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INFLUENCE OF REDUCING CRUDE PROTEIN ON GIMMIZAH CHICKENS PERFORMANCE DURING LATE LAYING PERIOD 1- SUPPLEMENTED WITH ZINC AND VITAMIN D_3

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ABSTRACT: This study was performed to investigate the influence of low crude protein diet (LCP, 13%) and different dietary levels of zinc with or without vitamin D_3 on the productive and reproductive performance of Gimmizah chickens during the late laying period. A total number of 280 (245 hens + 35 cocks) Gimmizah chickens aged 52-week were individually weighed and randomly divided into seven treatment groups with five replicates for each during the experimental period (52 - 64 weeks of age). The birds of the first group were fed the basal diet (15%CP) and served as control. Second one was fed LCP, 13% without any supplementation, whereas the third and fourth groups were fed LCP diet supplemented with zinc (Zn, 50 and 100 mg/kg diet, respectively). The fifth group was fed LCP diet supplemented with vitamin D_3 (Vit D_3, 2000 IU/kg diet). While, the sixth and seventh groups were fed LCP diet supplemented with Zn (50 mg/kg diet**)** plus Vit D_3 (2000 IU/kg diet), and Zn (100 mg/kg diet**)** plus Vit D_3 (2000 IU/kg diet), respectively. The chickens fed LCP diet had significantly the worst records of egg production, egg mass and feed conversion ratio compared with the control group. While, supplemented LCP diet with Vit D_3 or both levels of Zn plus Vit D_3 similarly restored the previous mentioned parameters to the level of control group. Specific gravity of eggs, yolk dry matter and yolk index for birds fed LCP diet were significantly decreased compared with control. However, supplemented LCP diet with studied agents significantly improved shell weight, shell thickness, SWUSA and yolk color compared with control. Fertility and hatchability percentages for aged chickens fed LCP diet supplemented with both levels of Zn plus Vit D_3 were significantly increased compared with control and LCP diet groups. Birds fed LCP diet supplemented with Vit D_3 or both levels of Zn plus Vit D_3 had significant improvement for RBCs, Hgb, PCV, WBCs, lymphocyte, phagocytic activity, cholesterol, HDL, LDL, antioxidant status and calcium compared with control and LCP diet groups. Total protein, albumin and globulin for birds fed LCP diet supplemented with 50 mg Zn /kg diet plus Vit D_3 did not represent any statistical change compared with control group. In conclusion, supplementing the chickens fed LCP diet (13% CP) during the late stage of laying cycle with Zn (50 mg/kg diet**)** plus Vit D_3 (2000 IU/kg diet) could be a good tool for realizing the best results of productive and reproductive performance besides the best record of economical efficiency.

Key words: Chicken-Crude protein-Zinc-Vitamin D_3-Productivity.

INTRODUCTION

Egg production rate was reduced for older laying hens due to inadequate nutrient intake and lower feed efficiency and this reduction accompanied with increase of egg size without concordant and equal increase in shell weight causing a decrease in eggshell quality and hatchability (Odabasi *et al*., 2007; Rizk *et al*., 2008; Zita *et al*., 2009). The changed parameters due to bird's age accompanied with disorders in the metabolism of vitamin D_3 (Bar *et al*., 1999) and diminish of calcium absorption (Keshavarz and Nakajima, 1993). Moreover, Wu *et al*. (2005) reported that aged chickens need special nutritional requirements. Thus, researchers have been interested in improving aged layer performance, eggshell quality and hatchability while reducing feed costs. Different strategies were mentioned to cover these points including reducing crude protein in diets (Zeweil *et al.*, 2011), and supplementing diets with vitamins and minerals (Nys *et al.*, 2001).

The protein content in the poultry diet plays an important role for improving growth, feed utilization, immunity and productive performance. Also, it exists in hormonal and enzymatic forms which play essential roles in the physiological processes (Beski *et al*., 2015). Layer birds have low dietary crude protein (CP) requirements, thus determining the ideal level of CP in layer diet for improving productive performance and economic returns of laying hens demand more information about bird needs of protein and its effect on performance parameters (Alagawany *et al*., 2016). Many researches have examined the influence of low crude protein diets in laying hens nutrition. Abd El-Maksoud *et al.* (2011) observed that lowering CP in birds diets had a significant effect on egg production and egg mass. Also, Khajali *et al*. (2008) revealed the reduction of chicken performance due to decreasing the protein level in diets by 1.5 % for Hy-line laying hens in the late stage of production.

Zinc (Zn) as trace element is involved in a wide range of protein synthesis and metabolism of carbohydrates (Underwood and Suttle, 1999). It is directly related to catalysis and co-catalysis of enzymes which control cell process including DNA synthesis, normal growth, bone development, reproduction, normal immune function and activating carbonic anhydrase enzyme which is essential for egg shell formation (Innocenti *et al*., 2004). Different studies on the role of Zn supplementation had been done in laying hens and proved the improvement of body weight, egg production, egg quality and shell thickness (Amen and Al-Daraji, 2012; Bahakaim *et al*., 2014; Gerzilov *et al*., 2015). Guo *et al*. (2002) reported that the improvement of eggshell strength in aged chickens need addition of 80 mg Zn/kg diet at 55 and 59 weeks of age. Additionally, Swiatkiewicz and Koreleski (2008) found that using amino acid complexes with Zn and manganese microelements alleviated the negative effect of hen age on eggshell quality, improving eggshell breaking strength in the late phase of the laying cycle (at 62 and 70 weeks of age).

Vitamin D_3 (cholecalciferol, Vit D_3) is an essential dietary factor responsible for normal growth, shell quality, egg production and reproduction in chickens (Ameenuddin *et al*., 1982). Also, it is required to regulate calcium (Ca) and phosphorus (P) homeostasis and bone mineralization (Abe *et al*., 1982). Vitamin D_3 is important for Ca utilization and necessary for good eggshell quality. Some research findings have demonstrated that dietary addition with active metabolite of Vit D_3 (25-OH-D_3), can positively affect eggshell quality (Bar *et al*., 1988). The physiological effect of Vit D_3 is believed to be a result of calcification facilities of bone and biosyntheses of Ca-binding protein, which is involved in active transport of Ca across the intestinal wall (Vaiano *et al*., 1994). Abdel-Azeem and El-Shafei (2006) found that feed conversion, shell thickness and plasma calcium ($P<0.05$) were significantly improved when the Vit D_3 increased from 2000 to 3000 IU/kg diet. Additionally, Abd El-Maksoud (2010) noted that increasing dietary levels of Ca up to 4% with a level of 4000 IU/kg diet of Vit D_3 improved eggshell quality without negative effects on productive performance.

The objective of this study was to determine the influence of lower crude protein diet (LCP, 13%) and different dietary levels of zinc with or without vitamin D_3 on the productive and reproductive performance and some physiological responses of Gimmizah chickens during the late laying period.

MATERIALS AND METHODS

The present study was carried out at El-Sabahia Poultry Research Station, Animal Production Research Institute, Agriculture Research Center. The experiment was performed from 15 March to 7 May 2016 to investigate the influence of low crude protein diet (LCP, 13%) and different dietary levels of zinc with or without vitamin D_3 on the productive and reproductive performance and some physiological responses of Gimmizah chickens during the late laying period.

Birds, management and experimental design

A total number of 280 Gimmizah chickens (245 hens + 35 cocks) aged 52-week were individually weighed and randomly divided into seven treatment groups. Each treatment group was represented by five replicates (7 hens + 1 cock) and housed in 35 floor pens (open sided system) until the end of the experiment (64 weeks of age). The first group was served as control and fed the basal diet which contains 15% CP. The second one was fed the low crude protein diet (LCP, 13%) without any supplementation. Whereas, birds of third and fourth groups were fed LCP diet supplied with zinc (Zn, 50 and 100 mg/kg diet, respectively). The fifth group was fed LCP diet supplied with vitamin D_3 (Vit D_3, 2000 IU/kg diet). While, sixth and seventh groups were fed LCP diet supplied with Zn (50 mg/kg diet) plus Vit D_3 (2000 IU/kg diet), and Zn (100 mg/kg diet) plus Vit D_3 (2000 IU/kg diet), respectively. Zinc was supplied to the diet in form of zinc oxide 72%. Experimental diets were formulated according to **Feed Composition for Animal and Poultry Feedstuffs in Egypt (2001)** as shown in Table 1. Feed and water were provided *ad libitum* throughout the experimental period. Birds were subjected to 16 hrs light and 8 hrs dark during the experimental period. Vaccination and medical care were done according to common veterinary care under veterinarian's supervision.

Measurements

Daily egg production (EP) and egg weight (EW, g) were detected for each replicate and egg mass (EM, g/h/d) were calculated. Feed intake (FI, g/h/d) was recorded weekly. 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. Eggs were collected for a 7-day period at 62 week of age and incubated in an automatic incubator. Eggs were candled on day 18 of incubation to identify non fertile eggs. Macroscopic fertility was calculated as the number of fertile eggs as relative to the total number of eggs set while hatchability percentages were calculated as the numbers of hatched chicks as relative to the fertile and total eggs set. Eggs laid on two successive days from each treatment at 60 and 64 weeks of age were used for measuring egg quality traits. Egg shell, yolk, yolk dry matter and albumen were weighed to the nearest 0.1 g (egg shells were washed, the inner eggshell membranes were separated and air-dried for 72 h before weighing). Eggshell thickness (mm) without membranes was determined by micrometer to the nearest 0.01 mm. While, yolk index (YI) was measured according to Funk (1948) and 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 branchial vein, (one into heparinized tube to separate plasma and the other one into unheparinized tube to separate serum) of five birds / treatment. Serum was stored at - 20º C until chemical analysis. Also, fresh blood samples were used for determination of hemoglobin (Hgb), red blood cell count (RBCs), packed cells volume (PCV) and 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 glucose, total protein, albumin, globulin, total lipids, triglycerides, cholesterol, HDL, LDL, urea, creatinine, calcium, and phosphorus were determined using commercial kits produced by Diamond Diagnostics Company (29 Tahreer St. Dokki Giza Egypt). The activity of serum aspartate amino transferase (AST), and serum alanine amino transferase (ALT), were determined spectrophotometrically using available commercial Kits. Serum total antioxidant capacity (TAC), superoxide dismutase (SOD) and Malondialdehyde (MDA) were colorimetrically determined using commercial Kits. The phagocytic activity (PA) and phagocytic index (PI) were measured as suggested by Leijh *et al*. (1986).

Economical efficiency

The total feed cost at the end of the experiment for each treatment was calculated depending upon the local market prices of the ingredients used for formulating the experimental diet. Economical efficiency (EE) and relative economic efficiency (REE) were calculated according to input-output analysis.

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:

$$Y_{ij} = \mu + T_i + e_{ij}.$$

Where: Y_{ij} = an observation, μ = overall mean, T_i = effect of treatment ($i=1,2,3,\ldots.7$) and e_{ij} = experimental random error.

Chicken, Crude protein, Zinc, Vitamin D_3, Productivity.

RESULTS AND DISCUSSION

Productive performance:

Data of Table 2 display the effect of reducing crude protein and different dietary levels of zinc with or without Vit D_3 on productive performance of Gimmizah chickens during late laying period. It can be observed that initial, final and the change of body weight did not represent any significant change among the experimental groups. Similar results were obtained by Sohail *et al*. (2003) who reported that there was no significant effect of decreasing dietary CP levels on BW. Also, Junqueira *et al*. (2006) reported that dietary CP levels (14, 16, 18 and 20%) had no significant influence on final BW and change of BW for commercial laying hens. Moreover, Alagawany (2012) indicated that final BW and change of BW for Gimmizah chickens were not significantly affected with low crude protein diet (13%). Contrarily, Yakout (2010) and Bouyeh and Gevorgian (2011) found that birds with the high CP levels recorded the best value of BW change.

Results of Table 2 indicated that reducing CP in layer diet, from 15 to 13% CP, significantly decreased EP by 8.62%. However, supplementing the diet with both levels of Zn (50 or 100 mg/kg diet) did not compensate the recorded reduction in EP %. On the other hand, addition of Vit D_3 (2000 IU/kg diet) or both levels of Zn plus Vit D_3 for the aged chickens fed LCP diet succeeded in recovery of the decrease in EP % with no statistical difference compared with the control group. Moreover, the highest EP % was recorded for the layer fed LCP diet supplied with Zn (50 mg/kg diet) plus Vit D_3 (2000 IU/kg diet) (65.6%). Also, the lowest significant records of EW (51.1 g/h/d) and EM (29 g/h/d), were observed for group fed LCP diet without any supplementation. In addition to, EW was significantly increased for groups of birds fed LCP diet combined with Vit D_3 (2000 IU/kg diet) compared with other experimental groups except that for group supplied with Zn (100 mg/kg diet). While, supplying LCP diet with both experimental levels of Zn with or without Vit D_3 significantly increased EM compared with those fed LCP diet (13% CP), while no statistical change was observed compared with the control group (layer fed 15% CP). These results are compatible with previous results reported by Meluzzi *et al*. (2001) who noted that EP for hens was significantly decreased by lowering CP levels from 170 g kg^{-1} to 130 and 150 g kg^{-1} CP in layer diets. Moreover, Bunchasak *et al*. (2005) found that birds fed 14% CP represented the worst records of EP, EW and EM than those fed 16 or 18% CP groups during peak period of production. Also, Abd El-Maksoud *et al*. (2011) confirmed the significant reduction of EP and EM with the decrease of CP levels in laying hen diets. On the other hand, Zeweil *et al*. (2011) reported that EP and EM of Baheij laying hens were not influenced by dietary CP levels (12, 14 and 16%). The reduction of productive performance for group of aged hens fed LCP diet could be due to inadequate intake of total nitrogen or insufficient amounts of essential amino acids.

There are different researches regarding the effect of Zn and Vit D_3 on EP, EW and EM. While, there is a paucity of information describing associated change in EP, EW and EM due to supplementing the LCP diet with Zn and Vit D_3. The results of EP improvement in this research are confirmed by different authors, as they reported the improvement of EP in laying hens after addition of Zn (El-Husseiny *et al*., 2008; Bahakaim *et al*., 2014; Gerzilov *et al*., 2015). Supplementing the diet with Zn plays an important role in synthesis and secretion of luteinizing and follicle-stimulating hormones and consequently the enhancement of productive performance as reported by Bedwal and Bahuguna (1994). Also, Gerzilov *et al*. (2015) reported that Zn had anti-stress and antioxidative properties. Moreover, addition of Vit D_3 alleviated the decline in productivity for birds fed deficient diets (Newman and Leeson, 1997). On the other hand, Mattila *et al*. (2004) found that Vit D_3 supplements (6,000 IU/kg feed) had no effects on productive traits of laying hens (20 to 67 wk of age) compared with the control diet (2,500 IU/kg feed). Moreover, Park *et al*. (2005) found that supplementing the diet containing 2,000 ICU/kg of Vit D_3 with the higher levels of Vit D_3 (4,000 or 8,000 ICU/kg) did not induce any difference in EP of laying hens (87 wk).

Results of FI and FCR throughout the experimental period indicated that FI did not statistically differ among the experimental groups and ranged between 124 to 131 g/h/day, while FCR for aged layers fed LCP diet alone was significantly impaired compared with the control group. This might be subjected to similar FI associated with low EP % and EW in LCP diet. Moreover, FCR for aged layers fed LCP diet supplemented with different experimental supplementations did not represent any significant differences compared with control. Moreover, best improvement value of FCR was recorded for groups fed LCP diet supplied with Vit D_3 or supplied with both levels of Zn plus Vit D_3 (3.60, 3.62 and 3.80 g feed/g egg, respectively). The results of the present study regarding FI and FCR are keeping with the results of previous studies. Moustafa *et al*. (2005) and Bouyeh and Gevorgian (2011) reported that feed consumption of laying hens was influenced numerically by CP levels in diets. Moreover, Khajali *et al*. (2008) reported that feed conversion value was impaired ($p<0.05$) for layers fed LCP diet compared to those for control. While, Abd El-Maksoud *et al*. (2011) noted that laying hens consumed more amount of feed in case of feeding low-CP (12 or 14 vs. 16%) diets. The improvements of feed efficiency for birds supplemented with Zn over NRC recommendation are attributed to the effect of Zn on various enzymatic activities by improving digestibility and nutrient absorption (Kucuk *et al*., 2003). Furthermore, Banerjee, (1988) mentioned that activity of some enzymes related to nutrients digestion was increased due to Zn supplementation. These results are supported by Durmus *et al*. (2004) who noted that addition of Zn to diet up to 120 mg/kg leads to improvement of FCR. Also, Cole and Lifshitz (2008) reported that Zn deficiency in animals is claimed to result in anorexia, poor food efficiency and growth impairment. However, Virden *et al.* (2003) and Kim and Patterson (2005) reported that Zn addition had no valuable effect on FCR and FI. The current results of improving FCR due to Vit D_3 supplementation are in accordance with the results of Abdel-Azeem and El-Shafei (2006) who reported that FCR was significantly improved when the Vit D_3 increased from 2000 to 3000 IU/kg in laying quail diet. Moreover, Panda *et al*. (2006) reported that increasing dietary Vit D_3 in laying diet had no effect on FI of white leghorn breeders during 72 to 88 wks of age. It is concluded from the previous results that adding Zn and Vit D_3 to LCP diet of aged Gimmizah chickens had the ability to overcome the age factor and alleviated the decline in the productivity due to lowering the dietary crude protein level.

Egg quality traits:

Lowering CP level for aged layers diets or supplementing the diets with different levels of Zn with or without Vit D_3 had no significant effect on egg shape index, yolk and albumen weight percentages (Table 3). The birds group fed LCP diet only showed significant decrease in egg specific gravity (g/cm$^{3)}$, yolk dry matter (%) and yolk index compared with those for the control group. While, shell weight (%), shell thickness (mm), SWUSA (mg/ cm^3) and Haugh unit score did not significantly differ compared with control group. Whereas, supplementation of LCP diet with both levels of Zn with or without Vit D_3 significantly improved most of the studied egg quality traits (shell weight, shell thickness, SWUSA and yolk color) compared with the control group. Moreover, egg specific gravity, yolk dry matter, yolk index and Haugh unit score did not significantly differ with control group except that for yolk index of group fed LCP diet supplemented with 100 mg Zn /kg diet. Conflicted results were obtained by Novak *et al*. (2008) who reported that the external and internal egg quality parameters did not represent any effect by low CP diets, Also, Haugh unit score and dry yolk weight were significantly increased by decreasing CP levels in layer diets (Alagawany, 2012). However, Zeweil *et al*. (2011) reported that the percentages of egg yolk and egg shape indices were not influenced by dietary CP (12, 14 and 16%) levels. In our study eggshell weight and thickness were not influenced by lowering CP level, which could be explained by the fact that eggshell synthesis requires only a small amount amount of protein (Praes *et al* ., 2104). The result of yolk color in our study is in agreement with data reported by Torki *et al*. (2015) who indicated that yolk color was higher in egg layers which fed diets contained 12 and 10.5% CP compared with those of control layers.

The results of current research regarding improvement of egg quality traits due to additional Zn are supported by Mabe *et al*. (2003) who suggested that Zn, manganese and copper may affect the calcite crystal formation and modification of crystallographic structure for eggshell. Also, Zamani *et al*. (2005) concluded that additional amounts of Zn to the diet had positive effect on eggshell thickness. Guo *et al*. (2002) reported that the improvement of eggshell strength in aged chickens need addition of 80 mg Zn/kg diet at 55 and 59 weeks of age. The importance of improving eggshell structure due to Zn supplementation are explained by Hunton (2005) who mentioned that egg shell is an important structure for embryonic development through the mechanical protection and gas exchange surrounding the eggs. However, Stevenson (1985) stated that high dietary levels of Zn (100 or 200 mg/kg) had no beneficial effect on eggshell thickness.

Improvement results of egg quality traits due to Vit D_3 supplementation as shown in Table 3 are harmony with those reported by previous authors as Elaroussi *et al*. (1994) who mentioned that the hydroxylation reactions is essential to produce metabolically active form i.e.1,25$(OH)_2D_3$ from cholecalciferol which, may be decreased in aged birds. The eggshell formation is depend on the level of 1,25$(OH)_2D_3$ which is needed for the regulation of Ca absorption and excretion and mobilization of Ca from the bone to provide adequate Ca (Abe *et al*., 1982). Ameenuddin *et al*. (1982) stated that Vit D_3 is one of the most crucial dietary factors responsible for eggshell quality in birds. However, addition of Vit D_3 alleviated the decline in productivity and shell quality for birds fed deficient diets (Newman and Leeson, 1997). Some researchers mentioned that addition of active form of Vit D_3, i.e. 25-OH-D_3, to the diet had a positive influence on eggshell quality (Bar *et al*., 1988). Furthermore, Bar (2008) reported that more Vit D_3 content could improve the eggshell quality by increasing the active form of Vit D_3 (1,25$(OH)_2D_3$) production in the kidney. The active form of Vit D_3 stimulates the synthesis of calcium-binding protein which is important for transportation of calcium across the intestinal membrane and may be essential for transportation of calcium for eggshell formation in the shell gland. Abd El-Maksoud (2010) reported that eggshell quality of laying hens was improved due to increasing dietary levels of Ca up to 4% with a level of 4000 IU/kg diet of Vit D_3. On the other hand, Panda *et al*. (2006) reported that increasing dietary Vit D_3 in laying diet had no effect on shell quality of white leghorn breeders during 72 to 88 wks of age. Similarly Browning and Cowieson (2014) fond that using high levels of Vit D_3 (up to 10,000 IU/kg feed) had no influence on eggshell quality.

Accordingly, results obtained herein revealed that the beneficial effect of supplementing the LCP diet with Zn and/or Vit D_3 on egg quality traits is more pronounced in late stage of laying cycle for Gimmizah chickens without adverse effect on laying performance.

Hatching traits:

Data of Table 4 declared that feeding the experimental aged Gimmizah chickens with LCP diet without any supplementations significantly decreased fertility, hatchability percentages compared with control. While, fertility and hatchability of total eggs percentages for chickens fed LCP diet supplemented with different experimental agents were significantly increased compared with control group. Moreover, aged chickens fed LCP diet supplemented with both levels of Zn plus Vit D_3 had significant increase of both hatchability percentages compared with the other experimental groups. It could be concluded from the aforementioned results that supplementing the LCP diet with Zn and Vit D_3 is essential in poultry diets to achieve best results of hatching success. Hatched chick weight percentages for groups fed LCP diet supplemented with Zn (100 mg/kg diet) or Vit D_3 or Zn (50 mg/kg diet) plus Vit D_3 were significantly increased compared with the other experimental groups. Supporting to our results regarding the improvement of hatchability due to Zn supplementation, Badawy *et al*. (1987) observed that hatchability increase is correlated with the increase of Zn supplementation and this increase is primarily due to decrease incidence of late embryonic mortality. Moreover, Swiatkiewicz and Koreleski (2008) reported that Zn supplementation is important for achieving normal productive and reproductive performance. The improvement of hatching output in our data of this research could be related to the improvement of eggshell quality as detected in Table 3 due to the experimental supplementation of Zn and Vit D_3 to the LCP diet.

Blood parameters:

Results of Table 5 illustrated that RBCs, Hgb, PCV, WBC, heterophil, lymphocyte, phagocytic activity and phagocytic index for birds fed LCP diet did not represent statistical change compared with those from control group. Generally, feeding Gimmizah chickens with LCP diet supplied with studied experimental agents improved the hematological parameters during late laying period. Since, layers fed LCP diet supplemented with Vit D_3 or both levels of Zn plus Vit D_3 had significant improvement for each of RBCs, Hgb, PCV, WBCs, lymphocyte and heterophil compared with the control group, while H/L ratio was not significantly differed among all experimental groups. The results reveal the beneficial effect of the combining ability of Zn and Vit D_3 on some hematological parameters. Southern and Baker (1983) documented that supplementation of 2000 mg Zn/kg of diet did not affect blood Hgb or PCV in chicks. Moreover, Torki *et al*. (2015) reported that ratio of heterophil to lymphocyte was significantly ($p<0.05$) declined by diets contained 15, 13.5 and 12 % of CP. Furthermore, supplementation of LCP diet with the studied agents significantly increased phagocytic activity and index compared with control and LCP diet groups. The appeared increase of phagocytic activity and index in the current results could play a vital role in improving the immunity of birds as confirmed by Solomons (1998) who stated that the improvement of the immunity function may be due to the playing role of Zn in humeral immune system. Also, Ibs and Lothar (2003) reported that Zn enhances proliferation ability of B-cells, pre B-cell and immature B-cell.

Blood glucose concentrations for groups fed LCP diet supplied with 50 mg Zn/kg diet or Vit D_3 or both levels of Zn plus Vit D_3 were significantly increased compared with the control and LCP groups (Table 6). The improvement of glucose concentrations due to Zn supplementation in our data is supported and explained by Underwood and Suttle, (1999) who mentioned that glucose improvement in this case could be due to the important role of Zn in metabolic activities such as carbohydrates metabolism. Also, Cole and Lifshitz, (2008) reported that Zn supplementation has a role in the regulation of appetite and insulin resistance.

Data of the same table show that total protein, albumin and globulin concentrations were significantly decreased for birds fed LCP diet compared to control group. Furthermore, supplying LCP diet with both levels of Zn with or without Vit D_3 significantly increased total protein and globulin compared with the group fed LCP diet. However, the value of albumin / globulin ratio did not represent any statistical change among the experimental groups. In this context, current results are generally in harmony with the results of Bunchasak *et al*. (2005) who mentioned that plasma total protein and globulin for layers were increased by increasing the dietary CP levels from 12-14 and 14-16%. On the other hand, plasma albumin was numerically affected by the dietary CP levels (Zeweil *et al*., 2011).

Total lipids, triglycerides and cholesterol for layers fed LCP diet alone were significantly increased compared with those for control group. Generally, the lipid profile was significantly improved for groups fed LCP diet supplemented with different studied agents compared with the LCP diet group. While, comparable with control group, total lipids, triglycerides did not represent any statistical difference. Also, the concentration of cholesterol and LDL were significantly decreased for layers fed LCP diet supplied with all experiment agents compared with the control and LCP diet groups, while, the opposite trend was observed with the increase of HDL. Supporting to the current results, Ghasemi *et al*. (2014) noted that Plasma triglycerides concentration was increased ($p<0.05$) for the group contained 13.9% CP compared to groups contained 15.4% CP in Lohmann laying hens. Also, Torki *et al*. (2015) found that blood triglycerides concentration was significantly higher in layers received 12 and 10.5% CP diets compared with those of control (16.5% CP). On the other hand, Saki *et al*. (2015) reported that blood total cholesterol and low density lipoprotein were not significantly influenced by different concentration of CP.

The improvement obtained herein of lipid profile due to Zn supplementation confirmed those of Herzig *et al*. (2009) who reported that plasma cholesterol was decreased ($p<0.05$) for broilers fed high amounts of dietary Zn. Also, Aksu *et al*. (2010) reported that supplementing the diet with organic complex of Zn, copper and manganese decreased plasma LDL cholesterol, combined with the increase in HDL cholesterol in chickens. In addition, Tomas and Eva (2011) declared the positive impact of Zn on lipid metabolism indices in cocks. On the other hand, Kucuk *et al*. (2008) did not confirm any statistic differences in the concentrations of glucose, total cholesterol and triglycerides due to supplementing the diet with 30 mg of Zn per 1 kg of a feed mixture.

The activity of AST and ALT enzymes were not significantly differed among all experimental groups. Plasma uric acid and creatinine concentrations were significantly decreased for the experimental groups fed LCP diet with or without supplemented agents compared with the control group. The antioxidant indices including MDA, TAC and SOD were significantly improved for the groups fed LCP diet supplied with different experimental agents compared with the control and LCP diet groups. Baum *et al*. (2000) mentioned that Zn is a vital part of superoxide dismutase (SOD) enzyme that plays antioxidant defense system. Furthermore, Atakisi *et al*. (2009) found that Zn supplementation improved TAC and reduced MDA concentrations in Japanese quails. The mechanism of Zn function as an antioxidant was explained by Bao *et al*. (2013) who stated that Zn increases the activation of antioxidant proteins, molecules, and enzymes such as glutathione (GSH), catalase, and SOD.

Blood calcium and phosphorus concentrations of groups fed LCP diet with or without experimental supplementations were significantly increased compared with the control group. The increase of plasma calcium due to Vit D_3 supplementation in this study is supported by Abdel-Azeem and El-Shafei (2006) who reported that plasma calcium was significantly improved when the Vit D_3 increased from 2000 to 3000 IU/kg in laying quail diet. Therefore, the improvement in antioxidant status, kidney function, phagocytic activity and phagocytic index due to supplementing the LCP diet with Zn (50 mg/kg diet) plus Vit D_3 (2000 IU/kg diet) could be the reason of improvement in productive performance for Gimmizah chickens at the late stage of egg production.

Economical evaluation:

Data of Table 7 indicated that highest economical efficiency (0.72) and relative economical efficiency (112.3%) were recorded for the group fed LCP diet supplemented with Zn (50 mg/kg diet**)** plus Vit D_3 (2000 IU/kg diet) compared with those for control group.

IN CONCLUSION, supplementing the Gimmizah chickens fed LCP diet (13% CP) during the late stage of laying cycle with Zn (50 mg/kg diet**)** plus Vit D_3 (2000 IU/kg diet) could be a good tool for realizing the best results of productive and reproductive performance besides the best record of economical efficiency.

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Table (1): Ingredient and calculated composition of the experimental diets for Gimmizah chickens

Ingredients	**Basal diet Kg/ton (D1)**	**Low crude protein diet Kg/ton (D2)**	**Calculated composition**		
				D1	**D2**
Yellow corn,	670.0	704.0	ME, kcal/Kg	2750	2750
Soybean meal (44%)	215.0	154.0	CP, %	15.0	13.0
Wheat Bran	8.0	34.0	Lysine, %	0.73	0.64
Limestone	81.0	81.27	Methionine, %	0.33	0.28
Dicalcium phosphate	18.0	18.5	TSAA,%	0.59	0.51
Premix*	3.0	3.0	Calcium, %	3.18	3.19
NaCl,	3.0	3.0	Avail. Phos. %	0.46	0.46
DL.Methionine	1.0	0.78	Zinc, mg/kg	71	71
L.Lysine HCl	0.0	0.45			
Choline Chloride	1.0	1.0			
Total	1000	1000			

*Provided the following per kg of diet:Vit. A, 1200 IU; Vit. D. 2000 IU; Vit. E, 100 IU; Vit. C, 3 mg; Vit. K, 4 mg; VitB1, 3 mg; Vit B2, 3 mg; Vit B6, 5 mg; Vit B12, 0.03 mg; Bantothinic acid, 15 mg; Folic acid, 2 mg; Biotin, 0.20 mg; Cobalt, 0.05 mg; Copper, 10 mg; Iodin, 50 mg; Manganese, 90 mg; Selenium, 0.20 mg and Zinc, 50 mg.

Table (2): Influence of reduced crude protein and different dietary levels of zinc with or without vitamin D_3 on productive performance of Gimmizah chickens during late laying period

Criteria	Control CP (15%)	Low crude protein (13%) diets						SEM	P Value
		Only	+Zn 50mg /kg diet	+Zn 100mg /kg diet	+Vit D_3 2000IU /kg diet	+Zn50mg + Vit D_3 2000 IU /kg diet	+Zn100mg + Vit D_3 2000 IU /kg diet		
Initial BW (52 WK),g	1851	1827	1835	1868	1854	1851	1873	90.34	0.7869
Final BW (64 WK),g	1953	1922	1933	1961	1953	1949	1968	104.7	0.9005
Change of BW(52-64 WK),g	102	95.0	97.9	93.1	99.0	98.0	95.1	55.02	0.9996
Egg production %	62.3^{ab}	56.7^{c}	58.3^{c}	57.7^{c}	62.0^{ab}	65.6^{a}	60.7^{b}	3.775	0.0271
Egg weight, g	53.7^{c}	51.1^{d}	53.8^{c}	55.5^{ab}	56.4^{a}	54.7^{bc}	53.7^{c}	0.5607	0.0001
Egg mass, g/h/d	33.5^{ab}	29.0^{c}	31.4^{ab}	32.0^{ab}	35.0^{a}	35.9^{a}	32.6^{ab}	2.094	0.0098
Feed intake, g/h/d	126	131	129	128	126	130	124	3.316	0.3231
FCR, g feed/g egg	3.92^{b}	4.51^{a}	4.14^{ab}	4.05^{ab}	3.60^{b}	3.62^{b}	3.80^{b}	0.2595	0.0248

a,b,c,d means having different superscripts in the same row are significantly different ($P < 0.05$).
SEM: standard error of means, P value: probability level, CP: crude protein, BW: body weight, FCR: feed conversion ratio.

Table (3): Influence of reduced crude protein and different dietary levels of zinc with or without vitamin D_3 on egg quality of Gimmizah chickens during late laying period

Criteria	Control CP (15%)	Low crude protein (13%) diets						SEM	P Value
		Only	+Zn 50mg /kg diet	+Zn 100mg /kg diet	+Vit D_3 2000 IU /kg diet	+Zn50mg +Vit D_3 2000 IU /kg diet	+Zn100mg +Vit D_3 2000 IU /kg diet		
Egg shape index	78.2	75.8	77.9	76.9	75.8	75.4	76.0	1.590	0.4131
Specific gravity, g/cm^3	1.083^{ab}	1.077^{c}	1.082^{ab}	1.086^{ab}	1.084^{ab}	1.088^{a}	1.080^{bc}	0.0104	0.0206
Shell weight %	8.88^{b}	9.00^{b}	9.95^{a}	10.16^{a}	10.45^{a}	10.37^{a}	10.07^{a}	0.3661	0.0003
Shell thickness, mm	0.331^{c}	0.348^{bc}	0.373^{ab}	0.370^{ab}	0.383^{ab}	0.373^{ab}	0.387^{a}	0.0163	0.0230
SWUSA[1], mg/cm^2	72.5^{b}	73.7^{b}	81.0^{a}	83.5^{a}	85.8^{a}	85.9^{a}	81.7^{a}	2.601	0.0001
Yolk weight, %	36.0	34.1	36.4	35.3	35.9	35.7	37.3	1.215	0.3058
Albumen weight %	55.1	56.9	53.6	54.5	53.6	53.9	52.7	1.305	0.0770
Yolk dry matter %	16.9^{ab}	15.2^{c}	16.4^{ab}	17.1^{a}	16.6^{ab}	16.2^{ab}	18.0^{a}	0.8367	0.0476
Yolk index	52.5^{a}	47.7^{b}	52.7^{a}	49.1^{b}	50.1^{ab}	50.0^{ab}	50.5^{ab}	1.354	0.0112
Yolk color	5.33^{b}	6.67^{a}	6.33^{a}	6.33^{a}	6.50^{a}	6.50^{a}	6.67^{a}	0.4107	0.0426
Haugh unit score	74.7^{ab}	68.2^{b}	82.6^{a}	79.4^{ab}	82.8^{a}	74.5^{ab}	82.4^{a}	5.862	0.0133

a,b,c means having different superscripts in the same row are significantly different ($P<0.05$).
[1*]SWUSA: shell weight per unit of surface area, CP: crude protein, SEM: standard error of means,
P value: probability level.

Table (4): Influence of reduced crude protein and different dietary levels of zinc with or without vitamin D_3 on hatching traits of Gimmizah chickens during late laying period

Criteria	Control CP (15%)	Low crude protein (13%) diets						SEM	P Value
		Only	+Zn 50mg /kg diet	+Zn 100mg /kg diet	+Vit D_3 2000 IU /kg diet	+Zn50mg +Vit D_3 2000 IU /kg diet	+Zn100mg +Vit D_3 2000 IU /kg diet		
Fertility %	88.0^{c}	83.0^{d}	91.5^{ab}	90.4^{b}	91.7^{ab}	92.6^{a}	92.4^{ab}	0.9571	0.0001
Hatchability of fertile eggs %	90.4^{b}	87.7^{c}	90.7^{b}	90.6^{b}	90.9^{b}	92.5^{a}	92.9^{a}	0.8922	0.0001
Hatchability of total eggs %	79.5^{c}	72.7^{d}	82.9^{b}	81.9^{b}	83.3^{b}	85.2^{a}	85.5^{a}	0.7746	0.0001
Hatched chick weight %	66.0^{bc}	65.0^{c}	66.1^{bc}	69.2^{a}	68.6^{a}	69.7^{a}	67.9^{ab}	0.6693	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, CP: crude protein.

Table (5): Influence of reduced crude protein and different dietary levels of zinc with or without vitamin D_3 on hematological parameters and some immunological traits of Gimmizah chickens during late laying period

Criteria	Control CP (15%)	Low crude protein (13%) diets						SEM	P Value
		Only	+Zn 50mg /kg diet	+Zn 100mg /kg diet	+Vit D_3 2000 IU /kg diet	+Zn50mg +Vit D_3 2000 IU /kg diet	+Zn100mg +Vit D_3 2000 IU /kg diet		
RBCs, x10^6/mm^3	2.40^{b}	2.35^{b}	2.44^{b}	2.38^{b}	2.65^{a}	2.62^{a}	2.67^{a}	0.0825	0.0016
Hgb, g/dl	10.66^{c}	10.84^{bc}	11.10^{bc}	10.86^{bc}	12.63^{a}	12.27^{a}	11.73^{ab}	0.4340	0.0003
PCV %	27.13^{c}	26.80^{c}	31.90^{b}	32.16^{b}	35.90^{a}	34.14^{a}	35.16^{a}	1.092	0.0001
WBCs, x10^3/mm^3	23.46^{bc}	22.92^{c}	24.86^{bc}	25.00^{ab}	26.56^{a}	26.86^{a}	25.95^{a}	0.8951	0.0042
Lymphocyte %	41.20^{cd}	39.40^{d}	45.00^{ab}	44.00^{b}	46.60^{a}	47.00^{a}	46.20^{a}	3.150	0.0160
Heterophil %	24.46^{c}	24.73^{bc}	27.70^{ab}	26.06^{abc}	27.56^{ab}	28.16^{a}	27.42^{ab}	1.327	0.0406
H/L ratio	60.80	62.82	61.88	60.28	60.44	60.18	60.04	5.817	0.9988
Phagocytic Activity%	17.0^{c}	16.3^{c}	20.3^{b}	19.7^{b}	19.3^{b}	22.0^{a}	21.0^{ab}	0.7589	0.0001
Phagocytic Index %	1.41^{c}	1.39^{c}	1.64^{ab}	1.57^{b}	1.55^{b}	1.77^{a}	1.64^{ab}	0.0721	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, CP: crude protein, RBC: Red blood cells, Hgb: hemoglobin, PCV: Packed-cell volume, WBCs: White blood cell, H/L ratio: Heterophil / lymphocyte ratio.

Table (6): Influence of reduced crude protein and different dietary levels of zinc with or without vitamin D_3 on some blood biochemical constituents of Gimmizah chickens during late laying period

Criteria	Control CP (15%)	Low crude protein (13%) diets						SEM	P Value
		Only	+Zn 50mg /kg diet	+Zn 100mg /kg diet	+Vit D_3 2000 IU /kg diet	+Zn50mg +Vit D_3 2000 IU /kg diet	+Zn100mg +Vit D_3 2000 IU /kg diet		
Glucose, (mg/dl)	187^{c}	190^{bc}	192^{ab}	191^{abc}	193^{ab}	195^{a}	192^{ab}	1.990	0.0136
Total protein, (g/dl)	4.66^{a}	3.58^{c}	4.21^{ab}	4.25^{ab}	4.15^{ab}	4.33^{a}	4.11^{ab}	0.2546	0.0134
Albumin, (g/dl)	2.71^{a}	2.12^{c}	2.49^{ab}	2.42^{abc}	2.37^{bc}	2.60^{ab}	2.35^{bc}	0.1428	0.0082
Globulin, (g/dl)	1.96^{a}	1.46^{c}	1.69^{b}	1.83^{ab}	1.78^{ab}	1.75^{ab}	1.76^{ab}	0.1095	0.0063
Total lipids, mg/dl	392^{b}	455^{a}	368^{b}	398^{b}	385^{b}	357^{b}	403^{b}	20.56	0.0020
Triglycerides, mg/dl	142^{b}	163^{a}	145^{b}	148^{b}	141^{b}	137^{b}	140^{b}	6.557	0.0102
Cholesterol, mg/dl	138^{b}	148^{a}	127^{c}	129^{c}	124^{c}	126^{c}	129^{c}	3.617	0.0001
HDL, mg/dl	49.72^{c}	50.23^{c}	53.57^{ab}	56.09^{ab}	55.32^{ab}	56.04^{ab}	57.01^{a}	1.709	0.0003
LDL, mg/dl	59.57^{a}	64.86^{a}	45.75^{b}	43.43^{b}	40.19^{b}	42.39^{b}	43.99^{b}	4.055	0.0001
AST, U/L	34.7	33.6	34.4	34.8	33.4	34.1	32.28	2.030	0.8837
ALT, U/ L	15.9	15.5	14.6	15.4	15.8	14.8	15.7	0.7797	0.5409
Urea, mg/dl	27.37^{a}	25.27^{b}	22.70^{cd}	23.10^{c}	21.27^{e}	20.67^{e}	21.67^{de}	0.6481	0.0001
Creatinine, mg/dl	0.926^{a}	0.883^{b}	0.772^{c}	0.830^{bc}	0.756^{c}	0.820^{bc}	0.791^{c}	0.0346	0.0003
MDA, Mmol/dL	1.180^{a}	1.117^{a}	0.824^{b}	0.836^{b}	0.827^{b}	0.787^{b}	0.766^{b}	0.0490	0.0001
TAC, Mmol/dL	396^{b}	405^{b}	454^{a}	456^{a}	461^{a}	469^{a}	462^{a}	8.989	0.0001
SOD, U/dl	221^{c}	218^{c}	252^{a}	257^{a}	234^{b}	259^{a}	254^{a}	5.717	0.0001
Calcium, mg/dl	22.51^{d}	23.32^{c}	24.28^{b}	24.62^{b}	25.72^{a}	25.46^{a}	25.53^{a}	0.3639	0.0001
Phosphorous, mg/dl	6.40^{b}	6.85^{a}	6.98^{a}	7.06^{a}	7.26^{a}	7.18^{a}	7.17^{a}	0.2020	0.0039

^{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, CP: crude protein, HDL: high density lipoprotein, LDL: low density lipoprotein, AST: Aspartate amino transferase, ALT: Alanine amino transferase, MAD: Malondialdehyde, TAC: Total antioxidant capacity, SOD: Superoxide dismutase. .

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Table (7): Influence of reduced crude protein and different dietary levels of zinc with or without vitamin D_3 on economical efficiency (EE) and relative economical efficiency (REE) of experimental treatments.

Criteria	Control CP (15%)	Low crude protein (13%) diets					
		Only	+Zn 50mg /kg diet	+Zn 100mg /kg diet	+Vit D_3 2000IU /kg diet	+Zn50mg +Vit D_3 2000 IU /kg diet	+Zn100mg +Vit D_3 2000 IU /kg diet
Egg production %	62.3	56.7	58.3	57.7	62.0	65.6	60.7
Total egg produced (EP% X84d)[1]	52.3	47.6	49.0	48.5	52.1	55.1	51.0
Egg price (LE)[2]	66.3	60.3	62.0	61.4	66.0	69.8	64.6
FI /day/ hen (g)[3]	126	131	129	128	126	130	124
Total FI /hen Kg (3X84day)[4]	10.6	11.0	10.8	10.8	10.6	10.9	10.4
Price of kg diet (LE)[5]	3.82	3.7	3.71	3.72	3.73	3.72	3.74
Total feed cost/hen(4X5, LE)[6]	40.4	40.7	40.2	40.0	39.5	40.6	39.0
Net Revenue (2-6, LE)	25.9	19.6	21.8	21.4	26.5	29.2	25.6
Economical efficiency, EE	0.64	0.48	0.54	0.53	0.67	0.72	0.66
Relative economical efficiency, EE	100	75.3	84.9	83.6	104.9	112.3	102.9

[2]Price of 30 eggs = 38 LE, Economical efficiency (E.E) = (Net Revenue / Total feed cost) *100
Relative economical efficiency (REE), assuming control treatment = 100 %

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الملخص العربى

"تأثير خفض مستوى البروتين على أداء دجاج الجميزة خلال المرحلة الاخيرة من الانتاج."

1- بإضافة الزنك وفيتامين د3

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أجريت هذة التجربة لدراسة تأثير خفض مستوى البروتين واستخدام مستويات مختلفة من الزنك وفيتامين د3 بالعلائق على أداء الدجاج البياض خلال المرحلة الاخيرة من الانتاج. استخدم فى هذة التجربة عدد 280 طائر (245 دجاجة و 35 ديك) عمر 52 اسبوع من سلالة الجميزة. تم وزن الطيور فرديا وقسمت عشوائيا الى سبع مجموعات كل مجموعة تتكون من خمس مكررات حتى نهاية التجربة عند 64 اسبوع. أستخدمت المجموعة الأولي كمجموعة مقارنة (كنترول) وتم تغذيتها علي العليقة الأساسية (15 % بروتين خام) ،المجموعة الثانية تم تغذيتها علي عليقة منخفضة فى محتواها من البروتين الخام (13 % بروتين خام)، المجموعتين الثالثة والرابعة تم تغذيتهما على نفس العليقة المقدمة للمجموعة الثانية مضافا إليها الزنك بمعدل 50 ، 100 مليجرام/كجم علف علي الترتيب. المجموعة الخامسة تم تغذيتها على نفس العليقة المقدمة للمجموعة الثانية مضافا إليها فيتامين د3 بمعدل 2000 وحدة دولية/كجم علف. المجموعتين السادسة والسابعة تم تغذيتهما على نفس العليقة المقدمة للمجموعة الثانية مضافا إليها الزنك بمعدل 50 مليجرام/كجم علف مع فيتامين د3 بمعدل 2000 وحدة دولية/كجم علف ، الزنك بمعدل 100 مليجرام/كجم علف مع فيتامين د3 بمعدل 2000 وحدة دولية/كجم علف على الترتيب. ويمكن إيجاز النتائج المتحصل عليها فيما يلى : أدى تغذية الدجاج خلال المرحلة الاخيرة من انتاج البيض على علائق منخفضة فى محتواها من البروتين الخام (13 % بروتين خام) الى انخفاض معنوى فى نسبة انتاج البيض وكتلة البيض وكذلك تدهور معنوى فى الكفاءة التحويلية للغذاء مقارنة بمجموعة المقارنة. بينما أدى اضافة فيتامين د3 أو الزنك مع فيتامين د3 إلى العلائق المنخفضة فى محتواها من البروتين إلى تحسن معنوى فى تلك الصفات مقارنة بمجموعة المقارنة. كذلك أدى تغذية الدجاج على علائق منخفضة فى محتواها من البروتين الخام إلى انخفاض معنوى فى الكثافة النوعية للبيض، نسبة الصفار الجاف، دليل الصفار مقارنة بمجموعة المقارنة. بينما أدت الاضافات التجريبية المختلفة لتلك العلائق الى تحسن معنوى فى كلا من وزن و سمك قشرة البيض ووزن القشرة بالنسبة لوحدة المساحة وكذلك لون الصفار مقارنة بمجموعة المقارنة.

أظهرت النتائج أن تغذية الدجاج خلال المرحلة الاخيرة من انتاج البيض على علائق منخفضة فى محتواها من البروتين الخام (13 % بروتين خام) مضافا اليها الزنك مع فيتامين د3 يودى الى تحسن معنوى فى نسبة الخصوبة ونسب الفقس مقارنة بمجموعة المقارنة أوتلك المغذاة على عليقة منخفضة فى محتواها من البروتين. كذلك أدى اضافة فيتامين د3 أو الزنك مع فيتامين د3 إلى علائق دجاج الجميزة المنخفضة فى محتواها من البروتين إلى تحسن معنوى عدد كرات الدم الحمراء والبيضاء، الهيموجلوبين، حجم كرات الدم، الخلايا الليمفاوية، النشاط البلعمى، مضادات الاكسدة، الكولستيرول الكلى، الكولستيرول منخفض الكثافة، الكولستيرول عالى الكثافة ، الكالسيوم مقارنة بمجموعة المقارنة أوتلك المغذاة على عليقة منخفضة فى محتواها من البروتين. من ناحية اخري فان محتوى الدم من البروتين الكلى، الجلوبيولين، الالبيومين بالنسبة للدجاج المغذى على علائق منخفضة فى محتواها من البروتين ومضافا اليها الزنك بمعدل 50 مليجرام/كجم علف مع فيتامين د3 بمعدل 2000 وحدة دولية/كجم علف لم يختلف معنويا عن مجموعة المقارنة.

الخلاصة: خلال الفترة الاخيرة من انتاج البيض يمكن تغذية الدجاج على علائق منخفضة فى محتواها من البروتين الخام (13% بروتين خام) مضافا اليها الزنك بمعدل 50 مليجرام/كجم علف مع فيتامين د3 بمعدل 2000 وحدة دولية/كجم علف وذلك للحصول على افضل نتائج بالنسبه للاداء الانتاجي والتناسلى بجانب تحقيق أفضل كفاءة اقتصادية.