EFFECT OF LIGHT REGIME AND FEEDING FREQUENCY ON SOME PRODUCTIVE, PHYSIOLOGICAL TRAITS AND HORMONAL PROFILES IN BROILER CHICKS

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ABSTRACT: *The effect of light regime and feeding system on broiler performance, carcass traits, serum hormones and metabolic profiles was studied using eight hundred and ten one-day-old broiler chicks from Arbor Acres strain. Broilers were distributed randomly in 3 by 3 factorial arrangement. Three light regimes, (continuous light (23L: 1D), constant light (15L: 9D) and intermittent light (4L: 8D)) were applied. Within each light regime there were three feeding systems i.e., ad libitum, one meal/d for 4h (7:11 a.m.) or two meals/d, each was available for 2h (7:9 a.m. and 12-14 p.m.).*

Results indicated that light regime significantly affected body weight (BW) and cumulative growth, showing that intermittent light and continuous light regime had similar cumulative growth and feed conversion ratio (FCR) and both were better than constant light schedule. Body weight and cumulative growth were *affected by feeding system. Ad libitum fed birds expressed better growth and cumulative growth than those fed once or twice a day, however FCR for the whole period was similar among different feeding regimes. There was a stepwise significant decrease in feed intake for the whole experimental period with decreasing feeding schedule. Viability percentage was not affected by their light schedule and/or feeding system.*

Dressing percentage was significantly improved with decreasing photoperiod, and it was maximized when intermittent light was applied, and acompanied with a significant decrease in blood percentage. Liver and gizzard percentage were affected (P<0.01) by the feeding system, where feeding once a day increased both parameters, while offering two meals a day increased gizzard only. Liver lipids at 5 wk of age and liver protein at 7 wk of age were significantly decreased due to intermittent light. Liver *protein and glycogen were increased at 5 wk of age, while liver lipids at 7 wk of age was decreased due to feeding broilers once a day. At 5 wk of age intermittent light increased serum albumin and globulin and decreased serum total lipids. At 7 wk of age, intermittent light significantly decreased serum total lipids and phosphorus, while increased serum cholesterol. At 5 wk of age, feeding twice a day significantly increased serum total protein and globulin, while decreased serum total lipids. Feeding once a day significantly increased serum phosphorus level at 7 wk of age. Serum T_4 and growth hormones were not affected by light regime and feeding system, however, serum T_3 at 5 wk of age only was significantly decreased due to constant and intermittent light schedule as well as feeding two meals a day.*

In conclusion, it is possible to use the intermittent light regime in broiler rearing programs without negative effects on growth and feed conversion with expected considerable saving in energy (electricity) expense of continuous light.

INTRODUCTION

Genetic selection for rapid growth in broilers has resulted in greater final BW and improved FCR. However, accelerated growth rates are associated with several undesirable effects such as increased fat deposition, and higher incidence of metabolic diseases, visual anomalies, skeletal deformities, and circulatory problems **(Olanrewaju *et al.*, 2006)**. These deficiencies, as well as the associated financial expense, have led to increased interest in developing management techniques that will maximize productivity while minimizing associated problems of broilers.

Lighting is one of the most important exogenous factors in controling of many physiological and behavioral processes. It is integral to sight, including both visual acuity and color discrimination **(Manser, 1996)**. Light allows the bird to establish rhythmicity and synchronize many essential functions, including body temperature and various metabolic steps that facilitate feeding and digestion. Of equal importance, light stimulates secretory patterns of several hormones that control, in a large part, growth, maturation, and reproduction **(Olanrewaju *et al.*, 2006)**.

The potential for changing photoperiods to influence broiler productivity and health is receiving considerable investigations **(Olanrewaju *et al.*, 2006; Shariatmadari and Moghadamian, 2007)**. Some lighting programs aimed to slowing the early growth rate of broilers thus allowing birds to achieve physiological maturity before maximal rates of muscle mass accretion. Their use in the industry is now significant and increasing **(Al–Homidan and Petchey, 2001).** Broiler chicks reared under intermittent light showed a temporary growth delay after change at an early age from continuous light and manifested catch-up growth during the subsequent period **(Ohtani and Tanaka, 1997).** It has been assumed that the reduction of activity during darkness may result in lower heat production, better FCR, or both. Under intermittent, birds eat about 80% of their total feed intake during the light period and eat little during the dark period **(Buyse and Decuypere, 1988).** This rhythm might exert some influence on intake and digestibility of feed in chickens subjected to intermittent schedule.

Few studies have been done to examine the effect of intermittent light on energy balance and feeding system of broiler chickens **(Ohtani and Lesson, 2000).** On the other hand, broiler chicks have shown compensatory growth after early feed restriction with improved FCR and decreased fat deposition **(Saleh *et al.*, 1996; Attia *et al.*, 1995).** Recently, there are increasing interest in energy (electricity) save as a result of the increase in feed price and energy cost **(FAO, 2008)** Therefore, the present study was conducted to investigate, the effect of different lighting regimes and feeding systems on broiler performance, carcass traits, serum hormones and metabolic profiles.

MATERIALS AND METHODS

The present study was carried out at the Poultry Experimental Station, Faculty of Agriculture, Minufiya University, Shebin El- Kom, Egypt. A total number of 810 commercial one-day-old Arbor Acres broiler chicks were used in this study.

The experimental design was 3×3 factorial with three light regimes and three feeding systems; the light regimes were continuous light (23L: 1D), constant light (15L: 9D) and intermittent light (4L: 8D) and the feeding systems were *ad libitum,* one meal/day available for 4h (7:11 a.m.) or two meals/day, each was available for 2h (7:9 a.m. and 12-14 p.m.).

Chicks were brooded in floor pens. They were fed during the first four wk of age on a basal starter ration and from 5 to 7 wk of age on a finisher diet (Table 1). Chicks were wing-banded and weighed individually at weekly intervals. Chicks were randomly assigned to three replicates in each treatment of 30 chicks, thus there were 90 chicks in each treatment, resulted in a total of 810 experimental chicks.

Body weight was recorded individually weekly. Cumulative growth was obtained from 1 to3, 1 to 4, 1 to5, 1 to 6 and 1 to7 wk of age. Feed consumption was determined for each replicate weekly starting from the 2nd wk of age and viability was recorded weekly, too. Feed conversion ratio was calculated as the amount of feed consumed per unit of body weight gain after the 1st wk.

Table 1. Composition of the experimental diets

Ingredients (%)	Diets	
	Starter	Finisher
Ground yellow corn	60.0	65.0
Soybean meal (44%)	31.5	29.0
Corn gluten (60%)	5.0	3.0
Bone meal	2.0	2.0
Limestone	0.40	0.50
Sodium Chloride	0.50	0.50
Lysine-HCL	0.60	-
Vit. Mixture*	+	+
Min. Mixture**	+	+
Crude Protein % (calculated)	23.14	21.28
ME, (Kcal/ Kg , calculated)	3021	2995.4
C/P Ratio (calculated)	131: 1	140: 1

***Vitamin Mixture:** 20mg Niacin, 4.5g Riboflavin, 3g Pyridoxine (B6), 13mg Cyanocobalamin (B_{12}) and 100mg Coline chloride 20000000 IU Vit A, 20000000 IU Vit D_3 and 400IU Vit E. ** **Mineral Mixture:** 906g Calcium carbonate, 55g Manganese, 35g Zinc, 2.65g Copper, 0.35g Iodine and 1.0g Selenium.

At the end of the 7th wk of age, a slaughter trial was done using 3 males and 3 females chosen randomly from each group. Males and females were individually weighed alive then slaughtered to complete bleeding, followed by plucking the feather. Empty carcass (dressing), liver, blood, heart and gizzard were weighed and their percentages to live body weight were calculated. Abdominal fat surrounding the gizzard, intestine and in the abdominal cavity were separately weighed and its percentages to the live weight were calculated. Liver samples were secured at 5 and 7 wk of age from 6 bird per replicate chosen randomly to determine liver lipids and protein using **AOAC (1990)** and glycogen by the method of **Der Vies (1954)**.

Individual blood samples were collected in dry clean centrifuge tubes from three males and three females within each treatment at the 5th and 7th wk of age. Serum was separated by centrifugation at 3000 rpm for 20 minutes. Constituents of blood serum were determined e.g. serum total protein **(Cannon, 1974)**, total lipids **(Boutwell, 1972)**, albumin **(Doumas *et***

***al.*, 1977)**, cholesterol **(Stein, 1986)**, calcium **(Sendroy, 1944)**, and inorganic P **(Gomorri, 1942)**, Globulin was calculated by the difference between total protein and albumin. Triiodothyronine (T_3), Thyroxine (T_4) and growth hormone (GH) were determined using commercial kits by Multi-channel Gama Counter Konrron 312.

Excreta were collected twice a day at 47, 48 and 49 days of age. Each three days collected excreta (or feces) was frozen and pooled after drying at 50 °C. Excreta weight was recorded. Energy of diet and excreta samples were determined using bomb calorimeter. Nitrogen analysis for these samples was conducted by using Micro Kjeldahl procedure.

Data were subjected to statistical analysis using **SPSS (1984)** using two-way factorial design. The following model was used:

$$Y_{ijk} = \mu + D_i + PC_j + (D \times PC)_{ij} + e_{ijk}$$

Where Y_{ijk} = the dependent variables; μ = general mean; D_i = effect of light regime; PCj = effect of feeding system $(D \times PC)_{ij}$ = effect of the interaction between light regime and feeding system; and e_{ijk} = random error. Before analysis, all percentages were subjected to arcsine transformation to approximate normal distribution. **Mean difference** at $p \leq 0.05$ was tested using the Multiple Duncan Test **(Duncan's, 1955)**.

RESULTS AND DISCUSSION

Body weight and cumulative growth: Results in Table (2) show that there was a significant effect (p<0.01) of light regime on body weight at 3, 5 and 7 wk of age. It was found that body weight at 3 wk of age was significantly decreased due to illumination of broiler chicks with constant and intermittent light compared to continuous light regime. At 5 wk of age, birds under continuous light and intermittent light had similar body weight and were heavier than those exposed to constant light. Light regime showed a significant effect on cumulative growth at 1-3 (p<0.01) and 1-4 (p<0.05) wk of age, indicating that chicks exposed to continuous light exhibited higher growth rate than those maintained under constant and intermittent light regimes. At the end of the experimental period (7 wk of age), there was a significant negative effect of alternatives light schedules on body weight, however, intermittent light showed significantly higher growth rate (6.9%) than constant light schedule.

Table 2. Effect of light regime and feeding system on body weight (g) and cumulative growth (%) (x ± S.E)

Traits / Treatments	Body weight			Cumulative growth rate, %				
	3 wk	5 wk	7 wk	(1-3) wk	(1-4) wk	(1-5)wk	(1-6) wk	(1-7) wk
Light regime	**	**	**	**	*	NS	NS	**
(23L:1D)	502.7 ± 5.9^a	1128.6 ± 67.6^a	1935.1 ± 23.5^a	131.8 ± 0.7^a	149.0 ± 1.8^a	164.8 ± 0.6	168.9 ± 4.5	179.7 ± 0.3^a
(15L:9D)	457.9 ± 6.9^c	995.1 ± 20.4^b	1675.5 ± 36.0^c	127.2 ± 0.9^b	147.3 ± 1.7^b	159.0 ± 3.9	171.5 ± 0.5	176.7 ± 0.5^b
(4L:8D)	476.4 ± 5.5^b	1098.6 ± 17.7^a	1791.3 ± 32.8^b	129.2 ± 0.6^b	152.3 ± 0.6^b	165.5 ± 0.5	173.0 ± 0.4	178.1 ± 0.4^a
Feeding system	**	**	**	**	*	*	NS	**
Ad libitum	502.3 ± 5.5^a	1228.5 ± 68.1^a	1969.7 ± 27.5^a	133.1 ± 0.6^a	152.9 ± 1.9^a	168.1 ± 0.6^a	170.8 ± 4.8	180.3 ± 0.4^a
One meal	469.1 ± 6.7^b	978.4 ± 13.0^b	1673.5 ± 32.8^c	127.5 ± 0.8^b	147.9 ± 0.6^b	161.6 ± 0.5^b	170.6 ± 0.4	176.5 ± 0.4^b
Two meals	466.9 ± 6.3^b	1018.9 ± 18.5^b	1765.2 ± 30.4^b	127.8 ± 0.8^b	147.9 ± 1.6^b	159.8 ± 3.8^b	171.9 ± 0.4	177.8 ± 0.4^b
Interaction (LR x FS)	**	**	**	**	**	NS	NS	NS

NS = not significant * = $P < 0.05$ ** = $P < 0.01$

a,b,c Means having different letters within each classification column are significantly different from each other

Moreover, cumulative growth of the intermittent light group was similar to the continuous light group at the end of the experiment, revealing compensatory growth and this was clear from the 5th wk where the significant differences in cumulative growth was diminished. The phenomena of compensatory growth had been reported in the literature (**Attia *et al.*, 1995; Saleh *et al.*, 1996**). The present results are similar to those reported by **Bölükbasi and Emsen (2006)**. The recovery of growth of broilers exposed to intermittent light could be attributed to low activity during dark period, better digestion of feed and less maintenance nutrient requirements **(Rahimi *et al.*, 2005)**.

Obviously, *ad libitum* fed chicks had heavier BW and cumulative growth throughout the experiment than those fed one meal or two meals/day, and chicks fed one meal/day showed lower (5.5%) growth rate than those fed two meals /day (Table 2). These results could be explained by the decrease (3.7%) in feed intake of these groups (Table 3). Similar results were reported by **Attia *et al.* (1995), and Saleh *et al.* (1996)**. There was a significant interaction between light regime and feeding system on body weight and cumulative growth throughout the experiment (Table 2), showing that *ad libitum fed* chicks under either continuous light or intermittent light exhibited the best growth and cumulative growth. Unfortunately is seems that there are very limited literature describing the effect of light regime × feeding system on economic traits. **Shariatmadari and Moghadamian (2007)** reported that lighting schedule and feeding regime did not have any interaction effect, except for relative growth rate ($p<0.05$) in which birds with feed restriction under intermittent schedule were heavier than birds with feed restriction under continuous light regime. Intermittent lighting and feed restriction had synergic activity and positive effects on BWG.

Daily feed intake: Table (3) shows that there were no significant differences between light regimes on feed intake. These results are in agreement with those by **Perry (1981)** who stated that chickens can learn to eat in the dark, but their feed intake in the dark is much reduced. They can also learn to increase feed intake during the light period in anticipation of the dark period, but are limited by their crop size. There was a significant effect of feed restriction on feed intake throughout the experimental period. For the whole experimental period, results indicated that there was a stepwise significant decrease in feed intake with decreasing feeding regime, with chicks fed one meal per day consumed less 13.8 and 3.6% feed than those fed ad libitum and two meals/day. Also, two meals/day consumed less 10.6% feed than those fed ad libitum. It was found that the ability of chicks to compensate for feeding one meal and two meals compared to ad libitum fed chicks was improved over time (e.g.20.8 and 17.9% during 2-3 wk of age, 19.4 and 15.4% during 2-5 wk of age) compared to 13.8 and 3.6% during 2-7 wk of age. No significant interaction effect between light regime and feeding system on feed consumption during any experimental period was observed. Similar results were reported by **Shariatmadari and Moghadamian (2007)**. They showed that there was a significant decrease in feed intake with increasing the severity of feed restriction.

Feed conversion ratio: Table (3) showed the data of FCR throughout the experimental period. No significant differences were observed among different light regimes in FCR during any tested period, showing that broilers exposed to constant light regime and intermittent schedule utilized the feed as efficient as those exposed to continuous light regime. In agreement with the present results **Rahimi *et al.* (2005) and Onbasilar *et al.* (2007)** found that intermittent light improved feed conversion and economic returns for broiler chicks. These interesting findings have an economic impact in poultry farming due to low (3.8%) feed intake in the chicks under intermittent light (Table 3) as well as a considerable saving in lighting (electricity) expense (8/23; 65%). Recently this is of economic consideration after the increase in the price of fuel and the use of grains for biofuel production **(Wang *et al.*, 2007; FAO, 2008).**

Table 3. Effect of light regime and feeding system on feed intake (g/chick/day), feed conversion rate (g feed/g gain) and viability (%) ($\bar{x}$ ± S.E)

Traits / Treatment	Feed intake (g/ chick/day)			Feed conversion ratio (g feed/g gain)			Viability
	(2-3) wk	(2-5) wk	(2-7) wk	(2-3) wk	(2-5) wk	(2-7) wk	(1-7) wk
Light regime	NS	NS	NS	NS	NS	NS	NS
(23L:1D)	58.1 ± 4.2	87.6 ±4.7	113.5 ± 5.2	2.31± 0.16	2.71 ± 0.23	2.81 ± 0.00	100.0 ± 0.0
(15L:9D)	53.1 ± 3.9	84.2±6.1	112.3±5.0	2.12 ± 0.15	2.32 ± 0.15	2.80 ± 0.00	100.0 ± 0.0
(4L:8D)	54.9 ± 5.3	85.6±6.5	109.2± 5..2	2.13± 0.20	2.31 ± 0.11	2.81 ± 0.00	100.0 ± 0.0
Feeding system	**	**	**	**	**	NS	NS
Ad libitum	63.6 ± 1.4^{a}	97.1±0.7^{a}	121.3±2.2^{a}	2.51 ± 0.05^{a}	2.60±0.02^{a}	2.81±0.00	100.0 ± 0.0
One meal	50.4 ± 0.2^{b}	78.3±0.9^{b}	104.5± 2.0^{c}	1.92 ± 0.01^{b}	2.11± 0.02^{b}	2.82± 0.00	100.0 ± 0.0
Two meals	52.2 ± 3.9^{b}	82.1 ±2.2^{b}	108.4 ± 2.5^{b}	2.01 ± 0.15^{b}	2.22 ± 0.06^{b}	2.80 ± 0.00	100.0 ± 0.0
Interaction (LS x FS)	NS	NS	NS	NS	-	NS	NS

NS = not significant ** = $P < 0.01$

a,b,c Means having different letters within each classification column are significantly different from each other

Results showed that chicks fed one or two meals/day had better FCR during 2 –3 wk (2.3.5 and 19.9%, respectively) and 2-5 wk (18.8 and 14.6%, respectively) wk of age, however for the whole period differences in FCR were diminished. The improvement in FCR up to 5th wk of age, could be due to lower feed consumed and feed waste as well, better digestion and low energy expenditure. Similar results were reported by **Shariatmadari and Moghadamian (2007)**.

No significant interaction effect between lighting regimes and feeding systems on FCR was observed during all experimental periods. Similarly, **Shariatmadari and Moghadamian (2007)** reported that lighting schedule and feeding regime did not have any interaction effect on FCR of broiler chicks.

Viability: Table (3) showed the impact of different lighting regime and/or feeding system on viability of broiler chicks. It was found that there were no significant differences in viability between feeding systems and light regimes at all ages. These results may be reflect good management condition and efficiency of keeping birds till 7 wk of age as well as small number of experimental chicks. Similar results were reported by **Shariatmadari and Moghadamian (2007)**. In the literature, intermittent lighting programs have shown increased livability and decreased metabolic diseases such as ascites associated with pulmonary hypertension syndrome, sudden death syndrome, tibial dyschondroplasia and other skeletal disorders and improved immune system **(Petek *et al.*, 2005; Pan *et al.*, 2008; Onbasilar *et al.*, 2007)**.

Metabolizable energy (ME): Table (4) illustrates that birds under both continuous and intermittent lights had numerically higher ME values than constant light at 5 and 7 wk of age. This result reflected the efficiency of both light regimes than constant one, this may explain the better feed efficiency due to low energy expenditure of intermittent light regime than constant. These results are in agreement with those obtained by **Ohtani and Leeson (2000)**, who indicated that intermittent light exhibited higher ME and total heat production than continuous light, while heat production during dark period was less than that in the light period. No significant differences were found between feeding systems in ME, although *ad libitum* fed chicks and those fed two times a day had numerically higher ME value than the those fed once a day (Table 4). The results indicated that feeding chicks once a day increased energy expenditure than the other treatments at 5 and 7 wk of age.

Table 4. Effect of light regime and feeding system on metabolizable energy (ME) (Kcal / g) ($\bar{x} \pm$ SE)

Treatments	5 wk	7 wk
	(ME) (Kcal / g)	(ME) (Kcal / g)
Light regime	**NS**	**NS**
(23L:1D)	2.671 ± 0.159	3.044 ± 0.111
(15L:9D)	2.361 ± 0.046	2.489 ± 0.063
(4L:8D)	2.597 ± 0.198	2.729 ± 0.275
Feeding system	**NS**	**NS**
Ad libitum	2.841 ± 0.172	2.792 ± 0.200
One meal	2.309 ± 0.057	2.581 ± 0.153
Interaction		
LR x FS	**NS**	**NS**

NS, not significant

Carcass characteristics: Table (5) shows that there was a highly significant difference was noticed due to only light regimes on dressing percentage of 7 wk old chicks (5). Intermittent light regime resulted in significantly higher dressing percentage than those of constant light (1.8%) and continuous light (3.6%). This result reflected the decrease in energy expenditure and change in metabolic process towards leanness due to low activity in the dark period and better nutrient utilization.

No significant difference was found among light regimes and feeding treatment on abdominal fat and feather (Table 5). Heart percentage was not affected by light regime and feeding system, too. Meanwhile, liver percentage and gizzard were not affected by light regime. While blood percentage was affected by light regime showing that percentage blood was significantly decreased due to intermittent light regime. On the other hand, liver percentage was enlarged due to offering feed once a day. Meanwhile, liver percentage and gizzard were not affected by light regime. Interestingly, gizzard was enlarged due to restricted time of feeding and this may be an adaptation response to improve nutrient digestion to overcome feed shortage (Table 3).

Table 5. Effect of light regime and feeding system on carcass characteristics at seven weeks of age ($\bar{x} \pm SE$)

Treatments	Dressing (%)	Abdominal fat (%)	Heart(%)	Liver (%)	Gizzard (%)	Blood (%)	Feather (%)
Light regime	**	NS	NS	NS	NS	**	NS
(23L:1D)	71.7 ± 0.95c	0.75 ± 0.12	0.47 ± 0.02	2.25 ± 0.13	2.07 ± 0.08	2.60 ± 0.27^{a}	5.22 ± 0.17
(15L:9D)	75.0 ± 1.22 b	0.89 ± 0.16	0.50 ± 0.02	2.51 ± 0.11	2.01 ± 0.07	2.22 ± 0.21^{a}	5.10 ± 0.02
(4L:8D)	80.3 ± 1.00 a	0.78 ± 0.10	0.48 ± 0.02	2.10 ± 0.11	2.13 ± 0.08	1.63 ± 0.13^{b}	4.7 ± 0.12
Feeding system	NS	NS	NS	**	**	NS	NS
Ad libitum	75.9 ± 1.20	0.91 ± 0.12	0.49 ± 0.02	2.10 ± 0.11^{b}	1.90 ± 0.06^{b}	2.30 ± 0.26	4.70 ± 0.16
One meal	73.7 ± 1.45	0.67 ± 0.11	0.48 ± 0.02	2.81 ± 0.10^{a}	2.23 ± 0.08^{a}	1.90 ± 0.22	5.30 ± 0.18
Two meals	77.4 ± 1.30	0.84 ± 0.15	0.47 ± 0.01	2.13 ± 0.06^{b}	2.11 ± 0.06^{a}	2.11 ± 0.21	4.90 ± 0.19
Interaction							
LR x FS	NS	NS	*	NS	NS	NS	NS

NS = not significant * = $P < 0.05$ ** = $P \leq 0.01$

a,b Means having different letters within each classification column are significantly different from each other

Only a significant interaction between light regime and feeding system was shown in heart percentage. Similar results were obtained by **Onbasilar et al. (2007) and Shariatmadari and Moghadamian (2007).** The latter authors found that feed restriction and lighting program did not have any significant effect on carcass composition (protein, fat, ash and dry matter), carcass parts percentage (except for drumstick), abdominal fat percentage, lung, heart, right and left ventricle weight and hematocrit percentage ($p<0.05$), but heart percent and drumstick percentage in birds fed 80 % of *ad libitum* were higher than the other groups ($p<0.05$).

Liver lipids, protein and glycogen: Table (6) demonstrated that at 5wk of age, birds subjected to an increasing photoperiod- continuous and constant light-exhibited significantly higher (39.2 and 37.7 %, respectively) liver lipids than that of the intermittent light system. However, liver protein and glycogen were not affected by light regime. The decrease in liver lipids due to using of intermittent regime indicated a decrease in lipogenesis and metabolic shift towards lean tissue and support muscle growth (Table 2). However, at 7wk of age, birds subjected to different light systems showed no changes in liver lipids and glycogens (Table 6). However, liver protein was significantly decreased by 6.2 and 3.0% respectively due to use of intermittent light compared to continuous and constant light schedule. These results disagreed with those obtained by **Al-Homidan (1994).**

Results also showed that at 5 wk of age *ad libitum* fed chicks and once-a-day fed chicks exhibited similar liver protein (63.9 and 63.3 %) and this was significantly higher by 4.8 and 3.8% respectively than those fed twice a day (61.0 %). On the other hand, liver lipids of *ad libitum* fed birds at 7 wk of age was (25.4 %) significantly higher than those of chicks fed once (21.2%) or twice (22.7%) a day. Chicks fed once a day exhibited significantly higher liver glycogen than those fed twice a day and *ad libitum* fed chicks at 5 and 7 wk of age. Also, chicks fed twice a day had significantly more liver glycogen than those fed *ad libitum*. This indicated that chicks under feed restriction tend to accumulate more glycogen in liver as an energy reserves. This may be due to feed restriction has been shown to be a potent stress **(Freeman *et al.* 1980).** The interaction between light and feeding systems indicated significant effect on glycogen content at 5 and 7 wk of age. Also, **AL-Homidan (1994)** noted that feeding chicks at less frequent time caused an increase in liver glycogen than that fed *ad libitum*.

Table 6. Effect of light regime and feeding system on liver lipids, protein and glycogen (%) at five and seven weeks of age ($\bar{x} \pm SE$)

Treatments	Liver analyses at 5 wk of age			Liver analyses at 7 wk of age		
	Liver lipids (%)	Liver protein (%)	Glycogen (mg / g)	Liver lipids (%)	Liver protein (%)	Glycogen (mg / g)
Light regime	**	NS	NS	NS	**	NS
(23L:1D)	18.1 ± 0.47^{a}	63.5 ± 0.64	0.48 ± 0.07	24.0 ± 0.95	69.7 ± 0.84^{a}	0.93 ± 0.19
(15L:9D)	17.9 ± 0.46^{a}	62.8 ± 1.09	0.47 ± 0.09	21.9 ± 1.28	67.4 ± 1.02^{a}	0.90 ± 0.14
(4L:8D)	13.0 ± 0.55^{b}	62.3± 0.97	0.57 ± 0.11	23.3 ± 1.15	65.4 ± 1.03^{b}	1.22 ± 0.16
Feeding system	NS	*	**	*	NS	**
Ad libitum	17.2 ± 0.74	63.9 ± 0.82^{a}	0.09 ± 0.01^{c}	25.4 ± 0.90^{a}	68.2 ± 0.91	0.30 ± 0.04^{c}
One meal	16.6 ± 1.01	63.6 ± 0.91^{a}	0.80 ± 0.03^{a}	21.2 ± 0.97^{b}	66.6 ± 1.12	1.59 ± 0.07^{a}
Two meals	15.1 ± 0.68	61.0 ± 0.81^{b}	0.64 ± 0.02^{b}	22.7 ± 1.22^{b}	67.8 ± 1.21	1.16 ± 0.05^{b}
Interaction						
LR x FS	NS	NS	**	NS	NS	*

NS = not significant * = $P < 0.05$ ** = $P < 0.01$

^{a,b} Means having different letters within each classification column are significantly different from each other

Biochemical metabolic profiles: Blood profiling, initially used to detect subclinical disorders due to incorrect feeding, has recently been given more widely to evaluate the effects of different treatments on metabolic, nutritional and welfare conditions of animals **(Bovera *et al.*, 2007)**. Table (7) indicates that serum total protein, cholesterol, phosphorus and calcium were not affected by light regime at 5 wk of age. Continuous light significantly decreased serum albumin ($p<0.05$) and increased serum globulin ($p<0.05$) compared to constant light regime at 5 wk of age. On the other hand, chicks illuminated with intermittent light exhibited the highest serum protein and albumin than continuous light regime. Serum total lipids was significantly higher of continuous light regime than constant (16.2%) and intermittent (14.5%) light, although serum cholesterol levels were not different among the three light regimes at 5 wks of age, reveal no physiological stress.

At 7 wk of age, differences in serum albumin and globulin were diminished (Table 8), and differences in total protein and Ca were not significant. On the other hand, there were significant effects of light schedule on serum total lipids ($p<0.01$), cholesterol ($p<0.01$) and phosphorus ($p<0.05$) at 7 wk of age. Results showed that serum total lipids and phosphorus were significantly decreased due to application of intermittent light system compared to continuous and constant regimes. However, serum cholesterol was significantly increased in groups exposed to constant and intermittent light systems, showing higher environmental stress at 7 wk of age compared to 5 wk of age. **Onbasilar *et al.* (2007)** found that H/L, glucose, cholesterol and triglyceride levels did not differ significant among different lighting groups.

Chicks fed twice a day exhibited significantly higher serum total protein (6.74 g/100 ml) than the other feeding treatments at only 5 wk of age. The *ad libitum* fed chicks exhibited a significant increase of serum albumin ($p<0.05$), while decreased serum globulin ($p<0.05$) at 5 wk of age compared to the other feeding systems. Feeding twice meal a day resulted in higher serum globulin than feeding one meal a day. The latter resulted in significantly higher (16.94 g / L) serum total lipids than the other feeding groups (~14.8 g/L) at 5 wk of age. This finding suggested that these chicks tend to store more lipids, as psychological effect, to fulfill their nutritional requirements during the period of restricted feeding. However, the effect was diminished at 7 wk of age (Table 8). At 7 wk of age, broilers fed one meal a day exhibited significantly ($p<0.05$) higher serum phosphorus level (10.12 mg /dl) than those fed *ad libitum* (9.74 mg /dl) and two meal (9.85 mg/dl), indicating higher bone catabolism.

Table 7. Effect of light regime and feeding system on biochemical constituents of blood serum at five weeks of age ($\bar{x} \pm SE$)

Treatments	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	Total lipids (g/L)	Cholesterol (mg/dl)	Phosphorus (mg/dl)	Calcium (mg/dl)
Light regime	NS	*	*	**	NS	NS	NS
(23L:1D)	5.01 ± 0.36	1.95 ± 0.16^{b}	3.06 ± 0.21^{a}	17.27 ± 0.50^{a}	163.98 ± 3.03	10.19 ± 0.51	9.68 ± 0.20
(15L:9D)	5.11 ± 0.32	2.51 ± 0.18^{a}	2.60 ± 0.15^{b}	14.48 ± 0.78^{b}	160.63 ± 1.85	9.27 ± 0.44	9.69 ± 0.12
(4L:8D)	5.59 ± 0.44	2.48 ± 0.17^{a}	3.11± 0.27^{a}	14.76 ± 0.58^{b}	162.21 ± 0.61	9.86 ± 0.22	9.49 ± 0.19
Feeding system	**	*	*	*	NS	NS	NS
Ad libitum	4.30 ± 0.22^{b}	2.63 ± 0.16^{a}	1.67± 0.07^{c}	14.84 ± 0.75^{b}	163.37 ± 2.32	9.07 ± 0.46	9.25 ± 0.15
One meal	4.94 ± 0.26^{b}	2.20 ± 0.13^{b}	2.74 ± 0.14^{b}	16.94 ± 0.46^{a}	163.62 ± 2.40	9.93 ± 0.26	9.69 ± 0.15
Two meals	6.74 ± 0.33^{a}	2.10 ± 0.22^{b}	4.64± 0.12^{a}	14.73 ± 0.76^{b}	159.85 ± 1.84	10.33 ± 0.44	9.93 ± 0.15
Interaction							
LR x FS	NS	NS	NS	NS	NS	NS	NS

NS = not significant **$* = P \leq 0.05$** **$** = P \leq 0.01$**

[a,b] Means having different letters within each classification column are significantly different from each other

Table 8. . Effect of light regime and feeding system on biochemical constituents of blood serum at seven weeks of age ($\bar{x} \pm SE$)

Treatments	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	Total lipids (g/L)	Cholesterol (mg/dl)	Phosphorus (mg/dl)	Calcium (mg/dl)
Light regime	NS	NS	NS	**	**	*	NS
(23L:1D)	4.94 ± 0.38	1.95 ± 0.08	2.99 ± 0.21	17.62 ± 0.49 ^{a}	145.95 ± 4.89 ^{b}	10.22 ± 0.19 ^{a}	11.94 ± 0.43
(15L:9D)	5.27 ± 0.19	2.00± 0.09	3.27 ± 0.11	18.42± 0.45 ^{a}	171.69 ± 2.77 ^{a}	10.25 ± 0.31 ^{a}	12.54 ± 0.33
(4L:8D)	5.57 ± 0.31	2.27± 0.06	3.30 ± 0.25	14.85 ± 1.06 ^{b}	172.87 ± 4.15 ^{a}	9.23 ± 0.26 ^{b}	12.29 ± 0.49
Feeding system	NS	NS	NS	NS	NS	*	NS
Ad libitum	5.37 ± 0.31	2.14 ± 0.10	3.23 ± 0.21	18.04± 0.52	162.06 ± 3.19	9.74 ± 0.19 ^{b}	12.99 ± 0.30
One meal	5.59 ± 0.34	2.04 ± 0.06	3.55 ± 0.28	15.87 ± 1.03	162.07 ± 6.98	10.12 ± 0.38 ^{a}	11.74 ± 0.34
Two meals	4.82 ± 0.23	2.03 ± 0.09	2.79 ± 0.12	16.96 ± 0.81	166.39 ± 5.56	9.85 ± 0.27 ^{b}	12.04 ± 0.51
Interaction LR x FS	NS	NS	NS	NS	NS	NS	NS

NS = not significant * = $P \leq 0.05$ ** = $P \leq 0.01$

[a,b] Means having different letters within each classification column are significantly different from each other

These results are in general agreement with those reported by **Rajman *et al.* (2006)** who found that feed restriction reduced protein, albumin, lipids, triacylglycerols, cholesterol, HDL and Ca in plasma, while glucose and P in plasma were not affected.

Serum hormone concentrations: Table (9) illustrates the changes in serum hormones concentrations at 5 and 7 wk of age due to different lighting regimes and feeding system. It is noticed that, there was no association between serum T_4 and growth hormone at 5 and 7 wk of age and growth of broiler chicks during these periods due to either light regime and feeding system (Table 2 and 9). However, serum T_3 of 5 wk old chicks was significantly decreased due to implement of constant and intermittent light regimes and feeding two meals a day. This could explain the decrease in growth of these groups and especially those exposed to constant light regimes, which may be due to metabolic changes during darkness. These results are in agreement with those reported by **Newcombe *et al.* (1992),** who reported that plasma T_3 was significantly less in fed restricted group compared to *ad libitum* fed chicks. On the other hand, **Brake *et al.* (1979)** found that T_4 was declined while T_3 was unaffected by feed and water resection. Plasma growth hormone and T_3 are decreased during the period of feed restriction and plasma growth hormone was elevated during the period of accelerated growth. In a recent study (**Rajman *et al.*, 2006**) feed restriction elevated plasma T_4 and corticosterone levels and reduced T_3.

In the present study there was no change in plasma growth hormone due to either light regimen and feeding system. These results are in agreement with those reported by **Buyse *et al.* (1997)** . **Buys *et al.* (1998)** found that at 28 and 42 d respectively plasma T_3 was significantly lower and higher respectively than that in continuous light, while T_4 was significantly higher at 14 and 21 d of broilers reared under intermittent light than those in the continuous light regime. These results indicated that the changes in T_3 and T_4 are age dependent. Similar results were found in plasma growth hormones at 35 and 42. Also, **Kuhn *et al.* (1996)** reported that male broiler chickens raised in near continuous lighting (23:1) and intermittent lighting (1L:3d) repeatedly had higher growth rates, higher plasma growth hormone levels and testosterone concentrations than birds under a continuous light (24L:0 d).

In conclusion, it is possible to apply the intermittent light regime in broiler rearing programs without negative effects on growth and FCR with expected considerable saving in energy (electricity) expense of continuous light.

Table 9. Effect of light regime and feeding system on serum hormone concentrations at five and seven weeks of age (x ± SE)

Treatments	Serum hormone levels at 5 wk of age			Serum hormone levels at 7 wk of age		
	Triiodothyronine (T_3; ng/dl)	Thyroxine (T_4; ug/dl)	Growth hormone (GH; IU/ml)	Triiodothyronine (T_3; ng/dl)	Thyroxine (T_4; ug/dl)	Growth hormone (GH; IU/ml)
Light regime	**	NS	NS	NS	NS	NS
(23L:1D)	137.17 ± 40.68^{a}	1.78 ± 0.34	0.298 ± 0.02	70.33 ± 19.22	1.27 ± 0.37	0.296 ± 0.01
(15L:9D)	65.00 ± 17.41^{b}	1.76 ± 0.27	0.308 ± 0.01	68.50 ± 10.46	2.17 ± 0.53	0.300 ± 0.01
(4L:8D)	94.83 ± 45.43^{b}	1.73 ± 0.32	0.303 ± 0.01	93.33 ± 24.71	1.22 ± 0.32	0.307 ± 0.01
Feeding system	*	NS	NS	NS	NS	NS
Ad libitum	153.66 ± 50.32^{a}	1.57 ± 0.27	0.310 ± 0.01	63.17 ± 17.54	1.33 ± 0.43	0.296 ± 0.01
One meal	100.33 ± 26.22^{a}	2.03 ± 0.33	0.311 ± 0.01	77.67 ± 12.23	1.80 ± 0.42	0.302 ± 0.01
Two meals	43.00 ± 10.20^{b}	1.76 ± 0.29	0.290 ± 0.02	91.33 ± 25.09	1.52 ± 0.49	0.305 ± 0.02
Interaction						
LR x FS	NS	NS	NS	NS	NS	NS

NS = not significant * = $P < 0.05$ ** = $P < 0.01$

a,b Means having different letters within each classification column are significantly different from each other

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الملخص العربي

تأثير نظم الإضاءة و عدد مرات التغذية على بعض الصفات الإنتاجية والفسولوجية و مستوي الهرمونات لدجاج اللحم

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أجريت هذه الدراسة بهدف قياس تأثير نظم الإضاءة و برامج التغذية على الأداء الإنتاجي وصفات الذبيحة وبعض قياسات الدم ، و مستوي الهرمونات المرتبطة بالنمو في كتاكيت اللحم. استخدم في هذه الدراسة ٨١٠ كتكوت Arbor Acres عمر يوم في تصميم إحصائي عاملي ٣×٣ (ثلاثة نظم إضاءة مع ثلاثة برامج تغذية)، و كانت نظم الإضاءة المتبعة هي نظام الإضاءة المستمر (٢٣ ساعة إضاءة : ساعة إظلام) و نظام الإضاءة الثابت (١٥ ساعة إضاءة: ٩ ساعة إظلام) و نظام الإضاءة المتقطعة (٤ ساعة إضاءة: ٨ ساعة إظلام) بينما كانت برامج التغذية هي نظام التغذية الحرة ونظام الوجبة الواحدة لمدة ٤ ساعات (٧ ص -١١ ص) و نظام الوجبتين ومدة كل وجبة ٢ ساعة (٧ ص - ٩ ص)، (١٢ص- ٢ م). تم قياس وزن الجسم و معدل النمو واستهلاك العلف اليومي للكتكوت ومعدل التحويل الغذائي و نسبة الحيوية وصفات الذبيحة. وتمثيل الطاقة ومحتويات الكبد من الدهن، البروتين والجليكوجين ومحتوى الدم من البروتينات والدهون الكلية ، الكوليسترول، الكالسيوم، الفوسفور، الألبيومين وهرمونات T_3, T_4 وهرمون النمو.

أثرت نظم الإضاءة المختلفة معنويا على وزن الجسم ومعدل النمو ومعدل استهلاك الغذاء ومعدل التحويل الغذائى في الأعمار المختلفة. وكان الأفضل تحت نظام الإضاءة المتقطع. بينما تحسنت نسبة التصافي و قلت نسبة الدم نتيجة استخدام نظام الاضاءة المتقطع و لم تتأثر نسبة الحيوية وأغلب صفات الذبيحة معنويا بأنظمة الإضاءة المختلفة.

كان لعدد مرات التغذية اثر عالي المعنوية على وزن الجسم ومعدل النمو عند كل الأعمار. أدت التغذية الحرة إلى إنتاج طيور اثقل وزنا في كل الأعمار من تلك التي غذيت على وجبة واحدة أو وجبتين. لم تتأثر نسبة الحيوية نتيجة تغيير النظام الغذائي المتبع. وجد أن نظام التغذية له تأثير معنوي على وزن والكبد والقونصة.

في الأسبوع السابع ظهر أن الطيور التي عرضت لنظام الإضاءة المستمر كانت اثقل وزنا تحت الثلاث نظم الغذائية. وضح ان معدل نمو الطيور التي غذيت تغذية حرة، وجبة واحدة ، وجبتين تحت نظام الإضاءة المتقطع كانت اعلى في معدل النمو.

تأثير التداخل بين نظام الإضاءة والتغذية على معدل استهلاك الغذاء، ومعدل التحويل الغذائي غير معنوي في جميع الفترات . أما بالنسبة لتمثيل الطاقة لم تتأثر بواسطة نظام الإضاءة و التغذية عند عمر ٧ أسابيع. لم يكن للتداخل بين الإضاءة والتغذية تأثير معنوية على نسبة التصافي ونسبة الدهن الحشوي، الكبد. القونصة و الدم و كان تأثير التداخل بين نظام الإضاءة والتغذية على نسبة القلب كان معنويا. لا يوجد تأثير للتداخل بين نظم التغذية والإضاءة على محتوى الكبد من دهن وبروتين عند ٥ ، ٧ أسابيع من العمر. ولكن كان تأثير التداخل معنوي على جليكوجين الكبد عند ٥ أسابيع ومعنوي عند ٧ أسابيع. لا يوجد تأثير للتداخل بين نظم الإضاءة والتغذية على كل مكونات الدم التي قدرت وكذلك على الهرمونات حيث كان التأثير غير معنوي عند ٥ ، ٧ أسابيع من العمر.

أوضحت الدراسة الحالية إمكانية استفادة مزارع الدواجن من نظام الإضاءة المتقطعة في تربية دجاج اللحم بدون تأثيرات ضارة على الصفات الإنتاجية الفسيولوجية مع توقع خفض في تكلفة إضاءة هذه المزارع حيث كان أداء دجاج التسمين أفضل تحت نظم التغذية الحرة مع الإضاءة المتقطعة مما نعكس في زيادة العائد الاقتصادي لتلك المزارع.