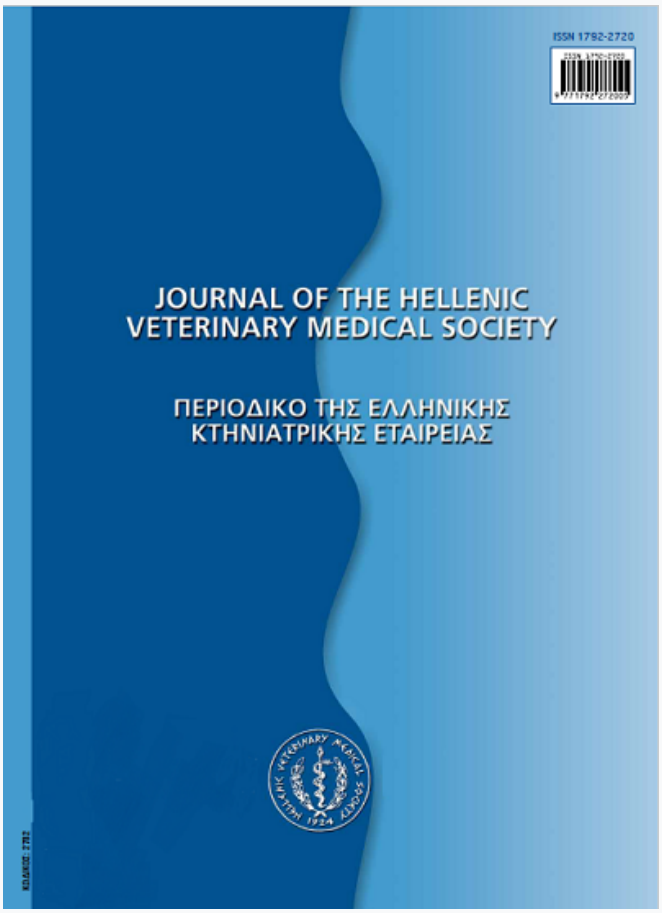
Journal of the Hellenic Veterinary Medical Society

Vol 69, No 2 (2018)



Impact of different light colors in behavior, welfare parameters and growth performance of Fayoumi broiler chickens strain

M. H. HESHAM, A. H. EL SHEREEN, S. N. ENAS

doi: 10.12681/jhvms.18017

To cite this article:

HESHAM, M. H., EL SHEREEN, A. H., & ENAS, S. N. (2018). Impact of different light colors in behavior, welfare parameters and growth performance of Fayoumi broiler chickens strain. *Journal of the Hellenic Veterinary Medical Society*, *69*(2), 951–958. https://doi.org/10.12681/jhvms.18017

J HELLENIC VET MED SOC 2018, 69(2): 951-958
ΠΕΚΕ 2018, 69(2): 951-958

Research article
Ερευνητικό άρθρο

Impact of different light colors in behavior, welfare parameters and growth performance of Fayoumi broiler chickens strain

M.H. Hesham, A-H El Shereen, S. N. Enas

Department of Veterinary Public Health, Faculty of Veterinary Medicine, Zagazig University, Egypt.

ABSTRACT. Light is considered one of the most managerial factors affecting poultry well-being. Therefore, the current study was conducted to investigate the effects of different light colors in behaviour, welfare and growth performance of Fayoumi chickens. A total of 300 one-day old chicks of Fayoumi broiler breed were weighed and randomly divided into 4 environmentally controlled chambers with different artificial light color (yellow, red, green and blue) until the end of the experimental period (12 weeks); each was divided into five replicate brooders (15 birds for each replicate). A scanning technique was used to report the chicken's behaviors. Moreover, the plumage condition, foot and toe hyperkeratosis, foot and toe lesions (foot pad dermatitis) and growth performance were evaluated. Light colors had significant ($P < 0.05$) effects of the impose of different light colors in all kinds of behaviour of Fayoumi chickens. It was found that eating frequency was the highest in blue light. Preening, dust bathing and drinking frequencies were the highest in green light. Birds reared in red light were more active, as expressed by greater walking, flying, head movement, litter scratching, body shaking, wing flapping, wing/leg stretching, feather pecking and aggression. While, birds in blue light were calmest, evidenced by more intense sleeping, sitting and idling behaviors. In spite of the fact that the light colors had no significant effect on plumage condition, health status of the foot and toe and growth performance, those parameters were better in birds kept in blue light than other light colors. We conclude that the blue light colour may improve the birds' welfare.

Key words: Fayoumi chickens, light color, welfare, performance.

Corresponding Author:
Hesham H. Mohammed, Department of Veterinary Public Health, Faculty of Veterinary Medicine, Zagazig University, El-Zeraa street 114; 44511-Zagazig; Egypt
Email: heshamvet_hosny@yahoo.com

Date of initial submission 17-3-2017
Date of revised submission 6-7-2017
Date of acceptance 25-7-2017

INTRODUCTION

Increasing competition and energy cost in the poultry industry are the mainsprings for chicken producers to minimize the cost of growth. From an economic standpoint, management strategies should focus on what is optimal for chicken welfare and growth performance simultaneously. Recently, producers and consumers are more concerned about the product quality and in which condition poultry is reared (Harper and Henson, 2001).

A high genetic diversity among commercial lines may be considered a key for selecting well adapted lines to tough environments, but these lines if exposed to novel environments, their welfare status may be affected (EFSA, 2010). Recent genomic studies confirmed that Fayoumi chickens were adapted and raised in hot and very dry areas of tropical and sub-tropical conditions (Hossary and Galal, 1994). It needs high capacity to tolerate harsh environmental Egyptian conditions with limited nutritional requirements when compared with breeds in the rest of the world (Ghamry et al., 2011).

Light is necessary for bird's vision influencing the visual acuity and color discrimination (Calvet et al., 2009). Moreover, the lighting system in chicken house must be designed and maintained in order to give a minimum illumination of 20 lux, that enables thorough inspection and vision without difficulty (RSPCA, 2013).

Domestic fowl differs from human in spectral sensitivity which illustrates the importance to identify the optimal light environment for health, behavior, welfare and production of broiler chickens. They are sensitive to ultraviolet, blue, green and red on the light spectrum (Prescott and Wathes, 1999) through retinal and deep brain photoreceptors (Kuenzel et al., 2015). Moreover, they also have 3 advanced light receptors within the brain that play a foremost role in the biological and physiological functions (Bertolucci and Foa, 2004; Wyse and Hazlerigg, 2009).

To increase their income, producers are capable of handling and modulating management factors such as temperature, humidity, ventilation, gases and light intensity, duration and color. From the aforementioned factors, light is the most critical one as it controls many physiological and behavioral functions (Olanrewaju et al., 2006). Light consists of 3 different aspects; intensity, photoperiod (duration) and spectral content color (Olanrewaju et al., 2006). The light color is estimated by various outputs from different wave lengths in the visible spectrum (Anja, 2015). The efficacy of lighting is to achieve a maximum production performance of broilers with simultaneous conservation of the welfare (Škrbić et al., 2012).

The source of light color can affects poultry performance (Jin et al., 2011). The green light activated growth rate, while the reddish orange light stimulated reproduction (Rozenboim et al., 2004). The green light can increase the growth of young birds, while the blue light stimulates the older ones (Classen et al., 2004). Egypt is a member of the OIE (World Organisation for Animal Health), therefore it should align its national legislation with the OIE recommendations on the welfare of broiler chickens (FAO, 2014), but the majority of areas in Egypt still use outdated lighting technology (El-Sheikh, 2016). The objectives of this experiment was to assess the impact of different light colors in behavior, growth performance and welfare parameters of Fayoumi chickens under subtropical condition.

MATERIAL AND METHODS

The present study was carried out at Faculty of Veterinary Medicine, Zagazig University, Egypt. The experimental procedures were conducted in accordance with the Zagazig University Animal Ethics Committee guidelines (Licence No. ANWD-206).

Experimental animals and management: A total 300 one-day old chicks of Fayoumi breed purchased from a commercial hatchery were weighed upon arrival and randomly distributed into 4 environmentally controlled chambers with different artificial light color (yellow, red, green and blue) with 24 hrs of photoperiod program until the end of the experimental period (12 weeks); each was divided into five replicate brooders (15 birds for each replicate). A scanning technique was used to report the chicken's behaviors. Moreover, the plumage condition, foot and toe hyperkeratosis, foot and toe lesions (foot pad dermatitis) and growth performance were evaluated. Light intensity for all treatments was kept at the same lux level (25 lux), measured with lux meter along a horizontal plane 20 cm above the litter. Chickens were vaccinated against the most common chicken

diseases of the area, namely Infectious bronchitis (at 5 days of life), Newcastle disease (at 5 and 10 days of life), Gumboro disease (at 7 and 14 days days of life) and fowl pox (at 30 days days of life). The pen floors were covered with approximately 10-cm of wood shavings. Food and water were available *ad libitum* throughout the study. The basal diet was calculated to meet the nutrient requirements of broilers (AOAC, 2002) which fed two types of rations; The first ration during the starter period (0-4wks; crude protein "CP" 23.20% and metabolized energy "ME" 3218 kcal/kg diet) and the second ration during the growing-finishing period (4-12wks; CP 19.55% and ME 3218 kcal/kg diet).

Behavioral observation: Direct observations of chicken's behaviors were carried out using a scanning technique (Fraser and Broom, 1990). Behavioral observations were performed as follows: each group was observed three times a day (20 min/each time) for four days weekly at a circularly fixed time from 6 A.M to 5 P.M in order to record the different behavioral patterns. The behavioral patterns in all experimental groups were recorded by the same person through standing directly in front of each group and waiting for ten minutes before recording data to avoid any disturbance in behaviors (Mohammed et al., 2010). After scanning, the numbers of Fayoumi chickens were counted in the observed chambers to calculate the frequencies of various behaviours/one hour. These numbers were used to record the activities of chicken according to Senaratna et al., (2011) in all experimental groups.

Growth performance: Growth performance was recorded according to Taha and Abd El-Ghany, (2013), where broilers were weighed on 1st day of age as one day-old live weight (Mohammed et al., 2017) and then live body weights were subsequently estimated weekly until 12th week of age. Daily body weight gain (DBWG) was estimated by the difference between the recorded initial and final body weight (BW) divided by the number of days in the whole period of experiment. Also, the average feed intake (FI) was measured daily after calculating the feed residues. Furthermore, relative growth rate (RGR) and feed conversion ratio (FCR): (feed intake/weight gain) over a period of experiment were estimated.

Plumage scores: It was measured for all birds from each group at the end of experimental period, where the plumage condition of the head, neck, breast, belly, back, wings, vent and tail was assessed by using 4- point scale from 1 to 4 for each part, where 4 was the best condition and 1 was the worst condition (Bright et al., 2006; Welfare Quality 2009).

Foot condition:-

At the end of experimental period, both feet of all chicken were examined, where the areas of possible foot pad dermatitis and hock burns should be distinguished and assigned using Tauson scale (Tauson et al., 1984) i.e. the scoring system assigned a value of 1 to 4 for each part, where 4 was the best condition and 1 was the worst condition.

Statistical analysis:- All statistical procedures were performed using the SAS statistical system Package V9.2 (SAS, 2002). Data were analyzed using one-way ANOVA with the general linear models

(GLM) procedure. The comparison of means was carried out using Duncan's multiple range tests.

RESULTS

There were significant ($P < 0.05$) effects of light color in all observed behaviour of Fayoumi chicken (Table 1). Eating and drinking frequencies were highest in chambers lit with blue and green light, respectively. Birds reared in chambers lit with red light were more active, as expressed by more intense walking, flying, head movement, litter scratching, body shaking, wing flapping, wing/leg stretching, feather pecking and aggression. In the meantime, birds kept in blue color chambers were calmer and this was evident by observing greater periods of sleeping, sitting and idling. An increase in preening and dust bathing was recorded in the green color chamber. In spite of the fact that there were no significant differences observed in plumage scores (Table 2), foot condition (Table 3) and growth performance (Table 4) among the experimental groups, all plumage scores, the health status of the foot and toe (hyperkeratosis and lesion appearance) and the final body weight, growth rate and daily weight gain of birds kept in chambers lit with blue light were relatively better than others light color, but the differences did not reach the significance (Table 2, 3 and 4). Feed intake and FCR were highest in chambers lit with red color.

Table 1. Frequencies of behaviour/hour in Fayoumi chicken under different light colors (mean±SE).

Behavior	Yellow	Red	Green	Blue
Eating	78.67±2.70^{d}	97.89±7.11^{c}	116.67±1.83^{b}	156.89±3.13^{a}
Drinking	64.89±3.97^{b}	40.89±1.37^{c}	78.89±1.49^{a}	67.33±3.25^{b}
Walking	217.33±1.83^{b}	279.67±1.94^{a}	220.00±6.65^{b}	222.22±4.55^{b}
Flying	17.33±1.13^{b}	28.00±0.94^{a}	9.77±0.52^{c}	11.56±0.69^{c}
Head movement	15.33±0.65^{ab}	17.00±0.62^{a}	14.00±0.53^{b}	10.11±0.63^{c}
Litter scratching	80.67±0.97^{c}	109.33±0.88^{b}	71.22±1.38^{d}	128.00±1.41^{a}
Sleeping	120.89±3.19^{b}	92.22±1.48^{c}	132.89±3.18^{a}	129.11±1.85^{a}
Siting	297.33±3.37^{b}	279.56±4.38^{c}	307.56±3.46^{b}	363.78±3.42^{a}
Idling	28.44±1.13^{c}	32.89±0.95^{b}	33.33±1.80^{b}	39.11±0.96^{a}
Preening	156.44±1.69^{d}	199.33±2.24^{b}	205.78±1.59^{a}	170.44±2.33^{c}
Dust bathing	2.22±0.36^{d}	9.78±0.55^{c}	16.89±0.54^{a}	15.11±0.56^{b}
Body shaking	15.22±0.72^{c}	24.67±0.78^{a}	23.11±0.77^{a}	18.67±0.97^{b}
Wing flapping	20.89±3.45^{b}	42.67±9.30^{a}	28.89±4.98^{ab}	36.44±0.80^{ab}
Wing/leg stretching	14.11±0.81^{c}	23.12±1.11^{b}	27.09±0.86^{a}	27.89±0.68^{a}
Feather pecking	9.22±0.46^{b}	14.22±0.64^{a}	8.11±0.51^{b}	9.33±0.53^{b}
Aggression	11.00±0.58^{b}	17.11±0.63^{a}	8.33±0.53^{c}	12.11±0.75^{b}

^{abcd} Means in the same row with different superscripts were significantly different at (P≤0.05). All observations were recorded with frequencies abases per one hour (scan sampling technique) in all birds of each group.

Table 2. Effect of different light colors in the plumage condition in all body parts of Fayoumi chickens.

Plumage condition	Yellow	Red	Green	Blue
Head	3.10±0.31	3.00±0.26	3.10±0.23	3.40±0.22
Nick	2.80±0.33	2.70±0.26	2.80±0.25	3.20±0.29
Back	2.70±0.30	3.10±0.22	2.70±0.21	3.20±0.24
Wing	2.80±0.36	2.30±0.34	2.70±0.37	2.80±0.32
Tail	2.70±0.36	2.40±0.34	2.60±0.37	2.80±0.33
Breast	2.50±0.37	2.40±0.40	2.50±0.31	2.50±0.30
Belly	2.30±0.36	2.50±0.34	2.60±0.40	2.70±0.37
Cloaca	2.50±0.31	2.30±0.30	2.70±0.33	2.50±0.34

The plumage condition in all body parts were recorded in all experimental birds, where 4 was the best condition and 1 was the worst condition.

Table 3. Effect of different light colors in the feet of Fayoumi chickens.

Feet condition	Yellow	Red	Green	Blue
Foot hyperkeratosis	2.30±0.33	2.70±0.34	2.70±0.21	3.30±0.30
Foot lesions	2.60±0.37	2.60±0.37	2.80±0.25	3.10±0.35
Toe hyperkeratosis	2.10±0.31	2.50±0.40	2.70±0.39	2.90±0.34
Toe lesions	2.40±0.33	2.40±0.34	2.90±0.35	3.10±0.35

Both feet of all chickens were examined with discriminating any problems like hyperkeratosis and lesions. The scoring system assigned a value of 1 to 4 for each part, where 4 was the best condition and 1 was the worst condition.

Table 4. Effect of different light colors in (means±SE) the growth performance of Fayoumi chickens.

Performance parameters	Yellow	Red	Green	Blue
Initial body weight (g)	34.15±0.41	34.35±0.66	35.09±0.80	34.48±0.45
Final body weight (g)	1048.6±8.52	1039.8±12.99	1053.1±8.69	1066.8±7.51
Feed intake (g/daily)	59.27±0.43	58.93±0.49	58.77±0.85	58.27±0.60
Growth rate	187.43±0.16	187.28±0.37	187.17±0.18	187.54±0.21
Daily weight gain (g/daily)	11.94±0.04	11.84±0.04	11.98±0.01	12.15±0.05
Feed conversion ratio	4.96±0.02	4.98±0.01	4.91±0.03	4.81±0.04

g= gram

DISCUSSION

Poultry vision is more affected by light through influencing color discrimination in the eye retina, which can differentiate colors with different sensitivity levels (Lewis and Morris, 2000), therefore we aimed to evaluate the effects of light colors on the behavior, growth performance, plumage and foot conditions in Fayoumi chickens that is considered one of the most famous Egyptian breeds. Broilers should be reared at light levels that let them see clearly and stimulate their activity (RSPCA, 2013).

Recently, Sejian et al., (2011) defined animal welfare as "the ability of an animal to cope physiologically, behaviorally, cognitively and emotionally with its physiochemical and social life environment, including the animal's subjective experience of its condition". Behavioural studies are of great importance for improving the understanding and appreciation of animals. Our results indicated that all studied behaviors were significantly affected by light colors (Senaratna et al., 2012).

In this study, high eating and drinking behavior frequencies were recorded in the blue and red light color chambers, respectively which supported by the findings of Prayitno et al., 1997[b] who reported that bright red light considerably increased feeding and drinking behaviors, particularly when applied early in the growth period. In contrast, Senaratna et al., (2011) stated that light colors had no effect on eating behavior. Kinetic behaviors (walking, flying and head movement) were significantly affected by light colors, where chicken was more active under red light color than other colors (Senaratna et al., 2012; Son and Velmurugu 2009). These results may be due to the different wavelengths of light, where the blue and green light color had a shorter wavelength (480 nm, 520 nm, respectively) than red (700 nm) and yellow colors (580 nm) (Shabiha et al., 2013).

Litter scratching was highest in blue light color chambers in the current study, which was supported by the results obtained by Senaratna et al., (2011) who stated that the litter scratching was usually associated with eating behavior (Senaratna et al., 2011) unlike chicken reared under blue light color were more comfortable and calmer than others due to the significant increase in sleeping, sitting and idling behaviors. This study supported the theory that blue color created a calming effect on birds, where the frequencies of physical activities was lower in chambers lit with blue light. Moreover, in the present experiment, sleeping, sitting and idling activities were much higher under blue light color, that may be attributed to the fact that blue light color alleviated the stress response in broilers throught the reduction in the level of serum interleukin-1, as described by Xie et al., (2008).

Comfort behavior (feather preening and dust bathing) was significantly higher in green light color. But, body shaking was observed in significantly higher frequencies in red and green light colors. Chicken in chambers lit with red color were higher in wing flapping that may be due to more activity than those raised under other colors (Rusty, 2011). In the current study wing/leg stretching was highest in chambers lit with blue and green color, which may be due to the fact that chicken were more calm than others

light colours. Abnormal behavior (aggression and feather pecking) were significantly higher in chickens reared under red light color than other colors due to the increase of activities of birds under red light color. This result may be due to light stimulation and may have an impact on the coping ability to the stressors (Campo et al., 2007). Moreover, the light color have an effect on brain organization that impact the behavioral responses, including fear behaviour (Dharmaretnam and Rogers, 2005). These results and interpretation were suggested by previous studies (Prayitno et al., 1997[a,b]; Danang, 2014), while another study stated that feather pecking and aggressive behaviors were higher with blue light, but the observed differences did not reach significance (Mohammed et al., 2010).

Light may be the most critical for chickens as it controls many behavioral patterns (Olanrewaju et al., 2006). Recently poultry producers and consumers are concerned with raising poultry in improved and comfortable conditions (Harper and Henson, 2001). Consumers equate good animal welfare standards with healthy feather and feet. Therefore, selecting optimal lighting colors allow birds to live a normal life. Previous studies mentioned that lighting treatments had insignificant effects on each of plumage and foot conditions (Farghly and Mahrose, 2012; Senaratna et al., 2011) which was comparable with our results.

The results on plumage condition was in disagreement with the observations of Van emous et al. (2003), who stated that different light sources might affect plumage condition as reflected by the incidence of feather pecking. Chicken reared under blue light color possessed the higher final body weight with higher daily weight gain while those reared under red light color were the lowest. The lighting is very important factor in regulating behavioral processes in chickens and different wavelengths of light have found to affect growth rate in broiler chickens (Bradley, 2015). This was also reported by Olanrewaju et al., (2011), who found that light was one of the major environmental factors for poultry production that influences growth development and physiological functioning.

The light wavelength affected broiler performance, including of those reared in open houses with natural (solar) lighting, which are frequent in tropical climates (Guevara et al., 2015).

CONCLUSION

In conclusion, Fayoumi chickens raised under different light colors had significant differences in all behaviors, but with no significant differences observed in plumage scores, foot condition or growth performance among different light colors. This study helps to support the theory that blue light creates a calming effect on birds.

ACKNOWLEDGEMENT

We are grateful to all staff of the Zagazig University for their support with this study. We would like to thank the anonymous referees for their helpful comments on the manuscript.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

Anja BR (2015) Effects of color of light on preferences, performance, and welfare in broilers. Poult Sci 94: 1767-1775.

AOAC (2002) Association official analytical chemists.Official Methods of Analysis.Gaithersburg, MD, U.S.A. Chapt. 4, pp 20-27.

Bertolucci C, Foa A (2004) Extraocular photoreception and circadian entrainment in nonmammalian vertebrates.Chronobiol Int 21: 501-519.

Bright A, Jones TA, Dawkins MS (2006) A non-intrusive method of assessing plumage condition in commercial flocks of laying hens. Animal Welfare 15, 113-118.

Bradley TH (2015) The effects of light color on performance and immune response of broiler chickens. Undergraduate research thesis, Department of Animal Sciences, The Ohio State University, USA.

Calvet S, Van den Weghe H, Kosch R, Estellés F (2009) The influence of the lighting program on broiler activity and dust production.Poult Sci 88: 2504-2511.

Campo JL, Gil MG, Davila SG, Munoz I (2007) Effect of lighting stress on fluctuating asymmetry, heterophil-to-lymphocyte ratio, and tonic immobility duration in eleven breeds of chickens. Poult Sci 43:355-363.

Classen HL, Annet CB, Schwean-lardner KV, Gonda R, Derow D (2004) The effects of lighting programmes with twelve hours of darkness per day provided in one, six or twelve hour intervals on the productivity and health of broiler chickens. British Poult Sci 45:S31-S32.

Danang B (2014) Effects the combinations of light color and intensity of light to age at first laying and production egg of Alabio laying ducks. IJB 5:80-85.

Dharmaretnam M, Rogers LJ (2005) Hemispheric specialization and dual processing in strongly versus weekly lateralized chicks. Behav Brain Res 162:62-70.

EFSA (European Food Safety Authority) (2010) Scientific Opinion on the influence of genetic parameters on the welfare and the resistance to stress of commercial broilers. EFSA Panel on Animal Health and Welfare. EFSA Journal 2010 8 (7):1666.

El-Sheikh (2016) Using led light in poultry production. 36th Annual meeting of Egyptian Poultry Science Association (EPSA), Faculty of Agriculture, Alexandria University, Egypt

Farghly MF, Mahrose KM (2012) Effects of light during storage and incubation periods on pre and post hatch performance of Japanese quail. Egyptian Poult Sci 32: 947-958.

FAO (2014) Review of animal welfare legislation in the beef, pork, and poultry industries, page 21.

Fraser AF, Broom DM (1990) Farm animal behavior and welfare. BaillièreTindall Publ., London, UK.

Ghamry AE, Allaway E, Hewida M, Yassein SA, Mallah GM (2011) Evaluation of Dietary calcium Requirements in Fayoumi laying hens. Iranian Appl Anim Sci 1:81-86.

Guevara BD, Pech PS, Zamora BR, Navarrete SL, Magana SH (2015) Performance of broilers reared under monochromatic light emitting diode supplemental lighting. Brazilian Poult Sci 17:553-558.

Harper G, Henson S (2001) Consumer concerns about animal welfare and the impact on food choice. Department of Agricultural and Food Economics. The University of Reading, United Kingdom.

Hossary MA, Galal ES (1994) Improvement and Adaptation of the Fayoumi chickens. Anim Genet Resour Inform 14:33-39.

Jin E, Jia I, Li J, Yang G, Wang Z, Cao J, ChenY (2011) Effect of monochromatic light on melatonin secretion and arylalkylamine N-acetyltransferase mRNA expression in the retina and pineal gland of broilers. The anatomical record 294:1233-1241.

Kuenzel WJ, Kang SW, Zhou ZJ (2015) Exploring avian deep-brain photoreceptors and their role in activating the neuroendocrine regulation of gonadal development. Poult Sci 94:786-798.

Lewis PD, Morris TR (2000) Poultry colored effects of color and intensity of light on behavioral and light. World Poult Sci 56:189-207.

Mohammed HH, Enas NS, Shereen EA (2017) Impact of different litter materials on behaviour, growth performance, feet health and plumage score of Japanese quail (Coturnix japonica). Europ Poult Sci 81.

Mohammed HH, Grashorn MA, Bessei W (2010) The effects of lighting conditions on the behavior of laying hens. Arch Geflügelk 74:197-202.

Olanrewaju HA, Thaxton JP, Dozier WA, Purswell J, Roush WB, Branton SL (2006) A Review of Lighting Programs for Broiler Production. International Poult Sci 5:301-308.

Olanrewaju HA, Purswell JL, Collier SD, Branton SL (2011) Effect of varying light

intensity on growth performance and carcass characteristics of broiler chickens grown to heavy weights. Int. J. Poult. Sci 10:921-926.

Prayitno DS, Phillips CJ, Omed H (1997[a]) The effects of color of lighting on the behavior and production of meat chickens. Poult Sci 76:452-457.

Prayitno DS, Phillips CJ, Stokes DK (1997[b]) The effects of color and intensity of light on behavior and leg disorders in broiler chickens. Poult Sci 76:1674-1681

Prescot NB,Wathes CM (1999) Spectral sensitivity of the domestic fowl (Gallus g. Domesticus). British Poult Sci 40:332-339.

Rozenboim I, Biran I, Chaiseha Y, Yahav S, Rosenstrauch A, Sklan D, Halevy O (2004) The effect of a green and blue monochromatic light combination on broiler growth and development. Poult Sci 83:842-845.

RSPCA (2013) RSPCA welfare standards for chickens, page 10, 11.

Rusty DR (2011) Broiler preference for light color and feed form, and the effect of light on growth and performance of broiler chicks. Master thesis in Dept. of Animal Sciences and Industry College of Agriculture, Kansas state university

SAS (2009) SAS statistical system Package-Jmp 8 User's Guide.2nd Cary, NC, SAS Institute Inc. USA.ISBN 978-1-60764-301-2.

Seijan V, Lakritz J, Ezeji T, Lal R (2011) Assesssment methods and indicators of animal welfare. Journal of Animal and Veterinary Advances 6 (4): 301-315.

Senaratna D, Samarakone TS, Madusanka AP, Gunawardane WD (2011) Performance, behavior and welfare aspects of broilers as affected by different colors of artificial light. Tropical Agricultural Res Extens 14:38-44.

Senaratna D, Samarakone TS, Madusanka AP, Gunawardane WD (2012) Preference of broiler chicken for different light colors in relation to age, session of the day and behavior. Tropical Agricultural Res 23:193-203

Shabiha S, Hassan R, Choe HS, Ryu KS (2013) Impact of different monochromatic LED light color and bird age on the behavioral output and fear response in ducks. Italian Journal Animal Sci 12:573-579.

Škrbić Z, Pavlovski Z, Lukić M, Petričević V, Milić D (2012) The effect of lighting program and type of litter on production and carcass performance of two broiler genotypes. Biotechnology in Animal Husband 28:807-816.

Son JH, Velmurugu R (2009) The effects of light colors on the

behavior and performance of broiler chickens. Korean Journal of Poultry Science 36 (4):329-335

Taha AE, AbdEl-Ghany FA (2013) Improving production traits for el-salam and mandarah chicken strains by crossing. Alexandria Vet Sci 39:18-30.

Tauson R, Ambrosen T, Elwinger K (1984) Evaluation of procedures for scoring the integument of laying hens–independent scoring of plumage condition. Acta Agriculturae Scandinavica 34:400-408.

Van Emous RM, Fiks-van niekerk TG, Reuvekamp BF (2003) Verrijkte kooien. Praktijk Rapport Pluimvee 9. Postbus 2176, 8203 AD, Lelystad, The Netherlands.

Welfare Quality (2009) Welfare Quality®assessment protocol for poultry (broilers,

laying hens). In: Welfare Quality®Consortium, Lelystad, Netherlands. pp. 1-14

Wyse C, Hazlerigg D (2009) Seasonal biology: Avian photoreception goes deep. Curr Biol 19:R685-R687.

Xie D, Wang ZX, Dong YL, Cao J, Wang JF, Chen JL, Chen YX (2008) Effects of monochromatic light on immune response of broilers. Poult Sci 87:1535-1539.