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Effects of light intensity on growth performance and antioxidative status of broilers

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Light consisting of intensity, color, and duration (Lewis and Morris 1998), stimulates growth, maturation and reproduction (Olanrewaju *et al.* 2006). Intermittent lighting programs resulted in better broiler productivity compared to constant light (Classen 2004, Rahimi *et al*. 2005). But knowledge on how light intensity affects poultry production is limited. Newberry *et al.* (1986), and Downs *et al.* (2006) demonstrated that light intensity influences birds' growth performance but others reported that it has no significant effect on broilers' production (Newberry *et al.* 1988, Lien *et al.* 2007, Olanrewaju *et al.* 2011). Charles *et al.* (1992) and Downs *et al.* (2006) observed a transient increase in average body weight of broilers but Lien *et al.* (2008) reported increased average BW in broilers provided with lower light intensity over the whole grow-out period. Melatonin (MET) is influenced by light intensity (Rivest and Wurtman 1983), and plays a vital role in antioxidative defense system (Hardeland and Pandi-Perumal 2005, Tomás-Zapico and Coto-Montes 2005). No research on the effect of light intensity on antioxidation of broilers has been reported. Therefore, main purpose of the present study was to evaluate effect of light intensity on antioxidation in broilers.

Bird management: Day-old Lingnan Yellow broiler chicks (600) were obtained from a local commercial hatchery, and kept as per standard procedure. The chicks were randomly distributed into 12 environmentally controlled rooms, every 3 adjacent rooms served as an experimental unit. The experimental units were provided with light intensity of 30 lx, 20 lx 10 lx and 5 lx respectively. All birds were provided with 24 h incandescent light. The treatments were under light intensity of 5, 10, 20, and 30 lx respectively. Each room contained 50 chicks (25 male and 25 female). The room temperature was set initially at 3°C and gradually reduced by 2°C per week until 21°C. Broilers were reared in floor pens covered with fresh wood shavings. In the experiment, broilers were offered with starter and finisher diets from 1–21 and 22–50 d of age respectively. The diets in both phases of the experiment are presented in Table 1. Feed and water were offered *ad lib*. All procedures of this study were approved by the Institutional Animal Care and Use Committee of Zhejiang University.

Experimental treatments: Light intensities in experiment were typically used in commercial production (5, 10, 20, and 30 lx). Illumination was provided by incandescent bulbs.

Table 1. Ingredients composition and nutrient analysis of experimental diets on a as-dry basis (g/kg, unless otherwise stated)

Ingredients	Starter (1 to 21 days)	Finisher (22 to 50 days)
Maize	547.0	605.0
Wheat	50.0	50.0
Soybean meal	290.0	230.0
Corn gluten meal	60.0	60.0
Soy-oil	10.0	15.0
Salt	3.0	3.0
Calcium bicarbonate	17.0	15.0
Limestone	13.0	12.0
Vitamin-mineral premix[1]	10.0	10.0
Composition (analyzed except for (ME) [2]		
ME (MJ/kg)	12.17	12.55
Crude protein	209.6	188.9
Lysine	11.0	9.5
Methionine	5.0	4.0
Methionine + cysteine	8.5	7.2
Calcium	9.9	8.9
Total phosphorus	6.6	6.0

[1]Supplied per kilogram of diet: retinol acetate, 9600 IU; cholecalciferol, 2700 IU; DL-Q-tocophery acetate, 36 mg; menadione, 3.0 mg; thiamine, 3.0 mg; riboflavin, 10.5 mg; pyridoxine, 4.2 mg; cobalamin, 0.03 mg; folic acid, 1.5 g; niacin, 60 mg; D-calcium pantothenate, 18 mg; D-biotin, 0.225 mg; iron, 80 mg; copper, 8.0 mg; manganese, 80 mg; zinc, 60 mg; iodine, 0.35 mg; selenium, 0.15 mg

[2]ME was calculated from data provided by *Feed Database* in China (1999) (Chinese Feed Database)

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The light bulbs were cleaned weekly to minimize dust build-up, which would otherwise influence light intensity. During whole experiment, light intensity of each room was consistent.

Measurements: Body weight (BW) was measured at the very start of experiment (d 1), and on d 21 and d 50, both BW and feed intake (FI) were measured for calculation of growth rate, feed intake and feed conversion. Mortality was recorded daily as it occurred. Feed conversion ratio (FCR) was calculated as total feed consumed by total body weight and adjusted for morality.

On d 21 and 50, 12 birds per treatment were randomly selected for processing, weighed and fasted for 12 h before slaughter. Blood samples were collected into a coagulant tube, centrifuged at 3,000 rpm for 10 min to obtain serum, tissue samples were packed in plastic bags and both were stored at −80°C for biochemical analysis and enzyme analysis.

Biochemical analysis and enzyme analysis: The commercial kits for all antioxidant indices were purchased commercially. Both serum and liver were analyzed for activity of total superoxide dismutase (T-SOD) and glutathione peroxidase (GSH-Px), total antioxidant capability (T-AOC), as well as content of lipid peroxidation product maleic dialdehyde (MDA). The procedures were carried out according to description of assay kits. The assay for T-SOD was based on its ability to inhibit oxidation of oxymine by xanthine-xanthine oxidase system. One unit (U) of SOD activity was defined as the amount that reduced absorbance at 550 nm by 50%. The activity of GSH-Px was determined by quantifying catalyzed reaction rate of GSH and one unit (U) of GSH-Px activity was defined as a decrease of 1.0 uM GSH per 5 min after decrease of GSH of non-enzymatic reaction is subtracted. The T-AOC reflects overall cellular endogenous antioxidative capability including both enzymatic and non-enzymatic antioxidants. In the reaction mixture, ferric ion is reduced by antioxidant reducing agents and blue complex Fe^{2+}-TPTZ [2.4.6-tri (2-pyridyl)-s-triazine] is produced. The optical density was measured at 520 nm. One unit (U) of T-AOC was defined as amount that increased absorbance by 0.01. The activity of T-AOC, GSH-Px and T-AOC were expressed as U/mg of protein in liver, and U/ml in serum. MDA can react with thiobarbituric acid and red complex is produced. The optical density was measured at 532 nm. The content of MDA was expressed as n mol/g of protein in liver and n mol/ml in serum. Protein concentration of liver was measured by Lowry method. In addition, serum melatonin (MET) was measured using ELISA, and its concentration was expressed as pg/ml.

Statistical analysis: Data were analyzed by a one-way ANOVA procedure of SPSS 16.0 for Windows. Values of $P < 0.05$ were taken as significant. Replicate was considered as experiment unit for performance determined. All results were expressed as means ± standard error (SE).

Table 2. Effect of lighting regimens on BW, FI and FCR of broilers (mean ± SE)

Growth period	30 lx	20 lx	10 lx	5 lx
BW (g)				
1 day	39.97	38.47	40.00	39.77
	±0.98	±0.29	±0.75	±0.35
21 day	389.28	388.70	437.53	431.74
	±4.99[b]	±6.06[b]	±4.23[a]	±3.32[a]
50 day	1628.5	1575.4	1623.5	1656.8
	±72.90	±63.96	±1.03	±37.25
FI (g/d)				
1 to 21 day	26.67	27.04	31.24	30.32
	±0.26[b]	±0.46[b]	±0.18[a]	±0.81[a]
22 to 50 day	111.05	109.73	106.24	112.42
	±3.07	±6.24	±2.58	±1.96
1 to 50 day	75.61	75.00	74.74	77.94
	±1.81	±3.53	±1.95	±1.54
FCR (g/g)				
1 to 21 day	1.60	1.62	1.65	1.63
	±0.01	±0.01	±0.01	±0.04
22 to 50 day	2.58	2.68	2.60	2.66
	±0.06	±0.34	±0.17	±0.02
1 to 50 day	2.38	2.44	2.36	2.41
	±0.04	±0.23	±0.10	±0.02

BW, body weight; FI, feed intake; FCR, feed conversion ratio.
[a, b] Means in a column with different superscripts are significantly different ($P < 0.05$)

A significant ($P< 0.05$) increase in 21-d average BW, and feed intake (FI) of broilers provided with light intensity of 5 and 10 lx from d 1 to d 21 were observed when compared with those provided with 20 and 30 lx, and they were slightly higher in 10 lx treatment in contrast to 5 lx treatment (Table 2). A possible reason is that broilers consumed more feed under low light intensity environment (5 and 10 lx). The low light intensity was found associated with less bird distraction and less activity (activity level was not measured in the study), such as walking, standing, as well as reduced incidences of fighting and feather pecking. It is these behavioral changes that likely contributed to transitory elevation of FI (Downs *et al.* 2006). However, overall average BW and FI were not influenced by light intensity. Our result was in agreement with what was reported by Downs *et al.* (2006), who found that reducing light intensity (from 10.76 to 2.69 lx) can stimulate FI and a subsequently BW improvement early, as compared with light intensity of 21.52 lx maintained at a constant level, while stimulation did not persist throughout the grow-out period. A similar BW is observed in broilers reared under light intensity of 5.38 lx contrary to 161.4 lx, which was reported by Charles *et al.* (1992). Conversely, Lien *et al.* (2007) observed a transitory decrease in FI from 2 to 3 wk, but not after when birds subjected to light intensity of 1.076 lx instead of 10.76 lx in either 23L: 1D or 18L: 6D photoperiod. Whereas many

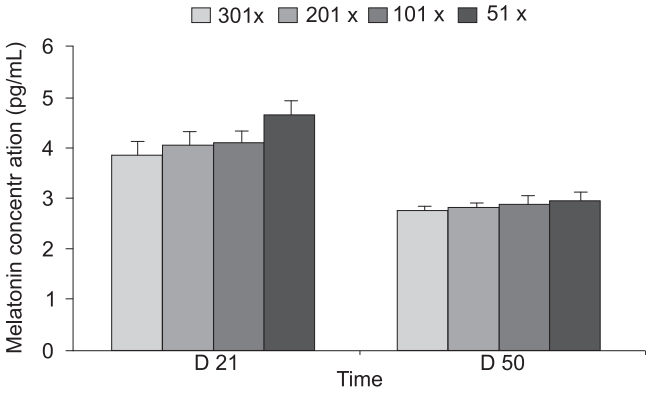

Fig. 1. Effect of light intensity on serum melatonin concentration in broilers.

previous research reports (Newberry *et al.* 1986 1988, Ahmad *et al.* 2011) on light intensity reported no effect on overall growth performance, which was indicated by average BW, FI, and FCR. FCR was not affected significantly by light intensity at any time in the present study throughout trial and it is in consistent with most studies on light intensity (Dorminey and Nakaue 1977, Newberry *et al.* 1986 1988, Deaton *et al.* 1988, Lien *et al.* 2008). No effect on FCR was likely due to parallel changes in average BW and FI occurring in study throughout trail. In contrast, Charles *et al.* (1992) and Downs *et al.* (2006) observed improved FCR with low light intensity. Generally, FCR is consistently reported to be unaffected by light intensity. All in all, considering electricity saving issue, providing low light intensity (5 or 10 lx) to broiler chickens may be a better practice due to the fact that either beneficial effect or no effect of low light intensity on FCR in broilers were reported.

No noticeable differences were observed (Fig.1) in serum MET concentration of broilers both on d 21 and d 50, but with a decreased light intensity, a higher MET concentration was detected in serum (Rivest and Wurtman 1983). However, the possible reasons for nonsignificant difference among 4 treatments are as follows: (i) light intensity used in present study may not be that sufficient enough to cause an obvious difference (Aoki *et al.* 1998), illumination acutely decreased melatonin concentration in systematic circulation only if light intensity is above a certain threshold. (ii) MET inhibition in pineal gland is triggered by a signal either through eyes or direct penetration through skull tissue (Morgan *et al.* 1995). The lack of a remarkable difference among light intensity treatments indicated that pineal gland of broiler chickens has ability to perceive light ranging from 5 lx to 40 lx either through eyes or direct penetration through skull (Deep *et al.* 2012).

It was generally recognized that SOD, GSH-Px, and catalase are 3 main antioxidant enzymes in scavenging oxygen free radical (McCord 1979). MDA, an end product of lipid peroxidation induced by oxygen-free radials in tissues can be a biomarker for radical-induced damage and endogenous lipid peroxidation (Wang *et al.* 2008). In addition, Tyssandier *et al.* (2004) reported that antioxidant status of subjects may be evaluated by measurement of T-AOC. In present study, we have detected a significantly elevated T-AOC and activity of GSH-Px both in serum and liver under light intensity of 5 lx at any phase and higher activity of liver T-SOD on d 21 (Table 3). A possible reason is that low intensity plays a vital role in antioxidative status

Table 3. Effect of light intensity on antioxidative status of broilers (mean ± SE)

Item	Growth period	Indices	30 lx	20 lx	10 lx	5 lx
Serum	21 d	T-AOC	5.84±0.50^{c}	7.29±0.73^{bc}	8.73±0.46^{b}	9.21±0.50^{a}
		T-SOD	102.37±1.83	100.35±1.94	100.17±2.98	105.85±1.62
		GSH-Px	231.95±9.47^{b}	240.50±9.83^{b}	266.90±13.28^{ab}	281.87±14.13^{a}
		MDA	5.62±0.58^{a}	4.39±0.55^{b}	3.81±0.16^{b}	4.22±0.26^{b}
	50 d	T-AOC	6.33±0.67^{ab}	5.37±0.43^{b}	6.76±0.37^{a}	6.76±0.27^{a}
		T-SOD	103.95±2.14	104.09±2.54	104.76±1.78	107.05±1.88
		GSH-Px	113.85±6.07^{b}	115.60±12.15^{b}	115.70±4.28^{b}	165.51±10.58^{a}
		MDA	5.56±0.26^{a}	4.82±0.41^{ab}	4.93±0.25^{ab}	4.21±0.26^{b}
Liver	21 d	T-AOC	3.90±0.18^{c}	5.50±0.45^{b}	5.28±0.46^{b}	7.35±0.55^{a}
		T-SOD	1304.2±68.00^{b}	1484.7±63.16^{a}	1446.4±55.48^{ab}	1461.7±43.12^{ab}
		GSH-Px	521.40±28.37^{b}	524.68±21.00^{b}	477.88±13.90^{b}	681.49±75.50^{a}
		MDA	9.30±1.23	8.77±0.58	7.14±0.61	8.31±1.06
	50 d	T-AOC	3.64±0.30^{b}	5.31±0.27^{a}	5.30±0.29^{a}	5.36±0.24^{a}
		T-SOD	1334.9±63.69	1235.4±17.56	1387.1±97.35	1273.7±38.94
		GSH-Px	523.73±22.86^{b}	498.50±18.56^{b}	605.69±26.66^{a}	558.06±22.19^{ab}
		MDA	21.48±2.80^{a}	21.27±2.22^{a}	16.01±1.35^{ab}	11.20±0.78^{b}

T-AOC, total antioxidant capability; T-SOD, total superoxide dismutase; GSH-Px, glutathione peroxidase; MDA, maleic dialdehyde. Means followed by different letters were significantly different ($P < 0.05$). The GSH-Px, SOD, and T-AOC were expressed as specific activity (U/mgprot) in liver and as U/ml in serum, respectively. The MDA concentrations were expressed as nmol/mgprot in liver and as nmol/ml in serum.

Table 4. Effect of light intensity on serum melatonin concentration of broilers (mean ± SE)

Item		30lx	20lx	10lx	5lx
Melatonin	21d	3.91±0.26	4.12±0.23	4.15±0.24	4.70±0.30
	50d	2.80±0.08	2.87±0.06	2.92±0.19	3.01±0.11

The Melatonin concentrations were expressed as pg/ml.

of broilers via MET, since higher concentration of serum MET was observed under low light intensity. Melatonin showed to be an effective antioxidant in a number of experimental models (Hardeland and Poeggeler 2003), particularly in scavenging free radicals (Horstman *et al.* 2002, Mathes 2010). Despite its intense free radicals scavenging power, it may induce upregulation of activity of antioxidant enzymes such as SOD, GSH-Px (Rodriguez *et al.* 2004, Tomas-Zapico and Coto-Montes 2005, Mathes 2010). The lower concentration of MDA both in serum and liver under low intensity might due to MET's function on radical scavenging. (Murawska-Cialowicz *et al.* 2011). These findings suggested that low light intensity enhanced antioxidative status of broilers by elevating activities of antioxidant enzymes and reducing lipid peroxidation products. Thus, low light intensity with 5 or 10 lx can be recommended to the commercial production of broilers according to the present study.

SUMMARY

A 50-d experiment using day-old Lingnan Yellow broilers (600) was conducted to investigate effects of light intensity on growth performance and antioxidative status of broilers. The chicks were randomly divided into 4 treatments with light intensity of 5, 10, 20, 30 lx respectively, and each treatment was replicated 3 times. There existed a significant increase in 1–21d feed intake of broilers provided with light intensity of 5 and 10 lx from d 1 to d 21 when compared with those provided with 20 and 30 lx, so did 21-d average body weightÿbut no obvious difference was observed in feed conversion ratio. Higher MET concentration was detected in serum of broilers under lower light intensity. Low light intensity of 5 lx significantly enhanced 21-d total antioxidant capability and activity of glutathione peroxidase both in serum and liver and 50-d GSH-Px activity in serum and reduced maleic dialdehyde in both 50-d serum and liver, 10 lx significantly increased 50-d GSH-Px activity in liver, 5lx and 10lx significantly increased 50-d serum T-AOC, and 20 lx, 10 lx and 5 lx significantly increased 50-d T-AOC and decreased 21-d serum MDA. Low light intensity improved 1–21 d growth performance of broilers and antioxidative status of broilers to some degree, but not overall phase. Thus, low light intensity of 5 or 10 lx are recommended in commercial production of broilers for the sake of producers' profit.

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