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APPLICATION OF INTERMITTENT FEEDING AND FLASH LIGHTING REGIMENS IN BROILER CHICKENS MANAGEMENT

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SUMMARY

Two experiments were conducted to evaluate the effect of intermittent feeding and flash lighting regimens on growth performance, carcass traits, blood parameters and economic efficiency of broiler chickens. In experiment 1, one hundred and twenty, one-day old Cobb chicks were equally distributed into four groups (each consisted of 3 replicates of 10 birds each). Chicks in the first group (G1) were fed *ad libitum* (Control, C), while the other three groups were fed according to intermittent feeding regimes consisted of different number of cycles per day, each cycle consisted of feeding period (F) followed by fasting period (S). Chicks of the second group (G2) were fed in 2 cycles per day, each of 6 hrs feeding followed by 6 hrs fasting (6F: 6S); chicks of the third group (G3) were fed in three cycles per day, each of 4 hrs feeding followed by 4 hrs fasting (4F: 4S) and chicks of the fourth group (G4) were fed in six cycles per day, each of 2 hrs feeding followed by 2 hrs fasting (2F: 2S). In experiment 2, one hundred and twenty, one-day old Cobb chicks were equally distributed into four groups (each consisted of 3 replicates of 10 birds each). Chicks in the first group (G1) were exposed to continuous light/day (Control, C), while the other three groups were exposed to intermittent flash lighting regimens as follows: the second group (G2) was exposed to 2hrs contiuous light+1hr dark for 8 cycles per day (2CL: 1D); the third group (G3) was exposed to 2hrs continuous light+1hr flash light for 8 cycles per day (2CL: 1FL) and the fourth group (G4) exposed to 1hrs continuous light + 2hrs flash light for 8 cycles per day (1CL: 2FL). The results indicated that intermittent feeding and flash lighting significantly ($P \leq 0.05$) affected body weight, body weight gain, feed consumption, feed conversion ratio, and consequently economic efficiency. However, it had no significant effect ($P \geq 0.05$) on most carcass traits, meat quality, blood parameters, lymphoid organs and conformation lengths except liver and abdominal fat percentages, tenderness and juiciness of meat, plasma lipids value, percentages of spleen and thymus weight. According to the results of present study and economic evaluation, it could be concluded that, it is possible to use the intermittent feeding regimen of 2F:2S for six cycles/day and flash lighting regimen of 2CL: 1FL for 8 cycled/day in broiler management to improve growth and economic efficiency as well as to reduce abdominal fat without any adverse effect till marketing age with expected considerable saving in costs of feed and (electricity).

Keywords: *broilers, intermittent feeding and flash lighting, carcass and blood traits, performance*

INTRODUCTION

In broilers production, rapid growth rates closely related with several physiological, behavioral and immunological problems such as skeletal and metabolic disorders and changes in behaviors coinciding with high cost of feeding, which is the most expensive item. Allowing birds an unlimited supply of feed usually results in consumption exceeds the bird's requirements for maintenance and production and the excess energy is converted into fat (Peter and Gernat 2006), that not only reduces carcass quality but also feed efficiency (Fontana *et al.*, 1993). Moreover, broilers have usually been kept on a continuous or nearly continuous lighting schedule so as to maximize feed intake and growth rate (Campo and Davila, 2002). Several managerial approaches, both lighting and feeding manipulations have been employed in attempts to restrict feed intake in order to reduce cost of feeding, improve feed efficiency, reduce excessive abdominal fat deposition, as well as lowering incidence of metabolic diseases, visual anomalies, skeletal deformities and circulatory problems. One of these feeding procedures involves restriction of feeding period or frequencies and intermittent lighting programs with compensatory growth are the key factors of feed management strategies to decrease the previous problems, which may be related to activity patterns, consequently energy expenditure (Mench, 2002; Nielsen *et al.*, 2003; Oyedeji and Atteh, 2005; Tolkamp *et al.*, 2005; Peter and Gernat 2006; Novel *et al.*, 2009; Onbasilar *et al.*, 2009; Farghly and Hassanien, 2012).

Light is integral to sight, including both visual acuity and allows establishing rhythmicity, as well as synchronizing many essential functions, including body temperature, stimulates secretory patterns of several hormones and various metabolic steps that facilitate feeding and digestion (Olanrewaju *et al.*, 2006). Alternative lighting programs can be classified into intermittent, restricted, combination of intermittent and restricted and light flashes schedules. Under intermittent light, birds eat about 80% of their total feed intake during the light period and eat little during the dark period (Buyse *et al.*, 1996). Furthermore, there are many potential welfare benefits associated with shorter photoperiods including: increased sleep, lower physiological stress, improved immune responsiveness, bone metabolism and leg strength, reduction in mortality and improvement in feed conversion, consequently, lower production costs. Also, it is assumed that the reduction of activity and resting or sleeping during darkness may result in lower heat production by 25% and have higher serum melatonin levels (Rahimi, *et al.*, 2005; Abbas *et al.*, 2007). Dust negatively affects the respiratory system of the birds and this is strongly affected by lighting program and the feeding system, it was 4 times higher during light than dark periods (Nielsen *et al.*, 2003; Calvet *et al.*, 2009). Melatonin is secreted during darkness by the pineal gland and sets the internal biological clock that governs different daily and seasonal cycles or rhythms in various physiological systems, including the cardiopulmonary, excretory, antioxidative thermoregulatory, behavioral, immune and neuroendocrine systems (Zeman *et al.*, 2004). Therefore, most of the recent researches have focused on restricting light regimens to improve productivity of broiler chickens.

Recently, there are increasing interest in energy (electricity) saving. Further research, is undoubtedly needed to establish the ultimate optimal feeding and lighting programs for broilers. Intermittent feeding or flashed light for broiler chicks was suggested as an alternative system that can be applied to manipulate continuous or restricted lighting and *ad libitum* feeding problems (Ahmad *et al.*, 2009; Azis, 2012; Svihusa *et al.*, 2013, Farghly, 2014). Moreover, broilers performance may be affected by the lack of nutrients (amino acids, minerals or vitamins) required for protein synthesis in cell through the feed absence time if the intervals of intermittent feeding or darkening were more than a certain time (Makled *et al.*, 2012). Thus, the present study was conducted on broiler chicks to evaluate the effect of different diurnal length of intermittent feeding and flashed lighting on their growth performance, carcass traits, blood parameters and economic efficiency.

MATERIALS AND METHODS

Birds and Management:

Two experiments were conducted at the Research Poultry Farm, Poultry Production Department, Faculty of Agriculture, Assiut University to evaluate the effect of intermittent feeding and flashed lighting system on growth performance, carcass traits, blood parameters and economic efficiency of broiler chickens. In experiment 1, one hundred and twenty, one-day old Cobb chicks were equally distributed into four groups (each consisted of 3 replicates of 10 birds each). Chicks in the first group (G1) were fed *ad libitum* (Control, C), while the other three groups were fed according to intermittent feeding regimes consisted of different number of cycles per day, each cycle consisted of feeding period (F) followed by fasting period (S). Chicks of the second group (G2) were fed in 2 cycles per day, each of 6 hrs feeding followed by 6 hrs fasting (6F: 6S); chicks of the third group (G3) were fed in three cycles per day, each of 4 hrs feeding followed by 4 hrs fasting (4F: 4S) and chicks of the fourth group (G4) were fed in six cycles per day, each of 2 hrs feeding followed by 2 hrs fasting (2F: 2S). In experiment 2, one hundred and twenty, one-day old Cobb chicks were equally distributed into four groups (each consisted of 3 replicates of 10 birds each). Chicks in the first group (G1) were exposed to continuous lighting 24 hrs a day (Control, C), while the other three groups were exposed to intermittent flashed lighting regimens as follows: chicks of the second group (G2) were exposed to 8 cycles per day each of 2hrs continuous light+1hr dark (2CL: 1D); chicks of the third group (G3) were exposed to 8 cycles per day each of 2hrs continuous light+1hr flashed light (2CL: 1FL) and chicks of the fourth group (G4) were exposed to 8 cycles per day each of 1hr continuous light + 2hrs flashed lighting cycles (1CL: 2FL). All sources of natural light were covered with heavy cotton black curtains and blackout plastic curtains which completely prevent any source of natural light. Flash lighting was composed of 20 flashes/ minute provided by flasher apparatus that contained timer and dimmer to justify the flash lighting period and intensity by using incandescent bulbs. Light intensity as measured at the middle of the room ranged between 5-10 lux. All birds in the second trial had full-access to feed and drinking water throughout the experimental period (6 weeks). Diets were formulated to contain 23% CP and 3000 Kcal, ME/Kg as starter from 0 to 3 wks old and 21% CP and 3100 Kcal. ME/Kg as grower from 3 to 6 wks old.

Measurements and Assessments:

Live body weight (BW) and feed consumption (FC) were weekly recorded. Average body weight gain (BWG) and feed conversion ratio (FCR, g feed/g gain) were weekly calculated from 0 to 6 weeks of age. At 6 weeks of age, three birds per group were taken as representative samples and slaughtered. The carcass was manually dissected and the following criteria were recorded: weights and percentages (of final body weight) of carcass, dressing (carcass weight + giblets weight), and intestinal tract (after removing their contents). Weights and percentages (of carcass weight) of liver, heart, pancreas, proventriculus, gizzard, abdominal fat, breast, legs (drumstick and thigh), lymphoid organs (spleen, thymus, bursa) and boneless meat were also recorded. Chemical composition of meat samples (mix of breast and legs) was determined according to AOAC procedures (1995). Sensory evaluation was carried out using a panel test by five persons to judge the meat samples for color, texture, tenderness, juiciness, flavour, aroma and acceptability with grades of 10 points. To estimate water holding capacity (WHC), section of muscles was weighed and placed between two filter papers, the papers with meat were placed between two glass plates. The weight losses were evaluated after pressure for 10 minutes by loads of 1.0 kg. Water holding capacity was then expressed as percentage: [(Damp filter papers weight - dry filter papers weight / meat sample weight) *100]. Blood samples were collected at slaughter in heparinized tubes. The blood samples were centrifuged at 3000 rpm for 15 min and the plasma obtained was stored at -20 °C until analysis. Plasma total protein, albumin, total lipids and transaminase enzymes activities (AST and ALT) were determined colorimetrically by diagnostic kits of Spectrum, (Cairo, Egypt). Economic efficiency (EE) and relative economic efficiency (REE) were calculated at the end of the experiment. Some conformation parameters (shank and keal bone lengths and body depth) were measured (cm) and health problems such as leg problems ((foot pad burns, hock discoloration) were recorded. Dead birds were recorded daily and expressed as percentage during the experimental period.

Statistical analysis:

The data obtained were subjected to statistical analysis by operating randomized complete block design (RCBD) using general linear models (GLM) procedure of SAS Institute (SAS, 1996). Significant differences between treatments means were verified using Duncan's multiple range test (Duncan, 1955). The following model was used for analysis of variance:

$$X_{ij} = \mu + \alpha_i + \beta_j + \epsilon_{ij}$$

Where: X_{ij} = observation (i = 1,…..,I; j= 1,……,j), μ = overall mean, α_i = replicates effect, β_j = treatments effect, ϵ_{ij} = experimental error.

RESULTS AND DISCUSSSION

Body weight (BW) and Body weight gain (BWG):

The results presented in Table (1.a) show that body weight and body weight gain of broiler chicks of G2 and G4 tended to decrease at 3 weeks of age ($P \leq 0.05$) than the control group. At 6 weeks of age, there were no significant differences in body weight and body weight gain between the treated groups and the control one. It seems that the broiler chicks of the intermittent fed groups were able to compensate the partial depression in body weight occurred till 3 weeks of age due to restricted feeding time. This may be due to gradual physiological adaptation of the birds to the different feeding regimes and probably due to improvement in efficiency of feed conversion. These results indicate that full compensatory growth was attained during the re-feeding period and it seems that the broilers quickly adapted to intermittent feeding. Velleman, *et al.* (2014) demonstrated that the timing of feed restriction to chicks is critical for the morphological development of the pectoralis major muscle and the expression of genes required for muscle satellite cell proliferation and differentiation. These findings are in agreement with those of Urdaneta-Rincon and Leeson (2002), Demir *et al.* (2004), Saleh *et al.* (2005), Tolkamp *et al.* (2005), Ozkan *et al.*, (2006), Khetani *et al.*, (2008), Onbasilar *et al.*, (2009), Butzen, *et al.*, (2013) and Velleman, *et al.* (2014). In contrast, Lippens *et al.* (2000), Petek (2000), Novel *et al.* (2009), Chris *et al.* (2011), Hassanein, *et al.* (2011), Azis (2012) and Svihus *et al.* (2013) reported that chicks fed ad libitum were heavier than restricted fed groups.

. Results in Table (1.b) show that the intermittent lighting or flash lighting had a significant effect ($P \leq 0.05$) on growth performance traits. It was found that body weight of broilers at 3 and 6 wks of age was significantly increased due to intermittent light or flash light (G2: 2CL,1D and G3: 2CL,1FL) compared to continuous light group. While, the intermittent flash lighting (G4: 1CL, 2FL) had intermediate values of body weight. Light treatments showed a significant effect ($P \leq 0.05$) on body weight gain at 1-3 and 1-6 wks of age, indicating that chicks exposed to intermittent light or flashes (G2: 2L,2D and G3: 1FL,2CL) exhibited higher body weight gain than those maintained under continuous lighting. The recovery of growth of broilers exposed to intermittent or flash lighting could be attributed to low activity during dark period, better digestion of feed and less maintenance nutrient requirements and having more available energy for growth (Rahimi *et al.*, 2005).. While, birds exposed to continuous light are mostly active that associated with more stress, causing disturbance to their nutrition metabolism and leading to have lower growth performance.

Table (1.a): Growth performance as affected by intermittent feeding (Mean ±SE).

Traits	Age (day)	Groups			
		G1 (C)	G2	G3	G4
Body weight, BW (g)	1	45.1±0.2	45.3±0.3	44.9±0.3	45.7±0.3
	21	746.2±7.8^{ab}	730.5±6.8^{b}	754.2± 8.0^{a}	730.6±8.3^{b}
	42	1913.4±13.3	1872.7±21.5	1914.1±15.6	1900.8±19.0
Body weight gain, BWG (g/bird/day)	1 - 21	33.4±0.4^{ab}	32.6±0.3^{b}	33.8±0.4^{a}	32.6±0.3^{b}
	22 - 42	55.6±0.9	54.4±1.0	55.2±0.8	55.7±1.0
	Overall mean	44.5±0.3	43.5±0.5	44.5±0.4	44.2±0.5
Feed consumption, FC (g/bird/day)	1 - 21	63.4±1.0^{a}	59.4±0.8^{ab}	61.1±1.2^{ab}	56.4±3.1^{b}
	22 - 42	95.6±2.1	91.1±1.2	94.7±1.8	93.2±2.1
	Overall mean	79.5±0.9^{a}	75.2±0.8^{b}	76.9±1.3^{ab}	74.8±0.9^{b}
Feed conversion ratio, FCR (g feed/g gain)	1 - 21	1.90±0.05^{a}	1.82±0.03^{ab}	1.81±0.03^{ab}	1.73±0.06^{b}
	22 - 42	1.72±0.04	1.68±0.05	1.68±0.03	1.67±0.05
	Overall mean	1.81±0.02^{a}	1.75±0.02^{ab}	1.74±0.03^{ab}	1.70±0.04^{b}

a-----b Means within row followed by different superscripts are significantly different ($P \leq 0.05$).

Table (1.b): Growth performance as affected by lighting regimens (Mean ±SE).

Traits	Age (day)	Groups			
		G1 (C)	G2	G3	G4
Body weight, BW (g)	1	45.4±0.2	44.9±0.3	45.7±0.3	45.2±0.3
	21	737.0±7.8^{b}	753.3±8.2^{b}	780.1± 10.7^{a}	747.6±7.1^{b}
	42	1920.3±14.9^{b}	1978.1±20.4^{a}	2004.4±20.6^{a}	1965.0±18.1^{ab}
Body weight gain, BWG (g/bird/day)	1 - 21	32.9±0.4^{b}	33.7±0.4^{b}	35.0±0.5^{a}	33.4±0.3^{b}
	22 - 42	56.4±0.9	58.3±1.0	58.3±1.0	58.0±0.9
	Overall mean	44.6±0.4^{b}	46.0±0.5^{a}	46.6±0.5^{a}	45.7±0.4^{ab}
Feed consumption, FC (g/bird/day)	1 - 21	63.6±1.4	59.6±1.5	61.4±1.4	58.9±1.4
	22 - 42	94.9±1.9^{a}	92.6±0.48^{ab}	90.4±0.8^{b}	90.4±1.3^{b}
	Overall mean	79.3±1.0^{a}	76.1±0.7^{ab}	75.9±0.7^{b}	74.6±1.3^{b}
Feed conversion ratio, FCR (g feed/g gain)	1 - 21	1.93±0.04^{a}	1.77±0.08^{b}	1.76±0.01^{b}	1.76±0.04^{b}
	22 - 42	1.68±0.03^{a}	1.59±0.02^{ab}	1.55±0.02^{b}	1.56±0.06^{ab}
	Overall mean	1.81±0.01^{a}	1.68±0.03^{b}	1.65±0.01^{b}	1.66±0.05^{b}

a-----b Means within row followed by different superscripts are significantly different ($P \leq 0.05$).

The replacement of the dark hour with flash lighting may have aided early growth by providing the birds more opportunity to see the feed, reduction of heat production and stimulates secretory patterns of several hormones (Abbas *et al.*, 2007; Farghly, 2014). Hoption (2006) found that the light programs affect the thyroid hormones that regulating basic metabolism, oxygen consumption (uptake), utilization of carbohydrates, proteins and fats, and heat production processes and to affect growth development. The effect of hormones on metabolism involves synthesis of other enzymes, which affect intracellular processes of oxidation and protein synthesis. Also, thyroid hormones stimulate intestinal differentiation and maturation as indicated by cellular changes, increases in alkaline phosphatase activity and digestive enzyme activity. Zeman *et al.* (2004) reported that melatonin, the major pineal hormone, play a major role in the growth and control of several metabolic processes in poultry. The present results are similar to those reported by Classen *et al.* (2004); Rahimi *et al.* (2005); Bölükbasi and Emsen, 2006). Downs *et al.* (2006); Gharib, *et al.* (2008); Abbas *et al.* (2008) and Mahmud, *et al.* (2011), who reported that intermittent light significantly affect body weight. Also, Farghly (2014) found that light flashes system caused a significant (P≤0.05) increase in body weight and weight gain as compared to continuous light. Classen *et al.* (2004); Lien *et al.* (2009); Lewis *et al.* (2009ab); Lewis *et al.* (2010) and Schwean-Lardner *et al.* (2013) indicated that early growth rate was significantly reduced by longer periods of darkness, but gain as well as final body weight was not affected by lighting programs. In contrast, Shutze, *et al.* (1996); Ingram and Hatten (2000) and Tuleun *et al.* (2010) found that broilers reared under continuous light gained more weight than those exposed to intermittent or restricted light. Hanaa Khalil *et al.* (2007) indicated that small difference between the lengths of light hours (2-4 hours) has small impact on body weight and body weight gain. Also, Onbaşılar *et al.* (2007) found that differences in body weight were not significant in different lighting groups.

Feed consumption (FC) and feed conversion (FCR):

Results in Table (1. a) reveal that feed consumption and feed conversion ratio at 21 days of age and the overall mean after 6 weeks of age were significantly different (P≤0.05) for G4 and tended to be different for G2 and G3 than the control group. The intermittently fed groups, especially G4, consumed less feed and utilized feed more efficiently. The improvement in feed conversion under the condition of intermittent feeding could be a result of reducing the amount of spilled feed than those fed ad libitum. Camacho *et al.* (2004) and Zhan *et al.* (2007) found that birds subjected to feed restriction system ate less feed compared with those fed ad libitum. Saleh *et al.* (2005), Novel *et al.* (2009), Chris *et al.* (2011) and Hassanein, *et al.* (2011) reported a significant improvement in feed conversion ratio with feed restriction compared with full feeding. However, Petek (2000), El-Fiky *et al.* (2008) and Ozkan *et al.* (2010) reported that feed restriction had insignificant effect on feed intake and feed efficiency. Svihus *et al.* (2013) found that ad libitum fed broiler chickens ate and drank on average twice per hour and spent close to three-quarters of their time resting, and apart from an increased standing and feed searching activity for intermittently fed birds compared to ad libitum fed birds during the last hour before feed was presented, no differences in activity was detected Chicks would consume all the feed they desired within 2 hrs, and empty their crops sufficiently to eat again after 1 hr of darkness.

Table (1. b) shows that there were significant differences (P≤0.05) between light regimens on feed consumption and feed conversion ratio indicating that broilers exposed to intermittent or flashed light schedule utilized the feed as efficient as those exposed to continuous lighting regimen. Feed consumption of intermittent light of both groups 3 and 4 was less than continuous light (G1), while, G2 group had intermediate values. The feed conversion ratio of intermittent light or flashes (groups 2, 3 and 4) was significantly (P<0.05) better than continuous light (G1). Despite the lower feed intake (80% of their total feed intake during the light) in broilers exposed to long hours of darkness or intermittent light (Ohtani and Leeson, 2000), their feed gain ratios were still comparable with those of broilers exposed to continuous light per day, presumably, due to lower energy expenditure on physical activity. Duve *et al.* (2011) indicated that broilers modify their feeding behaviour according to the prevailing light or dark schedule. Chickens can learn to eat in the dark or flashes, but by less amounts. 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 (Buyse *et al.,* 1996). Previous studies obtained similar results reported by Classen, *et al.* (2004), Schwean-Lardner *et al.* (2012) who showed that longer periods of darkness prevent regular access to feed and consequently reduce feed intake.

The obtained results are in agreement with Ohtani and Leeson, (2000), Oyedeji and Atteh (2005), Rahimi *et al.* (2005); Onbasilar *et al.* (2007), Lewis *et al.* (2009ab) and Fargly (2014), who reported that bio-intermittent light or light flashes schemes significantly affect the feed consumption and feed conversion of chickens. Significant improvement in feed conversion have been recorded in broilers reared under intermittent light schedule compared to birds receiving long photoperiod (Classen *et al.,* 2004, Rahimi *et al.,* 2005; Bölükbasi and Emsen, 2006; Gharib, *et al.,* 2008; Onbasilar *et al.,* 2007; Lien *et al.,* 2009; El-Slamoney *et al.,* 2010). The improvement in FCR could be due to lower feed consumed and feed waste as well as, better digestion and low energy expenditure during the dark phases by increased melatonin secretion. In contrast, some investigations have demonstrated that chickens exposed to continuous light increased feed consumption than those given period of light and darkness (Shutze, *et al.*, 1996). Mahmud, *et al.* (2011) and Mustafa and Muneer (2013) showed that the feed consumption by the birds under intermittent light was not significantly different from continuous light regimes but FCR was significantly better than the group exposed to continuous light. Also, Tuleun *et al.* (2010) and Duve *et al.* (2011) reported that feed conversion was not significantly different between continuous and limited lighting. Saiful *et al.* (2002); Oyedeji and Atteh (2005); Downs *et al.* (2006); Abbas *et al.* (2008) and El-Fiky *et al.* (2008) found that chicks reared under intermittent light showed no significant differences in feed consumption and feed conversion compared to those under continuous light.

Carcass traits and meat quality:

Results in Tables (2.a,b and 3.a,b) reveal that intermittent feed did not have significant effect on most of carcass characteristics and meat quality except on drumstick, liver and abdominal fat percentages; meat tenderness, juiciness and ether extract percentage (P≤0.05). This effect was more pronounced in G2 (6F:6S). These findings partially agree with those reported by Nematallah *et al.* (2003); Demir *et al.* (2004); Saleh *et al.* (2005); Khetani *et al.* (2008); Onbasilar *et al.* (2009) and Butzen, *et al.* (2013), who indicated that restricted feeding did not affect the carcass characteristics and the relative weights of different organs, except that of liver percentage. Velleman, *et al.* (2014) found that the timing of feed restrictions in chicks is critical in the deposition of fat in the pectoralis major muscle and expression of adipogenic genes. The significantly higher deposition of abdominal fat in the control birds over those of the intermittently fed chickens agrees with the findings of Nielsen *et al.* (2003), and Zhan *et al.* (2007). Moreover, Farghly and Hassanien (2012) did not reveal any significant differences in sensory characteristics except juiciness due to feed restrictions. In addition, Zhan *et al.* (2007) and El-Fiky *et al.* (2008) found that ether extract content of breast muscle was decreased, whereas protein content was increased by feed restriction. The results of Makled *et al.* (2012) indicated that the intermittent feeding of methionine and lysine had a significant negative impact on the chemical composition of femur meat (low protein and fat percentages). On the contrary, Lippens *et al.* (2000) and Camacho *et al.* (2004) reported no significant difference in abdominal fat due to feed restriction. Besides, Urdaneta-Rincon and Leeson (2002) and Zhan *et al.* (2007) found that feed restriction reduced breast muscle percentage. Also, Petek, (2000) and El-Fiky *et al.* (2008) found that broilers subjected to 6-hours feed removal had greater percentages of carcass, liver, heart and gizzard weights than those subjected to 3- hours feed removal and full-fed.

Table (2. a): Carcass traits and body organs as affected by intermittent feeding (Mean ±SE).

Traits	Groups			
	G1 (C)	G2	G3	G4
A: Carcass traits:				
Live BW (g)	1900.8±12.6	1884.5±14.2	1910.0±16.0	1896.8±10.5
Dressing, %	77.9±0.7	77.7±0.8	78.6±1.1	78.0±1.0
Drumstick, %	13.0±0.3^{a}	11.9±0.3^{b}	12.8±0.3^{ab}	12.8±0. 3^{ab}
Femur, %	14.1±0.6	14.2±0.6	14.2±0.4	14.0±0.3
Breast, %	24.3±0.5	24.0±0.5	24.4±0.4	24.0±0.6
Giblets, %	5.9±0.3	6.0±0.4	5.9±0.2	5.6±0.3
Boneless meat, %	82.6±0.9	82.0±0.3	83.0±0.8	82.9±0.6
Abdominal fat, %	1.8±0.1^{a}	1.5±0.1^{b}	1.5±0.1^{b}	1.7±0.1^{ab}
B: Body organs:				
Carcass weight (g)	1385.3±12.6	1369.5±15.8	1404.2±12.2	1383.5±9.6
Liver, %	2.91±0.06^{ab}	3.13±0.09^{a}	2.92±0.05^{ab}	2.60±0.04^{b}
Heart, %	0.50±0.02	0.49±0.02	0.48±0.01	0.50±0.02
Gizzard, %	2.51±0.05	2.40±0.08	2.53±0.04	2.49±0.06
Pancreas, %	0.48±0.02	0.46±0.01	0.46±0.01	0.47±0.02
Proventriculus, %	0.60±0.02	0.60±0.03	0.59±0.02	0.62±0.03
Small intestine, %	3.82±0.19	4.04±0.26	3.80±0.18	3.83±0.29
Small intestine length, cm	174.8±6.0	179.4±5.9	173.2±4.8	172.4±6.2

a-----b Means within row followed by different superscripts are significantly different (P≤ 0.05).

In the current study, no significant difference was found among lighting regimens on all carcass traits and meat quality except abdominal fat, ether extract percentages and juiciness value (Tables, 2.b and 3 b).

Birds exposed to continues lighting (G1, C) had significant highest value of abdominal fat and ether extract percentages compared to other treatments (G2, G3 and G4). However, birds subjected to intermittent or flash lighting (G2 and G3) had significant higher value of juiciness than those of G4. Lawrence and Fowler (1997) reported that thyroid hormones stimulate the basic metabolic rate through regulation of the metabolism of carbohydrates, proteins and lipids. Farghly (2014) found that no significant differences for the percentages of dressed carcass, drumsticks, femurs, breast, heart and gizzard among all groups under light flashes. However, the differences were significant (P≤0.05) for liver, giblets and abdominal fat percentages. Intermittent or flash lighting could be used as a tool for reducing abdominal fat and upgrading carcass quality of broilers. These results were similar to findings of Renden *et al.* (1996); Downs *et al.* (2006) and Onbaşılar *et al.* (2007) who, found that carcass traits and organ weights were not significant in different lighting groups. Chen *et al.* (2007) and Lewis *et al.* (2009b) reported that breast meat yield was unaffected by photoperiod in broilers. Also, El-Fiky *et al.* (2008) found that heart, liver and gizzard percentage were not affected by light regime. Buyse *et al.* (1996); Ohtani and Leeson (2000); Rahimi *et al.* (2005) and Oyedeji and Atteh (2005) found that there was significant reduction in abdominal fat of broilers exposed to intermittent light as against the continuous light per day. However, Chen *et al.* (2007) and El-Fiky *et al*. (2008) reported that no significant difference was found among light regimes on abdominal fat. El-Fiky *et al.* (2008) and Lien *et al.* (2009) found that chicks reared under intermittent light showed significant improvements in carcass characteristics. Intermittent lighting was found to enhance protein content of breast meat in broiler chickens when compared with continues light. This may have occurred because intermittent light promoted the retention of nitrogen (Buyse *et al.*, 1996). Li *et al.* (2010) found that intermittent lighting schedules produced higher protein content in breast meat.

Table (2. b): Carcass traits and body organs as affected by lighting regimens (Mean ±SE).

Traits	Groups			
	G1 (C)	G2	G3	G4
A: Carcass traits:				
Live BW (g)	1915.2±10.4	1905.8±13.9	1940.0±12.0	1908.6±15.8
Dressing, %	78.1±0.9	79.0±0.8	78.7±1.1	77.9±1.0
Drumstick, %	12.9±0.4	12.8±0.3	12.9±0.5	12.7±0. 3
Femur, %	14.0±0.3	14.2±0.4	14.1±0.6	13.9±0.5
Breast, %	23.9±0.7	24.3±0.4	24.4±0.6	24.2±0.5
Giblets, %	5.9±0.4	5.8±0.5	6.0±0.3	5.9±0.4
Boneless meat, %	82.8±0.4	82.9±0.9	83.0±0.6	83.7±0.8
Abdominal fat, %	1.7±0.1[a]	1.4±0.1[b]	1.4±0.1[b]	1.4±0.1[b]
B: Body organs:				
Carcass weight (g)	1382.1±9.8	1395.1±14.6	1410.4±16.3	1374.2±11.2
Liver, %	2.91±0.05	2.93±0.04	3.02±0.06	2.89±0.08
Heart, %	0.49±0.01	0.50±0.02	0.49±0.02	0.48±0.01
Gizzard, %	2.52±0.05	2.47±0.07	2.50±0.04	2.49±0.08
Pancreas, %	0.46±0.02	0.47±0.01	0.48±0.02	0.48±0.01
Proventriculus, %	0.61±0.02	0.58±0.03	0.59±0.03	0.59±0.04
Small intestine, %	4.02±0.26	3.94±0.18	3.92±0.19	3.89±0.33
Small intestine length, cm	180.1±4.9	176.4±8.0	177.2±6.2	175.9±7.4

a-----b Means within row followed by different superscripts are significantly different (P≤ 0.05).

No significant (P>0.05) differences were detected for all studied blood parameters between the intermittently fed chickens and the control ones (Table 4, a). It is noteworthy to mention that the revealed differences in liver weight and percentage did not have any ampact on AST and ALT activities. These results are similar to those of Nematallah *et al.* (2003), Demir *et al.* (2004) and Khetani *et al.* (2008), who reported that no significant differences were proved for blood parameters due to feed restriction. In contrast, Abdel-Fattah *et al.* (2003) and El-Fiky *et al.* (2008) found that feed restriction significantly affected values of total protein, albumin, globulin, total lipids, and cholesterol. Also, Rajman *et al.* (2006) and Ozkan *et al.* (2010) found that feed restriction or frequency reduced plasma protein, albumin, lipids and cholesterol. In addition, Moradi *et al.* (2012) found that multi-meal-fed birds had significantly lower blood glucose, AST, ALT and cholesterol than those fed once a day

Table (3. a): Meat quality traits as affected by intermittent feeding (Mean ±SE).

Traits	Groups			
	G1 (C)	G2	G3	G4
A: Sensory traits:				
Aroma	8.4±0.4	8.3±0.3	8.6±0.6	8.5±0.5
Color	8.4±0.5	8.4±0.4	8.2±0.5	8.3±0.4
Flavor	8.6±0.6	8.6±0.4	8.7±0.5	8.7±0.4
Tenderness	8.3±0.6[ab]	7.7±0. 6[b]	8.9±0.6[a]	7.7±0.3[b]
Juiciness	8.3±0. 3[ab]	7.7±0. 6[b]	8.9±0.6 [a]	8.3±0.4[ab]
Acceptability	8.4±0.2	8.2±0.4	8.6±0.6	8.3±0.3
B: Physical traits:				
Texture	8.5±0.4	8.3±0.3	8.9±0.2	8.8±0.1
WHC	7.1±1.7	6.7±1.3	7.0±1.5	7.0±1.8
C: Chemical traits:				
Moisture,%	68.0±1.2	67.7±1.1	68.1±0.7	67.9±1.3
Protein,%	18.2±0.3	18.2±0.2	18.2±0.2	18.1±0.2
Ether extract , %	12.2±0. 2[a]	11.0±0.3[b]	12.0±0.2[ab]	12.1±0.1[ab]
Ash, %	2.1±0.2	2.1±0.2	2.1±0.2	2.2±0.1

a-----b Means within row followed by different superscripts are significantly different (P≤ 0.05).

Table (3. b): Meat quality traits as affected by lighting regimens (Mean ±SE).

Traits	Groups			
	G1 (C)	G2	G3	G4
A: Sensory traits:				
Aroma	8.2±0.4	8.5±0.3	8.6±0.4	8.4±0.6
Color	8.2±0.4	8.4±0.4	8.5±0.5	8.4±0.5
Flavor	8.5±0.5	8.6±0.4	8.5±0.6	8.4±0.3
Tenderness	8.4±0.6	8.5±0. 5	8.4±0.5	7.9±0.7
Juiciness	8.3±0. 4[ab]	8.8±0. 6[a]	8.9±0.5 [a]	7.6±0.2[b]
Acceptability	8.6±0.5	8.3±0.6	8.6±0.4	8.1±0.4
B: Physical traits:				
Texture	8.5±0.3	8.5±0.4	8.6±0.2	8.2±0.3
WHC	7.2±1.5	7.1±1.3	7.0±1.4	6.9±1.9
C: Chemical traits:				
Moisture,%	68.1±1.0	68.1±1.1	67.9±0.9	67.9±1.2
Protein,%	18.0±0.4	18.1±0.2	18.3±0.2	18.2±0.3
Ether extract , %	12.3±0. 1[a]	11.3±0.2[b]	11.1±0.2[b]	11.0±0.1[b]
Ash, %	2.1±0.2	2.0±0.2	2.0±0.1	2.0±0.3

a-----b Means within row followed by different superscripts are significantly different (P≤ 0.05).

Blood Parameters:

Blood profiling, used to detect disorders due to incorrect lighting on metabolic, nutritional and welfare conditions of broilers. In the present study, there was no change in plasma parameters except total lipids values under light programs as results in Table (4, b) indice that total lipids was significantly decreased due to application of intermittent or flash lighting regimen (G2 and G3) compared to continuous regimen. Plasma total protein, total lipids, cholesterol, AST and ALT were not affected by lighting periods. This result could be due to both direct and indirect effects of melatonin on leptin hormone concentration. These results were in full agreement with those obtained by Onbasilar *et al.* (2007). Soliman *et al.* (2006) and Onbasilar *et al.* (2007) and El-Slamoney *et al.* (2010) who found that plasma total protein, total lipids, glucose, cholesterol and triglyceride levels did not differ significant among different lighting groups. El-Badry *et al.* (2009) revealed no significant differences in plasma total protein, globulin among light regimes groups, whereas, there was a significant decrease in plasma total protein. This may be attributed to the effect of light regimes on thyroid glands activity. Farghly (2014) found that no significant differences were observed for all blood parameters of flash lighting treated chickens and those of the control, except that of the total lipids, AST and H/L ratio. He found that total lipids were significantly lower in birds reared under light flashes programs for 9 hrs or 12 hrs as compared to the other groups.

Table (4. a): Blood parameters as affected by intermittent feeding (Mean ±SE).

Traits	Groups			
	G1 (C)	G2	G3	G4
Total proteins (g/dl)	4.02±0.02	3.96±0.04	4.00±0.01	3.92±0.03
Albumin (g/dl)	2.46±0.03	2.39±0.02	2.46±0.04	2.44±0.06
Globulin (g/dl)	1.56±0.06	1.56±0.08	1.54±0.09	1.57±0.09
Albumin: globulin ratio	1.58±0.11	1.53±0.06	1.60±0.04	1.55±0.09
Total lipids (g/dl)	13.40±0.32	12.90 ±0.44	12.92±0.25	13.32±0.36
AST (U/L)	11.00±0.84	10.74 ±0.62	10.88±0.56	10.94±0.48
ALT (U/L)	3.12±0.12	2.89 ±0.15	2.98±0.12	3.12±0.10

No significant differences were observed (P>0.05).

Table (4. b): Blood parameters as affected by lighting regimens (Mean ±SE).

Traits	Groups			
	G1 (C)	G2	G3	G4
Total proteins (g/dl)	4.12±0.02	3.99±0.03	4.00±0.02	3.99±0.04
Albumin (g/dl)	2.57±0.03	2.47±0.04	2.49±0.06	2.50±0.05
Globulin (g/dl)	1.55±0.08	1.52±0.07	1.51±0.08	1.49±0.09
Albumin: globulin ratio	1.66±0.09	1.63±0.06	1.65±0.08	1.68±0.13
Total lipids (g/dl)	15.12±0.29^{a}	12.11 ±0.39^{b}	12.10±0.55^{b}	13.44±0.28^{ab}
AST (U/L)	11.00±0.78	10.85 ±0.65	10.92±0.65	11.00±0.52
ALT (U/L)	3.06±0.12	2.92 ±0.11	2.96±0.14	3.12±0.20

a-----b Means within row followed by different superscripts are significantly different (P≤ 0.05).

Conformations and health problems:

From data of Table (5, a), it could be noticed that intermittent feeding significantly (P≤0.05) affected spleen percentage, while there were no significant differences (P>0.05) for conformations measurements, thymus or bursa percentages. The mortality rate and leg problems for C, G1, G2 and G4 were 6.66, 3.33, 0.00 and 3.33; and 10.00, 10.00, 3.33, 6.66, respectively. Early-life fast growth rate is accompanied by a number of problems, high incidence of metabolic disorders, high mortality and high incidence of skeletal diseases (Weeks *et al.,* 2000). They may suffer from respiratory diseases, spleen disease and sudden death syndrome (Demir *et al.,* 2004). Feed restricted birds showed an improvement in immune responses, disease resistance and lowering in metabolic or skeletal problems or mortality rate as compared to fully fed birds (Mench, 2002; Ozkan, *et al.*, 2010). In the present study, intermittent feeding had no effect on mortality of the broiler chicks. In accordance with that trend Oyedeji and Atteh (2005), Moreover, El-Fiky *et al.* (2008), Hassanein, *et al.* (2011) and Farghly and Hassanien (2012) showed that mortality rate was not significantly affected by feed restriction or frequencies. However, Gonzales *et al.,* (1998); Urdaneta-Rincon and Leeson (2002); Abdel-Fattah *et al.* (2003); Saleh *et al.* (2005) and O¨zkan *et al.* (2006) reported that early feed restriction significantly lowered (mortality rate of broiler chicks, because early age feed restriction may improve resistance to viral infections.

Sleep deprivation by continuous lighting can have negative impact behavior and health responses. Table (5, b) showed the impact of different lighting regimens on conformations and health problems of broiler chicks. No significant differences were found in conformations and lymphoid organs between different lighting regimens except percentage of thymus. Also, no remarkable differences were found among the experimental groups in leg problems score. Mustafa and Muneer (2013) indicated that increase in the period of darkness adversely effected the mean lymphoid organs (spleen, bursa and thymus weight) and chicks reared on 24 hr light had higher mean thymus weight. Regarding the mortality rate, the results show differences among the experimental groups (10.0, 10.0, 3.33 and 6.66 for G1, G2, G3 and G4, respectively). The intermittent lighting program, perhaps, improved the immune performance by enhancing both humoral and cell-mediated response, which was a key factor in reducing mortality rate. In the previous researches, intermittent lighting programs have shown increased livability and decreased metabolic diseases such as ascites, sudden death syndrome, tibial dyschondroplasia and other skeletal disorders and improved immune system (Brickett *et al.,* 2007; Onbasilar *et al.,* 2007; Onbasilar *et al.,* 2007; Lewis *et al.,* 2010). Schwean-Lardner *et al.* (2013) reported that total mortality, due to metabolic and skeletal disease decreased linearly with increasing inclusion of darkness periods. Evidence of the impact of lighting program on infectious disease was also suggested by positive effects of darkness and melatonin on immune function (Abbas *et al.,* 2008; Schwean-Lardner *et al.,* 2012). Another potential benefit of darkness is the change in bird metabolism that occurs during the dark period and the consequential rejuvenation of tissue (Brickett *et al.,* 2007). Abbas *et al.* (2008) observed that intermittent light regimen reduced mortality rate by 3 times compared to continuous light regimen. On the contrary, no significant differences between light treatments in mortality was reported by Rahimi, *et al.* (2005); Gharib, *et al.* (2008); Lewis *et al.* (2009b) and Farghly (2014).

Table (5.a): Conformations and health problems of broilers as affected by intermittent feeding (Means ±SE).

Traits		Groups			
		G1 (C)	G2	G3	G4
Lymphoid organs (%)	Spleen	0.20±0.04[ab]	0.21±0.03[ab]	0.25±0.02[a]	0.17±0.03[b]
	Thymus	0.38± 0.02	0.42± 0.01	0.39± 0.03	0.36± 0.02
	Bursa	0.16± 0.01	0.19± 0.03	0.18± 0.02	0.16± 0.02
Conformations (cm)	Shank length	5.5±0.14	5.4±0.15	5.4±0.18	5.6±0.14
	Keal bone length	5.8±0.28	5.6±0.33	5.6±0.19	5.8±0.22
	Body depth	12.00±1.00	11.82±0.60	11.88±0.48	11.96±0.66
Leg problems score	Foot pad burns	2.36	2.04	1.98	2.24
	Hock discoloration	2.93	2.70	2.58	2.90
Mortality rate, %		10.00	10.00	3.33	6.66

a-----b Means within row followed by different superscripts are significantly different ($P\leq 0.05$).

It has been demonstrated that including darkness to a lighting program can improve walking ability and physical activity, which affects energy expenditure and stimulate bone development in broilers (Sanotra *et al.,* 2002; Saiful *et al.,* 2002; Olanrewaju *et al.,* 2006). Increased exercise that is associated with darkness addition may also positively influence skeletal health (Schwean-Lardner *et al.,* 2012). However, it is presumably that increasing darkness increases foot pad lesions, because of increased contact of the foot pad with litter during the scotophase. Tuleun *et al.* (2010) found that continuous lighting reduced the severity of leg abnormality. Similar findings were reported by Farghly (2014) who indicated that the flash lighting did not affect the severity of the leg problems. Sanotra *et al.* (2002) concluded that the lighting program not only reduced leg problems but also reduced chronic fear in the birds. Hester *et al.* (2011) reported that birds exposed to the short lighting photoperiod had longer bones and more bone area because of a delay in bone growth plate closure, However, this delay in bones growth, did not improve bone mineralization. Hanaa Khalil *et al.* (2007) and Farghly (2014) demonstrated that there were no significant differences between light regimens with respect to bone measures (keel and shank lengths). On the contrary, some findings reported that lighting programs can reduce the incidence of leg disorders in broilers (Renden *et al.*, 1996, Lewis *et al.*, 2009a and Schwean-Lardner *et al.*, 2012 and 2013). Also, Ingram and Hatten (2000) reported that the photoperiod had significant effect on keel length and width as good indicators of skeletal development.

Economic efficiency:

Any feeding and light strategy that better control of energy intake and would improve feed conversion, minimize feed cost and avoid fatty carcass is usually more likely. The live body weight and feeding cost are generally considered the most important factors involved in achievement of maximum efficiency values. The results presented in Tables (6. a and 6.b) reveal that the relative economic efficiency was better with the intermittently fed group, especially G4 (2F:2S), than with the ad libitum fed group. These results are in agreement with those recorded by Abdel-Fattah *et al.,* (2003) and Novel *et al.,*

(2009) who stated that economical performance with feed restriction was better than that with full feeding as a result of improvements in viability and feed conversion. The economic aspect of different lighting programs also reveal that the performance of broiler chicks at using the intermittent flash lighting program (2CL: 1FL) in management of chicks improved the economic efficiency and relative economic efficiency of chicks compared with G1, G2 and G4. The results showed that an intermittent flash lighting schedule was more beneficial to broiler production by saving electricity. The first intermittent flash lighting program (G3) fulfills these profit and potentials. Therefore, based on the present study it may be the recommended lighting regimen In agreement with the present results, Rahimi *et al.* (2005), Onbasilar *et al.* (2007), El-Slamoney *et al.* (2010) and Farghly (2014) found that intermittent light or flash lighting improved economic returns for broiler chicks as well as a considerable saving in lighting (electricity) expense.

Table (5. b): Conformations and health problems of broilers as affected by lighting regimens (Means ±SE).

Traits		Groups			
		G1(C)	G2	G3	G4
Lymphoid organs (%)	Spleen	0.21±0.05	0.19±0.03	0.23±0.04	0.22±0.02
	Thymus	0.35± 0.03[b]	0.39± 0.01[ab]	0.43± 0.02[a]	0.44± 0.04[a]
	Bursa	0.17± 0.02	0.19± 0.01	0.18± 0.02	0.19± 0.03
Conformations (cm)	Shank length	5.4±0.12	5.5±0.17	5.6±0.18	5.5±0.14
	Keal bone length	5.8±0.19	5.8±0.28	5.7±0.22	5.9±0.30
	Body depth	12.00±0.82	11.88±0.76	11.94±0.55	12.00±0.60
Leg problems score	Foot pad burns	2.36	2.58	1.98	2.04
	Hock discoloration	2.90	2.58	2.36	2.70
Mortality rate, %		6.66	6.66	3.33	6.66

a-----b Means within row followed by different superscripts are significantly different ($P \leq 0.05$).

Table (6.a): Economic efficiency as affected by intermittent feeding.

Item	Groups			
	G1 (C)	G2	G3	G4
Total costs (feed costs + chick price)[1], L.E	19.69	18.90	19.21	18.82
Total revenue; selling price of BW[2] (bird /L.E)	26.84	26.17	27.08	26.69
Net revenue/ bird/L.E (without constant costs=25%)	7.15	7.27	7.87	7.87
Economic efficiency (EE)	0.36	0.38	0.41	0.42
Relative economic efficiency (REE)	100	106	114	117

[1] Price of 1 kg of ration =4.40 L.E [2] Cost of 1 kg of dressed carcass =18.00 LE

Table (6. b): Economic efficiency as affected by lighting regimens

Item	Groups			
	G1 (C)	G2	G3	G4
Total costs (feed costs + chick price)[1], L.E	19.65	19.06	19.03	18.80
Total revenue; selling price of BW[2] (bird /L.E)	26.93	27.67	28.36	27.59
Net revenue/ bird/L.E (without constant costs=25%)	7.27	8.60	9.33	8.80
Economic efficiency (EE)	0.37	0.45	0.49	0.47
Relative economic efficiency (REE)	100	1.22	1.33	1.27

[1] Price of 1 kg of ration =4.40 L.E [2] Cost of 1 kg of dressed carcass =18.00 LE

CONCLUSION

The results of this study suggest that intermittent feeding regimen following six cycles per day (2F:2S) and intermittent flash lighting program (2CL: 1FL) decreased feed consumption, improved feed efficiency and increased economic efficiency without any adverse effects on studied performance or physiological parameters till marketing age of broiler chickens with expected considerable saving in feed and energy (electricity) expenses. These recommended regimen (2F:2S) and (2CL: 1FL) seems to be more suitable for broiler strains selected for rapid growth that cannot stand intermittent nutrients supply for more than two hours. Also, such a regimen may be more practicable and acceptable in broilers farms that equipped with automatic feeding and lighting system.

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تطبيق نظم التغذية و إضاءة الوميض المتقطعة في رعاية كتاكيت التسمين

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تم اجراء تجربتين لتقييم تأثير نظم التغذية و إضاءة الوميض المتقطعة على أداء النمو, صفات الذبيحة, خصائص الدم و الكفاءة الاقتصادية لدجاج التسمين. التجربة الأولى: تم تقسيم 120 كتكوت Cobb عمر يوم إلى 4 مجاميع متساوية (كل مجموعة من 3 مكررات بمعدل 10 كتكوت/مكررة). غذيت طيور المجموعة الأولى تغذية حرة (كنترول), بينما غذيت طيور مجموعات المعاملة على عدد مختلف من دورات التغذية (تغذية+تصويم)/يوم. فتم تغذية المجموعة الثانية, الثالثة و الرابعة (معاملة 1, 2, 3) على دورتين يوميا من (6 ساعات تغذية+ 6 ساعات تصويم), 3 دورات يوميا من (4 ساعات تغذية+ 4 ساعات تصويم), و 6 دورات يوميا من (2 ساعة تغذية+ 2 ساعة تصويم), على التوالي. التجربة الثانية: تم تقسيم 120 كتكوت Cobb عمر يوم إلى 4 مجاميع متساوية (كل مجموعة من 3 مكررات بمعدل 10 كتكوت/مكررة). عرضت طيور المجموعة الأولى لإضاءة مستمرة طوال اليوم (كنترول) بينما عرضت طيور المجموعات الأخرى لعدد من معاملات الإضاءة المتقطعة (عادية أو فلاش/يوم). فتم تعريض طيور المجموعة الثانية, الثالثة و الرابعة (معاملة 1, 2, 3) لدورات متكررة من 2 ساعة إضاءة عادية+ 1 ساعة إظلام, 2 ساعة إضاءة عادية + 1 ساعة إضاءة فلاش, و 1 ساعة إضاءة عادية + 2 ساعة إضاءة فلاش, على التوالي. أوضحت النتائج المتحصل عليها أن التغذية و إضاءة الفلاش المتقطعة اثرت معنويا بالزيادة في وزن الجسم, استهلاك العلف, و الكفاءة التحويلية, وبالتالي الكفاءة الاقتصادية. ولكنها ذو تأثير غير معنوي على معظم صفات الذبيحة و جودة اللحم, الأعضاء الليمفاوية, أطوال الجسم التكوينية ما عدا نسبتي الكبد و دهن التجويف البطنى, عصيرية و طراوة اللحم, ليبدات الدم, ونسبتي الطحال و الثيموثية. نستخلص مما سبق ومن التقييم الاقتصادي إنه يمكن استخدام التغذية المتقطعة لـ 6 دورات يوميا (2 تغذية+ 2 تصويم) و برنامج إضاءة الفلاش المتقطعة (2اضاءة عادية+ 1 إضاءة فلاش) في رعاية كتاكيت التسمين لتحسين أداء النمو و الكفاءة الاقتصادية وخفض نسبة دهن التجويف البطنى بدون اى تأثيرات عكسية على صحة ورخاء الطيور مع توفير في تكاليف التغذية وتكلفة الطاقة الكهربائية للإضاءة المستمرة.