Abstract

Previous reports have suggested that green light enhances broiler growth at an early age, whereas blue light enhances growth at older ages. The aim of this study was to examine the effect of a switch in monochromatic light at 2 ages on growth and development of broilers. Male chicks (Anak, n = 640) were used. After hatch, chicks were weighed, wing-banded, and blocked into treatment groups. Chicks were grown in 1-m² pens in 8 isolated light-proof rooms (20 birds/pen). The light treatments were (1) Control white (mini-incandescent lamps), 2) blue light-emitting diode (LED) lamps, 3) green LED lamps, 4) blue LED switching to green at 10 d of age, 5) blue LED switching to green at 20 d of age, 6) green LED switching to blue at 10 d of age, and 7) green LED switching to blue at 20 d of age. There were 8 pens for treatment 1, and 4 pens for each of the other treatments. The light schedule was 23L:1D, and intensity was 0.1 watts/m². BW and feed consumption were recorded. Green light birds were significantly heavier at 4 d of age. Switching light at 10 d of age from green to blue caused a further increase in BW. This improved growth was maintained until the end of the experiment. Light switching from blue to green at 20 d of age also improved growth as compared with white light. Average feed efficiency and mortality rate did not differ between groups. No association was observed among light treatment, performance, and plasma triiodothyronine concentration. We suggest that green light stimulated growth of birds at early age, and shifting birds to a different light environment at 10 or 20 d of age might further stimulate growth.

Key words: body weight, broiler, growth, monochromatic light

Introduction

The only light source for chickens in environmentally controlled houses is artificial light. Thus, source, spectra, intensity, and regimen of light supplementation have become major factors in modern broiler management (Andrews and Zimmerman, 1993). Growth in broilers is affected by light spectra. Broilers reared under blue or green light become significantly heavier than those reared under red or white light, whereas feed conversion and mortality are not affected (Lauber and McGinnis, 1961; Oo-kawa, 1970; Foss et al., 1972; Wabeck and Skoglund, 1974). Previous studies in our laboratory showed that the effect of monochromatic light on growth and development of broilers is age related, i.e., green light stimulates growth at early age, whereas blue light stimulates growth in older birds (Rozenboim et al., 1999). Furthermore, green light accelerates muscle growth (Halevy et al., 1998), suggesting a possible mechanism for acceleration of growth associated with light stimulation. Circulating thyroid hormones triiodothyronine (T₃) and thyroxine (T₄) are important growth promoters (McNabb and King, 1993), are positively correlated with feed intake in chickens (May, 1978; Klandorf and Harvey, 1985; Yahav et al., 1995, 1996), and play a relatively important role in growth inhibition and compensatory growth acceleration in broiler chickens (Yahav and Plavnik, 1999).

The objective of this study was to investigate the effect of switching green and blue monochromatic light at different ages on growth of male broiler birds.

Materials and Methods

Birds

Male broiler chicks (n = 640, Anak, Israeli breeder Union), purchased from a commercial hatchery (Kfar...
TABLE 1. BW of male broilers (Anak) reared under white (control), 480 nm (blue), 560 nm (green), or switched at 10 and 20 d of age from green to blue light (GB10, GB20) and blue to green light (BG10, BG20)\(^1\)

<table>
<thead>
<tr>
<th>Age (d)</th>
<th>Blue</th>
<th>White</th>
<th>Green</th>
<th>BG10</th>
<th>BG20</th>
<th>GB10</th>
<th>BG20</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>41.2 ± 0.2</td>
<td>41.2 ± 0.2</td>
<td>41.2 ± 0.2</td>
<td>436 ± 7.0</td>
<td>480 ± 7.0</td>
<td>733 ± 11</td>
<td>792 ± 11</td>
</tr>
<tr>
<td>4</td>
<td>96.6 ± 0.9(^a)</td>
<td>96.8 ± 1.2(^b)</td>
<td>99.7 ± 0.9(^a)</td>
<td>461 ± 5.0(^ab)</td>
<td>764 ± 8.0(^ab)</td>
<td>764 ± 8.0(^ab)</td>
<td>733 ± 11(^b)</td>
</tr>
<tr>
<td>10</td>
<td>249 ± 2.2(^a)</td>
<td>250 ± 3.0(^b)</td>
<td>257 ± 2.0(^a)</td>
<td>436 ± 7.0(^b)</td>
<td>480 ± 7.0(^a)</td>
<td>1,168 ± 23</td>
<td>1,217 ± 32</td>
</tr>
<tr>
<td>21</td>
<td>740 ± 8.0(^b)</td>
<td>763 ± 10.0(^ab)</td>
<td>764 ± 8.0(^ab)</td>
<td>436 ± 7.0(^b)</td>
<td>480 ± 7.0(^a)</td>
<td>1,168 ± 23</td>
<td>1,217 ± 32</td>
</tr>
<tr>
<td>27</td>
<td>1,170 ± 15</td>
<td>1,205 ± 13</td>
<td>1,215 ± 17</td>
<td>1,168 ± 23</td>
<td>1,217 ± 32</td>
<td>1,232 ± 20</td>
<td>1,177 ± 27</td>
</tr>
<tr>
<td>34</td>
<td>1,717 ± 25(^a)</td>
<td>1,741 ± 26(^ab)</td>
<td>1,755 ± 32(^b)</td>
<td>1,664 ± 30(^b)</td>
<td>1,839 ± 39(^b)</td>
<td>1,849 ± 34(^a)</td>
<td>1,775 ± 35(^ab)</td>
</tr>
<tr>
<td>40</td>
<td>2,232 ± 51(^b)</td>
<td>2,302 ± 34(^a)</td>
<td>2,312 ± 43(^b)</td>
<td>2,302 ± 54(^b)</td>
<td>2,444 ± 54(^b)</td>
<td>2,466 ± 52(^a)</td>
<td>2,298 ± 32(^b)</td>
</tr>
<tr>
<td>46</td>
<td>2,707 ± 62(^b)</td>
<td>2,701 ± 40(^a)</td>
<td>2,814 ± 51(^b)</td>
<td>2,790 ± 36(^b)</td>
<td>2,840 ± 64(^a)</td>
<td>2,897 ± 50(^a)</td>
<td>2,780 ± 72(^a)</td>
</tr>
</tbody>
</table>

\(^{a,b}\) Values not marked with the same letters differ significantly (\(P < 0.05\)).

\(^1\) Data are means ± SE.

Menahem, Israel), were divided into 32 light treatment groups (n = 20) located in 8 light-proof rooms divided to 4 (1 m\(^2\)) pens sealed by wooden bars. Food and water were provided ad libitum. Artificial light systems were placed 10 cm above the birds using plastic ties attached to the ceilings of the rooms. Light intensity was measured in each cell at 20 constant locations and was brought to an average intensity of 0.1 W/m\(^2\) at the level of the birds’ heads. The light schedule was constant at 23L:1D during the entire experiment.

Light treatments were 1) control white (mini incandescent light bulbs, 8 pens in each experimental room, (WL)), 2) blue light (BL) at 480 nm (peak wavelength of 480 nm, half-band width between 470 and 490 nm) provided by light-emitting diode lamps (LED) (12 pens), and 3) green light (GL) at 560 nm (peak wavelength of 560 nm, half-band width between 552 and 565 nm) provided by LED (12 pens). When chicks were 10 d of age, 4 pens from the GL and 4 pens from the BL groups were transferred to blue (GB10) or green (BG10); this procedure was repeated with 4 pens of the GL and BL groups when chicks were 20 d of age (GB20 and BG20, respectively).

Body weights were recorded at 1, 4, 10, 15, 21, 27, 34, 40, and 46 d of age. In addition daily feed consumption was measured, and feed efficiency was calculated. Blood samples were taken at 12, 35, and 46 d of age and were assayed for T\(_3\) and T\(_4\) concentrations. The T\(_3\) and T\(_4\) were analyzed in plasma samples, by using RIA commercial kits,\(^2\) validated for domestic fowl (Yahav et al., 1995). The T\(_3\) assay was characterized by intraassay and interassay variations of 7.0 and 9.4%, respectively. The T\(_4\) assay was characterized by intraassay and interassay variations of 5.0 and 7.5%, respectively.

Statistical analysis of data was factorial by rooms and by light. Rooms were found not to be significant for all treated variables, and results were retested by one-way ANOVA using pens as replicates of the experiment. Significance was at 0.05.

RESULTS

Body weights are presented in Table 1. A significant increase in BW was observed in birds reared under GL as early as 4 d of age compared with all other treatment groups. Birds that were switched at 10 d of age from GL to BL had a higher BW at 15 d of age compared with birds reared under BL and BG10 birds. At 34 d of age both GB10 and BG20 birds were heavier then the BG10 and BL groups. By 40 d of age birds from GB10 were heavier than those in all other light treatment groups.

A significant increase in relative cumulative growth rate was observed at 4 d of age in birds reared under GL compared with WL reared birds (Figure 1). Switching of GL birds at 10 or 20 d of age to BL caused further acceleration in this parameter until 46 d of age. Shifting of birds from BL to GL at 10 d of age caused a reduction in cumulative growth rate at 15 d of age; however, growth rate was elevated by the end of the experiment at 46 d of age. Furthermore, shifting of BL reared birds to GL at 20 d of age caused an increase in their cumulative growth rate.

\(^2\)Diagnostic Products Corporation, Los Angeles, CA.

\[\text{Relative growth rate (% of white control birds)} = \frac{\text{BW of experimental group}}{\text{BW of white control group}}\times 100\]

\[\text{Cumulative growth rate} = \frac{\text{Total BW of each group}}{\text{Total BW of white control group}} \times 100\]

\[\text{Feed efficiency} = \frac{\text{Total BW of each group}}{\text{Total feed consumed}}\]

\[\text{Blood samples were taken at 12, 35, and 46 d of age and were assayed for T3 and T4 concentrations.}\]

\[\text{The T3 and T4 were analyzed in plasma samples, by using RIA commercial kits, validated for domestic fowl (Yahav et al., 1995).}\]

\[\text{the T3 assay was characterized by intraassay and interassay variations of 7.0 and 9.4%, respectively.}\]

\[\text{The T4 assay was characterized by intraassay and interassay variations of 5.0 and 7.5%, respectively.}\]
until the end of the experiment. No differences were found among the experimental groups in feed conversion at 46 d, which averaged 2.1 ± 0.2.

No significant differences were found in mortality rate of birds reared under different light spectra; averaged 5.0 ± 1.0% for the entire experiment.

Triiodothyronine concentration did not differ among treatments at the age of 12 d (Table 2). However, T3 concentration was lower in BL- and GB10-treated chicks compared with chicks exposed to WL. At 35 d of age, T3 was higher in the chickens exposed to WL, GL, and BG10 in comparison with those exposed to BL. T4 was significantly higher in BG10- compared with BL-treated chicks. At 46 d of age, the highest T3 was monitored in chickens exposed to BG20, whereas T4 was the highest in the BG10-treated chickens (Table 2).

**DISCUSSION**

The present study shows that switching environmental light spectra from green to blue at 10 d of age accelerates growth of male broiler chicks. Previous reports (Rozenboim et al., 1999) demonstrated that rearing broiler birds under GL accelerated growth at an early age and rearing broilers under BL accelerated growth at later age. We also found that early age acceleration of growth in the GL birds continued when they were shifted to BL. After switching to BL, there was a further increase in both growth rate and BW. Changing illumination from blue to green at 20 d also enhanced growth compared with WL- and BL-treated birds. In agreement with our data, broilers (Wabeck and Skoglund, 1974) and quail (Phogat et al., 1985) raised under blue or green fluorescent lamps gained significantly more weight than those reared under red or white fluorescent lamps, but feed conversion and mortality were not affected.

In a previous study (Rozenboim et al., 1998) we found that GL and BL enhance growth. It has been reported that GL promoted early age growth by enhancing proliferation of skeletal muscle satellite cells (Halevy et al., 1998). However, BL had less impact on early age muscle growth but was reported to increase plasma androgens (Rozenboim et al., 1999). Androgens enhance protein synthesis and reduce protein breakdown. As a result, androgens cause muscle to build up (Bates et al., 1987; Capaccio et al., 1987; Crowley and Matt, 1996) and are involved in the normal maintenance of muscular tissue.

Light intensity was measured in this experiment as W/m² at the level of the chicks’ heads, because birds receive light by retinal and extraretinal photoreceptors. However, light of different wavelengths has varying stimulatory capability on the retina (Lewis and Morris, 2000), which may cause a behavioral effect that could affect growth and development. Rearing laying hens under pure monochromatic red light at 0.01 W/m² caused a significant reduction in feed intake due to a reduction in physical activity (Rozenboim et al., 1998); similar findings (Newberry et al., 1986) have shown that rearing broilers under high light intensity (measured by lux units) causes retardation of the growth rate. In this study, an association among light treatment, performance, and plasma T3 concentration was not observed, although the highest T3 concentration was measured in the heaviest broilers exposed to BG20. In turkey toms exposed to different light intensities, a complicated association between T3 and performance was also exhibited (Yahav et al., 2000). This result was not the case when the correlation between T3 and performance was studied in relation to alterations in ambient temperature, in which case significant results were observed. In broilers, a significant correlation between feed intake and plasma T3 was found during exposure to different ambient temperatures (Yahav et al., 1996), whereas in turkeys this correlation was found with weight gain (Yahav, 1999). It can be speculated that ambient temperature dominates light regarding the effects on metabolic rate. Therefore, a significant correlation exists between environmental temperature and T3, an association that is not demonstrated with light. In conclusion, the present study shows that in broilers, even at low intensity, enhanced growth can be achieved by manipulation of light spectra during the rearing period. The finding that growth may be enhanced by manipulation of light spectra can be used to increase production efficiency.

**REFERENCES**


