from wing veins of 6 (3 male and 3 female/room) randomly selected chickens from each room. The birds were then returned to the appropriate rooms by using a standard handling procedure (Olanrewaju *et al*., 2008). In addition, unnecessary discomfort to the birds was avoided by using proper housing and handling techniques, as described by the NRC (1996). Blood samples were collected directly into heparinized (50 IU/mL) monovette syringes. All bleedings were completed within 45 s after birds were caught. After all birds were bled, the iced samples were transferred to the laboratory, centrifuged at 4,000 x g for 20 min at 4°C. Two mL of each of the plasma samples from the syringes were stored in 2.5 mL graduated tubes at -20°C for later corticosterone (CS) analyses. Plasma samples were removed from the freezer, thawed and analyzed for CS using a universal microplate spectrophotometer (Bio-Tek Instruments Inc., Winooski, VT) with ELISA reagent assay test kits from Enzo life Sciences (EIA-CS Kit, Enzo life Sciences, Farmingdale, NY), according to the manufacturer's instructions and previously used with broilers (Olanrewaju *et al*., 2008; 2010a).

Growth performance and carcass characteristics: On d 56 of each trial, 20 (10 males/10 females) birds per room were randomly selected for processing and group weighed. Birds were subjected to a 12-h feed withdrawal period. On d 57, birds were weighed again (post-feed withdrawal weights), placed in coops and transported to the Mississippi State University Poultry Processing Plant. This post-feed withdrawal weight was used to calculate carcass and breast meat yield. Birds were electrically stunned, bled, scalded, mechanically picked and mechanically eviscerated. Whole carcass (without neck, giblets, abdominal fat pad) and abdominal fat pad were weighed. Carcasses were split into front and back halves and placed on ice for 4 h after which the front halves were deboned to obtain weights of skinless, boneless, breast fillet (pectoralis major muscle) and breast tender (pectoralis minor muscle). Carcass yield (without neck, giblets, abdominal fat pad) were expressed as a percentage of live weight (post-feed withdrawal), while abdominal fat pad and total breast meat yield (sum of pectoralis major and minor muscles) were expressed as a percentage of carcass weight.

Statistical analysis: A 3 x 3 factorial arranged in a randomized complete block design was used in this study. Data were replicated over time, with trial being the blocking factor. Room was considered the experimental unit. The 9 treatments consisted of 3 levels of photoperiod x 3 levels of light intensity. The main effects of photoperiod and light intensity and the interaction of these 2 factors on live performance, processing yield and carcass quality were tested by using the MIXED procedure of SAS (SAS Institute, 2008). Means comparisons on d 14, 28, 42 and 56 were assessed by least significant differences and statements of significance were based on $P<0.05$.

RESULTS

The influence of photoperiod, light intensity and their interaction on BW, BW gain (BWG) on bimonthly data from d 14 through d 56 of age are presented in Table 1. There was significant main effect of photoperiod on BW on d 14 ($P<0.001$), d 28 ($P<0.019$), d 42 ($P<0.004$) and d 56 ($P<0.048$) of age. In addition, there was main effect of photoperiod on BWG on d 14 ($P<0.001$), d 28 ($P<0.017$), d 42 ($P<0.004$) and d 56 ($P<0.050$) of age. Broilers reared under the short/non-intermittent photoperiod had a significant reduction in BW and BW gain (BWG) from d 14 through d 42 of age as compared with birds reared under the long/continuous and regular/intermittent photoperiods, respectively. However, there was no significant effect on BW and BWG for birds reared under the long/continuous and short/non-intermittent photoperiods at 56 d of age. There was no main effect of light intensity on BW or BWG in the present study. In addition, there was also no significant effect of photoperiod x light intensity interaction on any of the examined variables. Mortality was not significantly different between treatments but rather variable and did not appear to be either photoperiod, light intensity or their interaction dependent (data not shown). As shown in Table 2, broilers reared under the short/non-intermittent photoperiod had significantly reduced feed intake on d 14 ($P<0.001$), d 28 ($P<0.047$), d 42 ($P<0.005$) and d 56 ($P<0.004$) of age as compared with those subjected to either the long/continuous or regular/intermittent photoperiods. There was no main effect of light intensity or photoperiod x light intensity interaction on feed intake. Moreover, as shown in Table 2, there were no main effects of photoperiod, light intensity or their interaction on feed conversion ratio observed from d 14 through d 56 of age. Broilers reared under the short/non-intermittent photoperiod had a significant reduction in live weight ($P<0.005$) and carcass weight ($P<0.004$) when compared with broilers reared under the long/continuous or the regular/intermittent photoperiods (Table 3). In addition, there was only significant ($P<0.011$) main effect of photoperiod in carcass yield between the long/continuous and the short/non-intermittent photoperiods. There was no significant main effect of photoperiod, light intensity or photoperiod x light intensity interaction on either the fat weight or fat yield in the present study. Similar to carcass results, broilers reared under the short/non-intermittent photoperiod had a significant reduction in fillet weight ($P<0.002$), fillet yield ($P<0.013$) and tender weight ($P<0.001$) when compared with broilers reared under the long/continuous or the

Table 1: Influence of photoperiod, light-intensity and their interaction on body weight (BW) and body weight gain (BWG) of heavy broiler chickens

	BW (kg)				BWG (kg)			
Item	14 d	28 d	42 d	56 d	14 d	28 d	42 d	56 d
Photoperiod treatment								
Long	0.409[a]	1.479[a]	2.799[a]	4.100[ab]	0.367[a]	1.436[a]	2.757[a]	4.057[ab]
Reg-inter	0.403[a]	1.496[a]	2.869[a]	4.211[a]	0.361[a]	1.453[a]	2.837[a]	4.169[a]
Short-non-inter	0.330[b]	1.247[b]	2.541[b]	3.801[b]	0.288[b]	1.204[b]	2.498[b]	3.759[b]
Intensity treatment								
10 lx	0.395	1.457	2.807	4.142	0.352	1.415	2.745	4.100
5.0 lx	0.383	1.415	2.735	4.081	0.340	1.372	2.692	4.039
0.5 lx	0.365	1.349	2.667	3.889	0.323	1.307	2.625	3.846
SEM[2]	0.011	0.055	0.053	0.102	0.010	0.054	0.052	0.103
Photoperiod-light intensity treatment								
Long-10 lx	0.427	1.543	2.896	4.203	0.385	1.501	2.854	4.161
Long-5.0 lx	0.415	1.495	2.797	4.071	0.373	1.453	2.754	4.028
Long-0.5 lx	0.386	1.399	2.706	4.026	0.343	1.355	2.663	3.983
Reg-Inter-10 lx	0.408	1.515	2.917	4.267	0.366	1.473	2.874	4.224
Reg-Inter-5.0 lx	0.414	1.532	2.924	4.341	0.372	1.489	2.882	4.299
Reg-Inter-0.5 lx	0.388	1.441	2.766	4.026	0.346	1.398	2.724	3.984
Short-non-inter-10 lx	0.349	1.314	2.609	3.957	0.306	1.272	2.566	3.914
Short-non-inter-5.0 lx	0.319	1.218	2.484	3.833	0.277	1.175	2.441	3.791
Short-non-inter-0.5 lx	0.323	1.209	2.531	3.614	0.281	1.167	2.488	3.572
SEM[3]	0.019	0.096	0.091	0.176	0.017	0.094	0.09	0.178
Source of variation				P-value				
Photoperiod	0.001	0.019	0.004	0.048	0.001	0.017	0.004	0.050
Light intensity	0.217	0.415	0.226	0.237	0.170	0.397	0.212	0.244
Photoperiod x Light intensity	0.821	0.970	0.816	0.926	0.771	0.966	0.807	0.929

[ab]Mean with in a column and effect that lack common superscripts differ significantly ($P \leq 0.05$)

[1]Pooled SEM for main effects (n = 6)

[2]Pooled SEM for interaction effect (n = 2)

Table 2: Influence of photoperiod, lihght-intensity and their interaction on feed intake and feed conversion of heavy broiler chickens

	Feed intake (kg)				Feed conversion (kg of feed/kg of gain)			
Item	14 d	28 d	42 d	56 d	14 d	28 d	42 d	56 d
Photoperiod treatment								
Long	0.4779[a]	2.098[a]	4.608[a]	8.402[ab]	1.302	1.460	1.672	2.043
Reg-inter	0.468[a]	2.084[a]	4.656[a]	8.504[a]	1.297	1.433	1.647	2.027
Short-non-inter	0.382[b]	1.719[b]	4.000[b]	7.559[b]	1.329	1.423	1.599	2.007
Intensity treatment								
10 lx	0.459	2.045	4.549	8.358	1.303	1.440	1.642	2.027
5.0 lx	0.448	1.961	4.430	8.265	1.317	1.425	1.643	2.015
0.5 lx	0.421	1.895	4.286	7.842	1.309	1.451	1.632	2.035
SEM[2]	0.012	0.103	0.114	0.158	0.020	0.026	0.026	0.029
Photoperiod-light intensity treatment								
Long-10 lx	0.504	2.200	4.788	8.630	1.310	1.465	1.678	2.059
Long-5.0 lx	0.484	2.076	4.585	8.407	1.297	1.429	1.665	2.035
Long-0.5 lx	0.445	2.019	4.452	8.170	1.301	1.488	1.673	2.036
Reg-Inter-10 lx	0.471	2.123	4.731	8.579	1.289	1.441	1.646	2.033
Reg-Inter-5.0 lx	0.492	2.159	4.814	8.925	1.321	1.449	1.670	2.041
Reg-Inter-0.5 lx	0.443	1.971	4.424	8.007	1.282	1.410	1.624	2.006
Short-non-inter-10 lx	0.402	1.814	4.127	7.865	1.312	1.415	1.603	1.989
Short-non-inter-5.0 lx	0.368	1.648	3.892	7.463	1.332	1.399	1.595	1.969
Short-non-inter-0.5 lx	0.377	1.696	3.982	7.349	1.345	1.455	1.600	2.064
SEM[3]	0.021	0.178	0.198	0.274	0.034	0.045	0.030	0.051
Source of variation				P-value				
Photoperiod	0.001	0.047	0.005	0.004	0.490	0.598	0.044	0.697
Light intensity	0.124	0.602	0.313	0.100	0.894	0.795	0.884	0.888
Photoperiod x Light intensity	0.528	0.964	0.79	0.576	0.893	0.800	0.893	0.724

[ab]Mean with in a column and effect that lack common superscripts differ significantly ($P \leq 0.05$)

[1]Pooled SEM for main effects (n = 6)

[2]Pooled SEM for interaction effect (n = 2)

Table 3: Influence of photoperiod, lihght-intensity and their interaction on live weights, carcass weights and yields of broiler at 56 d age[1,2]

		Carcass		Fat	
Item	Live weight (kg)	Weight (kg)	yield (%)	Weight (kg)	Yield (%)
Photoperiod treatment	4.07a	3.03a	74.49a	0.077	2.60
Long	4.16a	3.08a	74.06ab	0.083	2.74
Reg-inter	3.74b	2.75b	73.55b	0.071	2.65
Short-non-inter					
Intensity treatment					
10 lx	4.08	3.02	74.04	0.081	2.72
5.0 lx	4.03	2.98	73.89	0.078	2.67
0.5 lx	3.85	2.86	74.16	0.073	2.59
SEM[2]	0.077	0.051	0.197	0.004	0.133
Photoperiod-light intensity treatment					
Long-10 lx	4.10	3.06	74.61	0.075	2.49
Long-5.0 lx	4.08	3.04	74.55	0.079	2.65
Long-0.5 lx	4.02	2.99	74.32	0.077	2.65
Reg-Inter-10 lx	4.20	3.09	73.61	0.090	2.98
Reg-Inter-5.0 lx	4.31	3.20	74.28	0.082	2.57
Reg-Inter-0.5 lx	3.98	2.96	74.26	0.078	2.67
Short-non-inter-10 lx	3.95	2.92	73.91	0.078	2.68
Short-non-inter-5.0 lx	3.72	2.71	72.84	0.074	2.46
Short-non-inter-0.5 lx	3.55	2.09	73.90	0.063	2.46
SEM[4]	0.111	0.088	0.337	0.006	0.231
Source of variation			P-value		
Photoperiod	0.005	0.004	0.011	0.081	0.758
Light intensity	0.048	0.078	0.623	0.279	0.801
Photoperiod x Light intensity	0.432	0.396	0.111	0.581	0.606

[1]Mean within a column and effect that lack common superscripts differ significantly ($P \le 0.05$)

[2]Carcass with out giblets, necks and abdominal fat are expressed as a percentage of live weight

Table 4: Influence of photoperiod, lihght-intensity and their interaction on live weights and yields of broiler at 56 d age[1,2]

	Fillet		Tender	
Item	Weight (kg)	yield (%)	Weight (kg)	Yield (%)
Photoperiod treatment				
Long	0.812[a]	26.81[a]	0.162[a]	5.37
Reg-inter	0.825[a]	26.80[a]	0.164[a]	5.35
Short-non-inter	0.701[b]	25.43[b]	0.146[b]	5.34
Intensity treatment				
10 lx	0.811	26.77	0.163	5.43
5.0 lx	0.783	26.22	0.158	5.31
0.5 lx	0.744	26.05	0.151	5.32
SEM[2]	0.018	0.336	0.004	0.056
Photoperiod-light intensity treatment				
Long-10 lx	0.828	27.05	0.163	5.36
Long-5.0 lx	0.810	26.70	0.164	5.41
Long-0.5 lx	0.787	26.69	0.159	5.35
Reg-Inter-10 lx	0.836	27.03	0.168	5.45
Reg-Inter-5.0 lx	0.863	27.01	0.168	5.27
Reg-Inter-0.5 lx	0.776	26.36	0.157	5.34
Short-non-inter-10 lx	0.768	26.21	0.159	5.48
Short-non-inter-5.0 lx	0.677	24.97	0.142	5.26
Short-non-inter-0.5 lx	0.659	25.11	0.138	5.27
SEM[4]	0.032	0.583	0.005	0.097
Source of variation		P-value		
Photoperiod	0.002	0.013	0.001	0.890
Light intensity	0.059	0.317	0.058	0.285
Photoperiod x Light intensity	0.376	0.845	0.154	0.652

[1]Mean within a column and effect that lack common superscripts differ significantly ($P \le 0.05$)

[2]Pectoralis major and minor breast muscles are expressed as a percentage of carcass weight

regular/intermittent photoperiods but there was no main effect of photoperiod on tender yield (Table 4). There was also no main effect of light intensity or photoperiod x light intensity interaction on these examined variables in the present study. In addition, the photoperiods and light intensities that we used in this study apparently did not interact or acted independently to affect plasma corticosterone concentrations (data not shown).

DISCUSSION

When considering the birds' environments, lighting program is one of the major factors. Along with others (RH, air velocity, ambient temperatures, stocking density), the lighting program affects the birds' metabolism which in turn is responsible for maximizing growth performance and maintaining normal physiological processes and functions. The present results indicate that long/continuous and regular/intermittent photoperiods equally improved broiler growth performance and carcass characteristics as compared with the short/non-intermittent photoperiod. There were no significant effects of light intensity or photoperiod x light intensity interaction on any of the examined variables. Birds under the intermittent lighting program avoid the stress of continuous lighting and the opportunity to access feed all day long. A higher live weight is assumed as an advantage under continuous lighting. The results obtained in this study, are in agreement with the results reported by others (Buyse *et al.*, 1996; Hassanzadeh *et al.*, 2000; Lien *et al.*, 2007). It has been stated that intermittent lighting may provide a final weight similar to or better than continuous lighting (Buyse *et al.*, 1996). Similar results were obtained in studies of Lewis *et al.* (1998) when chicks reared under short photoperiods had reduced feed intake and growth rate in comparison with long-day treatments birds. However, in contrary to our results, Lien *et al.* (2007) observed an interaction effect between intensities of 1 and 0.1 foot candle and photoperiods of 23L:1D and 18L:6D on broiler BW and part yield. In addition, Buckland *et al.* (1975) reported that lighting regime had a significant effect on BW gain and leg abnormalities with birds reared under continuous light than those reared under intermittent light regimes.

The incidence of cannibalism is another detrimental problem when light is provided on a continuous basis and using intermittent light may help to eliminate this type of problem, as bird will remain quiet during the dark hours of light schedule. Furthermore, metabolic disorders and incidence of cannibalism which are common in broiler production under continuous lighting program, could be restrained by providing an intermittent lighting system. Results from this study demonstrates that regular intermittent lighting schedule may be more beneficial to broiler production than long/continuous by saving electricity without negative effects on poultry welfare and mortality. Although, there were significant differences in BW, BWG and Feed Intake (FI) but FCR was not significantly different among the treatments. These results are similar to reports by other investigators (Buckland *et al.*, 1976; Ohtani and Leeson, 2000), while other researchers reported that intermittent lighting can increase FCR of broiler chickens (Apeldoorn *et al.*, 1999; Rahimi *et al.*, 2005; Canan Bolukbasi and Hakki Emsen, 2006). In support of these, it has been reported that live weight gain declined with a decrease in photoperiod (Boon *et al.*, 2000).

The results indicated that short/non-intermittent photoperiod markedly affects broiler performance as shown by a significantly reduced feed consumption, growth performance and carcass yield, resulting in a negative impact on the metabolism of heavy broiler chickens. These metabolic changes were represented by reduced BW, BWG and carcass characteristics of broilers during the growth period that may have a significant negative impact on the genetic potential and production efficiency.

Concentrations of plasma corticosterone (CS) have been used as a stress indicator in broilers (Puvadolpirod and Thaxton, 2000; Olanrewaju *et al.*, 2006a). In this present study, concentrations of plasma CS were not affected by photoperiod, light intensity or their interactions, suggesting that these factors may not pose as stressors to the heavy broiler chickens. In conclusion, these data indicate that regular/intermittent and long/continuous photoperiods equally improved broiler growth performance and carcass characteristics as compared with a short/non-intermittent photoperiod which has been shown to have negative impact on growth performance and carcass characteristics of broilers grown to heavy weights. Furthermore, use of the regular-intermittent rather than the long-continuous photoperiod by the poultry industry may decrease energy utilization. The slightly faster growth rate and slight improvement in feed conversion efficiency of birds reared under the regular-intermittent would provide the industry with an additional reduced annual feed costs.

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