Comparative study on the beneficial effects of different dark-length schedules on the incidence of ascites and metabolic parameters in fast growing broiler chickens

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Abstract:

BACKGROUND: Increasing of oxygen consumption in fast-growing broiler chickens is associated with the more pronounced occurrence of right ventricular hypertrophy and ascites. While, rearing of susceptible chickens in dark condition could reduce the metabolic rate of birds and hence the incidence of ascites. **OBJECTIVES:** The present study was designed to investigate a comparative study on the influence of different dark-length schedules on the incidence of ascites and metabolic parameters in fast growing broiler chickens. **METHODS:** A total of 1000 day-old (Pure Sir Broiler Line Arian) chickens were obtained and subjected to four different lighting programs. Dead birds were autopsied for the lesions of ascites. Weekly growth performance of chickens was determined and blood samples were taken, on days 7, 12, 21, 28, 35 and 42 of age for hormonal analysis. **RESULTS:** The incidence of ascites was clearly higher in birds subjected to normal lighting program compared with those of dark exposed chickens. Control chickens showed significantly higher body weight compared to the dark exposure group birds at day 21 of age, while it did not differ at days 28, 35 and 42 of age. Such differences was accompanied with the lower levels of plasma T3 and T4 concentrations in dark group chickens than to control chickens at the earlier age (days 12 and 21). **CONCLUSIONS:** This phenomenon indicated a reduction of metabolic rate and oxygen consumption in dark group chickens that had been led to reducing of ascites incidence. Our data proves that increasing dark-length instead of continuous lighting may be beneficial for rearing of broiler chickens, especially, when the risk of ascites incidence is higher.

Introduction

Ascites is an important metabolic disorder in the broiler industry. It is a major noninfectious cause of death among broilers and can account for over 25% of broiler losses (Maxwell and Robertson, 1998). Ascites is the result of a malfunctioning heart and circulatory system and is caused by an imbalance between oxygen supply and the oxygen required to sustain rapid growth rates and high food efficiencies, could lead to ascites in broiler chickens (Decuypere et al., 2000, Hassanzadeh, 2010). The genetic background involved in this syndrome has been linked to altered metabolic needs of rapidly growing broilers, because lines selected for very high growth capacity and low feed conversion are more sensitive

to ascites than slower-growing broilers (Chimene et al., 1995, Balog, 2003). Ascites is a multifactorial problem mediated by environmental, nutritional, and genetic factors but mainly induced by exogenous and/or endogenous factors (Decuypere et al., 2000; Julian, 2005; Hassanzadeh, 2009). Ascites syndrome is no longer restricted to birds that are kept at high altitudes, as was initially reported by Cueva et al. (1974). However, it is now found in flocks that are kept at sea level as well (Hassanzadeh et al., 2000, 2001, 2010; Scheele et al., 2005; Al-Mesri and Hassanzadeh, 2010).

The different phenomenon of physiologic and the endogenous function, such as blood gas and thyroid hormones activities, are important regulatory mechanisms of metabolic rate during the growing period (Decuypere et al., 2000; Scheele et al., 2005). Thyroid hormone activity to regulate metabolism could become more apparent at different environmental conditions e.g. low ambient temperature (Scheele et al., 1992), altitudes (Hassanzadeh et al., 2004, 2005, 2008) different lighting programs (Buys et al., 1998; Hassanzadeh et al., 2000, 2003). Recently, researches have indicated that cardio-pulmonary parameters are extremely unfavourable to broiler chickens and suggest a reduction in gas exchange (pCo2 and pO2) area in broilers and therefore higher susceptibility to pulmonary hypertension and ascites (Scheele et al., 2005; Moayyedian et al., 2011; Hassanzadeh et al., 2010). Additionally, Dewil et al., 1996, reported that chickens of an ascites sensitive line consumed more oxygen due to high metabolic activity, hence showing significantly higher carbon dioxide tension (pCO2) and lower oxygen tension (pO2) in venous blood, compared to an ascites resistant line of birds.

It is common practice to raise broiler chickens in continuous, or near continuous illumination and/or is recommended that a short dark period should be included to accustom the birds to darkness and to minimize panic in case of power failure (Buyse et al., 1996). Currently, there is interest in discontinuous lighting patterns such as an increasing photoperiod lighting system (Classen et al., 1991; Hassanzadeh et al., 2003) and/or intermittent lighting schedules (Buys et al., 1998; Hassanzadeh et al., 2000, 2005) for broilers because these alternative lighting programmes could improve broiler performance and reduce the occurrence of metabolic disorders e.g. sudden death syndrome and ascites. The purpose of the present work was to design a comparative study on the beneficial effects of different dark-length programs on the incidence of ascites and metabolic parameters in fast growing broiler chickens .

Materials and Methods

A total of 1000 day-old fast growing broiler chickens (GGP stock of Pure Sir Broiler Line, Arian Co., Babolkenar, Iran) were reared under a nearly continuous lighting schedule 23 L: 1D until 9 days of age. From day 10 on, they were randomly divided over the four window-less and equal-sized rooms (7 × 5m), each containing five floor pens (50 chicks per pen) and housed in a low altitude farm 50m above the sea level in north of Iran. In the first room, control (Co) group was received a nearly continuous lighting schedule (23L:1D) up to end of study whereas for the second (L1), third (L2) and fourth (L3) room groups, lighting schedules were provided as presented in figure 1. Briefly the dark-length schedules in four group were included of:

group 1 (Control)= 1 to 42 days, 23L:1D.
group 2 (L1)= 1 to 9 days, 23L:1D;
10 and 11 days, 20L:4D;
12 and 13 days, 19L:5D;
14 to 17 days, 18L:6D;
18 to 20 days, 19L:5D;
21 to 23 days, 20L:4D;
24 to 42 days, 23L:1D.
group 3 (L2)= 1 to 9 days, 23L:1D;
10 and 11 days, 20L:4D;
12 and 13 days, 19L:5D;
14 to 21 days, 18L:6D;
22 to 27 days, 19L:5D;
28 to 30 days, 20L:4D;
day 31, 21L:3D ;
32 to 42 days, 23L:1D.
group 4 (L3)= 1 to 9 days, 23L:1D;
10 and 11 days, 20L:4D;
12 and 13 days, 19L:5D;
14 to 29 days, 18L:6D;
30 to 33 days, 20L:4D;
34 to 41 days, 21L:3D;
day 42, 23L:1D .

Birds had *ad libitum* access to high quality

commercial broiler crumbles (starter 22% CP and 2921 Kcal/kg ME) and pelleted (grower 19% CP and 3200 Kcal/kg ME) feed, respectively. In order to achieve the development of the ascites incidence, the experiment was performed in the middle of January until the end of February, in a farm located at low altitude which had regular ascites symptoms during the winter. During the study, except the lighting schedules, the rest of environmental conditions were remained similar in all groups.

Weekly, body weights and feed intake were measured per pen. On days 7, 12, 21, 28, 35 and 42 venous blood samples were obtained from 10 randomly selected birds per group. Blood was collected in heparinized tubes on ice until the separation of plasma. The separated plasma samples were stored at -20°C until further analysis of both thyroid hormones, T3 and T4 as described earlier (Buys et al., 1994; Hassanzadeh et al., 1997).

At 12, 21 and 28 days of age to measure the venous blood pCO2, pO2 and pH values by a blood gas analyzer (ABL 5; Radiometer system, Copenhagen, Denmark) additional venous blood samples were taken and collected in heparinized tubes from 50 randomly selected birds per group (10 birds per pen). Blood gas was measured immediately as described previously (Dewil et al., 1996; Hassanzadeh et al., 2010).

At the end of the experiment, 100 chickens per group were slaughtered and autopsied. These birds and also the broilers that died during the experimental period were examined for lesions of heart failure syndrome and ascites and the RV/TV ratio was determined as described previously (Julian, 1995; Hassanzadeh et al., 2002). At the same time 25 slaughtered birds from each experimental group were randomly chosen and used for determination of abdominal fat, liver and portion weights of carcass (breast, thigh, total back and wing) chickens.

Statistical analysis was performed using the "General linear model procedure" (SAS, 2002). If a significant overall effect ($p<0.05$) was found, treatment means were compared by using the Scheffe test.

Results

Weekly mortality from the right ventricular hypertrophy (RVH) and ascites and the RV/TV ratios of surviving birds are presented in Table 1. Over the 6 week of growing period, 60 (6%) of the 1000 chickens died due to RVF and ascites. The first cases of ascites occurred from week 4 and the rate of mortality increased considerably from weeks 4 to 6. During the 6 weeks of the experimental period, 21 birds which had been reared under Co (35%) program died due to RVF and ascites, while the rate of ascites mortality declined under dark condition especially when the duration of dark period increased per day, as it was even more benefited in L3 group chickens (15%) that had longer dark-length. Such phenomenon was observed for RV/TV measurement in slaughtered chickens at 6 weeks of age. The number of surviving birds with RVF was numerically higher in Co (13.100) room compared with the L1 (11.100), L2 (11.100) and the L3 (8.100) rooms.

Table 1. Weekly ascites mortality and right ventricular/total ventricular (RV/TV) of slaughtered broiler chickens that received different dark-length schedules. *Number of hypertrophied hearts /100 surviving birds at day 42 of age.

Groups/ Age	Ascites mortality in week				slaughtered birds	
	wk3	wk4	wk5	wk6	Total	RV/TV≥25
Co	0	2	6	12	21 (35%)	13.100*
L1	0	1	4	11	16 (27%)	11.100
L2	0	1	4	10	14 (23%)	11.100
L3	0	1	3	5	9 (15%)	8.100
Total	0	5	17	38	60	43.400

Mean body weight, feed intake and feed conversion ratio (FCR) of the different treatments and the results of the statistical analyses are summarized in table 2. Imposing the dark schedules significantly ($p<0.01$) reduced the absolute body weight of chickens in dark exposing birds compared to control chickens at day 21 of age (Table 2). At the end of the experiment, no significant differences were observed between the final body weights of different lighting programs chickens. From days 14 to 21, feed intake of Co birds tended to be significantly higher compared to birds reared under dark conditions but the differences was not significant, as at the end of study, cumulative feed intake did not differ between the four lighting schedules chickens (Table 2). Lighting programs had no significant effect on feed conversion ratios at all

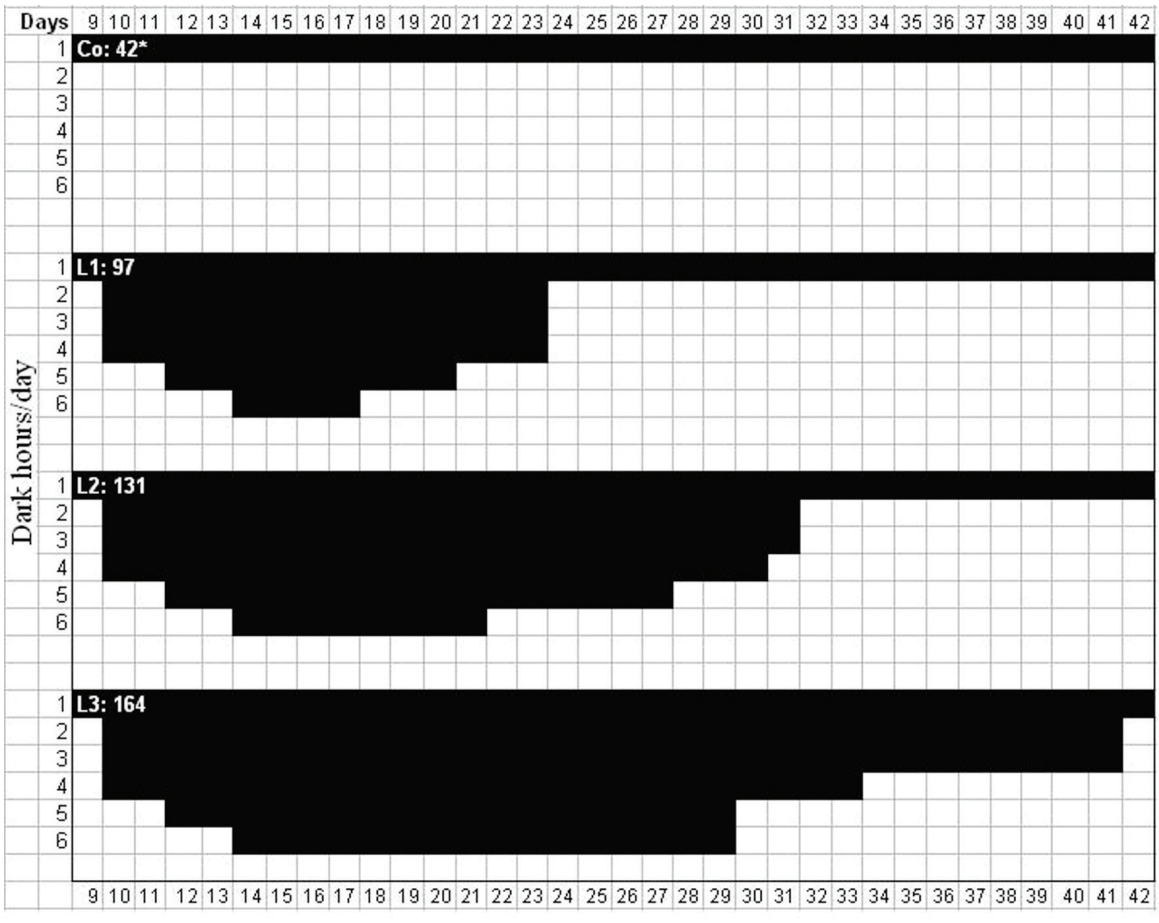

Figure 1. Four different dark-length programs that were applied during the rearing of broiler chickens. * Total hours of dark-length, during the 42 days of age.

ages.

During the days 12-21 of age, mean plasma T3 levels of Co birds were significantly ($p<0.0001$) higher than to the L1, L2 and L3 group chickens. From day 21 onward, there was no significant difference between the plasma T3 concentrations of lighting group birds. The phenomenon of T4 levels was Similar to the T3 levels. Co birds showed significantly higher plasma T4 concentration during days 12-21 of age that was even more pronounced at day 21 ($p< 0.0001$) of age (Figure 2).

Table 3 shows the average values of the venous blood pCO2 and pO2 tensions and also pH levels according to lighting programs. Except at day 28 of age which Co chickens showed significantly ($p<0.01$) higher pCO2 tension compared to the three groups of dark exposing chickens, no significant difference was found on pCO2 values at the earlier age. Additionally, the average blood pO2 and pH levels were similar in photoperiod schedules at all ages.

In this study, no significant differences was found between the proportional weights of abdominal fat, liver and also the portion weights of carcass to body weight in 6 week-old broiler chickens (Table 4).

Discussion

It has been shown that in fast growing chickens the increased metabolic rate causes a marked increase in oxygen requirement and cardiac output resulting in pulmonary arterial pressure and a pressure overload on the right ventricle (Julian, 1995; Hassanzadeh, 2010). Until now there has been no consensus about the origin of the ascites syndrome in broiler chickens at sea level. Powel (2000) suggested that the increased growth rate in modern fast growing broiler chickens at sea level requires a higher metabolic rate, and thus an increase in cardiac output, causing pulmonary hypertension and ascites. Experimental results obtained in other studies pointed to the

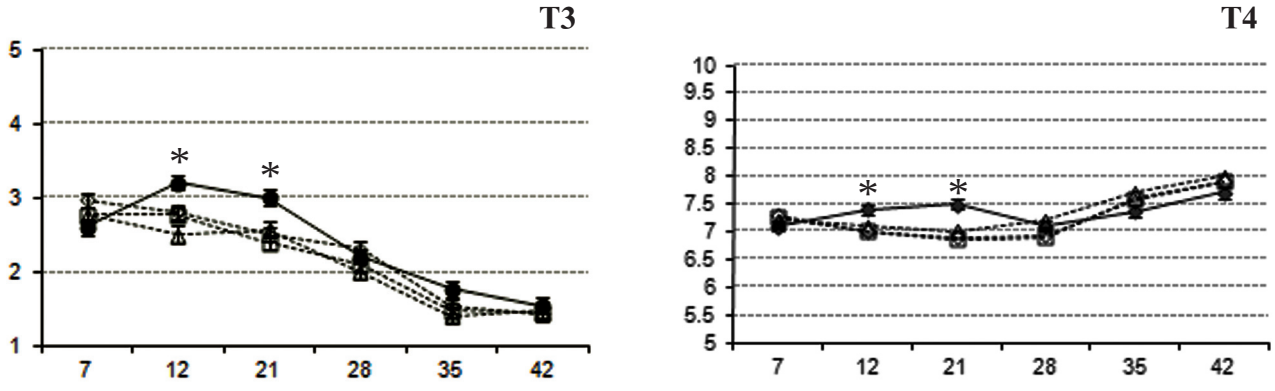

Figure 2. Weekly T3 (ng/ml) and T4 (ng/ml) concentrations of broiler chickens that received four different dark-length schedules. *Within age asterisks indicate significant difference between four groups ($p<0.05$). Co L1 L2 L3

important role of hypercapnia (high pCO2 in the blood) in activating vasoconstriction and high blood pressure at sea level, as an evident feature in ascites susceptible broiler population (Dewil et al., 1996; Scheele et al., 2003, 2005; Hassanzadeh et al., 2010).

In this study ascites mortality was achieved in fast growing broiler chickens by supplying a high quality pelleted diet in a poultry farm that always showed the incidence of ascites. As increased susceptibility of broiler chickens to ascites has previously been linked with high growth rate and feed efficiency (Scheele et al., 1992; Decuypere et al., 2000; Julian, 2005; Hassanzadeh et al., 2010).

Many authors reported that, the change of continuous to intermittent lighting at an early age is followed by initial growth depression. This depression is, however, followed by a period of compensatory growth, in a way that the birds reared in intermittent light reach the same final body weight by 6 week of age, as those reared in continuous light (Classen et al., 1991; Buyse et al., 1994; Buys et al., 1998; Hassanzadeh et al., 2000, 2003).

Results in our study demonstrate that rearing of fast growing broiler chickens under dark schedules leads to reduce the incidence of ascites. Remarkbaly also, such reduction was demonstrated by a direct correlation between the duration (dark-length) exposure of chickens and the numerically rate of ascites incidence (Table 1). These can be explained by different mechanism. It has been shown that in intermittent light, heat production and oxygen consumption are significantly lower during the dark periods of each light: dark cycle (Buyse et al., 1994). Because a lake of oxygen is known to be the primary cause of development of ascites, lower oxygen consumption in dark exposed chickens of our study, could reduce the incidence of ascites in L1, L2 and L3 group birds. Second mechanism could be the altered growth pattern between Co and L1, L2 and L3 chicks that coincided with a temporary lower tendency in feed intake of Co chickens compared to three dark exposing chickens (Table 2). Many reports showed that the incidence of ascites is much higher in fast-growing broiler lines than in slower growing ones (Decuypere et al., 1994; Hassanzadeh et al., 2010). Although in our study L1, L2 and L3 chickens reached the same final body weight as Co chickens by 42 days of age, but three groups of dark schedules chicks have a depression growth in the 3th week, followed by a compensatory growth in the period thereafter. This difference in growth rate results in a more concave growth pattern compared to that of Co chickens, such phenomenon confirmed earlier reports that discontinuous lighting reduced ascites incidence in chickens (Buys et al., 1998; Hassanzadeh et al., 2000, 2003, 2005). Buyse et al. (1994) pointed out that heat production, and hence oxygen requirements per kilogram of metabolic body weight of chickens following a normal growth trajectory at about 2 to 3 weeks of age, which is indicative of an amplified metabolic demand. This metabolic demand predisposes chickens for ascites development. The accumulation of fluid in the pericardium and the abdominal is only the final step in cascade of events leading to ascites. The predisposition for the development of syndrome

Table 2. Weekly body weight (BW), feed intake (FI) and feed conversion ratios (FCR) of broiler chickens that received different dark-length schedules. Within rows in each age, means with no common superscripts are significantly different ($p<0.05$).

Parameters / day		Experimental groups				
		Co	L1	L2	L3	P-value
BW	1	40 ± 1	40 ± 1	40 ± 1	40 ± 1	NS
	7	152 ± 11	151 ± 8	157 ± 12	155 ± 10	NS
	14	400 ± 17	395 ± 10	413 ± 11	397 ± 13	NS
	21	812 ± 12^{a}	772 ± 16^{b}	766 ± 13^{b}	771 ± 15^{b}	0.01
	28	1296 ± 21	1299 ± 13	1304 ± 13	1280 ± 28	NS
	35	1876 ± 33	1897 ± 24	1920 ± 27	1859 ± 20	NS
	42	2421 ± 26	2430 ± 46	2433 ± 27	2383 ± 30	NS
FI	1-7	133 ± 15	135 ± 13	135 ± 14	134 ± 12	NS
	7-14	364 ± 13	352 ± 14	361 ± 15	355 ± 16	NS
	14-21	728 ± 25	680 ± 30	688 ± 24	684 ± 22	NS
	21-28	958 ± 22	940 ± 17	957 ± 22	942 ± 31	NS
	28-35	1331 ± 47	1270 ± 23	1325 ± 19	1247 ± 28	NS
	35-42	1350 ± 33	1387 ± 36	1381 ± 29	1300 ± 23	NS
	1- 42	4866 ± 130	4763 ± 123	4848 ± 109	4660 ± 110	NS
FCR	1-7	1.18 ± 0.02	1.21 ± 0.03	1.16 ± 0.02	1.16 ± 0.02	NS
	7-14	1.47 ± 0.03	1.44 ± 0.04	1.41 ± 0.02	1.47 ± 0.06	NS
	14-21	1.78 ± 0.14	1.79 ± 0.11	1.96 ± 0.15	1.83 ± 0.14	NS
	21-28	1.97 ± 0.06	1.79 ± 0.05	1.78 ± 0.06	1.85 ± 0.09	NS
	28-35	2.28 ± 0.22	2.14 ± 0.12	2.15 ± 0.04	2.16 ± 0.05	NS
	35-42	2.52 ± 0.13	2.61 ± 0.13	2.69 ± 0.09	2.50 ± 0.14	NS
	1- 42	2.04 ± 0.08	1.99 ± 0.07	2.02 ± 0.05	1.98 ± 0.07	NS

Table 3. The average partial pressure of carbon dioxide (pCO2) and oxygen (pO2) and the pH levels in venous blood of broiler chickens that received different dark-length schedules. Within rows in each age, means with no common superscripts are significantly different ($p<0.05$).

Age	Parameters	Experimental groups				
		Con	L1	L2	L3	P-value
Day 12	pCO2 (mm Hg)	40.7 ± 1	41.3 ± 0.8	39.4 ± 0.7	40.8 ± 0.6	NS
	pO2 (mm Hg)	76.8 ± 3	76.4 ± 4	77.2 ± 2	76.3 ± 3	NS
	pH	7.6 ± 0.01	7.6 ± 0.01	7.5 ± 0.01	7.5 ± 0.01	NS
Day 21	pCO2 (mm Hg)	38.1 ± 0.8	39.5 ± 0.9	39.3 ± 1.0	40.6 ± 0.6	NS
	pO2 (mm Hg)	77.2 ± 3	78.2 ± 2	78.4 ± 2	77.4 ± 4	NS
	pH	7.6 ± 0.01	7.5 ± 0.01	7.5 ± 0.01	7.5 ± 0.01	NS
Day 28	pCO2 (mm Hg)	44.0 ± 0.6^{a}	40.3 ± 0.8^{b}	40.0 ± 1.0^{b}	40.2 ± 0.8^{b}	0.01
	pO2 (mm Hg)	76.8 ± 3	76.4 ± 2	75.2 ± 4	75.3 ± 3	NS
	pH	7.5 ± 0.01	7.6 ± 0.01	7.5 ± 0.01	7.6 ± 0.01	NS

already occurs during the first weeks of growing period (Decuypere et al., 2000; Bolog, 2003; Bahadoran et al., 2010). It is exactly during this initial period that the growth rate, and, thus, the oxygen requirements of the dark exposed chickens, are reduced, which alleviates the metabolic load and hence the development of ascites.

The management factors investigated in this experiment not only influenced the performance and ascites incidence of the birds, but also their endocrine function. The concentrations of T3 and T4 decreased in chickens that reared under dark schedules compared to their counterparts that were grown under continuous lighting programs (Figure 2). The coincidence reduction of ascites incidence with the thyroid hormones activity, as indicators for metabolic rate, are strengthening the view that a lower metabolic rate had a beneficial effect on oxygen

Table 4. The proportional weights of abdominal fat, liver and portion weights of carcass (breast, thigh, total back and wing) in 6 week-old broiler chickens that received different dark-length schedules.

Parameters	Experimental groups				
	Co	L1	L2	L3	P-value
Fat/BW	15 ± 1.2	16 ± 0.9	15 ± 1.0	17 ± 1.0	NS
Liver/BW	22 ± 0.8	22 ± 0.5	22 ± 0.8	23 ± 1.0	NS
Wing/BW	81 ± 0.8	82 ± 1.4	83 ± 0.8	81 ± 0.8	NS
Thigh /BW	195 ± 6.0	207 ± 5.0	197 ± 6.0	198 ± 6.5	NS
Breast/BW	235 ± 3.0	239 ± 5.0	238 ± 3.6	234 ± 3.0	NS
Back/BW	150 ± 2.0	151 ± 4.2	153 ± 2.0	154 ± 2.0	NS

requirement and therefore, the incidence of ascites (Buyse et al., 1994; Buys et al., 1998; Hassanzadeh et al., 2000, 2003, 2005).

The average partial pressure of pCo2 in venous blood of Co chickens was significantly higher than to the L1, L2 and L3 chickens at day 28 of age, that indicates a lower oxygen consumption in birds under dark conditions (Table 3). This supports the finding of Wideman et al. (1999) that a high carbon dioxide tensions in venous blood of domestic chickens are a predisposing factor for development of pulmonary arterial pressure and ascites incidence.

The beneficial effect of alternative lighting schedules on ascites incidence could be compared with the effect of early feed restriction (Shlosberg et al., 1991). Temporary growth reduction has no negative effects on proportional weights of lungs and heart, as is the case for muscles, but appear to have beneficial effects of these variables (Buys et al., 1998). Surprisingly, in the present study exposing of birds to different dark programs also had no negative effect on proportional carcass of 6-weeks old birds (Table 4), which is proven the achievement of compensatory growth in dark exposed chickens. However, Buyse et al. (1994) demonstrated that discontinuous lighting regimes can decline abdominal fat of chickens, however, it was not the case in our study.

Based on these data it can be concluded that alternative lighting schedules were superior to a long-photoperiod regime in term of flock health and can be recommended for commercial broiler production. However further researches concerning the effects of these lighting treatments on the metabolic disorders, growth performance, behavioral traits and welfare of the broiler chickens in commercial flocks instead of small scale experimental designs, could further elucidate the beneficial effects of these lighting regimes especially in ascites-inducing circumstances.

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مطالعه مقایسه‌ای تاثیر استفاده از مدل‌های مختلف برنامه خاموشی در وقوع سندرم آسیت و پارامترهای متابولیکی در جوجه‌های گوشتی با رشد سریع

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چکیده

زمینه مطالعه: در جوجه‌های گوشتی با رشد سریع، افزایش مصرف اکسیژن آنها را به آسیت مستعدتر نموده است و استفاده از مدل‌های تاریکی در پرورش جوجه از طریق کاهش مصرف اکسیژن سبب کاهش بروز آسیت می‌شود. **هدف:** مطالعه مقایسه‌ای استفاده از مدل‌های مختلف تاریکی برای کاهش وقوع آسیت و تاثیر آن بر پارامترهای متابولیکی جوجه‌های گوشتی است. **روش کار:** ۱۰۰۰ قطعه جوجه گوشتی جنس نر و از خط پدری لاین، تهیه و در چهار برنامه نوری متفاوت تقسیم و تا ۴۲ روزگی نگهداری شدند. جوجه‌ها و غذای مصرفی آنها هفتگی توزین و تلفات روزانه کالبدگشایی و گزارش گردید و غلظت هورمون‌های T3 و T4 خون آنها اندازه‌گیری شد. **نتایج:** استفاده از برنامه‌های خاموشی سبب کاهش تعداد تلفات آسیت گردید. وزن جوجه‌ها از نظر آماری فقط در ۲۱ روزگی بطور معنی‌دار، تحت تاثیر روش خاموشی قرار گرفت و جوجه‌های گروه کنترل نسبت به سایر گروه‌ها از وزن بیشتری برخوردار بودند. در حالی که وزن نهایی جوجه‌های چهار گروه در پایان دوره از نظر آماری اختلاف معنی‌داری را نشان نداند. از طرفی غلظت T3 و T4 پلاسمای خون جوجه‌ها تحت تاثیر برنامه خاموشی قرار گرفت. فعالیت این هورمون‌ها همزمان با کاهش سرعت رشد جوجه طی هفته‌های دوم و سوم دوره پرورش نسبت به گروه شاهد به شکل معنی‌داری کاهش یافت که موید کاهش فعالیت متابولیک و کاهش مصرف اکسیژن در این سنین حساس است. **نتیجه گیری نهایی:** آرمایش نشان داد اگر در مرغداری‌های گوشتی خطر ابتلا به آسیت بالا باشد جهت کاهش تلفات ناشی از آسیت می‌توان به جای برنامه نوری مداوم، مدت زمان خاموشی را در سالن‌ها افزایش داد بدون اینکه تاثیر منفی قابل توجه‌ای بر وزن نهایی جوجه‌های گروه خاموشی داشته باشد.

واژه‌های کلیدی: جوجه گوشتی، آسیت، زمان تاریکی، هورمون های تیروئیدی.

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