The Effects of Color of Lighting on the Behavior and Production of Meat Chickens

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ABSTRACT Male and female meat chickens were reared for 28 d in blue, green, red, or white light at 30 lx and the effects on tissue growth and bird behavior recorded. Birds reared in red or white light were more active, as expressed by greater walking activity in the white light treatment and by greater floor-pecking, wing-stretching, and aggression in the red light treatment. In these two treatments, gut contents and skin and bone weights were reduced. After 28 d, the preference of the birds for blue, red, or green lights was determined, as well as residual effects of rearing color on bird growth. In the first few hours of the test, the birds chose to remain in their rearing color, except that the birds reared in red light quickly showed a preference for blue light. After 1 wk, birds in all treatments showed a preference for blue light, except that the birds reared in blue light showed some preference for a novel color, green. It was concluded that blue or green light is preferable to red or white light for broilers because it keeps the birds calmer and is chosen by the birds themselves.

(*Key words*: color, lighting, behavior, preference, body composition)

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INTRODUCTION

Chickens possess normal vertebrate trichromatic vision (Cornsweet, 1970) and can readily be trained to discriminate colors (Bell and Freeman, 1971). They differ from mammals in that light penetrates the skull to influence the hypothalamus and in particular reproduction (Foster and Follet, 1985). Because photoperiod, which is essentially a change in light intensity, is known to influence the growth and behavior of meat chickens (Morris, 1968), it is to be expected that color, which is essentially a change in intensity at certain wavelengths, would also affect growth and behavior. Reported results vary, probably because of spectral overlap of colors, differences in spectral sensitivity with age and experience, and confusion of wavelength and light intensity in some reported experiments. However, short wavelengths generally increase body growth and feed efficiency (North and Bell, 1993; Prayitno, 1994). These effects of short wavelengths could be explained by the greater penetration of the avian skull by long wavelengths (700 to 750 nm), compared with short wavelengths (400 to 450 nm) (Benoit, 1964; Hartwig and van Veen, 1979). It is possible that the effects on growth could be explained by stimulation of bird activity by the long wavelength light penetrating the skull, rather than being related to the direct effect of light on hypothalamic gonadotropin production. If activity is increased in long wavelengths and feed conversion efficiency decreased, these responses could explain the adverse effects on growth.

There is no published information on the effect of color of light on bird activity. It has been reported that there is less cannibalism in laying hens under red light than under green or white light (Bowlby, 1957; Schumaier *et al.*, 1968), presumably because the birds cannot see the blood stimulant under red light; however, this behavior is not normally observed in meat chickens.

The objective of this experiment was to record the behavior and performance of meat chickens under short, medium, and long wavelengths of light. In addition, at the end of the experiment, the preference of the birds for the different wavelengths of light was recorded to give some information on the effects of light color on animal welfare.

MATERIALS AND METHODS

Forty male and forty female chicks of a commercial meat strain (Cymru Ross) were reared for the 1st wk after hatch in white light before being allocated by weight to four treatments: white, red, green, or blue light from 7 to 28 d of age. Birds in each treatment were housed in two cages of 156 × 60 cm, each containing five male and five female birds. Cages were made of wire

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mesh and contained a feeder and drinker for *ad libitum* availability. From 1 to 14 d of age a starter pellet with 230 g CP and 3,100 kcal ME/kg was fed, followed by a grower ration with 150 g CP and 2,485 kcal ME/kg up to the end of the experiment.

Each cage was supplied with three 40-W tungsten filament bulbs connected with variable resistors. Blue, green, and red filters[3] were selected for their distinct wavelength patterns (peak transmission at 450, 550, and 650 nm, respectively). These filters transmitted 1.1, 15.0, and 9.3% of light, respectively, but the variable resistors were used to obtain a light intensity of 30 lx in each cage. This was measured at 15 points at normal bird eye level (20 cm above the floor of the cage) using a photometer[4] with a spectral sensitivity approximating to that of a chicken's eye (peak sensitivity at 550 nm compared with 560 nm for the chicken's eye, Kare, 1965). This intensity is greater than recommended for commercial practice but was necessary for the observation of behavior. A photoperiod of 23 h light was used, with 1 h darkness beginning at 1400 h. Birds were weighed weekly and feed consumption in each cage weighed daily. The temperature pattern was that recommended in the U.K. by the Farm Electric Centre (1990) and the temperature in each cage was monitored daily to ensure equal temperatures. Each cage was thermally and photopically isolated.

The behavior of the birds was recorded by daily observation of each treatment for 90 min for 16 d, giving one complete recording of the 23 lit h of the day by the end of the experiment. At 5-min intervals each bird was classified as feeding, standing, sitting, dozing (neck recumbent, eyes half closed), or sleeping (eyes fully closed). Incidents of walking, drinking, pecking at the floor, wing stretching, and aggression were recorded by one-zero measurements (presence or absence of the behavior) within 5-min periods.

On Day 28, one half of the birds in each treatment (five birds per cage) were slaughtered humanely by neck dislocation. The number of males and females from each cage was adjusted to ensure that an equal number of each sex was slaughtered in each treatment (five males and five females). The head, shank, intestines, liver, crop, gizzard, and lungs were removed and the full and empty weight of the crop and gizzard measured. The remainder of the carcass was bisected using scalpel and scissors. One half was homogenized, dried at 90 C for 6 d, and ground before analyzing for fat, protein, and ash contents by the procedures of the Ministry of Agriculture, Fisheries and Food (1986). Feathers were removed from the other half of the carcass, and it was dissected into skin, muscle, bone (without the keel of the breast bone), and fat.

[3]LEE Filters Ltd., Walworth Industrial Estate, Andover, UK, filters 120, 139, and 106 respectively.

[4]Macam Photometrics Ltd, 10 Kelvin Square, Livingston, EHS4 5JG UK.

The rest of the birds were placed into eight pens (one for each cage), the shape of equilateral triangles with side length 2.15 m. For the first 5 d, the pens were fitted with the same colored lights as in the first part of the experiment to allow the birds to adjust to their new environment. After this, in the corner of each pen, a colored light was hung 60 cm from the floor. The lights were red, blue, and green from the first part of the experiment, with one 40-W tungsten filament bulb plus filter in each corner. Variable resistors were used to achieve the same mean intensity in the corner as in the first part of the experiment (30 lx), measured at five points 25 cm above the ground. The corners were visually isolated by solid boards but with an opening at the front so that the birds were free to enter any corner. Each corner was provided with a drinker and feeder for *ad libitum* consumption.

A video camera was hung 2.5 m above the center of each pen and the position of the birds recorded for the first 3 h of the color preference test and then for 24 h after 1 wk had elapsed. Body weight was recorded at the beginning and end of the preference test to determine residual effects of the light treatments in the first part of the experiment. After this, birds were slaughtered by neck dislocation.

Statistical Analysis

For the first part of the experiment, the difference between treatment means was examined by a generalized linear model that included treatment, sex of bird, and cage as main effects and all two-way interactions, using the statistical package Minitab (Ryan *et al*., 1985).

For the preference test, the time spent in the different colored areas was examined by a generalized linear model that included light color, rearing color, and sex of bird as main effects and the two-way interactions. Growth rate during this test was analyzed by a model that included rearing color, sex of bird, and the interaction between the two main effects.

RESULTS

The growth and chemical composition of the birds were not affected by treatment, and feed consumption was similar for all treatments (Table 1). The full crop and gizzard were heavier for birds reared in green and blue light, but this was due to heavier gut contents in these treatments. Skin and bone weights were also greater in birds reared in green and blue light than in those reared in red or white light.

There were no overall treatment effects on feeding time (Table 2), but the interaction with sex of bird demonstrated that the feeding time of male birds was increased in the green and blue treatments, and the female birds increased in the white and to a lesser extent the red treatments (Table 3). A similar interaction occurred in drinking time: male birds spent more time drinking in the blue treatment and female birds spent more time drinking in the white treatment. Birds in the red light spent more time in aggressive interaction,

TABLE 1. The body weight, cumulative feed consumption (FC), feed conversion ratio (FCR), and carcass composition of broilers reared in different colored lights to 28 d of age

	Light color					
Variable	White	Red	Green	Blue	SED[1]	Probability
BW,[2] g	1,202	1,183	1,195	1,224	29.1	0.58
FC,[3] g	2,202	2,123	2,153	2,219		
FCR[3]	1.83	1.79	1.80	1.81		
Carcass composition,[4] %						
Protein	44.8	44.9	44.6	44.8	1.02	0.99
Fat	43.2	43.9	42.4	42.1	1.70	0.74
Ash	7.4	7.5	7.6	7.7	0.29	0.73
Feathers	4.5	5.0	4.6	5.2	0.37	0.08
Empty crop and gizzard	2.5	2.6	3.1	2.7	0.41	0.87
Full crop and gizzard	3.8	3.6	5.0	5.6	0.17	0.02
Gut contents	1.3	1.0	1.9	2.8	0.21	0.00
Skin	14.5	14.5	16.0	16.4	0.14	0.05
Muscle	53.9	53.6	52.7	51.0	0.63	0.43
Bone	18.4	18.2	20.1	20.2	0.16	0.02
Fat	11.6	11.1	10.4	11.6	0.43	0.54

[1]Standard error of the difference between two means.

[2]Two pens of 10 birds each per mean.

[3]Mean value for the two pens per treatment.

[4]Two pens of five birds each per mean.

pecking at the floor, and wing stretching. These activities were less common in birds reared in green or blue light, with birds reared in white light being intermediate. Birds in the red and white light spent longer sleeping, whereas birds in the green and blue lights spent relatively longer sitting and dozing, respectively. Walking activity was greatest in birds in white light and least in birds in green light.

In the first 3 h of the preference test, birds that had been reared in green and blue light preferred to remain in these colors (Table 4). Birds reared in red light remained initially in this color, but by the 3rd h had transferred to the blue light. Birds reared in white light preferred the red light, which was closest in spectral output to the white light. There were no differences in color choice between male and female birds ($P > 0.95$). After 1 wk during which the birds were allowed to choose the color of their environment, their preferences had changed (Table 5), and birds in all treatments chose a novel color. Birds reared in white, red, or green lights preferred the blue light, spending 47, 41, and 37 min/h there, respectively. The green light was their second choice. Birds reared in blue light preferred the green light as their first choice (35 min/h) and then the blue light (18 min/h). Female birds showed a stronger preference for blue light than male birds.

Male birds that had been reared in red and white lights gained more weight during the preference testing period than males reared in blue or green light (Table 6); however, the reverse was true for female birds.

DISCUSSION

Rearing color particularly affected bird behavior, rather than growth. In particular, birds in the red and white light were more active, which was evident in the

TABLE 2. The time spent by broilers in different light color in major behaviors and the frequency of less common behaviors[1]

	Light color					
Behavior	White	Red	Green	Blue	SED[2]	Probability
Feeding, min/h	13.5	12.7	13.1	13.0	0.37	0.13
Standing, min/h	8.1	7.9	8.4	8.6	0.35	0.21
Sitting, min/h	11.5	11.3	13.8	11.2	0.40	0.00
Dozing, min/h	15.9	14.4	14.4	16.7	0.40	0.00
Sleeping, min/h	13.0	13.7	10.3	10.6	0.32	0.00
Walking, no./h	1.18	1.04	0.83	1.03	0.05	0.00
Drinking, no./h	1.11	0.93	1.02	1.09	0.05	0.00
Pecking at floor, no./h	0.69	0.91	0.66	0.61	0.05	0.00
Wing stretching, no./h	0.46	0.69	0.42	0.35	0.04	0.00
Aggressive interaction, no./h	0.05	0.07	0.00	0.04	0.01	0.00

[1]Two pens of 10 birds each per mean.

[2]Standard error of the difference between two means.

TABLE 3. The feeding and drinking behavior of male and female broilers reared under different light colors[1]

	Male				Female				Color[2]		Sex[3]		Interaction	
Variable	White	Red	Green	Blue	White	Red	Green	Blue	SED	Probability	SED	Probability	SED	Probability
Feeding, min/h	13.1	12.0	13.7	13.7	14.0	13.3	12.4	12.3	0.37	0.13	0.26	0.66	0.53	0.00
Drinking, no./h	1.07	0.88	1.08	1.14	1.16	0.98	0.96	1.04	0.05	0.00	0.04	0.84	0.07	0.04

[1]Two pens of five birds each per mean.

[2]Statistical significance of the color effect is based on the mean of both sexes.

[3]Statistical significance of the sex effect is based on the mean of color treatments.

white-reared birds in greater walking activity and in the red-reared birds in greater floor pecking, wing stretching, and aggression. The total number of incidents of walking, floor-pecking, wing-stretching, and aggression was 2.4, 2.7, 1.9, and 2.0 per hour for birds in white, red, green, and blue lights respectively. An increase in wing stretching, and both nonaggressive and aggressive pecking has been reported for meat chickens in red light compared with equiluminescent blue light (Prayitno *et al.*, 1995). This finding suggests that the hypothalamically active red light may stimulate interactive behavior, with greater effects in the red light treatment in this experiment, because more long wavelength light would have reached the hypothalamus in the red treatment than in the white treatment In female birds, ingestive behavior was also stimulated by the red and white light, but this was not true for males. This result may be because males directed their increased motivation for activity in these treatments towards interactive behavior with other birds and the environment. The total number of incidents per hour of walking + floor-pecking + wing-stretching + aggression was 2.5, 2.7, 2.0, and 1.7 for male birds in the white, red, green, and blue, respectively. The greater activity of birds in the red and white lights appears to have necessitated greater sleep in these birds, whereas the birds in the green and blue lights spent relatively more time sitting or dozing.

The absence of significant effects on growth of the birds in the first 4 wk of life probably arises because the effects recorded by others (e.g., Woodard *et al.*, 1969; Foss *et al.*, 1972; Wabeck and Skoglund, 1974) were small and would not be detectable using the numbers used in this experiment. Most authors have reported no effect of light color on poultry growth, usually for the same reason (Smith and Phillips, 1959; Kondra, 1961; Schumaier *et al.*, 1968; Peterson and Espenshade, 1971; Wathes *et al.*, 1982). However, effects on growth are not usually allometric for all body parts, as demonstrated in this experiment. Foss *et al.* (1972) found that red and white light stimulated the growth of the comb and testes in broilers, confirming the effect of red light in stimulating reproduction via the hypothalamus, and Sturkie (1986) reported that red light stimulated testes growth. The increased gut contents of birds reared in green and blue light in this experiment may result from the decreased activity reducing rate of feed passage. Gut contents decrease in ruminants when activity increases following the annual turnout to pasture from winter housing, although this result is also connected to dietary changes (Balch and Line, 1957). The increase in skin weight in birds reared in green or blue light may arise from greater contact with excreta in these treatments. In the red and white treatments, the greater activity of the birds tended to push the excreta through the wire-mesh floor and there was therefore less skin contact when the birds were sitting.

The reason that there were significant residual effects of light color on bird growth, but no effects in the first 4 wk may be due to the sexual development of the birds in the latter part of this experiment. It suggests that

TABLE 4. The time spent in the first 3 h in red, green, and blue light by birds that had been reared in red, green, blue, or white light[1]

	Red light[3,4]				Green light[3,4]				Blue light[3,4]			
Rearing color[2,3]	Hour 1	Hour 2	Hour 3	$\bar{x}$	Hour 1	Hour 2	Hour 3	$\bar{x}$	Hour 1	Hour 2	Hour 3	$\bar{x}$
	(min/h)											
White	42	49	53	48	2	5	1	3	16	6	6	9
Red	36	20	5	20	1	1	1	1	23	40	55	39
Green	10	3	8	7	47	45	49	47	4	12	3	6
Blue	2	20	14	12	5	9	11	8	31	31	35	32

[1]Ten birds contribute to each mean.

[2]Statistical significance of hour × color occupation effect (P = 0.06), SED 3.42.

[3]Statistical significance of hour × rearing color effect (P = 1.00), SED 3.95.

[4]Statistical significance of hour × rearing color × color occupation effect (P < 0.01), SED 6.88.

TABLE 5. The effect of previous light color on the time spent in each color by male and female birds after 1 wk of color selection[1]

Rearing color	Red		Green		Blue	
	Male	Female	Male	Female	Male	Female
	(min/h)					
White	5.8	5.0	8.9	6.3	45.3	48.9
Red	9.3	8.5	10.3	9.6	40.7	41.8
Green	9.1	7.9	16.2	13.5	34.8	38.5
Blue	6.9	7.2	36.5	34.1	16.7	18.8
Statistical significance						
Effect			SED	*P*		
Sex			0.56	0.99		
Sex × rearing color			1.11	1.00		
Sex × color preference			0.96	0.00		
Sex × rearing color × color preference			1.93	0.89		

[1]Five birds contribute to each mean.

there were residual effects of the red and white light treatments that stimulated the growth of the males. Sexual development may have encouraged them to be more aggressive and dominate access to the feeder, which reduced the intake and growth of the females in these treatments.

The preference of birds to remain in their color of rearing was weakest for birds reared in red light. After 1 wk had passed, all treatments had migrated to the blue light, except that birds reared in the blue light still showed some preference for a novel color, green, that was closest in the visual spectrum. The birds' priorities were therefore first for a novel color, particularly those reared in red, and second to move to blue light. The preference for blue light and aversion to red light could be because they find the stimulatory effect of red light on the hypothalamus aversive, or because the blue light is perceived as being of different intensity if the photometric sensor did not equate to the spectral sensitivity of the chicken. Although the peak spectral sensitivity was similar, the sensitivity at each end of the spectrum (blue and red) may not have been, and small differences in minimum and maximum sensitivities would cause large differences in the perceived intensities of the lights. Female birds may have shown a greater preference for blue light because of reduced aggressive tendencies of birds in this color.

TABLE 6. Residual effects of rearing color on weight gain of male and female birds during the color preference test[1]

Rearing color[4]	Sex[2,3]	
	Male	Female
	(g/d)	
White	58.2	45.0
Red	59.4	56.6
Green	54.8	60.5
Blue	53.2	62.2

[1]Five birds contribute to each mean.

[2]Statistical significance of sex effect ($P = 0.70$), SED = 2.49.

[3]Statistical significance of the interaction between the sex effect and rearing color effects ($P = 0.02$), SED = 4.93.

[4]Statistical significance of the rearing color effect ($P = 0.26$), SED = 73.3.

REFERENCES

Balch, C. C., and C. Line, 1957. Weight changes in grazing cows. J. Dairy Res. 24:11–20.

Bell, D. J., and B. M. Freeman, 1971. Physiology and Biochemistry of the Domestic Fowl. Vol. 2. Academic Press, London, UK.

Benoit, J., 1964. The role of the eye and of the hypothalamus in the photostimulation of gonads in the duck. Ann. N. Y. Acad. Sci. 117: 204–215.

Bowlby, G.M.S., 1957. Some preliminary investigations into the effect of light on broilers. World's Poult. Sci. J. 13:214–226.

Cornsweet, T. N., 1970. Page 475 *in*: Visual Perception. Academic Press, New York, NY.

Farm Electric Centre, 1990. Page 36 *in*: Controlled Environments for Livestock. Farm Electric Centre, Stoneleigh, UK.

Foss, D. C., J. R. Carew, and E. L. Arnold, 1972. Physiological development of cockerels as influenced by selected wavelengths of environmental light. Poultry Sci. 51: 1922–1927.

Foster R. G., and B. K. Follett, 1985. The involvement of a rhodopsin-like photopigment in the photoperiodic response of the Japanese quail. J. Comp. Phys. A. Sensory, Neural Behav. Phys. 157:519–528.

Hartwig, H. G., and T. van Veen, 1979. Spectral characteristics of visible radiation penetrating into the brain and stimulating extraretinal photoreceptors. J. Comp. Phys. 130:277–282.

Kare, M. R., 1965. The special senses. The eye and vision. Pages 407–418 *in*: Avian Physiology. P. D. Sturkie, ed. 2nd ed. Cornell University Press, Ithaca, NY.

Kondra, P. A., 1961. The effects of colored light on growth and feed efficiency of chicks and poults. Poultry Sci. 40:268 (Abstr.)

Ministry of Agriculture, Fisheries and Food, 1986. The Analysis of Agricultural Materials. Reference Book 427. 3rd ed. Her Majesty's Stationery Office, London, UK.

Morris, T. R., 1968. Light requirements of the fowl. Pages 15–39 *in*: Environmental Control in Poultry Production. T. C. Carter, ed. Oliver and Boyd, Edinburgh, UK.

North, M. O., and D. D. Bell, 1993. Commercial Chicken Production Manual. 4th ed. AVI Publishing Co. Westport, CT.

Petersen, R. A., and J. Espenshade, 1971. Performance of laying hens maintained in colony cages under low intensity 'Panelescent Tape-Lites'. Poultry Sci. 50:291–293.

Prayitno, D. S., 1994. The Effects of Colour and Intensity of Light on the Behaviour and Performance of Broilers. Ph.D. thesis, University of Wales, Bangor, UK.

Prayitno, D. S., C.J.C. Phillips, H. M. Omed, and D. Piggins, 1995. The effect of colour of lighting on the performance and behaviour of broilers. Br. Poult. Sci. 35:173–175.

Ryan, B. F., B. L. Joiner, and R. A. Ryan, 1985. Minitab Handbook. 2nd ed. Duxberry Press, Boston, MA.

Schumaier, G., P. C. Harrison, and J. McGinnis, 1968. Effects of colored fluorescent light on growth, cannibalism, and subsequent egg production of single comb White Leghorn pullets. Poultry Sci. 47:1599–1602.

Smith, L. T., and R. E. Phillips, 1959. Influence of colored neon lights on feed consumption in poults. Poultry Sci. 38:1248. (Abstr.)

Sturkie, P. D., 1986. Pages 37–47 *in*: Avian Physiology. 4th ed. Springer-Verlag, NY.

Wabeck, C. J., and W. C. Skoglund, 1974. Influence of radiant energy from fluorescent light sources on growth, mortality and feed conversion of broilers. Poultry Sci. 53:2055–2059.

Wathes, C. M., H. H. Spechter, and T. S. Bray. 1982. The effects of light illuminance and wavelength on the growth of broiler chickens. J. Agric. Sci. Cambridge 98:195–210.

Woodard, A. E., J. A. Moore, and W. D. Wilson, 1969. Effect of wavelength of light on growth and reproduction in Japanese quail (*Coturnix coturnix japonica*). Poultry Sci. 48: 118–123.