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INFLUENCE OF CHROMIUM SOURCES ON PERFORMANCE OF GIMMIZAH CHICKENS FED LOW METABOLIZABLE ENERGY AND CRUDE PROTEIN DIETS

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ABSTRACT: This study was done to investigate the influence of chromium sources (organic; Cr-Methionine and inorganic; $Crcl_3$) on the performance of Gimmizah chickens fed low metabolizable energy (LME) or low metabolizable energy and crude protein (LMECP) diets. A total number of 280 (245 hens + 35 cocks) of Gimmizah chickens (aged 28-weeks) were individually weighed and randomly divided into seven treatment groups, with five replicates for each (7 hens+1cock) and housed (open system) in 35 floor pens during the experimental period (28 - 44 weeks of age). The first group was fed the basal diet and served as a control (2750 kcal ME/kg diet + 17.0 %CP). The second one was fed low metabolizable energy diet (LME, 2600 kcal ME/kg diet + 17.0 % CP). The third group was fed low metabolizable energy and crude protein diet (LMECP, 2600 kcal ME/kg diet and 15.5 %CP).While the fourth and fifth groups were fed LME diet supplemented with 1200 µg/kg diet of organic or inorganic chromium (Cr), respectively. Whereas the sixth and seventh groups were fed LMECP diet supplemented with 1200 µg/kg diet of organic or inorganic Cr, respectively. The groups fed LME supplemented with both sources of Cr significantly improved egg production, egg mass, feed conversion ratio, shell thickness, Haugh units and SWUSA compared with the groups fed LME and LMECP diets and similarly equal with the control group. Layers fed LME supplemented with organic Cr significantly increased fertility, hatchability percent of both total and fertile eggs and chick weights compared with the groups fed LME or LMECP diets and were statistically equal with the control group. The blood concentration of total lipids, triglycerides, Ca, MDA, TAC, GSH and insulin were significantly improved for groups fed LME or LMECP supplemented with both sources of Cr compared with the other groups. Blood concentration of cholesterol, heterophil, phagocytic activity and phagocytic index for the group fed LME diet supplemented with organic Cr were significantly improved compared with the groups fed LME and LMECP diets. Economical efficiency value indicated that the group fed LME diet supplied with organic Cr recorded the highest economical efficiency (1.13) and relative economical efficiency (113.6 %) compared with the control group. **In conclusion,** addition both sources of Cr for LME diet improved and recovery the layer performance to the control group. However, addition of organic Cr for LME diet recorded the best economical efficiency compared with the other experimental groups.

Key words: Chromium- low metabolizable energy- low crude protein- insulin-layer.

INTRODUCTION

The most important part of poultry industry is feeding. Feeding makes up the major cost of production (about 60-75% of total cost), so good nutrition will reflect on the birds performance and their products (Kamalzadeh *et al*., 2009). Dietary protein and energy represent approximately 85% of total feed cost. In Egypt and developing countries, there is a difficulty in providing poultry requirements from energy and protein due to the lack of cereals and legumes, as well as the dependence of human nutrition on these materials (Hamzat *et al*., 2003). This makes poultry more susceptible to nutritional stress.

Dietary energy and protein levels have an independent effect on the performance of the chickens. As a general rule, the chicken eats to satisfy its energy requirements. Therefore, the energy content of the diet determines the quantity of feed consumed, including the quantity of protein, minerals and vitamins contained in that feed. Carbohydrates and lipids are the main sources of energy in the diet (Shanaway, 1994). Feeding inadequate energy levels may reflect in low egg production and body weight, and worse egg quality. Also, the efficiency of energy utilization may be impaired (Araújo and Peixoto, 2005). Wu *et al.* (2005) observed that laying hens (21-week-old) reduced feed intake by 1% for each 39 kcal/kg increase in AMEn dietary levels, and reduced egg and yolk weights, but not egg production, egg mass, body weight, or livability. However, Jalal *et al*. (2006) did not observe any differences in feed intake, egg production, body weight, and egg weight due to feeding young Hy-line W-36 laying hens (21 weeks old) diets with AMEn levels of 2800, 2850, and 2900 kcal/kg.

Protein is a vital nutrient of animal and poultry feeds. Several studies have examined the effects of low-protein diets in laying hen nutrition. Abd El-Maksoud *et al.* (2011) confirmed the significant effect of different CP level on layer performance, while egg production and egg mass were increased with increasing CP levels from 12-16% for laying hens diets. Novak *et al*. (2006) demonstrated that lowering CP in laying hens diets reduced egg weight through the experimental period (18-60 weeks old). On the other hand, Zeweil *et al.* (2011) reported that egg production and egg mass were not affected by dietary CP level (12, 14 and 16%) of Baheij laying hens.

Chromium is a well-known essential trace element for humans and animals. It is required for carbohydrate, lipid, protein, and nucleic acid metabolism (Mertz, 1969). Chromium stimulates and regulates the action of insulin (Anderson, 1994 and Mowat, 1994) which is involved in anabolic processes (Colgan, 1993). Moreover, chromium deficiency can disrupt the carbohydrate and protein metabolism, reduce the insulin sensitivity in peripheral tissues, and also impair the growth rate (Sahin and Sahin, 2002 and Kroliczewska *et al.*, 2005). Supplementation of dietary chromium as CrPic decrease mortality and alters glucose metabolism in chickens (Lien *et al*., 1996). Holdsworth and Neville, (1990) and Lien *et al.* (1996) reported that dietary chromium supplementation increased serum insulin, total protein and albumin concentrations, whereas cholesterol and corticosterone concentrations were decreased for chickens, rats and calves. Chromium supplementation resulted in higher egg production, egg weight, egg mass and albumin quality (Uyanık *et al*., 2002 and Yıldız *et al*., 2004). Organic Cr supplementation did not affect body weight and feed consumption for laying hens (Eseceli *et al*., 2010) or laying quails (Yıldız *et al*., 2004).

In this connection Sahin *et al*. (2001) showed that Cr supplementation, particularly at 1200 ppb increases the performance, egg quality and serum insulin concentration of Japanese quails. Moreover, Sahin *et al*. (2002) reported that separately or as a combination, vitamin C and Cr supplementation resulted in an improved live weight gain, feed efficiency and carcass traits, as well as in a decrease in serum corticosterone and Malondialdehyde (MDA). In addition, Preuss *et al.* (1997) showed that Cr is an efficient antioxidant and influences lipid peroxidation by fighting free radical damage in the body. The beneficial effects of chromium can be observed more efficiently under environmental, dietary and hormonal stress. Chromium supplementation at a level of 1200 µg/kg diet can alleviate the negative effects of heat stress on egg production, egg quality, egg hatching and some plasma constituent of laying Japanese quail reared under Egyptian summer conditions (Abdel-Mageed and Hassan, 2012). Hanafy (2011) observed that Cr supplementation at levels of 250, 500, 1000 and 1500 µg/kg diet as Cr-yeast increased percentages of fertility and hatchability in Bandarh laying hen. Chromium availability from most feedstuffs is extremely low and its addition to diet can influence animal metabolism and production criteria positively, as well as the composition of animal products (Spears, 1999). The objective of this study was to investigate the influence of chromium sources on the performance and some physiological responses of Gimmizah chickens fed low metabolizable energy or low metabolizable energy and crude protein diets.

MATERIALS AND METHODS

The present study was carried out at El-Sabahia Poultry Research Station, Alexandria Governorate belonging to Animal Production Research Institute, Agriculture Research Center. The experiment was conducted from 17 April to 6 August 2017 to investigate the influence of dietary chromium sources on the performance and some physiological responses of Gimmizah chickens fed low metabolizable energy or low metabolizable energy and crude protein diets.

Birds, management and experimental design

A total number of 280 (245 hens + 35 cocks) of Gimmizah chickens (aged 28-weeks) were individually weighed and randomly divided into seven treatment groups. Each treatment group was represented by five replicates (7 hens + 1 cock) and housed (open system) in 35 floor pens until the end of the experiment (44 weeks of age). The first group was served as a control and fed the basal diet which contains (2750 kcal ME/kg diet and 17.0 % CP). The second one was fed the low metabolizable energy diet (LME, 2600 kcal ME/kg diet and 17.0 %CP). The third group fed low metabolizable energy and crude protein diet (LMECP, 2600 kcal ME/kg diet and 15.5 % CP). Whereas the fourth and fifth groups were fed LME diet supplemented with 1200 µg /kg diet of either Cr-Methionine or Crcl3, respectively. While the sixth and seventh groups were fed LMECP diet supplemented with 1200 µg /kg diet of either Cr-Methionine or Crcl3, respectively.

Basal diet covered the nutrient requirements according to Feed Composition Table for Animal and Poultry Feedstuffs in Egypt (2001), as shown in Table (1). Feed was supplied by a constant amount (125 g/day/hen), while water was provided *ad libitum* throughout the experimental period. Birds were illuminated with a 16 - 8 h light-dark cycle. Vaccination and medical care were done according to common veterinary care under veterinarian's supervision.

Measurements

Daily egg production (EP) and egg weight (EW) were recorded for each replicate and egg mass (EM) were calculated. Feed intake (FI) was recorded weekly and for all the experimental period (the amount of ration, 125 g/day/hen, was completely consumed per each day). Egg production was calculated during the production period, then feed conversion ratio (FCR) was calculated as g of feed required per each g of egg mass. Eggs were collected for a 7-day period at 40 weeks of age and incubated in an automatic incubator. Eggs were candled on day 18 to identify infertile eggs or containing dead embryos. Fertility was calculated as the number of fertile eggs relative to the total number of eggs set, while hatchability for total and for fertile eggs were calculated as the number of hatched chicks relative to the total egg set and for fertile eggs, respectively. Eggs laid on three successive days from each treatment at 38 and 42 weeks of age, were used for measuring egg quality traits. Egg shell, yolk and albumen were weighed to the nearest 0.1 g (egg shells were washed, the inner egg shell membrane was separated and air-dried for 72 h before weighing). Egg shell thickness (µm) without membrane and yolk index (YI) were measured according to Funk (1948), Haugh unit score (HU) according to Haugh (1937) and shell weight per unit of surface area (SWUSA) according to Carter and Jones (1970).

Blood analyses

At the end of the experiment, in the morning (at 09.00 to 10.00 h) two blood samples (3 ml, each) were collected from the brachial vein, (one into heparinized tube to separate plasma and the other one into unheparinized tube to separate serum) of five birds / treatments. Blood serum were separated by centrifugation of blood at 2000 rpm for 10 min and was then frozen (-20°C) until chemical analysis. Fresh blood samples were used for determination of hemoglobin (Hgb), red blood cell count (RBCs), packed cells volume (PCV), white blood cell counts (WBCs). White blood cell differential was done according to Hawkey and Dennett (1989). Plasma was immediately separated by centrifugation for 10 minutes at 3200 rpm. Some plasma criteria as total protein, albumin, globulin, glucose, total lipids, triglycerides, cholesterol, HDL, LDL, calcium, and phosphorus were determined using commercial kits produced by Diamond Diagnostics Company (29 Tahreer St. Dokki Giza Egypt). Serum total antioxidant capacity (TAC), glutathione (GSH) and malondialdehyde (MDA) were colorimetrically determined using commercial Kits. Serum insulin concentration was determined via radioimmunoassay method using procedures described by McMurtry *et al.* (1983). The phagocytic activity (PA) and phagocytic index (PI) were measured as suggested by Leijh *et al.* (1986).

Statistical analysis

Data were statistically analyzed using one way ANOVA of SAS® (SAS Institute, 1996). Differences among treatment means were estimated by Duncan's multiple range test (Duncan, 1955). The following model was used to study the effect of treatments on the parameters investigated as follows: $Yij = \mu + Ti + eij$. Where: Yij = an observation, μ = overall mean, Ti = effect of treatment (i=1,2,3,…..7) and eij = experimental random error.

RESULTS AND DISSCUSION

Results of Table (2) indicated that initial, final and the change of body weight were insignificantly ($P \geq 0.05$) differed among the experimental groups. These results are in agreement with Samanta *et al*. (2008) and Toghyani *et al*. (2012) who reported that dietary supplementation with chromium improved growth performance only under heat-stressed conditions or during growing period. Egg production percentage (EP) for layer groups fed low metabolizable energy (LME) or low metabolizable energy and low crude protein diets (LMECP) was significantly decreased by 16.93 and 18.63 %, respectively compared with the control group. However, the layer groups fed LME diet supplied with both sources of Cr significantly increased EP compared with the group fed LME by 18.84, 15.71 % and the group fed LMECP diets by 21.31 and 18.12 %, respectively. Moreover, the layer groups fed LME diet supplied with both sources of Cr were statistically equal with the control group. On the other hand, EP for layer groups fed LMECP diet supplemented with both sources of Cr were significantly decreased compared with the control and LME diet supplemented with organic Cr groups. However, EP for layer groups fed LMECP diet supplemented with both sources of Cr were statistically equal with the groups fed LME or LMECP diets, Table 2. The amount of feed represented daily for consumption was equal (125 g/h/d) during all experimental period. The equalization of the amount of feed represented was done to prevent the more consumption of feed especially for the treatment groups fed LME diets. Feed conversion ratio (FCR) was significantly differed among all experimental groups Table (2). However, it is clear that FCR for the treatment groups consumed LME diet supplied with both sources of Cr were significantly improved compared with the all experimental groups except the control group which were statistically equal (3.35, 3.34 for LME supplied with both sources of Cr and 3.28 for control). The decline in FCR for the groups fed LME and LMECP diets are similarly with that reported by Leeson *et al.* (2001). Also, Yakout *et al.* (2004) observed a significant reduction in feed intake, while feed conversion improved by dietary protein level increase. DePersio *et al.* (2015) indicate that feeding Hy-Line W-36 hens increasing energy and nutrient dense diets improved feed efficiency. However the observed improvement in FCR are in agreement with that reported by Gursoy (2000) who reported that trivalent organic Cr supplementation could result in improved feed efficiency. Also, Zhang *et al.* (2002) illustrated that Cr supplementation has been observed to improve broiler feed conversion ratio by 6.2%. Samanta *et al.* (2008) observed that dietary Cr supplementation has been shown to positively affect FCR in growing poultry. On the other hand, organic Cr supplementation did not affect feed consumption for laying hens (Eseceli *et al.*, 2010). Generally, the groups fed low crude diet (15.5 %) consumed the significant low amount of CP compared with the groups fed the diet containing the high amount of crude protein (17.0 %), 19.38 *vs.* 21.25 g/h/day. Also, the experimental groups fed LME diets (2600 kcal ME /kg diet) consumed the significant low amount of metabolizable energy compared with the control group (2750 kcal ME /kg diet), 327.5 *vs.* 343.8 Kcal/h/day. The previous similarity of ME or CP consumed are reflected to the equalization of the amount of feed represented during the experimental period. Results clearly indicated that egg weight (EW) and egg mass (EM) for the groups fed LMECP diet supplied or unsupplied with both sources of Cr were significantly decreased compared with the groups fed control or LME diet supplied with organic Cr, which were statistically equal. These results are in agreement with Leeson *et al*. (2001) who reported that when birds fed diets with the lowest nutrient density produced the fewest eggs and trend in reduced egg size. Also, Hassan *et al*. (2000) and Yakout *et al*. (2004) indicated that with increasing dietary protein level, egg weight and egg mass was improved. Similarly Khajali *et al*. (2008) noted that layer performance can remain satisfactory on reduced-CP diets for short periods, but long-term feeding of reduced-CP diets may not be advisable because it will reduce performance in the late stage of production. On the other hand, Moustafa *et al*. (2005) found that dietary CP had no significant differences among dietary treatments in both total egg number and egg production percentages. Ding *et al.* (2016) observed no significant differences in EW of the layers fed diets with different ME levels. However, Mirfendereski and Jahanian (2015) reported that dietary Cr-Met supplementation caused significant increases in egg production and egg mass. Also, Amata (2013) showed that Cr has been a positive effect on laying egg productions. Similarly, Sahin *et al.* (2002) reported that the beneficial effects of Cr could be more efficiently under environmental and hormonal stresses. On the other hand, Torki *et al* (2014) demonstrated that Cr revealed no effect on egg production, mass and volume. The improvement in layer performance due to supplementation of Cr may be due to that Cr is a useful essential element for metabolism of food. It is a part of glucose tolerance factor (GTF), the prime role of Cr regarding metabolism is mediated through activating insulin (Anderson, 1987) and helps insulin to progress glucose into the cell for energy generation (Sahin *et al*., 2001). Also, Ahmed *et al*. (2005) demonstrated that addition of Cr in poultry diet may boost the utilization of dietary energy through stimulation of insulin action and thus could help maintain productivity of birds even if the dietary energy level is lowered. Also, Sahin and Sahin (2002) indicated that the digestibility of dry matter, ash, organic matter, crude protein and ether extract was increased due to Cr supplementation in laying hens. Moreover, Sahin and Sahin (2002) reported that Cr supplementation may improve functioning of pancreas with regards to secretion of digestive enzymes, which improves the retention of nitrogen and minerals. Amatya *et al*. (2004) indicated that Cr supplementation improved the metabolizability of the organic nutrients. Ahmed *et al.* (2005) suggested that Cr may exert a protective effect on pancreatic tissue which results in increased pancreatic functions comprising of the release of digestive enzymes and an enhanced nutrient utilization, that may be due to the antioxidative role of Cr.

Amata (2013) stated that chromium has also been shown to play a key role in lipid, protein and nucleic acid metabolism in livestock.

Results of Table 3, illustrated that some of egg quality traits was significantly affected by the content of ME, CP in the layer diet and Cr supplementation. Egg shape index for the egg laid form the groups fed LME or LMECP diets unsupplied or supplied with both sources of Cr were statistically equal, but they significantly decreased compared with the control group, Table 3. The eggshell thickness, Haugh unit score and shell weight per unit of surface area (SWUSA) for the groups fed LME and LMECP diets supplied with both sources of Cr were statistically equal with results recorded for layer fed the control diet and they were significantly increased compared with the groups fed LME and LMECP diets. However, yolk, albumen and shell weight percent, yolk index and yolk color were not significantly differed among all treatment groups Table 3. In literatures, the effect of ME and CP on egg quality are fluctuated, Yakout (2000) and Moustafa *et al*. (2005) showed that dietary protein level had no effect on shell thickness, shell percentage, albumen percentage, yolk weight and Haugh unit. Junqueira *et al.* (2006) and Ding *et al.* (2016) compared diets of different ME and CP levels on the egg quality of layers and they did not find any effects on the Haugh units. However, the previous results are in agreement with Sahin *et al.* (2001) who reported that dietary Cr supplementation improved eggshell weight, eggshell thickness, albumen index, albumen weight, yolk index, yolk weight and egg specific gravity of Japanese quails. Similarly, Amata (2013) demonstrated that chromium had positive effects on egg quality in laying hens. Also, Sahin *et al.* (2002) observed improving in egg quality traits in laying Japanese quails exposed to heat stress. However Lien *et al*. (1996) reported that shell thickness was not affected by chromium picolinate supplementation under thermally neutral conditions. Other studies by Southern and Page (1994) showed that Cr supplementation did not affect significantly egg quality traits such as Haugh units and specific gravity, this could suggest that marked beneficial effects of chromium on egg quality is observed only under conditions of stress.

The fertility percentages for the experimental groups fed LME diet supplied with both sources of Cr and the group fed LMECP supplied with organic Cr were statically equal with the control group and all of them significantly recorded the highest fertility percentages compared with the group fed LMECP diet, Table 4. However, the group fed LMECP diet recorded the lowest significant fertility percentage compared with the other experimental groups, except the groups fed LMECP diet supplied with inorganic Cr and the group fed LME diet, which was statistically equal with them, Table 4. The hatchability percentages for layer groups fed LME and LMECP diets supplied with both sources of Cr were statistically equal with the result observed for the control group. Egg fertility and egg hatchability were significantly differed due to different protein levels in diet (Yakout, 2000 and Moustafa *et al.*, 2005). However, the experimental groups fed LME diet supplied with both sources of Cr recorded the significantly highest hatchability percentages compared with the group fed LME or LMECP diets. The absolute and relative baby chick weight hatched from the experimental groups fed LME diet supplied with both sources of Cr were statistically equal with those hatched from control group. However, the lowest absolute and relative baby chick weight were recorded for the groups fed LMECP diet supplied or unsupplied with Cr, Table 4.

The red blood cells count (RB**C**s), hemoglobin concentration and packed cells volume did not differed among the experimental groups, Table 5. The count of white blood cells (WBCs) and the phagocytic index percentage for the group fed LME diet supplied with organic Cr were significantly increased compared with the all experimental groups but it is statistically equal with that recorded in the control group. Heterophil percentages for the groups fed LME diet supplemented with organic Cr and LMECP diet supplemented with both sources of Cr were significantly decreased compared with the other experimental groups except the group fed LME diet supplemented with inorganic Cr which was statistically equal with them. On the other hand, lymphocyte percentages and ratio between heterophil and lymphocyte did not significantly differ among the experimental groups. The phagocytic activity percentage was significantly increased for the groups fed LME and LMECP diets supplied with both sources of Cr compared with the groups fed LME and LMECP diets but they were statistically equal with the activity of control group, Table 5. Results reported by Jahanian and Rasouli (2015) indicated that dietary supplementation of CrMet had no marked effect on lymphocyte count, it decreased the proportion of heterophil to normal status. Dietary $CrCl_3$ supplementation reduced the counts of heterophil and monocyte and the ratio of heterophil/lymphocyte (H/L), while lymphocyte counts, total antibody, antibody titers (IgG and IgM) increased (Uyanik *et al.*, 2002). Rao *et al.* (2012) reported that the ratio between heterophil and lymphocyte was not affected due to dietary supplementation of organic Cr in commercial broiler chickens. Rajalekshmi *et al.* (2014) found that supplementation of chromium propionate in male broiler chickens had no significant effect on the lymphoid organ weights during the whole study period of 42 days.

The blood concentration of total protein and globulin and the ratio between albumin and globulin were not significantly differed among all experimental groups, while the blood concentration of albumin for the group fed LMECP diet was significantly decreased compared with the other experimental groups, Table 6. The concentration of total lipids, triglycerides and malondialdehyde (MDA) were significantly improved for the groups fed LME and LMECP diets supplied with both sources of Cr compared with the other experimental groups. On the other hand, the blood concentration of cholesterol for the group fed LME diet supplied with organic Cr was significantly decreased compared with the other experimental groups. However, the concentrations of high and low density lipoprotein were not significantly differed among all experimental groups, Table 6. Results of Bunchasak *et al.* (2005) indicated that as protein level increased, serum protein fraction and serum total protein were tended to increase. On the other hand, Moustafa *et al*. (2005) reported that protein level in diet had no significant differences in serum total protein, total lipids and cholesterol among all dietary treatments. However, several studies reported that Cr supplementation had a beneficial effect on poultry lipid profile. Kim *et al.* (1995) reported that HDL cholesterol increased and total serum cholesterol decreased in the diets of broilers supplemented with chromium. Also, Sahin *et al.* (2001) indicated that Cr supplementation markedly decreased blood cholesterol concentrations in Japanese quail under thermo neutral zones, while protein concentrations increased linearly. Similarly, Torki *et al.* (2014) demonstrated that Cr lowered serum total cholesterol and triglycerides but increased serum albumin and total proteins**.** Mirfendereski and Jahanian (2015) reported that supplemental CrMet decreased plasma cholesterol levels. Zheng *et al*. (2016) found that supplementation of organic Cr can reduce the cholesterol content in serum. However, Sands and Smith (2002) did not observe significant differences in serum cholesterol levels in broilers fed Cr supplemented diets. The reduction of blood cholesterol with addition of Cr is observed as the main response regarding lipid metabolism, which may be on account of an enhanced activity of insulin that decreases lipolysis and increases fatty acids assimilation in the adipocytes (Anderson, 1987 and Vincent, 2000, 2001). Moreover, Onderci *et al.* (2005) reported that supplied Japanese quail diet with 1, 2 or 4 mg Cr kg^{-1} reduced serum, muscle and liver MDA. The concentration of total antioxidant capacity (TAC) and glutathione (GSH) were significantly improved for the groups fed LME and LMECP supplied with both sources of Cr compared with the other experimental groups, Table 6. These results are in agreement with Rao *et al.* (2012) who reported that supplementation of commercial broiler chickens with dietary organic chromium, ameliorates oxidative stress by reducing lipid peroxidation and increasing the activities of plasma glutathione peroxidase and glutathione reductase. Also, Shrivastava *et al.* (2002) and Van de Ligt *et al.* (2002) indicated that chromium is an important in altering the immune response by immunostimulatory or immunosuppressive processes as shown by its effects on T and B lymphocytes, macrophages, cytokine production and immune responses that may induce hypersensitivity reactions.

The blood concentration of calcium and Ca/P ratio were significantly increased for the groups fed LME and LMECP diets supplied with both sources of Cr compared with the control group. The blood concentration of phosphorus was not significantly differed among all experimental groups**.** Sahin *et al*. (2002) reported that Cr supplementation increased serum concentration of calcium (Ca), phosphorous (P) and potassium and decreased level of sodium. Also, Sahin and Sahin (2002) observed that CrPic (400 µg kg^{-1} of diet) supplementation improved the retention of minerals and decreased the excretion of Ca, P, Cr, Nitrogen, zinc and iron in laying hens. On the other hand, Uyanik *et al.* (2002) documented that feeding $CrCl_3$ did not affect serum Ca and P, but increased magnesium concentration at the level of 100 mg kg^{-1} of feed.

The blood concentration of insulin was significantly increased for the groups fed LME and LMECP diets supplied with both sources of Cr compared with the other experimental groups, while the blood glucose concentration appears the opposite trend, Table 6. The result clearly indicated that while serum insulin increased, the glucose concentration decreased, these results may be due to more diffusion of glucose into tissue cells. Moreover, insulin has been shown to increase the glucose and amino acid uptake into muscle cells in order to regulate energy production, muscle tissue deposition, fat metabolism, and cholesterol utilization. If glucose cannot be utilized by body cells due to a low insulin level, it is converted into fat and stored in fat cells Tesseraud *et al.* (2007). Furthermore, if adequate amino acids cannot enter the cells, muscles cannot be built (Anderson, 1987). Moreover, chromium deficiency can disrupt the carbohydrate and protein metabolism, reduce the insulin sensitivity in peripheral tissues, and also impair the growth rate (Sahin and Sahin, 2002 and Sahin *et al*., 2003). However, an appropriate recommendation on the chromium requirement of poultry has not been made (NRC, 1994 and 1995) and most poultry diets are basically composed of plant-origin ingredients, usually low in Cr (Giri *et al.*, 1990). Steele and Rosebrough (1981) indicated that Cr acts as a cofactor of insulin activity and the presence of this mineral is needed for maintaining proper glucose metabolism (Ahmed *et al.*, 2005 and Moeini *et al.*, 2011*).* Holdsworth and Neville (1990) reported that the primary role of chromium in metabolism is to potentiate the action of insulin through being a component of glucose tolerance factor (GTF). The mechanism involves increased insulin binding through increasing the number of insulin receptors and increasing insulin receptor phosphorylation when the chromium is bound to a low molecular weight chromium binding substance (LMWCr; also referred to as chromodulin), Anderson (1994). In the blood, Cr is bound to and transported to tissues by transferrin, a process regulated, at least in part, by insulin (Clodfelder *et al*., 2001). Amata (2013) showed that chromium is involved in glucose metabolism where it plays a vital role in the auto amplification mechanisms of insulin signaling. Vincent (2000) reported that chromodulin binds chromic ions in response to an insulin mediated chromic ion influx and the metal saturated oligopeptide is then able to become bound to an insulin stimulated insulin receptor which activates the receptor's tyrosine kinase activity. Chromodulin thus appears to play a role in the auto amplification mechanism of insulin signaling. Mirfendereski and Jahanian (2015) reported that dietary CrMet supplementation decreased plasma concentrations of glucose.

The economical study indicated in general that, supplementation of Cr recorded best economical efficiency (EE) and relative economical efficiency (REE) compared with all experimental groups. However, the groups fed LME or LMECP diets and supplied with organic Cr recorded the highest EE and REE (1.13, 1.10 and 113.6, 111.4 %, respectively) compared with the EE and REE recorded with the rest groups Table 7.

IN CONCLUSION,

addition of both sources of Cr to LME diet improved and recovery the layer performance to the control group. However, addition of organic Cr for LME diet recorded the best economical efficiency compared with the other experimental groups.

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Table (1): Composition and calculated analysis of the experimental diets.

Feedstuffs	Basal diet Kg/ton	LME diet Kg/ton	LMECP diet Kg/ton
yellow Corn	627	562	587
Wheat Bran	0	80	97
Soybean Meal (44 %CP)	266	251	206
Vit.-mineral mixture*	3	3	3
NaCl	3	3	3
Di-Calcium phosphate	18	18	18
Limestone	77	77	79.5
Sunflower oil	5	5	5
L.Lysine HCl	0	0	0.5
DL.Methionine	1	1	1
Total	1000	1000	1000
Calculated chemical composition**			
Crude protein%	17.03	17.02	15.51
ME kcal/kg diet	2750	2600	2600
Ether extract %	3.18	3.24	3.36
Crude fiber %	2.85	3.43	3.38
Calcium %	3.06	3.06	3.13
Available phosphorus %	0.46	0.48	0.47
Lysine % diet	0.85	0.85	0.79
Lysine % CP	5.01	4.98	5.09
Methionine %diet	0.35	0.35	0.33
Methionine % CP	2.05	2.06	2.13
TSAA % CP	3.75	3.77	3.89
TSAA % diet	0.75	0.76	0.76
Meth /Lys ratio	0.41	0.41	0.42

*Vit+Min mixture provides per kilogram of diet: vitamin A, 12000 IU; vitamin E, 10 IU; menadione, 3 mg; Vit. D_3, 2200 ICU; riboflavin, 10 mg; Ca pantothenate, 10 mg; nicotinic acid, 20 mg; choline chloride, 500 mg; vitamin B_{12}, 10 µg; vitamin B_6, 1.5 mg; vitamin B_1, 2.2 mg; folic acid, 1 mg; biotin, 50 µg. Trace mineral (milligrams per kilogram of diet): Mn, 55; Zn, 50; Fe, 30; Cu, 10; Se, 0.10;Antioxidant, 3 mg.

**Calculated values were according to NRC (1994) text book values for feedstuffs.

Table (2) Influence of chromium sources on performance of Gimmizah chickens fed either low metabolizable energy or low metabolizable energy and crude protein diets.

Criteria	Control	LME	LMECP	LME*		LMECP**		SEM	P value
				Cr Org	Cr Inorg	Cr Org	Cr Inorg		
Initial BW ,g	1615.9	1600.0	1625.6	1597.9	1592.2	1629.5	1611.5	14.91	0.4567
Final BW ,g	1786.9	1763.0	1785.6	1766.9	1759.2	1700.5	1776.5	22.16	0.8299
BW change ,g	171.0	163.0	160.0	169.0	167.0	170.0	165.0	18.83	0.9995
Egg production, %	70.34^{a}	58.43^{c}	57.24^{c}	69.44^{a}	67.61^{ab}	63.48^{bc}	60.32^{bc}	2.473	0.0008
Egg weight, g	55.06^{a}	54.76^{ab}	53.66^{c}	55.34^{a}	55.38^{a}	54.63^{bc}	53.81^{bc}	0.340	0.0019
Egg mass, g/hen/d	38.76^{a}	32.03^{bc}	30.81^{c}	38.25^{a}	37.45^{ab}	34.34^{bc}	32.49^{bc}	1.381	0.0002
Feed intake, g/hen/d	125.0	125.0	125.0	125.0	125.0	125.0	125.0	ND	ND
FCR, g feed/g egg mass	3.28^{c}	3.95^{ab}	4.13^{a}	3.35^{c}	3.34^{c}	3.64^{b}	3.88^{ab}	0.1527	0.0004
CP intake, g/h/d	21.25^{a}	21.25^{a}	19.38^{c}	21.25^{a}	21.25^{a}	19.69^{b}	19.38^{c}	0.1042	0.0001
ME intake, Kcal/h/d	343.8^{a}	327.5^{b}	327.5^{b}	327.5^{b}	327.5^{b}	327.5^{b}	327.5^{b}	0.0924	0.0001

^{a,b,c} means having different superscripts in the same row are significantly different (P<0.05).
SEM = Standard error of means P value = Probability level *LME = low metabolizable energy
** LMECP = low metabolizable energy and crude protein Cr Org = Organic Chromium
Cr Inorg = Inorganic Chromium FCR= Feed conversion ratio ND = Not done.

Table (3) Influence of chromium sources on egg quality traits of Gimmizah chickens fed either low metabolizable energy or low metabolizable energy and crude protein diets.

Criteria	Control	LME	LMECP	LME*		LMECP**		SEM	P value
				Cr Org	Cr Inorg	Cr Org	Cr Inorg		
Egg Shape index	80.58^{a}	77.21^{bc}	77.23^{bc}	75.47^{c}	77.07^{bc}	77.51^{bc}	76.17^{bc}	0.588	0.0210
Yolk weight, %	32.59	33.10	31.49	32.86	33.56	33.62	32.99	0.592	0.0661
Albumen weight, %	56.86	57.05	58.56	57.06	56.15	55.88	56.80	0.594	0.0843
Shell weight, %	10.54	9.83	9.93	10.17	10.28	10.48	10.19	0.303	0.0742
Shell thickness, µm	0.348^{ab}	0.331^{c}	0.320^{c}	0.369^{a}	0.342^{ab}	0.346^{ab}	0.344^{b}	0.052	0.0306
Yolk index	52.33	53.59	53.06	50.97	53.53	53.97	49.66	0.699	0.3342
Haugh units	87.80^{a}	80.29^{c}	80.23^{c}	86.38^{a}	83.53^{ab}	83.61^{ab}	82.99^{ab}	0.736	0.0331
SWUSA	86.24^{ab}	80.05^{c}	81.27^{c}	90.30^{a}	83.37^{b}	85.27^{ab}	84.06^{b}	0.866	0.0284
Yolk color	6.11	6.55	6.66	6.44	6.44	6.33	6.55	0.272	0.6771

^{a,b,c} means having different superscripts in the same row are significantly different (P<0.05).
SEM = Standard error of means P value = Probability level *LME = low metabolizable energy
** LMECP = low metabolizable energy and crude protein Cr Org = Organic Chromium
Cr Inorg = Inorganic Chromium.

Table (4) Influence of chromium sources on hatchability traits of Gimmizah chickens fed either low metabolizable energy or low metabolizable energy and crude protein diets.

Criteria	Control	LME	LMECP	LME*		LMECP**		SEM	P Value
				Cr Org	Cr Inorg	Cr Org	Cr Inorg		
Fertility,%	90.76^{a}	81.29^{bc}	77.77^{c}	92.08^{a}	88.02^{ab}	91.14^{a}	82.75^{bc}	2.249	0.0002
Hatchability of fertile eggs, %	88.55^{ab}	87.07^{b}	84.87^{b}	94.03^{a}	93.09^{a}	90.12^{ab}	88.85^{ab}	1.799	0.0135
Hatchability of total eggs, %	80.25^{ab}	70.07^{c}	66.87^{c}	86.60^{a}	82.04^{ab}	82.16^{ab}	73.37^{bc}	2.9271	0.0003
Chick weight, g	38.81^{ab}	38.56^{bc}	38.04^{d}	39.96^{a}	38.73^{ab}	38.28^{cd}	38.14^{d}	0.103	0.0001
Chick weight, %	71.50^{ab}	70.43^{bc}	69.22^{c}	72.26^{a}	71.90^{ab}	69.14^{bc}	69.57^{bc}	0.642	0.0165

^{a,b,c} means having different superscripts in the same row are significantly different ($P<0.05$).
SEM = Standard error of means P value = Probability level *LME = low metabolizable energy
** LMECP = low metabolizable energy and crude protein Cr Org = Organic Chromium
Cr Inorg = Inorganic Chromium.

Table (5) Influence of chromium sources on some blood hematology of Gimmizah chickens fed either low metabolizable energy or low metabolizable energy and crude protein diets.

Criteria	Control	LME	LMECP	LME*		LMECP**		SEM	P value
				Cr Org	Cr Inorg	Cr Org	Cr Inorg		
RBCs, x10^{6}/mm^{3}	2.63	2.60	2.50	2.72	2.57	2.51	2.53	0.119	04963
Hgb, g/dl	12.16	11.94	11.88	11.78	12.02	10.98	11.78	0.118	0.8502
PCV, %	34.98	34.70	32.80	35.42	33.44	32.90	31.76	1.222	0.2601
WBCs, x10^{3}/mm^{3}	25.22^{ab}	24.00^{bc}	23.16^{c}	25.48^{a}	24.26^{b}	23.68^{c}	23.18^{c}	0.451	0.0053
Lymphocyte, %	45.60	45.00	43.20	47.60	46.60	45.40	45.60	2.324	0.9222
Heterophil, %	26.48^{a}	27.72^{a}	26.24^{a}	24.45^{b}	24.01^{ab}	22.24^{b}	22.82^{b}	1.299	0.0025
H/L ratio	59.22	61.26	62.24	51.34	52.04	51.36	51.22	6.196	0.5200
Phagocytic Activity,%	19.8^{abc}	18.4^{c}	18.8^{bc}	21.6^{a}	22.20^{a}	21.4^{ab}	21.8^{a}	0.863	0.0185
Phagocytic Index,%	1.51^{ab}	1.39^{b}	1.41^{b}	1.66^{a}	1.68^{b}	1.63^{b}	1.62^{b}	0.063	0.0109

^{a,b,c} means having different superscripts in the same row are significantly different ($P<0.05$).
SEM = Standard error of means P value = Probability level *LME = low metabolizable energy
** LMECP = low metabolizable energy and crude protein Cr Org = Organic Chromium
Cr Inorg = Inorganic Chromium.

Table (6) Influence of chromium sources on some blood biochemical constituents of Gimmizah chickens fed either low metabolizable energy or low metabolizable energy and crude protein diets.

Criteria	Control	LME	LMECP	LME*		LMECP**		SEM	P value
				Cr Org	Cr Inorg	Cr Org	Cr Inorg		
Total protein, g/dl	5.26	5.04	4.76	5.41	5.35	5.24	5.12	0.172	0.2664
Albumin, g/dl	2.97[a]	2.87[ab]	2.61[c]	3.18[a]	3.13[a]	2.98[a]	2.92[ab]	0.101	0.0289
Globulin, g/dl	2.29	2.17	2.15	2.23	2.22	2.26	2.20	0.099	0.9709
A/G ratio	1.30	1.34	1.22	1.43	1.41	1.33	1.32	0.055	0.2472
Total lipid, mg/dl	495[a]	504[a]	512[a]	395[c]	442[bc]	409[c]	442[bc]	14.136	0.0001
Triglycerides,mg/dl	161[a]	164[a]	165[a]	139[d]	151[bc]	143[cd]	151[bc]	3.527	0.0004
Cholesterols,mg/dl	143[a]	138[a]	145[a]	125[b]	140[a]	137[a]	144[a]	2.634	0.0010
HDL, mg/dl	50.3	51.7	54.9	51.7	54.7	52.5	51.1	1.705	0.5241
LDL, mg/dl	60.4	54.0	57.2	45.3	54.8	56.0	61.7	3.741	0.1611
MDA, Mmol/dl	1.15[a]	1.15[a]	1.20[a]	0.82[c]	0.90[bc]	0.90[bc]	0.95[bc]	0.061	0.0026
TAC, Mmol/dl	407[b]	399[b]	396[b]	444[a]	445[a]	461[a]	449[a]	11.330	0.0026
GSH, U/dl	973[b]	967[b]	970[b]	999[a]	991[a]	994[a]	990[a]	2.709	0.0001
Calcium, mg/dl	22.1[d]	22.8[cd]	22.6[d]	24.5[ab]	24.0[b]	25.5[a]	25.2[ab]	0.397	0.0001
Phosphorus, mg/dl	7.31	7.13	7.05	7.28	7.13	7.20	7.22	0.117	0.7950
Ca/P ratio	3.02[c]	3.20[bc]	3.21[bc]	3.37[ab]	3.36[ab]	3.54[a]	3.49[a]	0.074	0.0020
Insulin, U/L	3.94[b]	3.87[b]	3.83[b]	5.95[a]	5.75[a]	5.83[a]	5.79[a]	0.112	0.0001
Glucose, mg/dl	221[a]	217[a]	214[a]	186[b]	195[b]	190.0[b]	191[b]	3.867	0.0001

[a,b,c] means having different superscripts in the same row are significantly different ($P<0.05$).
SEM = Standard error of means P value = Probability level *LME = low metabolizable energy
** LMECP = low metabolizable energy and crude protein Cr Org = Organic Chromium
Cr Inorg = Inorganic Chromium.

Table (7) Influence of chromium sources on economical efficiency (EE) and relative economical efficiency (REE) of Gimmizah chicken fed either low metabolizable energy or low metabolizable energy and crude protein diets at the end of the experiment.

Items	Control	LME	LMECP	LME*		LMECP**	
				Cr Org	Cr Inorg	Cr Org	Cr Inorg
Average of total EP%	70.34	58.43	57.24	69.44	67.61	63.48	60.32
Total egg produced (EP%X112d)[1]	78.8	65.4	64.1	77.8	75.7	71.1	67.6
Egg price (LE)[2]	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Total price of egg (1X2, LE)[3]	118.17	98.16	96.16	116.66	113.58	106.65	101.34
FI /day/ hen (g)[4]	125	125	125	125	125	125	125
Total FI /hen (3X4, kg)[5]	14.77	12.27	12.02	14.58	14.20	13.33	12.67
Price of kg diet (LE)[6]	4.07	3.9	3.6	3.92	3.91	3.62	3.61
Total feed cost/hen(5X6, LE)[7]	60.11	47.85	43.27	57.15	55.52	48.25	45.74
Net Revenue (3-7, LE)	58.01	50.31	52.89	59.51	58.06	58.40	55.60
Economical efficiency, EE	1.07	0.80	0.91	1.13	1.07	1.10	1.01
Relative economical efficiency, REE	100.0	74.3	91.6	113.6	108.4	111.4	101.4

Cr Org = Organic Chromium Cr Inorg = Inorganic Chromium

$$\text{Economical efficiency (E.E)} = \frac{Net\ revenue}{Total\ \ feed\ \ cost} \text{ X 100}$$

Relative economical efficiency (REE), assuming control treatment = 100 %.

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الملخص العربى

"تأثير مصادر الكروميوم المختلفة علي أداء دجاج الجميزة المغذى على علائق منخفضة فى محتواها من الطاقة الممثلة والبروتين الخام "

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أجريت هذة الدراسة لمعرفة مدي تأثير مصادر الكروميوم المختلفة (عضوى؛ كروميوم – مثيونين أو معدنى؛ كلوريد الكروميوم) علي اداء دجاج الجميزة المغذى على علائق إما منخفضة فى محتواها من الطاقة الممثلة أو منخفضة فى محتواها من الطاقه الممثلة والبروتين الخام.أستخدم فى هذة الدراسة عدد 280 طائر (245 دجاجة و 35 ديك) عمر 28 أسبوع من سلالة الجميزة. تم وزن الطيور فرديا وقسمت عشوائيا الى سبع مجموعات كل مجموعة تتكون من خمس مكررات (عدد 35عشة) فى عنبريعمل بالنظام المفتوح (7 دجاجا ت وديك لكل مكررة) حتي نهاية التجربة عند 44 أسبوع. أستخدمت المجموعة الأولي كمجموعة مقارنة (كنترول) وتم تغذيتها علي العليقة الأساسية (2750 ك ك طاقة ممثلة / كجم علف و17 % بروتين خام) ،المجموعة الثانية تم تغذيتها علي عليقة منخفضة فى محتواها من الطاقة الممثلة فقط (2600 ك ك طاقة ممثلة / كجم علف و17 % بروتين خام) ،المجموعة الثالثة تم تغذيتها علي عليقة منخفضة فى محتواها من الطاقة الممثلة والبروتين الخام 2600 ك ك طاقة ممثلة / كجم علف و15,5 % بروتين خام) ،المجموعتين الرابعة والخامسة تم تغذيتها علي العليقة المقدمة للمجوعة الثانية مضافا إليها الكروميوم العضوى و المعدنى بمعدل 1200 ميكروجرام / كجم علف على الترتيب. ،المجموعتين السادسة والسابعة تم تغذيتها علي العليقة المقدمة للمجوعة الثالثة مضافا إليها الكروميوم العضوى و المعدنى بمعدل 1200 ميكروجرام / كجم علف على الترتيب. ويمكن إيجاز النتائج المتحصل عليها فيما يلى :

1 – أدى اضافة الكروميوم العضوى و المعدنى إلى العلائق المنخفضة فى محتواها من الطاقة الممثلة إلى تحسن فى انتاج البيض وكتلة البيض والكفاءة التحويلية للغذاء لدرجة انها لم تختلف معنويا عن مجموعة المقارنة.

2 – أدى اضافة الكروميوم العضوى اوالمعدنى إلى العلائق المنخفضة فى محتواها من الطاقة الممثلة أو المنخفضة فى محتواها من الطاقه الممثلة والبروتين الخام معا إلى تحسن معنوي فى سمك القشرة وزن القشرة بالنسبة لوحدة المساحة وكذلك وحدات هيو حيث انها لم تختلف معنويا عن مجموعة المقارنة.

3 - اوضحت نتائج التجربة أن تغذية الدجاج على علائق منخفضة فى محتواها من الطاقه الممثلة والبروتين الخام معا أدى إلى انخفاض معنوى فى نسبة الخصوبة ونسبة الفقس من البيض الكلى ووزن الكتكوت مقارنة بمجموعة المقارنة ، وأن اضافة الكروميوم العضوى الى العلائق المنخفضة فى محتواها من الطاقة الممثلة فقط أدى إلى ارتفاع معنوي فى تلك الصفات وانها لم تختلف معنويا عن مجموعة المقارنة.

4 - اضافة الكروميوم العضوى اوالمعدنى إلى العلائق المنخفضة فى محتواها من الطاقة الممثلة أو المنخفضة فى محتواها من الطاقه الممثلة والبروتين الخام معا أدى إلى انخفاض معنوي فى محتوى الدم من الجلوكوز والدهون الكلية والجلسريدات الثلاثية وكذلك مستوى دليل أكسدة الدهون (المالونالدهيد) بينما ادى الى ارتفاع معنوى فى محتوى الدم من الكالسيوم والانسيولين ومضادتالاكسدة الكلية والجلوتاثيون مقارنة بباقى المجموعات التجريبية. اضافة الكروميوم العضوى إلى العلائق المنخفضة فى محتواها من الطاقة الممثلة فقط أدى إلى تحسن معنوي فى الخلايا متعددة الصبغ والنشاط البلعمى ودليل النشاط البلعمى مقارنة بالمجموعات المغذاة على علائق منخفضة فى محتواها من الطاقة الممثلة أو منخفضة فى محتواها من الطاقه الممثلة والبروتين الخام.

من النتائج يمكن استخلاص أنه تحت ظروف هذة التجربة فأن اضافة الكروميوم العضوى او المعدنى إلى العلائق المنخفضة فى محتواها من الطاقة الممثلة فقط أدى الى تحسن اداء دجاج الجميزه المغذي على هذة العليقة حيث انها لم تختلف معنويا عن مجموعة المقارنة ، كما ان اضافة الكروميوم العضوى إلى العلائق المنخفضة فى محتواها من الطاقة الممثلة فقط حقق افضل كفاءة اقتصادية (113,6%) مقارنة بالمعاملات التجريبية الأخرى.