ISSN 1682-8356
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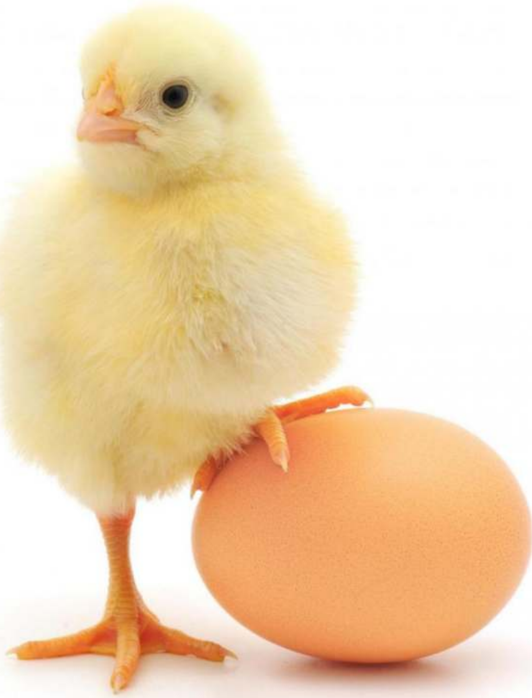

INTERNATIONAL JOURNAL OF POULTRY SCIENCE

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International Journal of Poultry Science 14 (10): 562-569, 2015
ISSN 1682-8356

The Effect of Color Light and Stocking Density on Some of External and Internal Egg Traits of Layers

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Abstract: The study was conducted in the poultry farm of Veterinary Medicine College-University of Basra. This study was designated to investigate the effect of color light and stocking density on some productive performance of layers including external and internal characteristics of produced eggs. A total of 180 Isa Brown layers were used in this study with an average of 36 birds in each of five separated treatments were exposed to white light (WL) as a control, red light (RL), blue light (BL), green light (GL) and Blue-Green mix light (BGL) by a light-emitting diode system (LED) applied according to light intermittent program (16 h light-8 h dark) for 12 weeks with light intensity 5 watt/m^2. In each treatment birds were randomly housed into 6 wooden sealed pens of 1 m^2 in three replicates for each density 5 and 7 birds/m^2. The results of the present study recorded significant interactions on accumulative egg production (Hen House) HH%, egg weight and egg mass in layers reared under RL at level of density 5 birds/m^2. The results also revealed that light color and stocking density had no effect on egg shell weight, thickness, shell percentage, yolk weight, yolk ratio and albumin weight and ratio.

Key words: Color light, eggs, layers, stocking density

INTRODUCTION

A good commercial layer management is required for the optimum growth and subsequently high egg production (Samad, 2005). Many production facets influence performance and welfare of animals. The most important ones are environmental temperature and lighting conditions (Mohammed *et al.*, 2010). Light is as an important management tool to regulate production and welfare by modulating various behavioral and physiological pathways. Artificial lighting consists of 3 aspects: photoperiod, wavelength and light intensity (Deep *et al.*, 2010). The lighting program (day length and light intensity) for pullets and laying hens is a key factor in determining the onset of sexual maturity and egg production. Color is an important aspect of light that has been considered at one time as a management tool in poultry production (Prayitno *et al.*, 1997). The visual system of birds differs from that of mammals and humans. These include in particular the ability to distinguish longer visual sequences of up to 150-250 individual images per second (humans can only see up to 25-30 individual images per second) and their tetrachromatic color vision (trichromatic in man), enabling birds to see colors in a spectral range of 360-400 and 600-700 nanometer wavelengths. These characteristics have to be taken into consideration in the selection of artificial light sources and the design of lighting programs for pullets and laying hens (Thiele, 2009). In avian species light perception is conducted in 2 major sites: (1) The retina which equipped with rods and cones operating similarly to human retina with peak sensitivity in the yellow green band. (2) Extra-retinal photoreceptors located in several parts of the brain activated majorly by long wavelength (red) (Rozenboim *et al.*, 2004).

The other factor of this study is stocking density. Instead of being expressed as the number of birds per unit area, density is calculated as bird weight per unit area. Regardless of which method is used to report density, the same factors and issues are present (Fairchild, 2005). From this perspective, high stocking densities applied to maximize profit per unit area result in negative general welfare perceptions, in particular within the poultry production sector (Vanhonacker and Verbeke, 2009).

Egg production is one of the oldest farming activities in history (Penn State, 1999). Light schedule, intensity or illuminance and color are important factors that influence avian productivity (Cao *et al.*, 2008). Rozenboim *et al.* (1999) conducted a study to test effects of different light wavelengths on layer performance. Layers were housed under wavelengths of 560 nm (green), 660 nm (red) and 880 nm (infrared). Egg production at 58 weeks was statistically poorer ($p<0.05$) under the infrared lighting and they concluded that this was due to the chickens' inability to see at this wavelength of infrared. It was concluded that photostimulation by red light resulted in an acceleration of sexual development in Thai native hens compared to hens exposed to full-spectrum lighting; however, live performance, egg production, egg shell quality and fertility were not affected whatever the light treatment (Gongruttananun and Guntapa, 2012). Er *et al.* (2007), found that the rate of egg production in blue light was significantly higher than those in other light groups from 19 to 37 week, but rate of egg production in both white and red light groups was not significantly different from 38 to 52 week. Pyrzak *et al.* (1984) reported that mean egg weight for hens illuminated with green light was significantly heavier than egg weight for those exposed to red light. For external egg traits, there is a negative relationship between egg length and egg shape index confirms the finding of earlier workers (Ewa *et al.*, 2005). In other hand positive correlations between egg weight, shell weight and shell thickness has also been reported by Farooq *et al.* (2001).

Egg shell quality criteria such as shell weight and shell strength were significantly affected by color of light. 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. For internal egg traits, albumen height is an important indicator of an egg's quality and freshness. Quality eggs have higher albumen height relative to their weight (Bialka *et al.*, 2004). El-Abd (2005) revealed that there were no significant differences in albumen height and Haugh unit score due to different light colors. In turkey, 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 (El-Fiky *et al.*, 2008).

MATERIALS AND METHODS

Birds and bird's husbandry: A total of 180 Isa Brown layers were raised under control condition from 25 week until 36 week of age in the poultry farm at the College of Veterinary Medicine, Basra University. The layers used in this study with an average of 36 birds in each of five separated rooms 3 x 3 x 4 meters were exposed to white light (WL) as a control, red light (RL), blue light (BL), green light (GL) and Blue-Green mix light (BGL) by a light-emitting diode system (LED) applied according to light intermittent program (16 h light -8 h dark). Light sources were equalized on the intensity of 5 watt/m^2 (20 lux) at bird head level. The birds were randomly housed into 6 wooden sealed pens of 1 m^2 in three replicates for each density 5 and 7 birds/m^2. Half cylinder plastic feeders were placed in each pen. The birds were supplied with feed and water *ad libitum* and pellet diets were formulated to meet the nutrient recommendations for poultry according to NRC (1994). The total dietary metabolic energy was 2759 kcal/kg, 17.75% crude protein and 3.60% calcium according to Isa Brown programs (Isa Brown, 2010). A nipple water drinking system was set up in each pen and was adjusted as birds grew to ensure the watering system was kept at a proper level.

Measurements of egg

Egg production, egg weight and egg mass: Eggs were collected as often as possible, at least 4 times during laying period (from early morning to early afternoon). The egg production rate calculated on the basis of the number of chicken at the beginning of the experiment HH% (Hen House egg production) according to the equation: HH (%) = (total egg number/no. of birds initially housed x no. Days in lay) x 100. Egg weight was measured using a 0.0 g (gm) sensitive digital scale. The weight of all eggs taken from each replicates in various treatments and the rate of egg weight calculated according to the following equation: Average egg weight (gm) = total egg weights during a certain period/the number of eggs produced during that period. The egg mass (EM) of produced eggs in various replicates per week calculated according to the following equation: EM (gm/hen) = (total eggs number x average egg weight (gm)/no. of birds initially housed) x 100 (Al Fayadh and Naji, 1989).

Measurements of external egg traits: At the end of 36th week of age, 3 eggs from each replicate randomly chosen were weighed; length and width of the egg were measured with electronic digital sensitive caliper. Shape index (SI) is estimated using the following equation: Shape index = (egg width/egg length) x 100 (Anderson *et al.*, 2004). The shell weight with membrane was obtained by carefully placing the opened part in the shell and weighing on the electronic scale. The thickness of the shell (millimeter mm) with intact membranes was measured at three deferent points and the average of the broad, sharp and middle part of the egg was obtained by using the electronic digital caliper, it was determined according to Monira *et al.* (2003). Shell ratio was estimated from the equation: Shell ratio (%) = (Shell weight/Egg Weight) x 100 (Carter, 1975).

Measurements of internal egg traits: The measurements of the internal components were obtained by carefully making an opening around the sharp end of the egg, large enough to allow passage of both the albumen and the yolk through it without mixing their contents together. The yolk is then carefully separated from the albumen and placed in a petri dish for weighing. Simultaneously, the associated albumen is placed on another petri dish and weighed. Both petri dishes used in weighing the egg contents had initially being weighed and the difference in the weights of the petri dish after and before the egg component is taken as the weight of the egg components. The yolk diameter and albumin height of the egg were measured with electronic caliper (Reddy *et al.*, 1979). The following measurements of egg quality traits were calculated according to Romanoff and Romanoff (1949): Yolk index (%) = (Yolk height (mm)/Yolk diameter (mm) x 100, Yolk ratio (%) = Yolk weight (gm)/Egg weight (gm) x 100, Albumen ratio (%) = Albumen weight (gm)/Egg weight (gm) x 100. The Haugh unit is used to give a more accurate evaluation of albumen height differences between eggs with different weights. Haugh unit score of each egg was determined using Equation: Haugh Unit HU = 100 log ($H-1.7 W^{0.37} + 7.6$) in which, H is albumen height observed (mm), W is egg weight (gm) (Monira *et al*., 2003).

Models of analysis: Data was analyzed using completely randomized design (CRD) according to SPSS (2009). The significant tests for the differences between each two means for any studied trait were done according to Duncan's multiple rang test:

Model was: $Y_{ijk} = M+L_i+D_j+(LD)_{ij}+e_{ijk}$

Where,

Y_{ijk} : Observation on the ij individual
M : Overall mean
L_i : Light effect
D_j : Density effect
$(LD)_{ij}$: Interaction between light and density
e_{ijk} : Random error

RESULTS AND DISCUSSION

Egg production: The effect of light color and stocking density on egg production rates HH% of layers during the weeks of experiment presented in Table 1. A significant effect ($p<0.05$) of color light was recorded between the different treatments. The best rate of egg production at the age of 25, 29, 33 and 36 weeks recorded in layers reared under the influence of GL, RL, BGL and BL were 78.22, 95.23, 89.99 and 78.97% respectively. On the other hand, the effect of stocking density in egg production rates differed significantly ($p<0.05$) in layers reared under 5 birds/m^2 compared with layers reared under 7 birds/m^2 at different weeks of age 25, 29, 33 and 36 which recorded 80.56, 95.61, 90.09 and 86.09%, respectively. The analysis of variance showed a significant interaction ($p<0.05$) between light color and stocking density in egg production rates HH%. The best rate was 100% at the age of 29 week in the treatment of layers reared under the influence of RL and at level of density 5 birds/m^2. The table indicated to the existence of significant increase ($p<0.05$) in accumulative egg production % in the treatment of layers reared under the influence of RL 84.70%. As for the bird density, the table showed a significant increase in birds at the level of density 5 birds/m^2 85.19% as well as, the table indicated to the presence of significant interaction of light color and stocking density in accumulative egg production 92.37% in the treatment of birds reared under the influence of RL and the level of density of 5 birds/m^2. The result of this study revealed a significant value of the egg production rates HH% in layers exposed to RL. This result is consistent with the result of Pyrzak *et al*. (1984, 1987) who reported 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 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, possibly due to the ability of red light to stimulate the hypothalamus to secrete hormones stimulating fertility and egg production (Wabeck and Skoglund, 1974). The results does not agree with Er *et al*. (2007) who observed that egg production rate was significantly higher under blue light compared with other lights (red, green and white). On the other hand, the stocking density results indicated significant differences in egg production in layers reared under 5 birds/m^2. These results are consistent with the findings of the Altan *et al*. (2002), Onbasilar and Aksoy (2005) and Sarica *et al*. (2008), which pointed to a reduction in the egg production rate of layers by increasing bird density. High stocking densities were expected to lead to higher glucocorticoid levels, especially because these were combined with increasing group size as an expression of increased stress (Buijs *et al*., 2009).

Egg weight: As shown in Table 2, egg weight was increased significantly ($p<0.05$) in layers reared under RL at 25 and 29 week which recorded 59.19 and 62.58 gm, respectively. These findings agreed with Pyrzak and Siopes (1986), who pointed that in turkeys, egg weight in RL was consistently heavier than those in other light treatments. At the age 33 and 36 week, egg weight recorded 63.55 and 64.08 gm, respectively in layers reared under the influence of BGL. In contrast, the easier penetration of longer wavelength radiation to the hypothalamus makes red light more sexually stimulatory than blue or green, although the hypothalamic photo-receptors are more sensitive to blue/green light when illuminated directly. Egg production traits, however, appear to be minimally affected by wavelength (Lewis and Morris, 2000). 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. Pyrzak *et al*. (1987) suggested that egg weight was affected by light treatment while, Rozenboim *et al*. (1998) for chickens suggested that egg weight was unaffected by light color. Er *et al*. (2007) referred that egg weight in the WL was the heaviest, whereas egg weight in the RL was generally smaller than those in other lights therefore, the RL should be used in producing small size eggs. The differences in the above cited results could be attributed

Table 1: Effect of light color and stocking density on Hen House egg production (HH %) of layers at different weeks (M±SE)

Age week	Light color stocking density	WL	RL	BL	GL	BGL	Effect of stocking density
25th week	5 birds/m^2	77.14±1.65	78.09±11.50	84.75±4.14	95.23±0.95	67.61±3.43	80.56±4.33^a
	7 birds/m^2	68.02±1.36	65.30±1.17	67.34±1.17	61.22±0.00^B	58.50±0.68	64.07±0.87^b
	Effect of light color*	72.58±1.50^b	71.69±6.33^b	76.04±2.65^a	78.22±0.47^a	63.05±2.05^c	*
29th week	5 birds/m^2	92.37±2.51	100.00±0.00**	97.14±1.65	94.28±3.29	94.28±2.85	95.61±2.06^a
	7 birds/m^2	68.70±3.78	90.47±0.68	87.07±2.45	68.02±1.79	78.23±1.79	78.49±2.09^b
	Effect of light color*	80.53±3.14^c	95.23±0.34^a	92.10±2.05^a	81.15±2.54^c	86.25±2.32^b	*
33th week	5 birds/m^2	77.14±0.00	93.32±0.95	96.18±0.95	94.28±0.00	89.52±0.95	90.09±0.57^a
	7 birds/m^2	70.74±1.36	82.31±0.68	66.66±0.68	76.87±1.36	90.47±0.68	77.41±0.95^b
	Effect of light color*	73.94±0.68^c	87.81±0.81^a	81.42±0.81^b	85.57±0.68^{ab}	89.99±0.81^a	*
36th week	5 birds/m^2	89.52±0.95	87.61±0.95	83.80±0.95	88.57±0.00	80.95±0.95	86.09±0.76^a
	7 birds/m^2	65.98±0.68	61.90±0.68	74.14±0.68	61.90±0.68	76.87±0.68	68.15±0.68^b
	Effect of light color*	77.75±0.81^a	74.75±0.81^b	78.97±0.81^b	75.23±0.34^b	78.91±0.81^a	*
Accumulative	5 birds/m^2	87.69±1.80	92.37±1.90^{A**}	90.22±1.92	92.29±1.42	83.24±2.25	89.16±1.85^a
egg production	7 birds/m^2	70.41±1.56^B	77.03±1.33	73.85±1.74	70.97±1.33	76.12±1.26	73.67±1.44^b
(%)	Effect of light color*	79.05±1.68^b	84.70±1.61^a	82.03±1.83^{ab}	81.63±1.37^{ab}	79.68±1.75^b	*

*^{a,b,c}Means in horizontal rows with different superscripts were significantly different of light color and in vertical rows of stocking density at (p<0.05)

**^{A,B,C}Means in vertical rows with different superscripts were significantly different of interaction between light color and stocking density at (p<0.05)

SE: Standard error, N.S: Not significant

Table 2: Effect of light color and stocking density on egg weight of layers at different weeks (M±SE)

Age week	Light color stocking density	WL	RL	BL	GL	BGL	Effect of stocking density
25th	5 birds/m^2	59.18±0.58	60.46±1.16	56.16±1.74	57.48±0.57	53.45±1.15^B	57.34±1.04
week	7 birds/m^2	56.38±0.00	57.93±0.57	56.57±0.00	54.86±0.01	56.52±0.00	56.45±0.11
	Effect of light color*	57.78±0.29^{ab}	59.19±0.86^a	56.36±0.87^{bc}	56.17±0.29^{bc}	54.98±0.57^c	N.S.
29th	5 birds/m^2	60.04±0.01	63.80±0.57	60.05±0.58	60.75±1.15	63.60±0.01	61.64±0.46
week	7 birds/m^2	61.60±1.16	61.37±0.01	61.32±0.57	62.94±0.58	59.26±0.00	61.29±0.46
	Effect of light color*	60.82±0.85^b	62.58±0.29^a	60.68±0.57^b	61.84±0.86^{ab}	61.43±0.00^{ab}	N.S.
33th	5 birds/m^2	63.26±0.77	62.03±0.08	61.53±0.15	59.70±0.21	63.22±0.13	61.94±0.26^a
week	7 birds/m^2	59.93±0.26	61.98±0.08	60.52±0.61	60.13±0.27	63.89±0.27	61.29±0.29^b
	Effect of light color*	61.59±0.51^b	62.00±0.08b	61.02±0.38^b	59.91±0.24^c	63.55±0.20^a	*
36th	5 birds/m^2	63.04±0.21	64.73±0.48^{A**}	64.59±0.12	64.16±0.33	64.26±0.09	64.15±0.24^a
week	7 birds/m^2	62.31±0.19	63.87±0.14	62.31±0.08	63.50±0.02	63.91±0.25	63.18±0.13^b
	Effect of light color*	62.67±0.20^c	64.30±0.31^a	63.45±0.10^b	63.83±0.17^{ab}	64.08±0.17^a	*

*^{a,b,c}Means in horizontal rows with different superscripts were significantly different of light color and in vertical rows of stocking density at (p<0.05)

**^{A,B,C}Means in vertical rows with different superscripts were significantly different of interaction between light color and stocking density at (p<0.05)

SE: Standard error. N.S: Not significant

to differences in spectral sensitivity with age and strains of birds and confusion of wavelength and light intensity in some experiments.

The stocking density results as in Table 2 indicated no significant differences in egg production at 25 and 29 week but significant increase (p<0.05) was recorded in layers reared at level of density 5 birds/m^2 at 33 and 36 week 61.94 and 64.15 gm, respectively. Onbasilar and Aksoy (2005) in his study on Brown laying hens (Hyline Brown) allocated as one, three or five hens in each cage 8, 41 and 46 cm^3. The group with five hens per cage had significantly lower mean estimates than other groups with respects to body weight, egg production and egg weight. Increasing the stocking density of birds per 1 m^2 area should help to improve the economic results of rearing and reduce production costs, but quite frequently this is a stress factor that compromises animal welfare (Makowski *et al.*, 2004). There was a significant interaction (p<0.05) between light color and stocking density in the treatment of layers reared under the influence of RL at the level of density 5 birds/m^2 which recorded 64.73 gm at 36 week of age.

Egg mass: Color light had a significant effect (p<0.05) on egg mass in layers reared under GL at 25 week 43.88 (gm/bird) and BL at 29 week 56.06 (gm/bird) and BGL at 33, 36 week 57.19 and 50.56 gm/bird, respectively as shown in Table 3. The results of this study were not agreed with Hassan *et al.* (2013), who had not noticed a significant effect of the programs of different lighting for the period from 57-22 weeks. The significance of egg mass in the current results may be due to the higher egg production rates and eggs weight which represented in measure of egg mass (El-Turky, 2011). The stocking density showed a significant results (p<0.05) of egg mass in layers reared under 5 birds/m^2 at different weeks 46.59, 58.85, 55.74 and 55.22 gm/bird respectively, compared to those at density level of 7 birds/m^2 36.41, 46.25, 47.55 and 43.05 gm/bird. This result is consistent with Benyi *et al.* (2006) who noted that there is a rise in the egg mass rates with low stocking density, while Sarica *et al.* (2008) in his study on Isa Brown for the period from 53-18 weeks found an absence of significant differences in egg mass between the various densities. These results perhaps due to the

Table 3: Effect of light color and stocking density on egg mass (gm/hen) of layers at different weeks (M±SE)

Age week	Light color Stocking density	WL	RL	BL	GL	BGL	Effect of stocking density
25th	5 birds/m^2	45.65±0.97	48.36±0.01	48.13±1.85	54.19±0.94	36.64±5.68	46.59±1.89^a
week	7 birds/m^2	39.11±1.33	37.82±0.68	38.09±0.66	33.58±0.00	33.44±0.01^B	36.41±0.53^b
	Effect of light color*	42.38±1.15^a	43.09±0.34^a	43.11±1.25^a	43.88±0.47^a	35.04±2.84^b	*
29th	5 birds/m^2	54.89±1.98	63.79±0.01^{A**}	58.33±0.99	57.27±2.00	59.96±1.81	58.85±1.35^a
week	7 birds/m^2	42.73±2.51	43.83±1.44	53.80±1.91	44.95±1.48	45.95±1.21	46.25±1.71^b
	Effect of light color*	48.81±2.24^{bc}	53.81±0.72^{ac}	56.06±1.45^a	51.11±1.74^c	52.95±1.51^{ac}	*
33th	5 birds/m^2	48.79±0.59	57.89±0.59	59.18±0.58	56.28±0.20	56.59±0.60	55.74±0.51^a
week	7 birds/m^2	42.39±0.81	51.01±0.42	40.34±0.41	46.21±0.81	57.80±0.43	47.55±0.57^b
	Effect of light color*	45.59±0.70^c	54.45±1.43^b	49.76±0.49^{bc}	51.24±0.50^b	57.19±0.51^a	*
36th	5 birds/m^2	56.43±0.60	56.71±0.61	54.12±0.61	56.82±0.29	52.01±0.61	55.22±0.54^a
week	7 birds/m^2	41.10±0.42	39.53±0.43	46.19±0.42	39.30±0.43	49.12±0.43	43.05±0.42^b
	Effect of light color*	48.76±0.51^b	48.12±0.52^b	50.16±0.51^a	48.06±0.36^b	50.56±0.52^a	*

*a,b,c Means in horizontal rows with different superscripts were significantly different of light color and in vertical rows of stocking density at ($p<0.05$)

**A,B,C Means in vertical rows with different superscripts were significantly different of interaction between light color and stocking density at ($p<0.05$)

SE: Standard error, N.S: Not significant

Table 4: Effect of light color and stocking density on some external traits of layer eggs at 36th week of age (M±SE)

External egg traits	Light color stocking density	WL	RL	BL	GL	BGL	Effect of stocking density
Egg	5 birds/m^2	58.59±0.22	59.66±1.22	56.87±0.35	57.01±1.04	57.57±1.30	57.94±0.82
length	7 birds/m^2	57.10±1.10	58.61±1.08	56.76±0.26	59.06±0.5	57.07±0.54	57.72±0.69
(mm)	Effect of light color*	57.84±0.6^{ab}	59.13±1.15^a	56.81±0.30^b	58.03±0.7^{ab}	57.32±0.92^b	N.S.
Egg	5 birds/m^2	44.69±.29	43.30±0.71	44.75±0.83	45.46±0.65	44.45±0.17	44.53±0.53
width	7 birds/m^2	44.30±.21	43.68±0.24	44.47±0.10	43.38±0.35	44.62±0.41	44.09±0.26
(mm)	Effect of light color*	44.49±0.25^a	43.49±0.47^b	44.61±0.46^a	44.42±0.50^{ab}	44.53±0.29^a	N.S.
Shape	5 birds/m^2	76.27±0.79	72.57±2.63	78.68±1.79	79.74±2.56	77.21±1.93	76.89±1.94
index	7 birds/m^2	77.58±1.85	74.52±1.72	78.34±0.53	73.45±1.17	78.18±1.32	76.41±1.31
(%)	Effect of light color*	76.92±1.3^{ab}	73.54±2.17^b	78.51±1.16^a	76.59±1.8^{ab}	77.69±1.62^a	N.S.
Shell	5 birds/m^2	6.00±0.57	5.66±0.33	5.66±0.88	6.33±0.66	6.66±0.33	6.07±0.55
weight	7 birds/m^2	5.33±0.88	6.00±0.57	6.00±0.00	6.00±0.57	6.00±0.57	5.87±0.51
(gm)	Effect of light color N.S.	5.67±0.72	5.83±0.45	5.83±0.44	6.17±0.61	6.33±0.45	N.S.
Shell	5 birds/m^2	0.37±0.00	0.35±0.00	0.33±0.00	0.35±0.04	0.38±0.00	0.35±0.00
thickness	7 birds/m^2	0.36±0.01	0.35±0.01	0.37±0.00	0.37±0.02	0.37±0.01	0.36±0.01
(mm)	Effect of light color N. S.	0.36±0.00	0.35±0.00	0.35±0.00	0.36±0.03	0.37±0.00	N.S.
Shell	5 birds/m^2	9.54±1.00	9.17±0.49	8.91±1.12	9.93±1.00	10.65±0.64	9.64±0.85
ratio	7 birds/m^2	8.50±1.39	9.63±0.97	9.62±0.05	9.66±0.88	9.55±0.83	9.39±0.82
(%)	Effect of light color N. S.	9.02±1.19	9.40±0.73	9.26±0.58	9.79±0.94	10.10±0.73	N.S.

*a,b,c Means in horizontal rows with different superscripts were significantly different of light color and in vertical rows of stocking density at ($p<0.05$)

SE: Standard error, N.S: Not significant

easy move of layers towards feeders and drinkers with low density in the cage that led to raising the production rates and the rate of eggs weight (Bello *et al*., 2012).

External egg traits: The monochromatic light effect on the eggshell quality have been reported previously; however, little is known about the monochromatic light effect on the egg length, egg width and the eggshell index (Pyrzak *et al*., 1987). The effect of light color and stocking density on external characteristics of eggs at 36 week as presented in Table 4 revealed a significant increase ($p<0.05$) of egg length under RL 59.13 mm while egg width and egg shape index were higher significantly ($p<0.05$) under BL 44.61 mm and 78.51% respectively. This result is inconsistent with El-Abd (2005) who noted the absence of significant differences between the different colored lighting programs in turkey egg traits. The results also disagreed with that of Er *et al*. (2007) who found that correlation coefficients among egg length, egg width and age in all treatments were highly significant during the experimental stage and that GL group was higher compared with other groups.

The Table also showed no differences ($p>0.05$) in egg shell weight, thickness and shell ratio % between experimental groups. This result is consistent with Gongruttananun and Guntapa (2012) who reported in their study on the Thai local chicken for the period 20-46 weeks that the differences in the relative weight of eggs shell of chickens reared under different color lights were not significant, this result may be attributed to the close relationship between egg weight and the thickness of the shell. The results of this study also agreed with the findings of the El-Abd (2005) which explained that the differences in the characteristics of eggs as a result of the use of colored lighting were not significant, while Pyrzak *et al*. (1984) referred that the egg shells for chickens reared under blue light was higher than that of chickens reared under the influence of red light. The

Table 5: Effect of light color and stocking density on some internal traits of layer eggs at 36th week of age (M±SE)

Age (week)	Light color stocking density	WL	RL	BL	GL	BGL	Effect of stocking density
Yolk	5 birds/m^2	17.33+0.33	17.00±0.57	15.33±0.33	18.66±0.33	17.00±0.57	17.06±0.42
weight	7 birds/m^2	16.66±0.33	16.00±1.00	18.66±1.33	17.33±0.88	18.00±2.08	17.33±1.12
(gm)	Effect of light color N.S	17.00±0.33	16.50±0.78	17.00±0.83	18.00±0.60	17.50±1.32	N.S.
Yolk	5 birds/m^2	27.50±0.33	27.55±0.81	24.38±0.83	29.31±0.37	27.11±0.68	27.17±0.60
ratio	7 birds/m^2	26.59±0.61	25.65±1.46	29.93±2.07	27.97±1.61	28.65±3.00	27.76±1.75
(%)	Effect of light color N.S	27.04±0.47	26.60±1.13	27.15±1.45	28.64±0.99	27.88±1.84	N.S.
Yolk	5 birds/m^2	51.87±0.08	49.74±2.95	47.92±2.81	50.54±1.26	48.53±1.43	49.72±1.70
index	7 birds/m^2	50.94±1.76	42.95±3.88	49.18±1.81	45.96±1.56	47.78±2.27	47.36±2.25
(%)	Effect of light color*	51.40±0.92^{a}	46.34±3.41^{b}	48.55±2.31^{ab}	48.25±1.41^{ab}	48.16±1.85^{ab}	N.S.
Albumen	5 birds/m^2	39.66±0.88	39.00±0.57	42.00±1.15	38.66±0.66	39.00±0.57	39.66±0.76
weight	7 birds/m^2	40.66±0.66	40.33±0.33	37.66±1.20	38.33±1.76	38.66±1.85	39.13±1.16
(gm)	Effect of light color N.S.	40.16±0.77	39.66±0.45	39.83±1.17	38.50±1.21	38.83±1.21	N.S.
Albumen	5 birds/m^2	62.94±0.84	63.25±1.24	66.69±0.62	60.74±1.37	62.23±0.48	63.17±0.91
ratio	7 birds/m^2	64.88±0.93	64.70±0.76	60.43±2.04	61.79±2.52	61.77±3.27	62.71±1.90
(%)	Effect of light color N.S.	63.91±0.88	63.98±1.00	63.56±1.33	61.27±1.94	62.00±1.87	N.S.
Haugh	5 birds/m^2	78.96±2.21B	91.94±2.48	90.73±2.52	88.66±0.03	86.87±1.36	87.43±1.72^{b}
unit	7 birds/m^2	94.95±1.72^{A**}	89.70±5.04	90.42±0.48	94.72±0.18	90.54±0.17	92.06±1.51^{a}
	Effect of light color*	86.95±1.96^{b}	90.82±3.76^{ab}	90.58±1.50^{ab}	91.69±0.10^{a}	88.70±0.76^{ab}	*

^{*a,b,c}Means in horizontal rows with different superscripts were significantly different of light color and in vertical rows of stocking density at ($p<0.05$)

^{**A,B,C}Means in vertical rows with different superscripts were significantly different of interaction between light color and stocking density at ($p<0.05$)

N.S: Not significant

results of the present study were disagreed with that of Er *et al.* (2007) who revealed that eggshell thickness in the G light group was significantly thicker than those in W and B lights and there was no significant difference in other light groups.

The stocking density had no significant effect ($p>0.05$) on above traits in various weeks. The results of the current study agreed with the findings of Guo *et al.* (2012) who referred to the absence of significant differences in the measurements of eggs produced in different densities, as well as Sarica *et al.* (2008) in his study on Isa Brown layers reared under various densities for the period from 18-53 weeks. The analysis of variance showed no significant effect ($p>0.05$) between light color and stocking density in different treatments. The results can be attributed to the fact that the layers diet was balanced in its content of calcium, phosphorus and sedimentation stability of the shell material (Safamehr *et al.* 2013).

Internal egg traits: The results of internal egg measurements which included yolk weight, yolk ratio, albumin weight and albumin ratio as shown in Table 5 were not significant ($p>0.05$) under different color lights but the results showed a significant effect ($p<0.05$) in yolk index under WL 51.40% and Haugh unit under GL91.69. Lewis *et al.* (2007) referred to the similarity between pullets in the white and green light groups for all the adult production parameters agrees with the conclusion of Lewis and Morris (2000) that light color has a minimal influence on performance in laying hens. For yolk weight, the results of the current study disagreed with El-Fiky *et al.* (2008) who reported that turkey reared under infrared light revealed an increase in yolk weight compared other light colors (fluorescent, incandescent light and ultraviolet illumination). The results of yolk ratio, albumin weight and albumin weight agreed with that of Gongruttananun and Guntapa (2012) in his study on Thai local chicken for the period of 20-46 weeks, he pointed that there was not significant effect of color lights.

These results probably due to the close relationship between egg weight and the weight yolk and albumin and according to Yakubu *et al.* (2008). The strong association between egg weight and albumen height, yolk height, yolk weight, albumen weight, shell thickness and yolk width, indicate that improvement on any of these traits through artificial breeding could result in concomitant improvement of the other traits. The significant result of yolk index in birds reared under WL agreed with that of El-Fiky *et al.*(2008), who reported a significant increase of yolk index in turkeys reared under the effect of fluorescent lamps compared with other colors. The significant effect of GL disagreed with that of Hassan *et al.* (2013), who explained that the use of color lighting for the period from (57-22) week had no significant effect on Hugh unit of eggs produced from chickens reared under different treatments. In turkey Haugh unit and albumen height score were significantly improved due to illumination of turkey hens with incandescent light compared to the other color of lights especially fluorescent (El-Fiky *et al.*, 2008). On the other hand Table 5 displayed no differences under different bird densities except for Haugh unit which was significantly higher 92.06 in birds reared at level 5 birds/m^2. This result agreed with that of Altan *et al.* (2002) who reported that increasing cage density to 5 birds/cage in white layers decreased the Haugh unit, whereas egg shell quality and egg weight were not affected. Analysis of variance indicates no significant interaction between light color and bird density in all egg traits except for Haugh unit which was significantly higher in birds reared under WL at level of 5 birds/m^2 which recorded 94.95.

Conclusion: The results of this study by used five different color lighting schedules and two level of stocking density showed that layers reared under red light at level of 5 birds/m^2 has a significant positive effect on production performance compared with other treatments. Knowing what layers prefer for light color and density can be of help to producers in trying to improve production performance. Also, from welfare standpoint it is important to provide the layers with a comfortable environment to reduce stress and maximize health and performance.

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