

EFFECT OF LIGHT COLOR ON SOME PRODUCTIVE, REPRODUCTIVE, EGG QUALITY TRAITS, AND FREE RADICALS IN TURKEY

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ABSTRACT: *The effect of different light colors on productive and reproductive performance, egg quality traits, carcass traits, luteinizing hormone (LH), free radicals and metabolic profiles were studied in turkey from 12 to 50 wk of age. Seventy two White Holland 12 wk old turkeys were distributed randomly among four treatment groups in straight run experimental design. Each treatment consisted of 9 females and 9 males distributed randomly among three replicates of equal sex. The first group was exposed to 12 h/d of incandescent light (control), the second was exposed to 12 h/d of fluorescent light, the third group was exposed to 12 h/d of infrared light and the fourth group was exposed to 12 h/d of ultraviolet light.*

Results indicated that fluorescent light significantly improved body weight (BW), bone strength, sperm concentration, live spermatozoa, egg number, egg mass, absolute shell weight (g) and shell strength, while significantly decreased age at sexual maturity and egg free radicals. Exposure to infrared light significantly increased age at sexual maturity, shell weight (g), shell strength, hatchability and free radicals, while significantly impaired egg number, egg mass, motility and sperm concentrations and live spermatozoa.

Exposure to incandescent significantly increased plasma LH before sexual maturity, while fluorescent and ultraviolet light decreased it and infrared light had intermediate effects.

Incandescent light significantly increased growth and body weight at sexual maturity, plasma Ca level before sexual maturity only. Sperm motility, live spermatozoa, hatchability and Haugh unit score were improved in response to incandescent light. On the other hand, egg mass, egg shell quality and free radicals were significantly decreased. Ultraviolet light significantly decreased growth and body weight at sexual maturity,

sperm motility, hatchability, albumen height and bone strength of toms while increased egg mass, plasma Ca of females, and shell strength.

In conclusion, it is advisable to use the fluorescent light in turkeys management system during the rearing and laying period with expected saving (20-30%) in energy (electricity) expense of incandescent light and an improvement in productive performance.

INTRODUCTION

Light allows the bird to establish rhythmicity and synchronize many essential functions, including body temperature and various metabolic steps that facilitate feeding and digestion. Of equal importance, light stimulates secretory patterns of several hormones that control, in large part, growth, maturation, and reproduction (Robinsen and Renema, 1999). Currently, there are a wide variety of lighting programs (wavelength, intensity, and duration) and devices available to poultry producers, each possessing its own characteristics and applicability to rearing poultry (Olanrewaju et al., 2006). Color is the third major aspect of light and dictated by wavelength and it exerts variable effects on broiler performance. Day light has relatively wavelengths between 400 and 700 nm. Birds sense light through their eyes (retinal photoreceptors) and through photosensitive cells in the brain (extra-retinal photoreceptors). Specific light wavelength may have an impact on production and characteristics of broilers. During the early period, short wavelengths appear to stimulate growth. However, when the bird approaches the time of sexual maturity long wavelengths (orange-red) increase growth and are effective in stimulating sexual hormonal pathways that culminate in fertile egg production.

Growth in birds is affected by light spectra. Light of different wavelengths has varying stimulatory effects on the retina and can result in behavioral changes that will affect growth and development (Lewis and Morris, 2000). Studies show that young broilers have a strong preference for bright light (Davis et al., 1997). Levenick and Leighton (1988) observed that semen volume was significantly greater for turkeys under the red and white color than those exposed to blue color. Scott and Siopes (1994) found that light color (blue, green, red or incandescent) equalized at a photon output of 9.0 $\mu\text{m}/\text{sec}/\text{m}^2$ had no effect on the total number of erythrocytes, leukocytes or plasma corticosterone levels, cutaneous basophil hypersensitivity, anti-SRBC titers, number of heterophils and heterophil/lymphocyte ratios. Prayitno et al. (1997a;b) observed that bright red light considerably increased walking, feeding and stretching particularly when applied early in the growth period, and increase growth

when provided at the beginning of the rearing period, but decreased it besides bone strength when provided later. Bone length, weight, and torsion were not affected by light color treatments. They added that blue and green light is preferable to red or white light for broilers because the former two colors keep the chicks calmer and is chosen by the birds themselves. However, Jones et al. (2000) found that there no effect of ultraviolet light on fertility and hatchability.

El-Husseiny et al. (2000) found a significant positive influence of green color on the growth, feed intake, feed conversion, dressing weight, liver weight, abdominal fat percentage, apparent digestibility of nutrients, ME values and adrenal gland. It is also affected T3 and T4 concentrations in plasma, while white and red light had a positive effect on the pituitary gland and comb, and a significant increase in the testes weight, egg production and feed conversion was observed. Tag El-Din et al. (2006) reported that chickens exposed to green light increased growth, egg weight, hatchability and improved feed utilization, while those exposed to white color consumed more feed during the intervals 12-20 wk of age, and increased egg number and fertility followed by those kept under incandescent and green lights in a descending order.

Studies have been conducted to study the stability and dosimetric properties of radiation induced free radicals (**Regulla et al., 1994; Wieser et al., 1994, Onori and Pantaloni, 1994; Engin and Demirtas, 2004**). **Gamal (2005)** showed that the ESR dosimetric signal ($g=2.0018$) of modern egg shell has a reasonable sensitivity for electron and gamma radiation dose at room temperature.

Recently, there are increasing interest in energy save as a result of the increase in feed price and energy cost (**FAO, 2008**). Therefore, the present study was conducted to study, the impact of different light colors on age at sexual maturity, productive and reproductive performance, egg quality, bone strength, carcass traits and free radicals of turkeys from 12 to 50 wk of age.

MATERIALS AND METHODS

The present study was carried out at the Poultry Experimental Station, Faculty of Agriculture, Minufiya University, Shebin El-Kom, Egypt. A total number of 72 of 12 wk old White Holland turkeys were used in this experiment. Turkeys were distributed randomly among four light treatment groups in floor pens in straight run experiment design. Each treatment consisted of 9 female and 9 male chicks were, distributed randomly in 3 replicates of equal number and housed in a floor pen (2×2 m²). The first

group was exposed to 12 h/d of incandescent light (control; 6 lux), the second was exposed to 12 h/d of fluorescent light (7 lux), the third group was exposed to 12 h/ d of infrared light (15 lux) and the fourth group was exposed to 12 h/d of ultraviolet light (24 lux). The location and the height of the lamps were similar among the treatments and were set at 1.5 m from the floor. Pens were light-proofed by covering the windows with black sheets to prevent day light. Birds were kept under similar environmental and hygienic condition. The experimental period lasted 38 wk from 12 to 50 wk of age.

Birds were fed ad libitum commercial starter ration containing 29% CP, 2924 Kcal ME/kg diet and 21% CP with 3069 kcal ME/kg diet from 11 to 20 wk of age. While from 21-40 wk of age diet contained 17% CP and 2955 Kcal ME/kg. From 21 wk on, males were fed 120 g/d and females 100 g/d and progressively increased by 20 g /wk to reach 300 and 200 g respectively, and kept consistent thereafter. Chicks were leg-banded and weighed individually.

Criteria Of Response: Body weight was recorded to the nearest g individually at 21, 25, 33 and 41 wk of age. Pullets were individually weighed to the nearest g at first egg laid. Age at sexual maturity was recorded individually at first egg laid for pullet in each treatment.

Table 1. Composition of the experimental diets

Ingredients (%)	Diets	
	Grower (11-20 wk of age)	Laying (21-45 wk of age)
Ground yellow corn	31.2	60.0
Wheat bran	31.2	0.0
Soybean meal (49% CP)	29.1	33.5
Fat	4.0	0.0
Ca-phosphate	1.8	2.0
Limestone	1.35	3.0
Sodium Chloride	0.25	0.40
Vit. +Min mixture *	1.0	1.0
DL- Methionine **	0.10	0.10
Crude Protein % (calculated)	21.0	17.0
ME, (Kcal/ Kg , calculated)	3069	2955
Crude fat,%	5.8	5.8
Crude fiber,%	2.8	3.1

***Vitamin Mixture:** 20mg Niacin, 4.5g Riboflavin, 3g Pyridoxine (B6), 13mg Cyanocobalamin (B₁₂) and 100mg Choline chloride 20000000 IU Vit A, 20000000 IU Vit D₃ and 400IU Vit E. ** **Mineral Mixture:** 906g Calcium carbonate, 55g Manganese, 35g Zinc, 2.65g Copper, 0.35g Iodine and 1.0g Selenium.

Hen-day egg production and daily egg weight were recorded, Egg number/hen and egg mass were calculated for the whole period for each treatment. Eggs of each treatment were collected and broken to determine egg quality according to **Attia *et al.* (1995)**. Fertility and hatchability of total eggs set were measured.

Semen was collected individually and measured for 12 times according to **Kalamah *et al.* (2002)** from 5 males of each treatment using massage method. The determination included ejaculate volume, motility, semen pH, sperm concentration, and live sperm percent.

Individual blood samples were taken from 8 birds within each treatment at 25 and 40 wk of age. Blood samples were collected at 1.00 p.m. into dry clean heparinized centrifuge tubes. Plasma was separated by centrifugation at 3000 rpm for 20 minutes and stored frozen at -20° C until analysis. Biochemical constituents of blood plasma were determined {e. g. total protein (**Cannon, 1974**), total lipids (**Boutwell, 1972**), albumin (**Doumas *et al.*, 1977**), cholesterol (**Stein, 1986**), calcium (**Sendroy, 1944**), GOT and, GPT activities (**Reitman and Frankel, 1957**)}. Globulin was calculated by differences between total protein and albumin. Whereas, Ca and LH hormone were determined using commercial available kits only before sexual maturity (25 wk of age) and after sexual; maturity (40 wk of age).

At the end of the experiment, a slaughter trial was done using 3 toms and 3 females chosen randomly from each experimental group. Toms and females were individually weighed alive then slaughtered to complete bleeding, followed by plucking the feathers. Empty carcass (dressing), liver, gizzard, spleen, testes, ovary and oviduct were weighed and their dressing percentage was calculated to live BW. The hardness of legs shank bone (bone strength) was measured with manual instrument at 44 wk of age (Newton Model)

Free radicals were measured using fresh covered eggs, the eggs were cracked and the mixed liquid (albumen and yolk) were collected in the covered tubes. The liquid were reflized in reflizing machine until the liquid convert into powder. The height of the powder inside the tube was `10 mm, ensuring a homogenous magnetic field inside the cavity. The ESR measurements were performed with an X-band ESR spectrometer (Bruker, EMX), opening at 9.7 GHZ with a 100 kHz modulation frequency. Samples with a mass of 150 mg were placed in quartz tube with an internal diameter of 3 mm. The experimental parameters were microwave power 100 g, time constant was 40 ms and the field –sweeping rate of 100 g /164 s. The ESR

signal intensity was recorded 10 times, with 10 scans each time, after storing the powder samples at 100 °C for one h to remove the short-lived radicals and then it was measured as peak –to-peak height. A standard sample of MgO doped with Mn²⁺ was used separately to calibrate the ESR intensity, spectrometer stability and the signal g-factor.

Data were subjected to statistical analysis using **SPSS (1984)**. Mean differences at $p \leq 0.05$ were tested using the Duncan Test (**Duncan's, 1955**).

RESULTS AND DISCUSSION:

Body weights and age at sexual maturity of females: Results in Table (2) show the effect of light color on body weight, at different ages, and age at sexual maturity. It was found that when data were pooled over sex the fluorescent light significantly increased body weight of 21 and 25 wk old turkey when compared to other color of lights which showed no significant differences among them. However, the effect of fluorescent light depends on sex and age of turkeys.

At 33 wk of age, differences within female treatments were diminished, while toms exposed to fluorescent light were still heavier than only those exposed to incandescent light. When data were pooled over sex turkey exposed to fluorescent light were significantly heavier than those exposed to the other light colors. At 41 wk of age, the results revealed that, toms exposed to fluorescent light were heavier by 7.3 and 13.7% respectively than those illuminated with infrared and ultraviolet light, meanwhile difference from incandescent light was diminished. This revealed that turkeys exposed to incandescent light exhibited compensatory growth at latter age (**Olanrewaju *et al.*, 2006**). On the other hand, there were no significant differences among female groups due to color of light at 41 wk of age. When data were pooled over sex, it was found that turkeys exposed to fluorescent light were significantly heavier by 4.3 and 9.3% respectively than those exposed to infrared and ultraviolet lights. These results indicated that fluorescent light stimulated growth of turkey and the effect was obvious within toms than females suggesting different sex respective. This effect could be due to different wavelengths of light which has varying stimulatory effects on the retina and can result in behavioral changes that will affect growth and development (**Lewis and Morris, 2000**).

Table 2. Effect of different light colors on body weights at different ages and age at sexual maturity of turkeys (average± SE)

Parameter	Sex	Incandescent	Fluorescent	Infrared	Ultraviolet
Body weight at 21 wk of age	♀	2323±87.9 ^a	2271±142.6 ^a	1921±114.4 ^b	2063±124.2 ^{ab}
	♂	2600±20.4 ^b	3283±86.6 ^a	2918±128.5 ^b	2688±75.4 ^b
	Average	2461.5±74.4 ^b	2777±150.4 ^a	2420±147.1 ^b	2376±103.9 ^b
Body weight at 25 wk of age	♀	2969±86.2 ^b	3496±226.7 ^a	2797±146.9 ^b	2802±164.5 ^b
	♂	3395±104.1 ^b	3844±186.1 ^a	3607±141.9 ^{ab}	3560±90.7 ^b
	Average	3182±81.1 ^b	3670±157.6 ^a	3202±139.2 ^b	3182±129.2 ^b
Body weight at 33 wk of age	♀	3366±69.7	3464±127.2	3214±117.6	3233±152.5
	♂	4055±117.8 ^b	4682±196.5 ^a	4318±182.9 ^{ab}	4242±117.1 ^{ab}
	Average	3711±86.6 ^b	4073±196.9 ^a	3767±176 ^b	3737±155.9 ^b
Body weight at 41 wk of age	♀	4105±54.8	4124±127.2	4192±60.1	4075±64.1
	♂	7405±238.8 ^a	7534±200.6 ^a	6987±231.7 ^b	6502±268.2 ^c
	Average	5755±308.8 ^{ab}	5829±453.5 ^a	5590±359.1 ^b	5289±334.1 ^c
Body weight at sexual maturity	♀	4316±88.1 ^a	4023±164.9 ^{ab}	4183±109.3 ^{ab}	3800±28.8 ^b
	♂	246±1.0 ^{ab}	237±3.5 ^b	261±11.3 ^a	244±3.2 ^{ab}

a,b,c Means within diet in the same row with different superscript letters are significantly different ($p \leq 0.05$)

In the literature, the effect of light color on growth of birds are inconclusive e.g. chickens under blue or green light become significantly heavier than those reared under red or white light (Rozenboin et al., 2004). Prayitno et al. (1997a;b) observed that bright red light considerably increased walking, feeding and stretching particularly when applied early in the growth period, and increased growth when provided at the beginning of the rearing period, but decreased it when provided later.

Body weight of females at sexual maturity of pullets exposed to incandescent light was significantly heavier (13.6%) than those illuminated with ultraviolet light (Table 2). On the other hand, differences between groups illuminated with fluorescent and infrared and the aforementioned groups were not significant. It is obvious that, chicks illuminated with fluorescent light reached sexual maturity significantly faster by 24 days only those exposed to infrared light. Differences in age at sexual maturity between the incandescent light and ultraviolet light and the abovementioned groups were not significant (Table 2). Siopes and Wilson (1980) suggested that differences in spectral composition between fluorescent light and incandescent light were responsible for differences rates of maturation of quail. On the other hand, El-Abd (2005) observed that difference in age at sexual maturity due to various light color was not significant.

Egg production traits: Results in Table (3) indicate that fluorescent light resulted in highest egg number and egg mass among different light colors. However, the difference (64.5%) was significant only on egg number compared to infrared light, and in egg mass compared to incandescent (69.6%) and infrared (19.7%) lights. It is worth noticing that egg number of hens exposed to incandescent light and ultraviolet light and those exposed to fluorescent light was similar. Moreover, differences in egg mass between hens exposed to fluorescent light and ultraviolet light were not significant. Furthermore, differences in egg weight were not significant among various colors of lights. These results indicate that fluorescent light had higher productive efficiency than other light colors. Similarly, Jones et al. (2000) found that turkeys exposed to white color laid significantly more eggs than those exposed to blue and green light. However, Jerome et al. (1997) indicated that ultraviolet light did not affect egg production. On the other hand, Pyrzak et al. (1984) showed that red light stimulates egg production efficiency whereas green and blue light had little or no effect, meanwhile eggs laid under blue and green light were consistently larger (1 to 2 g) than those laid under red light. Along the same line, Orderkirk (1993) concluded that egg production of laying hens responded better to red portion of the spectrum while chicks grow better under the blue-green portion of light

spectrum. On the other hand, light color had no significant effect on egg number, whereas egg weight of hens exposed to red light was significantly heavier throughout the laying period than those in the other light colors (e.g. blue and incandescent lights) showing greater egg weight of hens exposed to (long wavelength) red and incandescent lights (Wells, 1971; Pryzak and Soipes, 1986a;b). However, Tag El-Din et al. (2006) reported that laying hens exposed to green light laid heavier egg weight, while those exposed to white color laid more eggs followed by those kept under incandescent and green lights in a descending order. The differences in the above cited results could be attributed to spectral overlap of colors, differences in spectral sensitivity with age and experience and confusion of wavelength and light intensity in some experiments, strain and age of birds (Prayitno et al., 1997a;b).

Although significant differences were shown among different color treatment in egg traits, differences in ovary and oviduct weight (Table 3) did not confirm these effects. This may be due to small sample size and /or higher sampling error.

Table 3. Effect of different light colors on egg production traits (total egg number/treatment), egg weight (g) and total egg mass (kg/treatment), weight of ovary and oviduct (g) and plasma LH before and after sexual maturity of turkey hens (average± SE)

Parameter	Incandescent	Fluorescent	Infrared	Ultraviolet
Total egg number	254±17 ^a	306±15 ^a	186±12 ^b	286±19 ^a
Egg weight (g)	68.37±2.50	68.00±3.35	65.8±1.90	68.96±2.10
Total egg mass (kg)	17.38±0.94 ^b	20.81±1.02 ^a	12.27±0.92 ^c	19.71±1.15 ^a
Ovary weight (g)	4.33±0.57	5.33±3.21	3.33±0.57	4.00±2.00
Oviduct weight (g)	74.33±3.05	76.33±2.51	77.00±1.00	76.33±3.21
Luteinizing hormone (U/l)				
Before sexual maturity (25 wk of age)	1.40±0.22 ^a	0.66±0.13 ^b	1.07±0.11 ^{ab}	0.86±0.57 ^b
After sexual maturity (40 wk of age)	0.14±0.03	0.12±0.01	0.11±0.01	0.14±0.03 ^b
Average	0.77±0.10	0.39±0.11	0.58±0.11	0.50±0.15

a,b,c Means within diet in the same row with different superscript letters are significantly different (p < 0.05)

Luteinizing Hormone: Table (3) illustrates that, there was significant effect of light color on LH concentrations only before (25 wk of age) sexual maturity. In this respect incandescent light resulted in significantly higher plasma LH than those exposed to fluorescent and ultraviolet light. The latter groups did not show significant differences between them, meanwhile plasma LH of hens illuminated with infrared light was intermediate. After sexual maturity (40 wk of age) differences in plasma LH was diminished. In the literature, the effect of light color on LH is rare.

Eggs quality, eggshell, free radicals and bone strength: Table (4) shows that there were significant changes in weight of albumen, yolk and shell due to light color. The results revealed that infrared lights significantly increased yolk weight (g) compared to the other light colors. An opposite trend was observed in albumin weight (g). The increase in yolk weight of group exposed to infrared light could be due small egg weight (Table 3), as the most increase in egg weight is mostly related to the increase in albumen weight. On the other hand, Pyrzak et al. (1984) found that weight of albumen in turkey hens were significantly greater in eggs from hens exposed to red and incandescent light than those of the other light treatments. However, El-Abd (2005) observed that difference in yolk weight due to light color was not significant.

Table 4. Effect of different light colors on egg quality, bone strength and shell quality and plasma calcium of turkeys (average± SE)

Parameter	Sex	Incandescent	Fluorescent	Infrared	Ultraviolet
Yolk parameters					
Yolk weight (g)	♀	20.19±2.02 ^b	21.14±1.75 ^b	24.38±1.52 ^a	20.29±1.40 ^b
Yolk index	♀	53.0±3.7 ^a	45.0±1.0 ^b	44.7±0.6 ^b	44.6±0.8 ^b
Albumen parameters					
Albumen weight (g)	♀	41.22±2.61 ^a	39.13±3.27 ^a	34.41±3.01 ^b	40.53±3.18 ^a
Albumen height	♀	8.04±1.62 ^a	5.03±1.01 ^c	6.51±1.14 ^b	6.86±0.92 ^b
Haugh unit score	♀	85.95±1.66 ^a	63.57±1.57 ^b	76.81±1.89 ^a	79.01±1.19 ^a
Free radicals	♀	67.24±1.43 ^b	69.34±1.47 ^b	75.60±1.78 ^a	80.53±1.75 ^a
Bone and shell quality					
Bone strength (Newton)					
	♀	207.9±5.2	170.7±5.9	217.8±56.6	255.1±42.7
	♂	470.9±21.2 ^{ab}	532.8±67.9 ^a	402.2±72.6 ^{ab}	339.4±51.9 ^b
	Average	339.4±33.6	347.3±33.6	309.9±33.6	297.2±33.6
Shell weight (g)	♀	9.79±0.66 ^b	10.40±0.77 ^a	10.18±0.70 ^a	10.10±0.60 ^{ab}
Shell strength (Newton)	♀	49.60±15.69 ^b	59.60±21.19 ^a	63.47±15.48 ^a	63.87±13.66 ^a
Egg shape index	♀	73±0.60 ^b	78±0.4 ^a	75±0.5 ^b	75±0.4 ^b
Plasma Ca (mg/100 ml)					
Before sexual maturity (25 wk of age)					
	♀	7.74±0.44 ^a	6.51±0.53 ^b	6.50±0.53 ^b	8.68±0.65 ^a
	♂	7.48±0.65 ^a	5.51±0.53 ^b	5.60±0.59 ^b	7.07±0.53 ^b
	Average	7.61±0.39	5.83±0.38	6.05±0.40	7.87±0.42
After sexual maturity (40 wk of age)					
	♀	9.42±0.59 ^c	13.34±0.59 ^b	11.48±0.59 ^b	13.84±0.58 ^a
	♂	6.60±0.53	6.48±0.65	7.05±0.65	6.48±0.53
	Average	8.01±0.40 ^b	9.91±0.44 ^{ab}	9.27±0.44 ^{ab}	10.16±0.40 ^a

a,b,c Means within diet in the same row with different superscript letters are significantly different (p < 0.05)

Albumen height and Haugh unit score were significantly improved due to illumination of turkey hens with incandescent light compared to the other color of lights especially fluorescent. The decrease in albumen height and Haugh unit score due to exposure to fluorescent light may reflect the increase in laying rate and egg mass (Attia et al., 1995). On the other hand, other light colors showed intermediate values for albumen quality. El-Abd (2005) revealed that there were no significant differences in albumen height and Haugh unit score due to different light colors.

It was found that incandescent light and fluorescent ones significantly decreased free radicals in eggs compared to infrared by 11.1 and 8.3%, respectively and to ultraviolet by 16.5 and 13.9%, respectively. It is also obvious that infrared had less (6.1%) harmful effects than ultraviolet light, although difference was insignificant. Bartoll et al. (2000) indicated that free radicals observed in Ca carbonates can be created not only by high energy radiation such as α , β , and γ rays, but also by the interaction of solids with sunlight, light of Hg lamps or UV lasers. Also, Gamal (2005) showed that the ESR dosimetric signal of fresh egg shell has a reasonable sensitivity for electron and γ radiation dose at room temperature.

Egg shape index and yolk index were also significantly affected by light color. Obviously, fluorescent light and incandescent light significantly increased egg shape index and yolk index respectively compared to the other color of lights. El-Abd (2005) observed that differences in egg shape index and yolk index due to different lights color were not significant.

Egg shell quality criteria (e.g. shell weight (g) and shell strength as well as their related criteria such as bone strength and plasma Ca) were significantly affected by color of light. It was found that incandescent light significantly decreased egg shell weight (g) and shell strength compared to fluorescent and infrared lights, showing that fluorescent light improved egg shell quality, and further increase was confirmed in bone strength of toms only. In partial agreement with the present results Pyrzak et al. (1984) found that shell weight was significantly better in blue than red and incandescent light, thus wavelength can affect egg shell quality of turkey hens. However, El-Abd (2005) reported that differences in egg shell quality due to different colors of lights were not significant.

Toms exposed to fluorescent light had significantly better (57%) bone strength than only those exposed to ultraviolet light. On the other hand, differences among other color of lights and the abovementioned

groups were not significant. Obviously, differences in bone strength among females were not significant, and thus when data were pooled over sex difference due to male was diminished. Lewis and Morris (2000) observed that fluorescent and ultraviolet light may be beneficial in reducing of leg abnormalities in meat type birds.

It was observed that female turkeys exposed to incandescent light recorded significantly higher plasma Ca before sexual maturity compared to fluorescent and infrared light at 25 wk of age (Table 4). However, the opposite is true after sexual maturity at 40 wk of age. Also, ultraviolet light had significantly higher plasma Ca level than fluorescent and infrared lights at 25 and 40 wk of age. It is worth noticing that plasma Ca level of females was significantly higher after sexual maturity compared to the value recorded before maturity, and this increase is related to demand for Ca for egg shell formation and the effect of estrogen and parathyroid hormone on Ca metabolism (Sturkie, 1990). It is obvious that, incandescent light resulted in significantly higher plasma Ca level of males only before sexual maturity than other light colors which showed no significant differences among them. These results are in partial agreement with those reported by Aymen et al. (1993) who found that light colors had no significant effect on plasma Ca level.

Semen quality, fertility and hatchability: Table (5) shows that color of light had no significant effect on testes weight (g), semen volume and pH of semen, and thus fertility percent. On the other hand, incandescent light improved sperm motility compared to other light colors. Sperm concentration increased (26.6%) significantly due to fluorescent compared to infrared light, and this trend (6.8%) was also existed in live spermatozoa percent. These results showed that fluorescent light improved semen quality, and this is in agreement with the slight insignificant increase in testes weight of fluorescent light. Wall and Jones (1976) indicated that there no significant differences in sperm concentrations due to light source, although total sperm output was significantly higher in toms exposed to incandescent light.

Fertility percentage ranged from 88 to 89%, and differences among various color treatments were not significant. On the other hand, hatchability was significantly affected by light color. Results reveal that hens exposed to incandescent and infrared lights had similar hatchability being significantly higher than those illuminated with either fluorescent or ultraviolet ones. The later groups showed also similar values. Recent results by Tag El-Din et al. (2006) indicated that chickens exposed to green light had better hatchability, while those exposed to white color

had higher fertility followed by those kept under incandescent and green lights in a descending order. However, Jones et al. (2000) found that there were no effects of ultraviolet light on fertility and hatchability.

Table 5. Effect of different light colors on testes weight, semen quality, fertility and hatchability of turkeys (average± SE)

Parameter	Incandescent	Fluorescent	Infrared	Ultraviolet
Testes weight (g)	13.33±2.08	15.33±6.02	13.33±4.51	10.66±3.21
Semen volume (mm)	5.35±2.38	5.74±2.91	5.14±2.31	5.90±2.81
Sperm motility (1-5)	4.44±0.89 ^a	4.02±0.97 ^b	3.67±1.06 ^b	3.90±1.12 ^b
Semen pH	8.02±0.30	7.97±0.32	8.05±0.35	7.93±0.35
Sperm concentrations x10 ⁹	8.41±2.57 ^{ab}	9.65±4.90 ^a	7.62±3.95 ^b	8.92±4.89 ^{ab}
Live spermatozoa (%)	92±1.7 ^a	91±1.7 ^a	85.2±1.8 ^b	89.5±1.7 ^a
Fertility (%)	88±2.0	89±2.0	89.0±2.0	88.0±2.0
Hatchability (%)	36.0±0.3 ^a	27.0±0.3 ^b	35±0.5 ^a	29.0±0.3 ^b

^{a,b} Means within diet in the same row with different superscript letters are significantly different ($p \leq 0.05$)

Dressing And Body Organs: Table (6) shows the effect of light color on dressing percentage and body organs of female, toms and mixed sex of turkeys. No significant differences were shown in dressing percent and the weight of spleen. Meanwhile, significant differences were noticed due to light color on the weight (g) of liver and gizzard, and the effect was obvious within only toms, furthermore it was diminished when data of both sex was pooled. Liver weight (g) was enlarged due to exposing of toms to fluorescent light compared to the other color of light, with the effect of infrared was more severe. However, **Khaled (2003)** found that there were no significant differences in relative weight of liver due to various color of lights

Table 6. Effect of different light colors on dressing (%), liver weight (g), gizzard weight (g) and spleen weight (g) of turkeys (average± SE)

Parameter	Sex	Incandescent	Fluorescent	Infrared	Ultraviolet
Dressing (%)	♀	77.7±2.8	77.0±2.8	78.4±2.9	78.4±2.8
	♂	77.7±2.8	77.7±2.8	7.7±2.87	77.7±2.6
	Averag	77.7±2.8	77.7±2.8	7.7±2.87	77.7±2.7
Liver weight (g)	♀	74.7±0.57	63.7±9.86	82.0±14.42	79.0±15.52
	♂	99.0±19.31 ^b	112.3±12.42 ^a	80.0±9.53 ^c	91.33±18.50 ^{bc}
	Averag	86.8±18.08	88.0±28.48	81.0±10.99	85.2±16.70
Gizzard weight (g)	♀	168±11.4	137±28.1	178±23.7	145±14.1
	♂	147±24.5 ^b	195±11.6 ^a	158±19.4 ^b	195±41.0 ^a
	Averag	158±20.5	166±37.2	168±22.1	170±38.9
Spleen weight (g)	♀	4.66±0.58	4.00±1.00	5.00±1.00	4.66±1.52
	♂	6.00±1.00	6.66±0.57	4.66±0.57	5.33±1.52
	Averag	5.33±1.03	5.33±1.63	4.83±0.75	5.00±1.41

^{a,b,c} Means within diet in the same row with different superscript letters are significantly different ($p < 0.05$)

Interestingly, there was a significant increase in gizzard weight due to illumination of toms with fluorescent light compared to incandescent and infrared light, showing an adaptive response in digestive organs which could explain the improvement in performance of birds exposed to fluorescent lights. Gizzard plays an important role in increasing the digestion process through increase the digesta surface area (**Sturkie, 1990**).

Biochemical Profiles Of Blood:

Liver functions: Data in Table (7) illustrate that ultraviolet light significantly increased plasma total protein and globulin of only female turkeys compared to other color of lights which shows no significant differences among them. When data were pooled over sex, ultraviolet light still had higher plasma total protein and globulin than those exposed to infrared light. Meanwhile, those exposed to fluorescent and incandescent light had intermediate values. Results indicate that there were no significant differences in plasma albumin and albumin to globulin ratio due to different colour of lights. On the other hand, **Saad (1995)** concluded that serum total protein, albumin and globulin were not significantly affected by different color of lights. Also, **Faltes *et al.* (1988)** found that albumin to globulin ratio was not significantly affected by different light treatments.

Plasma GOT, GPT and alkaline phosphatase activities were not significantly affected by color of light, nor there were significant differences due to the interaction between light color and sex of turkeys. This indicated that light color had no harmful effect on liver function as determined by liver enzymes. These results are in agreement with those reported by **Saad (1995)**.

Plasma Lipids And Cholesterol: Results in Table (7) show that color of light had a significant effect on plasma total lipids of females. Obviously, florescent light increased plasma total lipids at 40 wk of age by 8.7, 24.0 and 45.3% compared to incandescent, infrared and ultraviolet lights, respectively. Meanwhile, plasma cholesterol was not affected by light color and sex of turkeys, meaning that different light colors did not induce physiological stress. The increase in plasma total lipids and liver weight indicated an increase in lipid synthesis for egg formation and supported the increase in egg number and egg mass of fluorescent illuminated group (Table 3). Liver is the site for lipid synthesis for yolk formation (**Sturkie, 1990** and **Attia *et al.*, 1995**). Similar results were reported by **Saad (1995)** who found that plasma cholesterol as an indication of environmental stress was not significantly affected by different light treatments. Also, **Onbasilar *et al.* (2007)** found that H/L, glucose, cholesterol and triglyceride levels did not differ significant among different lighting groups.

Table 7. Effect of different light colors on plasma constituents of turkeys (average± SE)

Parameter	Sex	Incandescent	Fluorescent	Infrared	Ultraviolet
Total protein (g/100ml)	♀	4.40±0.23 ^b	4.36±0.23 ^b	3.88±0.23 ^b	5.60±0.23 ^a
	♂	3.62±0.21	3.63±0.25	3.87±0.25	3.50±0.21
	Average	3.97±0.18 ^{ab}	4.03±0.22 ^{ab}	3.88±0.17 ^b	4.45±0.36 ^a
Albumin (g/100ml)	♀	2.80±0.16	2.88±0.16	2.58±0.16	2.78±0.16
	♂	2.48±0.142	2.28±1.74	2.73±0.174	2.57±0.142
	Average	2.64±0.11	2.56±0.12	2.66±0.12	2.67±0.11
Globulin (g/100 ml)	♀	1.60±0.216 ^b	1.48±0.216 ^b	1.30±0.210 ^b	2.82±0.215 ^a
	♂	1.13±0.197	1.35±0.241	1.15±0.240	0.93±0.197
	Average	1.37±0.146 ^{ab}	1.42±0.162 ^{ab}	1.23±0.162 ^b	1.88±1.46 ^a
Albumin to globulin ratio	♀	1.42±0.82	2.99±0.82	2.02±0.82	1.04±0.82
	♂	2.33±0.75	1.71±0.91	2.39±0.91	2.88±0.75
	Average	2.14±0.55	2.35±0.61	3.09±0.61	1.96±0.55
GOT (U/L)	♀	117.0±11.79	111.8±9.81	133.0±5.39	145.0±1.58
	♂	72.0±15.03	59.0±11.09	58.3±10.77	61.3±16.87
	Average	92.5±11.70	88.3±11.54	99.8±14.13	99.4±15.86
GPT (U/L)	♀	8.0±0.89	8.4±1.17	7.6±1.17	7.6±1.33
	♂	7.3±1.12	8.0±1.41	6.0±1.41	9.0±1.43
	Average	7.7±0.69	8.2±0.84	6.9±0.89	8.4±0.97
Alkaline phosphatase (U/L)	♀	123.2±13.1	127.2±21.6	120.2±28.5	133.6±11.28
	♂	110.5±19.26	103.5±16.49	90.3±7.17	96.8±5.57
	Average	116.9±11.37	115.4±12.6	105.2±12.59	115.2±11.37
Total Lipids (G/L)	♀	2.30±0.97 ^b	2.50±0.73 ^a	1.90±0.45 ^b	1.72±0.74 ^b
	♂	1.47±0.62	1.18±0.09	1.15±0.1	1.55±0.61
	Average	1.85±0.87	1.96±0.91	1.57±0.51	1.62±0.64
Cholesterol (mg/100ml)	♀	146.8±15.54	117.4±15.54	109.2±15.54	110.2±15.54
	♂	106.5±14.18	99.5±17.37	98.5±17.37	134.7±14.18
	Average	126.7±10.5	108.5±11.7	103.9±11.66	122.4±10.52

^{a,b,c} Means within diet in the same row with different superscript letters are significantly different ($P < 0.05$)

In conclusion, it is possible to use the fluorescent light in turkeys management system during the rearing and laying period with expected saving in energy (electricity) expense of incandescent light and expected an increase in productive performance and economic returns.

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الملخص العربي

دور لون الإضاءة على بعض الصفات الإنتاجية والفسيوولوجية و جودة البيض و الشوارد الحرة في الرومي

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أجريت هذه الدراسة بهدف قياس تأثير لون الإضاءة على الأداء الإنتاجي و التناسلي و الفسيولوجي و الشوارد الحرة و هرمون LH و صفات الذبيحة و بعض قياسات الدم في الرومي من سلالة الهولندي الأبيض و استخدم في هذه الدراسة 72 كتكوت عمر 12 أسبوع حني عمر 50 أسبوع حيث تعرضت الطيور لأربعة ألوان من الإضاءة هي لون الإضاءة العادية و لون الضوء الأبيض (الفلورسنت)، و الأشعة تحت الحمراء و الأشعة فوق البنفسجية حيث تعرضت الطيور إلي 12 ساعة يوميا من هذه الألوان . و استخدم في كل مجموعة 18 طائر تسعة من كل جنس وزعت بين ثلاث مكررات بكل منها 6 طيور (ثلاثة من كل جنس).

أظهرت النتائج إن تعرض طيور الرومي الهولندي الأبيض للون الضوء الأبيض (الفلورسنت) أدى إلي زيادة معنوية في وزن الجسم و التبكير في النضج الجنسي، و قوة العظام و قلت من الشوارد الحرة و زادت من تركيز الاسبرمات، و نسبة الاسبرمات الحية و العدد الكلي للبيض، و كتلة البيض، و وزن القشرة و صلابتها. كما أدى تعرض الرومي للأشعة تحت الحمراء إلي زيادة العمر عند النضج الجنسي و وزن القشرة و قوة صلابتها و نسبة الفقس مع ظهور الشوارد الحرة و أدى إلي نقص معنوي في عدد و كتلة البيض الناتج و حركة الاسبرمات و تركيز السائل المنوي و نسبة الاسبرمات الحية.

بينما أدى تعرض الطيور إلي اللون العادي إلي زيادة معنوية في وزن الجسم عند النضج الجنسي، مستوى الكالسيوم في الدم قبل النضج الجنسي و زادت حركة الاسبرمات، و نسبة الاسبرمات الحية و تحسنت نسبة الفقس و جودة البياض ولكن قلت كتلة البيض و جودة القشرة زادت الشوارد الحرة بالبيض.

أدى تعرض الطيور إلي الأشعة فوق البنفسجية إلي نقص معدلات النمو و كذلك الوزن عند النضج الجنسي و زاد من كتلة البيض، مستوى الكالسيوم في دم الإناث و حسن من جودة القشرة و مع ذلك قلل من صلابة العظام في الذكور و حيوية الاسبرمات و نسبة الفقس و ارتفاع البياض.

أدى التعرض إلي اللون العادي إلي زيادة هرمون LH في بلازما الدم في فترة ما قبل النضج الجنسي بينما أدى التعرض إلي اللون الفلورسنت و الأشعة فوق البنفسجية إلي نقص هذا الهرمون بينما أدى التعرض إلي الأشعة تحت الحمراء إلي تغيرات غير معنوية في مستوى الهرمون في الدم.

أوضحت الدراسة الحالية إمكانية استفادة مزارع الدواجن من لون الإضاءة الفلورسنت في تربية الرومي خلال مرحلة الرعاية و إنتاج البيض مع توقع خفض في تكلفة إضاءة هذه المزارع مما ينعكس في زيادة الإنتاج و العائد الاقتصادي لتلك المزارع.