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The effect of color light and stocking density on some traits of broiler carcasses

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Abstract
This study was designed to investigate the effects of color light and stocking density on some traits of broilers carcass. A total of 675 Ross 308 one-day-old broiler chicks were used in this study. The chicks were exposed to white light (WL) as a control. While, the treatment light was Red light (RL), Blue light (BL), Green light (GL), and Blue – Green mix light (BGL) (produced by light-emitting diode system, LED), were applied for 24 hours daily in separated rooms. The birds were randomly housed into 9 wooden sealed pens of $1m^2$ in three replicates for each density 12, 15 and 18 birds/m^2 in the room. The results showed that the carcass weight and dressing and breast muscle percentages were significantly increased) P< 0.05) at 35th day in broilers exposed to BGL under 12 birds/m^2, while thigh muscle percentage was increased significantly) P< 0.05) in broilers reared in BL with no effect under different densities. No significant differences were observed in percentage weight of liver and gizzard however, positive effect of heart percentage was recorded in broilers reared under GL with no effect on stocking density. No significant difference of color light and stocking density on abdominal fat percentage of broilers at 35th day were observed in regard of inedible organs, on the other hand, a significant increase of bursa Fabricius (BF) percentage in broilers reared under WL with no effect of different densities. The small intestine length (cm) was differed (P< 0.05) in broilers reared under GL and 18 birds/m^2, while small intestine weight (gm) was higher (P< 0.05) under BL and 12 birds/m^2 . In conclusion, this study revealed no significant differences (P>0.05) in the diameter of the breast muscle fibers in broilers reared under different color lights and densities. In addition, no interaction has been found between light color and stocking density on carcass traits of broilers within all experimental groups.

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Introduction

Light is an important management tool that regulate broiler production and welfare by modulating various behavioural and physiological pathways. Artificial lighting for broilers consists of 3 aspects: photoperiod, wavelength, and light intensity. All of these aspects have significant effects on broiler production and welfare (Deep *et al.,* 2010). Visible Light can be defined as electromagnetic radiation is produced in differing wavelengths between 390 and 740 nanometres that can be seen by the naked eye (Heinrich, 2005). The eye of the chicken appears to be more sensitive to a broader spectrum than humans, in addition, chickens can see ultraviolet and infrared as well (Rierson, 2011). Light signals are perceived by the avian brain either through eyes (retina) or direct penetration of skull tissue. In the retina, light signals are transduced to electric impulses, directed towards the brain through various neural channels (Gunturkun, 2000). Carcass traits are important economic indexes in chicken breeding (Yin *et al.,* 2012). It is affected by genetic, nutritional and environmental factors (Bourdon and Brinks, 1986). The grow-out lighting protocols for broiler flocks vary and are designed to maximize such production indexes as feed conversion, final weight of the bird carcass and weights individual carcass parts (breast, legs, wings) (Lien *et al.,* 2008). There are two mechanisms of muscle growth: hyperplasia (increase in fiber number) and hypertrophy (increase in fiber size). It is well known that breast yield from the modern-day broiler chicken can vary from 17 to 25 % of the birds body weight (Wilkinson and Scott, 2005). The process of muscle fiber development is nearly complete at the time of hatch. Post-hatch muscle fiber growth occurs through muscle fiber enlargement or hypertrophy, which results from the recruitment of satellite cell nuclei (Velleman, 2007). As satellite cells are the only source of additional nuclei in skeletal muscles of chickens, various studies suggested that the higher muscle weight found in the green and blue light groups may be due to increased satellite cell proliferation during the first days of age (Halevy *et al.,* 1998). Karakaya *et al.,* (2009) found that, feed consumption, body weight and total muscle weight values of the muscles from GL-BL and GL-GBL mix lighting groups were significantly higher than those of incandescent (control) lighting groups. Cao *et al.,* (2008) indicated that broilers reared under BL were larger in the weights of carcass, breast muscle, thigh, crus, and net chamber at d 49 as compared with other light groups. Rearing of broilers in lower stocking density provides more intensive growth and higher absolute yield of processed carcass (Skrbic *et al.,* 2008). Dozier *et al.,* (2006) concluded that increasing stocking density beyond 30 kg BW/m2 adversely affects growth responses and meat yield of broilers grown to 1.8 kg, but does not alter physiological stress indicators. This study intended to evaluate the effects of colour lights and bird density as it relates to broiler carcass, cuts, edible and inedible visceral organs, as well as, the diameter of breast muscle fibers.

Materials and methods

Animals and animal husbandry

A total of 675 Ross 308 one-day-old broiler chicks were used in this study. The chicks were raised under control condition from day one until 35 days of age in the poultry farm at the College of Veterinary Medicine, Basra University. Broiler chicks were reared into five light groups in separated rooms 3 x 3 x 4 meters with an average

135 chicks in each room under LED colour lights include: White light as a control, Red light (660 nm), Blue light (480 nm), Green light (560 nm) and Blue – Green mix light. Stocking density (12, 15 and 18 birds/m^2) were randomly housed into 9 wooden sealed pens of $1m^2$ in three replicates in the room. Light sources were equalized on the intensity of 5 watt/ m^2 (20 lux) at bird head level and light period of 24 hours daily. Room temperature was initially 34°C which was subsequently reduced by 2°C/week to 22°C by 35 days. Three- dietary pellet rations were used to feed the chicks, which consist of starter, grower, and finisher diets. Total dietary metabolic energy for the starter, grower and finisher were 2925, 3111 and 3171 kcal/kg respectively, while the values of crude protein were 22.21, 20.14 and 18.08 % respectively. Half cylinder plastic feeders were placed in each pen. The birds were supplied with feed and water *ad libitum*, and diets were formulated to meet the nutrient recommendations for poultry according to NRC, (1994). The feeders were checked twice daily and feed was weighed with continuous manual addition according to chicks need. Nipple water drinking system was set up in each pen and was manually adjusted as birds grew to ensure the watering system was kept at a proper level.

Measurement of carcass traits

At 35 days of age, 3 chickens from each replicate randomly chosen were weighed and slaughtered after 12 hours of starvation, immersed in 53°C water for 2 minutes, and plucked in a rotary drum. The carcass was weighed and eviscerated manually by cutting around the vent to remove all of the viscera then abdominal fat, liver, gizzard, heart, small intestine and bursa were collected and weighed (Toghyani *et al.*, 2012). Each carcass was cut into breast muscle and thigh muscle. All weights were recorded to the nearest 0.1 gm and calculated as a percentage of live body weight. Length of the intestine was measured with the cut done from the start of the duodenal loop to the end of the cloaca (Kana *et al.*, 2012). Pieces of 1 cm^3 breast muscle specimens were fixed in 10% buffered formalin. Each piece of tissue was trimmed at the thickness of 5 microns (μ) in size, fixed and dehydrated in a series of increasing alcohol concentration, and embedded in paraffin wax using rotary tissue processor. The sections were stained with Mayer's Hematoxylin and eosin (Luna, 1986).

Results and discussion

Carcass traits

The results of the present study revealed that carcass weight, dressing percentage and breast muscle percentage were significantly increased ($P< 0.05$) under BGL 1406.44 gm, 74.16 % and 25.20% respectively at 35th day (Table 1). These results were in agreement with (Halevy *et al.*, 1998; Rozenboim *et al.*, 1999; El-Husseiny *et al.*, 2000; Rozenboim *et al.*, 2004; Cao *et al.*, 2007; Cao *et al.*, 2008; Karakaya *et al.*, 2009 and Zhang *et al.*, 2012), who indicated the positive relation of G and B lights on carcass properties. It is possible that the effects of GL and BL on growth could be explained by stimulation of bird activity by the long wavelength light penetrating the skull, rather than being related to the direct effect of light on hypothalamic gonadotrophin production (Khosravinia, 2007). Green light enhances growth at an early age, occurred probably by enhancing proliferation of skeletal muscle satellite cells (Halevy *et al.*, 1998). Blue light enhanced growth at later age, occurred probably by elevation in plasma androgens. Androgens enhance protein synthesis and reduce protein breakdown. As a result, androgens cause muscle accretion and involved in the normal maintenance of muscular tissue (Crowley and Matt, 1996). The effect of stocking density on the carcass weight, dressing percentage and breast muscle percentage were significant ($P< 0.05$) in birds reared under 12 birds/m^2 1348.46 gm, 72.26 % and 24.84 % respectively. The results of this work were consistent with the findings of Biligili and Hess, (1995), who conducted a study, which examine densities of 0.8, 0.9 or 1.0 square foot per bird. Body weight, feed conversion, mortality, carcass scratches and breast meat yield were significantly improved, when birds were given more space. El-Deek and Al-Harthi, (2004) found that best dressing percentage was obtained from group stocked at 14 bird/m^2. The significant effect of bird density on carcass weight and breast muscle percentage was also confirmed by Shawkat and Al-Salhie, (2008). The study indicated that the broilers raised under the BL were increased significantly ($P<0.05$) in thigh muscle percentage 28.65% in compare with other groups (Table. 1). The result was in agreement with Cao *et al.*, (2008), who indicated that thigh weight of broilers under BL were observed to be heavier than those under the GL, WL and RL. Similarly, Xie *et al.*, (2011) showed that broilers exposed to blue light (BL), green light (GL), red light (RL), and white light (WL) using a light-emitting diode system for 49 days, revealed better improves in the meat quality of Arbor Acre broilers with BL by elevating anti-oxidative capacity than does RL. However, no significant was observed in difference of stocking density on thigh percentage within all experimental group with different densities. This result is in disagreement with Shawkat and Al-Salhie, (2008) and Skrbic *et al.*, (2011), who approved that the better carcass conformation in conditions of lower stocking density occurred as a basis for development of musculature and higher yields of meaty carcass parts.

Internal edible organs

The effects of the various color lights on edible organs are represented in Table (2). No significant differences were observed in percentage weight of liver and gizzard, however, positive effect of heart percentage was recorded in broilers reared under GL 0.64%, and stocking density had no effect between different bird densities. This result was in agreement with Khaled, (2003) and Senaratna *et al.*, (2011), who summarized that there were no significant differences in relative weight of liver due to various color of lights. However, it is in disagreement with El-Husseiny *et al.*, (2000), who evaluated the influence of colored light (white-blue-red-green) on the performance of broiler. A significant positive influence of green light on liver weight percentage was observed. The results of stocking density were in agreement with Sekeroglu *et al.*, (2011), who noted that, there was no differences in liver percentage of broilers reared under (9, 13 and 17 birds/m^2). El-Deek and Al-Harthi (2004) found no significant effect on chemical composition of liver and plasma constituents of broiler chicks as well as liver functions.

Inedible organs

The results of the fat accumulation in inedible organs is represented in Table (3). The results revealed no significant difference of colour light on abdominal fat percentage of broilers at 35th day. The absence of a significant effect was disagreed with El-Husseiny *et al.*, (2000), who referred to the influence of green light on abdominal fat weight percentage. On the other hand, the results of experiment showed no significant effect between broilers reared under different densities, this result confirmed by El-Deek and Al-Harthi, (2004), who reported no differences on abdominal fat percentage in broilers reared under (10, 14 and 18 birds/m^2). The results of this study revealed a significant increase) $P< 0.05$) of bursa Fabricius percentage in broilers reared under WL 0.11% in compare with other groups, while insignificant effect of stocking density on bursa Fabricius percentage recorded in the present study under different densities. These results are in agreement with Buijs *et al.*, (2009), who indicated no significant density effects on either the absolute bursa weight or the bursa: BW ratio. Whereas, Heckert *et al.*, (2002) and Bennett and Stephens, (2006), found that the bursa weight was significantly lighter with increasing density, which might produce immunosuppression in broilers since stress can also decrease bursa size.

Table (1) Effect of light colour and stocking density on carcass traits (gm) of broilers at 35 days (M ± SE).

Carcass traits	Light color / Stocking density	WL	RL	BL	GL	BGL	Effect of stocking density
Carcass Weight (gm)	12 birds/m^2	1356.66 ±121.97	1285.66 ±130.20	1388.00 ±118.30	1336.00 ±89.40	1376.00 ±110.77	1348.46^{a} ±114.12
	15 birds/m^2	1105.00 ±25.69	1193.33 ±165.61	1339.66 ±132.24	1196.66 ±20.57	1376.66 ±223.33	1242.26^{b} ±113.48
	18 birds/m^2	1157.66 ±194.31	1208.00 ±33.30	1243.00 ±119.87	1223.66 ±260.68	1466.66 ±88.19	1259.80^{b} ±139.27
	Effect of light color *	1206.44^{c} ±113.99	1229.00^{bc} ±109.70	1323.55^{b} ±123.47	1252.11^{bc} ±123.55	1406.44^{a} ±140.76	*
Dressing percentage %	12 birds/m^2	72.74±2.64	69.63±3.29	72.95±0.73	71.65 ±1.51	74.32±2.31	72.26±2.06^{a}
	15 birds/m^2	68.48 ±2.88	72.52±2.48	73.71±0.54	72.52 ±0.11	73.48±1.39	72.14±1.48^{a}
	18birds/m^2	67.37 ±4.22	71.09±0.72	72.36±1.11	68.80 ±4.26	74.68±0.96	70.86±2.25^{b}
	Effect of light color *	69.53^{c}±3.24	71.08^{b}±2.16	73.00^{b}±0.79	70.99^{bc}±1.96	74.16^{a}±1.55	*
Breast Muscle Percentage %	12 birds/m^2	22.31 ±0.99	24.95 ±0.59	24.75 ±1.05	24.93 ±0.20	27.28 ±0.36	24.84±0.63^{a}
	15 birds/m^2	22.53 ±0.66	24.01 ±0.81	23.90 ±0.90	22.51 ±0.97	24.65 ±1.94	23.52±1.05^{b}
	18birds/m^2	21.80 ±1.52	23.63 ±1.10	24.21 ±0.96	23.79 ±0.17	23.69 ±0.44	23.42±0.83^{b}
	Effect of light color *	22.21^{b}±.05	24.20^{a}±0.83	24.29^{a}±0.97	23.74^{ab}±0.44	25.20^{a}±0.91	*
Thigh muscle percentage %	12 birds/m^2	28.37±1.02	27.13 ±0.67	28.47 ±0.33	28.04 ±0.94	27.94 ±0.26	27.99 ±0.64
	15 birds/m^2	27.10 ±0.97	27.53 ±0.70	28.98 ±0.53	29.88 ±1.30	27.94 ±0.66	28.29± 0.83
	18birds/m^2	26.41 ±0.70	28.80 ±0.04	28.49 ±0.67	26.67 ±0.84	28.39 ±0.57	27.75± 0.56
	Effect of light color *	27.29^{b}±0.89	27.82^{ab}±0.47	28.65^{a}±0.51	28.20^{ab}±.02	28.09^{ab}±0.49	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.

Table (2) Effect of light color and stocking density on internal edible organs (gm) of broilers at 35 day (M ± SE)

Internal edible organs	Light colour / Stocking density	WL	RL	BL	GL	BGL	Effect of stocking density
Liver weight %	12 birds/m^2	3.24 ±0.03	2.99 ±0.21	2.99 ±0.29	3.51 ±0.33	3.30 ±0.06	3.20±0.18
	15 birds/m^2	3.96 ±0.22	3.25 ±0.13	2.95 ±0.15	3.94 ±0.31	3.54 ±0.13	3.53±0.18
	18 birds/m^2	3.43 ±0.44	3.22 ±0.26	3.68 ±0.36	3.37 ±0.44	3.05 ±0.08	3.35±0.31
	Effect of light color N.S.	3.54 ± 0.23	3.16± 0.20	3.21 ± 0.26	3.61± 0.36	3.30± 0.09	N.S.
Gizzard weight %	12 birds/m^2	2.28 ±0.06	1.90 ±0.27	1.93 ±0.29	1.97 ±0.36	1.85 ±0.07	1.99±0.21
	15 birds/m^2	1.71 ±0.25	1.65 ±0.18	1.90 ±0.18	1.52 ±0.17	1.97 ±0.03	1.75±0.16
	18birds/m^2	1.85 ±0.20	1.74 ±0.14	1.79 ±0.43	1.96 ±0.11	1.92 ±0.11	1.85±0.19
	Effect of light color N.S.	1.95 ± 0.17	1.76± 0.19	1.88 ± 0.30	1.82± 0.21	1.91± 0.07	N.S.
Heart weight %	12 birds/m^2	0.61 ±0.07	0.45 ±0.07	0.58 ±0.06	0.68 ±0.06	0.59 ±0.06	0.58±0.06
	15 birds/m^2	0.57 ±0.03	0.51 ±0.05	0.54 ±0.05	0.66 ±0.03	0.57 ±0.13	0.57±0.05
	18birds/m^2	0.54 ±0.03	0.54 ±0.04	0.56 ±0.06	0.59 ±0.06	0.49 ±0.07	0.55±0.05
	Effect of light color *	0.57±0.04^{ab}	0.50±0.05^{b}	0.56±0.05^{ab}	0.64±0.05^{a}	0.55±0.08^{ab}	N.S.

a, b,c Means in horizontal rows with different superscripts were significantly different of light colour and in vertical rows of stocking density at (p<0.05). SE: standard error.

The results of this study revealed a significant increase (P< 0.05) of small intestine length (cm) in broilers reared under GL and 18 birds/m^2. This result was in agreement with Xie *et al.*, (2009), who studied Arbor Acres male broilers were exposed to red, green, blue and white light from LED lamps. The study found that small intestine mucosal structure is improved to an extent in broilers when illuminated with green light at the early growth stage (0-7 days) under 15 Lux light intensity, accordingly improving the absorption function of the small intestine and accelerating growth. The result of this study revealed also that the small intestine weight (gm) was higher (P< 0.05) under BL and 12 birds/m^2 in compare with other groups at 35th day.

The result of this study was confirmed previously by Xie *et al.*, (2011), who found that villus height of small intestine was increased in broilers exposed to GL and BL than those in the WL group. The suggestion that both mucosal mechanical and immunological barriers of the small intestine might be improved by rearing broilers under GL at an early age and under BL at an older age.

The present study indicated no significant differences (P>0.05) in the diameter of muscle fibers of the breast muscle in broilers reared under different color lights and densities (Table. 4) (Figure. 1,2,3).

The results of this study were consistent with the findings of Liu *et al.*, (2010), who measured the myofiber size of pectoral muscle in post-hatching broilers reared under different light spectra. The myofiber cross-sectional area μm^2 showed no significant differences were observed between GL and BL groups or WL and RL groups (p > 0.05) respectively. Whereas Cao *et al.*, (2008) showed that myofiber areas of major pectoral muscle were larger in GL at early period (0 to 26 day) and in BL at later period (27 to 49 day), which was probably due to the proliferation of skeletal muscle satellite cells and the increase of number of myofibers.

In conclusion, this study indicated that carcass weight percentage, dressing percentage and breast muscle percentages were significantly increased at 35th day in broilers exposed to BGL under 12 birds/m^2. No significant differences of light color or stocking density were observed in percentage weight of liver, gizzard and abdominal fat. No significant differences in the diameter of the breast muscle fibers in broilers reared under different color lights and densities. In addition, no interaction has been found between light colour and stocking density on carcass traits of broilers within all experimental groups.

Table (3) Effect of light colour and stocking density on inedible organs (gm) of broilers at 35 days (M ± SE)

Inedible organs	Light colour / Stocking density	WL	RL	BL	GL	BGL	Effect of stocking density
Abdominal fat percentage %	12 birds/m^2	1.64±0.26	1.80±0.44	2.11±0.03	1.96±0.29	2.06±0.19	1.91±0.24
	15 birds/m^2	1.80±0.14	2.19±0.10	1.60±0.10	1.80±0.51	1.84±0.11	1.84±0.19
	18 birds/m^2	1.89±0.26	1.58±0.08	2.17±0.20	1.79±0.37	1.45±0.20	1.77±0.22
	Effect of light color N.S.	1.77±0.22	1.85±0.20	1.96±0.11	1.85±0.39	1.77±0.16	N.S.
bursa Fabricius percentage %	12 birds/m^2	0.10±0.02	0.07±0.01	0.08±0.01	0.07±0.01	0.05±0.00	0.07±0.06
	15 birds/m^2	0.10±0.01	0.08±0.01	0.09±0.02	0.06±0.00	0.07±0.01	0.08±0.01
	18birds/m^2	0.13±0.00	0.07±0.01	0.05±0.00	0.07±0.00	0.06±0.01	0.08±0.00
	Effect of light color *	0.11±0.01^{a}	0.07±0.01^{b}	0.07±0.01^{b}	0.06±0.00^{b}	0.06±0.00^{b}	N.S.
Intestine Length (cm)	12 birds/m^2	163.6±10.9	163.0 ±7.7	181.0 ±7.0	187.6 ±4.3	158.3 ±10.9	170.7±8.2^{ab}
	15 birds/m^2	144.3 ±7.3	151.3 ±8.6	171.6 ±12.3	171.0 ±4.9	164.3 ±8.2	160.5 ±8.2^{b}
	18birds/m^2	171.6±20.1	176.3 ±6.3	179.3 ±8.5	183.3 ±19.6	171.0±9.4	176.3±12.8^{a}
	Effect of light color *	159.8±2.8^{b}	163.5±7.5^{ab}	177.3±9.2^{ab}	180.6± 9.6^{a}	164.5± 9.5^{b}	*
Intestine weight (gm)	12 birds/m^2	78.6 ±10.3	58.6 ±4.3	93.3 ±9.5	75.3 ±10.3	76.3 ±9.8	76.4 ± 8.8^{a}
	15 birds/m^2	67.3 ±2.9	56.6 ±1.4	74.0 ±12.4	57.3 ±3.4	59.6 ±6.9	63.0 ± 5.4^{b}
	18birds/m^2	76.0 ±15.5	61.0 ±6.4	68.6 ±3.2	58.3 ±9.3	67.6 ±12.4	66.3± 9.4^{ab}
	Effect of light color *	74.0± 9.6^{ac}	58.7 ± 4.0^{bc}	78.6 ± 8.4^{a}	63.6 ± 7.7^{c}	67.8± 9.7^{abc}	*

a, b,c Means in horizontal rows with different superscripts were significantly different of light colour and in vertical rows of stocking density at ($p<0.05$). SE: standard error

Table (4) Effect of light colour and stocking density on the diameter of breast muscle fiber (μm) of broilers at 35 day (M ± SE).

	Light color / Stocking density	WL	RL	BL	GL	BGL	Effect of stocking density
Diameter of breast muscle fiber (µm)	12 birds/m²	54.9 ± 3.60	60.52 ± 0.38	59.85± 1.29	57.11 ± 2.74	47.07 ± 2.10	55.89 ± 2.02
	15 birds/m²	62.32± 0.90	57.00 ± 2.87	47.70± 0.82	55.60 ± 3.33	50.52 ± 2.26	54.62 ± 2.03
	18 birds/m²	58.27± 1.42	48.26 ± 4.39	49.80± 4.72	49.61 ± 3.49	51.27 ± 0.91	51.44 ± 2.98
	Effect of light color N.S.	58.49± 1.97	55.26 ± 2.54	52.45± 2.27	54.10 ± 3.18	49.62 ± 1.75	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

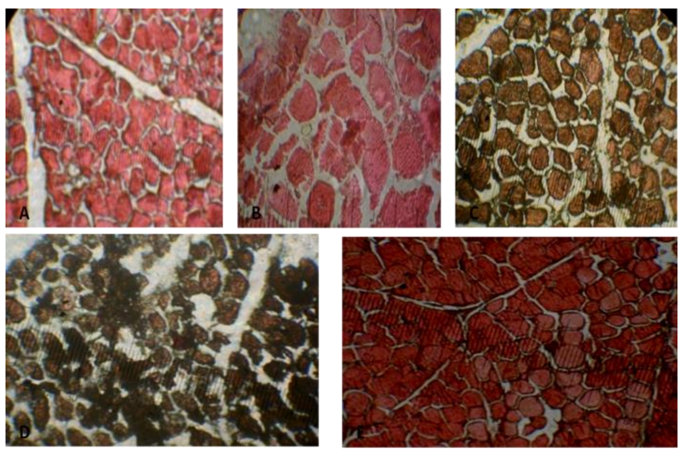

Figure (1) Cross-sections of breast muscle fiber in broilers reared under 12 birds/m^2 (A) WL (B) RL (C) BL (D) GL and (E) BGL. (Hematoxylin-eosin stain, 160 X).

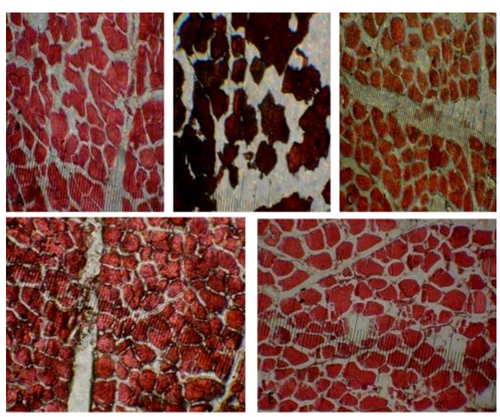

Figure (2) Cross-sections of breast muscle fiber in broilers reared under 15 birds/m^2 (A) BL, (B) RL, (C) BL, (D) GL and (E) BGL. (160 X).

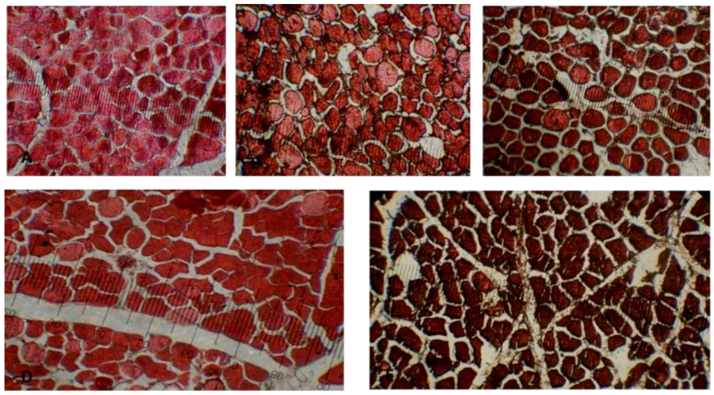

Figure (3) Cross-sections of breast muscle fiber in broilers reared under 18 birds/m^2 (A) BL, (B) RL, (C) BL, (D) GL and (E) BGL. (160 X).

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