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SUPPLEMENTATION EFFECTS OF CHOLINE CHLORIDE TO LAYER HEN RATION ON PRODUCTIVE PERFORMANCE

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ABSTRACT

A flock of one hundred twenty-eight laying hens of brown Loman classic chickens, fifty-seven weeks old, was used in the current study. Hens were raised in the poultry fields - Department of Animal Production -College of Agriculture and Forestry, University of Mosul, in a semi-closed hall divided into pens. The hens were allocated into four groups with 3 replicates/ group, the hens were fed a balanced diet supplemented with choline chloride in proportions of 0.0, 0.12, 0.17 and 0.22 % of diet respectively, to evaluate the effect of choline as a nutritional supplement on the productive performance of laying hens in the late productive age stages. The rearing period lasted seven weeks, during which some productive traits and egg characteristics were measured—as well as some reproductive parameters and some blood biochemical characters. The results revealed that choline supplementation improves significantly the weekly average egg weight, egg production, and egg mass as well as feed conversion ratio, thickness of the shell. Weight of the shell, the diameter, and the height of the yolk. All studied blood parameters were insignificantly affected by choline chloride supplementation. In conclusion, the choline chloride supplementation improves productive performance, especially in the late stages of production for laying hens.

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INTRODUCTION

Laying flocks is one of the two fundamental components of poultry production, as their survival and productivity over an extended period are key factors in their success. Since their long-term survival and productivity are critical to their success, laying flocks is one of the two essential elements of the poultry industry (Raquib *et al*., 2022 and Al-Zuhariy, 2022).

Nutritional supplements and medicinal plants (Alkado *et al*., 2023) have been introduced in the poultry industry and layer flocks due to their impact on enhancing egg production and performance and maintaining efficiency as much as possible at the late stages of production (Fadel *et al*., 2023).

DL-methionine, which is considered one of the most significant amino acids present in the constituent parts of the egg, notably the yolk, has a higher mean ratio benefit (Igbasan *et al*.,2012). Recently, employing choline chloride has been shown to lower the expense of using methionine, because it is a part of the phospholipid of egg yolk, which is rich in phosphatidyl choline, it is also involved in the synthesis of phosphorous lecithin, this makes up 75% of all low-density phospholipids

(Moghadam *et al*., 2021 and Abou-Kassem *et al* .,2022), and is transported from the liver to the egg yolk via blood stream . (Long *et al*., 2018; Neijat *et al*., 2017; and Zhai *et al*., 2013) reported that adding 1.7% choline chloride increased the amount of low-density lipoproteins released by the liver.

Choline is also a water-soluble vitamin important in synthesizing membrane phospholipids (Hollenbeck, 2010). It is officially recognized as an essential nutritional factor by the Food and Nutrition Board of the Institute of Medicine in the United States. Dong *et al*. (2019) stated that adding choline at different levels decreased total liver fat and triglycerides and enhanced the activity of liver enzymes. These dietary modifications, such as the use of medicinal plants and nutritional supplements, are intended to enhance production and raise the quality of animal products (Abdul-Majeed and Al-Krad, 2023; Al-Khateeb and Al-Sufi 2023; Mustafa *et al*., 2024 and Qader and Tayeb, 2024).

As a management strategy to overcome the low feed assimilation rate due to oviduct deterioration with the advancing age of laying hens, the goal of the current research is to use choline chloride as a dietary supplement to maintain egg quality and productive performance in later stages of production. This will address productivity decline and enhance the reproductive and digestive performance of laying hens during late stages of production.

MATERIALS AND METHODS

Ethical approve

The study and sample collection were carried out with the agreement of the approval of the ethical committee and animal welfare committee under the number Um. Vet . 2023.089 University of Mosul College of Veterinary Medicine institutional animal care and use committee.

The experiment was conducted in animal production fields—College of Agriculture and Forestry—University of Mosul. It used a semi-close hall divided into pens, each with an area of 2.25 m^2. The study includes four treatments with four replicates (8 hens/replicate).

The experimental treatments were as follows: T1: The hens were reared on a standard diet. T2: Hens were reared on a standard diet supplied with 0.12% choline chloride, T3: Hens were reared on a standard diet supplied with 0.17% choline chloride, T4: Hens were reared on a standard diet supplied with 0.22% choline chloride.

The study included a flock of 128 laying hens of the Lohman Brown Classic chicken breed, reared for research purposes. The hens were 57 weeks old, and the study lasted for seven weeks. Choline was added to the meal, which was formulated according to (N.R.C., 1994) regulations and administered to the hens in different amounts Table 1.

Also, a few traits associated with egg quality were examined, including the height of the albumin, the yolk index, the weight and thickness of the shell, and the weight, height, and diameter of the yolk. Using the electronic vernier caliper and electronic balanced, the ovary and oviduct were weighed to calculate their relative weight, which was subsequently estimated using the live body weight percentage.

Table (1): The feed components of the diet.

contents of the ration	% ration
yellow corn	55
Soybean oil	1.6
Soybean meal	22.4
Wheat Bran	3
Wheat	5
Lime reservation	10.5
Premix	2.5
Calculated chemical analysis	
Metabolic energy	2726 kcal/kg
Protein	16.06 %

At the end of 7 weeks of treatment, biochemical blood tests were performed. Blood samples were taken from the wing veins of the studied hens once. The following parameters were determined: total protein, albumin, glucose, cholesterol, triglycerides, low-density lipoprotein (LDL), and high-density lipoprotein (HDL).

Statistical analysis: A complete randomized design (CRD) was used. data were analyzed using SAS, (2009), Duncan's multiple range test was applied to determine differences between treatments (Steele and Torrie,1960), with a significant range ($P \leq 0.05$) and according to the equation model:

$$-Yij = \mu + Ti + Eij$$

Since: - Y_{ij} = value of treats, μ = average of treats, T_i = transaction effect, E_{ij} = impact of experimental error.

RESULTS AND DISCUSSION

Table (2) indicates that average eggs weight, during weeks 57, 58, 59, 61 and 62 significantly increased in the treatments that contained choline chloride 0.12, 0.17, and 0.22 % compared to the control 0 % choline chloride, compared to the control 62.99 gm the average eggs weight for the entire period 57–63 increased ($P \leq 0.05$) in supplemented treatments (65.55, 64.99, and 65.11 g) for T2, T3 and T4 respectively.

Upon examining Table 3, the choline chloride addition treatments considerably enhanced the average number of eggs produced per hen per week at weeks 58, 59, 61, and 63 compared to the control. This was also evident in the egg mass, as shown in Table 4. However, these significant differences between the addition treatments and the control diminished in the following weeks (63, 62).

This was ascribed to the eggs' higher nutritional content due to choline supplementation because choline contributes to providing the methyl group needed to methionine synthesis, which is regarded as one of the most significant fundamental components of eggs (Zhang *et al*., 2013), these findings are also consistent with the findings of Moghadam *et al.* (2021), who revealed that, when 40-week-old layers were fed a diet containing flax seeds, egg weight increased dramatically ($p \leq 0.05$) by 40 gm of choline chloride /100 kg ration as compared to control.

The current results disagree with those of (Zhai *et al.,* 2013 and Janist *et al*., 2019), whom recorded that the weight of eggs was not affected by adding choline chloride to the diet at a rate of 1000, 1500, 2000, and 2500 mg/Kg and Olgun *et al.*

(2022), when added 1500, 2000,2500, 3000, 3500 and 4000 mg/Kg choline chloride, as well as with results of Gul *et al*. (2023).

Table (2): Effects of choline chloride ration supplementation on average weekly egg weight (gm).

Treatments / Production weeks		T1	T2	T3	T4
average egg weight (g)	57 Week	63.20 ±1.65 b	64.57±1.09ab	65.36±1.40 a	65.98 ±1.89a
	58 Week	63.14± 1.39 b	66.38 ±1.72a	65.63±1.35 a	66.82± 2.7a
	59 Week	63.17± 2.85 b	67.34 ±1.35a	65.68± 2.97ab	64.82±1.71ab
	60 Week	62.27 ± 1.21b	64.57±1.63 a	63.82 ±1.40 ab	64.04± 1.54 a
	61 Week	62.33±1.18 b	65.27±2.73 a	65.31± 3.43 a	65.47±2.51 a
	62 Week	63.71 ± 2.71b	65.75± 2.50a	65.50±1.63 a	65.71±13.93 a
	63 Week	63.17 ±1.41 a	64.99±1.99 a	63.63 ±1.20 a	62.90 ±1.07 a
	the mean	62.99 ±1.05b	65.55±2.35 a	64.99±1.31 a	65.11± 2.11 a

-The differences in the letters horizontally indicates significance between the means (P≤ 0.05).
-T1: without supplied with chlorine chloride. T2: supplied with 0.12% chlorine chloride.
-T3: supplied with 0.17% chlorine chloride T4: supplied with 0.22 %. chlorine chloride

Table (3): Effects of choline chloride ration supplementation on Egg number (egg/ hen /week).

Treatments / Production weeks		T1	T2	T3	T4
Number of egg /hen/week	57 Week	5.13 ±0.41 a	5.35 ±0.11 a	5.45 ± 0.22 a	5.50± 0.14 a
	58 Week	4.99 ± 0.2 b	5.23 ±0.24 a	5.20± 0.43 a	5.09 ±0.24 a
	59 Week	4.96 ±0.1 b	5.20 ±0.52 a	5.11±0.17 a	4.99± 0.15 a
	60 Week	5.15± 0.4 a	5.13 ±0.25 a	5.10 ±0.2 a	5.20 ±0.41 a
	61 week	4.55 ± 0.3 b	5.01 ±0.3 a	4.99 ±0.4 a	4.99± 0.51 a
	62 Week	4.80 ± 0.47 a	4.99± 0.32 a	4.96 ±0.18 a	4.85± 0.46 a
	63 Week	4.16± 0.51 b	5.15 ±0.42 a	5.13 ±0.29 a	5.05 ± 0.54 a

-The differences in the letters horizontally indicates significance between the means (p≤ 0.05)
-T1: without added chlorine chloride. T2: Added of 0.12% chlorine chloride
-T3: Added of chlorine chloride 0.17%. T4: Added of chlorine chloride 0.22%

Table (4) shows that when compared with the control during weeks 59, 60, 61, and 62, there was no significant effect on egg mass for the treatments 0.12, 0.17, and 0.22% choline chloride compared to 0.0%, and the considerable impact increased at week 63 of the hen's age in the added treatments 0.12, 0.17, 0.22% compared to 57-63 weeks, where it reached 382.89, 389.31, 426.05, 320.27 gm/hen/week, respectively.

These results agreed with those of Omara (2012), who found that egg mass increased significantly when he added choline 0.16 % to the diet compared to the

control. Mustafa *et al.* (2024) stated that dietary choline chloride supplements significantly affect egg mass and production. This is attributed to the increase in the choline content of the egg components, which is linked to methionine when it gives the methyl group to homocysteine (Francis *et al.,* 2012 and Zhang *et. al.,*2013), this also agreed with Moghadam *et. al.* (2021), where it was found that eggs mass increased significantly by added 40 gm choline chloride /100 gm to the egg-laying diet at 40 weeks of age compared to the diet without choline chloride, while disagreed with Rajalekshmy (2010), as he did not find any significant effect for choline addition at different levels 0, 500 and 1000 mg/g on eggs mass. This also contradicted Janist *et al.* (2019) and Gul *et al.* (2023), as adding choline chloride to the diet did not affect egg mass.

Table (4): Effects of choline chloride ration supplementation on Egg mass (gm/hen/ week).

Treatments / Production weeks		T1	T2	T3	T4
Eggs mas weight g	57week	324.5±11.50b	345.35±8.14ab	345.12±10.11ab	382.89±14.76a
	58week	315.27±7.13b	340.33±9.12a	341.35±15.34a	348.31±9.12a
	59 week	313.32±7.51a	350.17±8.27a	335.62±8.45 a	323.5± 11.34a
	60week	320.69±10.12a	311.24± 9.44a	325.48±12.33 a	333.0±12.61 a
	61week	321.00 ±7.35 a	327.00±5.05 a	325.90± 5.98 a	326.69±10.93a
	62week	307.87± 8.63a	328.09±11.77a	324.88± 9.73 a	318.69±9.93a
	63week	262.78± 9.72b	324.30±9.41a	326.42± 9.15 a	322.70±11.85a
	(57-63) weeks	320.27±8.72b	382.89± 9.72a	389.31±10.12a	426.05±11.0a

- the differences in the letters horizontally indicates significance between the means ($p \leq 0.05$).
- T1: without supplied chlorine chloride. T2: supplied 0.12% chlorine chloride. T3: supplied 0.17 % chlorine chloride. T4: supplied 0.22% chlorine chloride.

From Table (5), at each of weeks 57, 58, 59, 60, 61, 62, 63, supplementing choline chloride to the feed at a rate of 0.12, 0.17, 0.22 % did not significantly influence the amount of feed consumed compared to the control treatment. These results agree with Rajalekshmy (2010), who found that choline supplementation did not influence feed intake.

From Table (6), the feed conversion ratio improved ($P \leq 0.05$) for all treatments involving the use of chlorine chloride and for each week of rearing as compared to the control group, this may be due to the function of choline in the metabolic process (Olgun *et al.*, 2022), and also its ability to improve the intestinal environment by increasing the digestion and absorption process due to the development of villi (Abramowicz *et al.,* 2020), which ultimately increases the rate of utilization of nutrients. Also, choline has the advantage of improving the nutritional content of amino acids due to its being a methyl group donor (Moghadam *et al.*, 2017). This is in line with the findings of researcher Omara (2012), who discovered that adding 0.16% choline to the hen meal greatly increased the feed conversion ratio compared to the control. on the other hand, the obtained results disagreed with those of Zhai *et al.* (2013), as the feed conversion ratio was impaired significantly ($P \leq 0.05$) when the

feed was prepared with choline chloride by 425, 850, 1700, 3400, and 6800 mg/kg. These results also disagreed with Yonke and Gita (2019), a non-significant effect is found when adding choline at 0.1, 0.2%.

Table (5): Effects of choline chloride ration supplementation on feed consumption (gm/hen/ week).

Treatments / Production weeks		T1	T2	T3	T4
Feed computation (gm/hen/ week	57week	908.6±17.59 a	899.05±18.17a	901.60±12.11a	925.23±16.76a
	58week	900.0±11.07 a	899.79±14.17a	902.6±10.55 a	903.76±17.14a
	59week	901.03±10,12a	919.99±9.19 a	915.84±12.33a	918.72±9.56 a
	60week	921.13±12.13a	910.04±12.33a	891.20±12.13a	893.0± 9.13 a
	61week	923.49±7.13a	850.20±11.23a	870.2± 9.33 a	894.2± 6.55 a
	62week	901.0±11.15 a	918.02±12.7 a	916.12±15.0 a	893.2±16.74 a
	63week	946.1±8.06 a	914.53±13.12a	913.98±9.11a	913.24±14.22a

- The differences in the letters horizontally indicate significance between the means (P≤ 0.05).
- T1: without supplied chlorine chloride. T2: supplied with 0.12% chlorine chloride. T3: supplied 0.17 % chlorine chloride. T4: supplied 0.22% chlorine chloride.

Table (6): Effects of choline chloride ration supplementation on feed conversion ratio.

Treatments / Production weeks		T1	T2	T3	T4
feed conversion ratio (gm egg/gm feed)	57week	2.80 ± 0.31 a	2.60±0.17 b	2.61±19.23 b	2.41±0.06 b
	58 week	2.85 ±0.19 a	2.64 ±0.18 b	2.65 ±0.22 b	2.59 ±0.13 b
	59 week	2.87±0.35 a	2.75 ±0.23 b	2.73± 0.80 b	2.68 ±0.29 b
	60 week	2.87 ±28.62 a	2.45 ±0.26 b	2.30 ± 0.21 b	2.62 ±0.14 b
	61week	2.82 ±0.34 a	2.60±0.27 b	2.67± 0.38 b	2.73 ±0.18 b
	62 week	2.96± 0.38 a	2.79± 0.16 b	2.82±0.16 b	2.80 ± 0.14 b
	63 week	2.99± 0.48 a	2.82± 0.20 b	2.80 ± 0.33 b	2.83 ±0.20 b

- The differences in the letters horizontally indicates significance between the means (P≤ 0.05)
- T1: without added chlorine chloride. T2: Added of 0.12% chlorine chloride
-T3: Added of chlorine chloride 0.17%. T4: Added of chlorine chloride 0.22%

Also, egg production (Table 7) was higher in the treatments supplied with choline chloride than in the control treatment for the periods 57-58-59 weeks and 60-61-63 weeks, as well as for the total period of rearing 57-63 weeks, where it was 73.37, 74.01, and 72.89 %, respectively, compared with 69.74%.

Table (8) demonstrates a significant increase (P≤0.05) in shell thickness as the level of chlorine chloride increased, reaching 0.36, and 0.37 mm in the two additions of T3 and T4 compared with the control 0.35 mm, the same trend in shell weight in

T3 and T4 compared to control and T2 at 0.17% and 0.22% resulted in a significant increase in shell weight compared to the control and 1.2% levels of chlorine chloride, coming in at 5.57,5.71,5.18, and 5.20 gm, respectively. The same table makes it evident that the weight of the yolk for the fourth treatment, 0.22% has increased significantly when compared to the weights for the 0.0, 0.12, and 0.17% treatments, 18.47, 16.95, 16.14, and 17.48 gm.

Table (7): Effects of choline chloride ration supplementation on hen day production.

Indicator / Weeks	H.D.P %			
	T1	T2	T3	T4
57 -58- 59	71.81	74.67	75.05	74.19
60- 61-62	69.29	72.05	73.81	71.67
57-63	68.12	73.39	73.16	72.80
The mean	69.74	73.37	74.01	72.89

- The differences in the letters horizontally indicate significance between the means (P≤ 0.05)
- T1: without added chlorine chloride. T2: Added 0.12% chlorine chloride. -
-T3: Added of chlorine chloride 0.17%. T4: Added chlorine chloride 0.22%

The yolk diameter increased significantly (P≤0.05) with the supply of choline chloride 0.12, 0.17, 0.22% compared to 0.0% and reached 41.66, 42.68, 43.07 mm compared to 41.03 mm, and in the yolk height 17.73, 18.08, 18.72, 17.41 mm respectively. It is clear from the table that the yolk index was not significantly affected when choline chloride was added.

Table (8): Effects of choline chloride ration supplementation on egg quality.

Treatments / Traits	T1	T2	T3	T4
Shell thickness (mm)	0.35± 0.01c	0.35±0.01c	0.36 ±0.01b	0.37±0.006a
Shell Weight (gm)	5.18±0.07 b	5.20±0.07b	5.57±0.032a	5.71±0.013 a
Yolk weight (gm)	16.95±0.35b	16.14±0.33b	17.48±0.13b	18.47±0.29a
Yolk diameter (mm)	41.03±2.29c	41.66±1.06b	42.68± 0.92a	43.07±1.14 a
Yolk High (mm)	17.41±0.16c	17.73±0.28c	18.08± 0.98b	18.72±0.18 a
Albumin High (mm)	7.69± 0.45a	7.52±0.16bc	7.62± 0.06ab	7.69± 0.14 a
Yolk Index	0.42± 0.004a	0.43± 0.20 a	0.42± 0.002 a	0.43 ±0.003a

the differences in the letters horizontally indicates significance between the means (P≤ 0.05)
- T1: without added chlorine chloride. T2: Added of 0.12% chlorine chloride
-T3: Added of chlorine chloride 0.17%. T4: Added of chlorine chloride 0.22%

The shell thickness increased greatly when the diet was prepared with choline chloride 425, 850, 1700, 3400, and 6800 mg/kg, which is consistent with the findings of Zhai *et al.* (2013), furthermore, Janist *et al.* (2019) discovered that when the feed was made with 1000, 1500, 2000, and 2500 mg/kg. Once 1000 mg/kg was added, the thickness of the shell rose dramatically (P≤ 0.05). The properties of the yolk were shown to significantly improve when 40 g/100 Choline chlorides were given to the layer diet at 40 weeks of age, as compared to the diet lacking choline chloride. These results aligned with Moghadam *et al.* (2021) and Gul *et al*. (2023). This finding

contrasts with Rajalekshmy (2010), who found no effect when choline was added at different amounts 0, 500, or 1000 mg/kg. When choline was utilized as a methionine enhancer in the ratio of laying hens to the control, the weight of the yolk and albumin, and the weight of the egg shell all significantly decreased. These results were in contrast to those of (wang *et al.*, 2017 and Yonke and Gita, 2019), who stated that the addition of 1.7, 3.4, 6.8 mg/kg did not significantly affect these characteristics.

Table 9 shows no significant differences between the treatments adding chlorine chloride in the percentages of the ovary and oviduct. This result agrees with Zaki et al. (2023), who added 0.5% choline chloride to the diet. On the other hand, Attia et al. (2016) observed that the oviduct weight increased by adding choline chloride to the diet.

Table (9): Effect of supplied choline chloride on the relative weight of the ovary and oviduct % in laying hens.

Treatments / Trait	T1	T2	T3	T4
Ovary	2.14 ±0.01 a	2.45± 0.04 a	2.55± 0.07 a	2.62 ±0.01 a
Oviduct	3.17 ±0.09 a	3.64±0.07 a	3.51±0.05 a	4.28± 0.06 a

- The difference in the letters horizontally indicates significance between the means (P≤ 0.05). -
-T1: without added chlorine chloride. T2: Added 0.12% chlorine chloride.
-T3: Added chlorine chloride 0.17%. T4: Added chlorine chloride 0.22%

Table 10 shows no significant differences (P≤ 0.05) between the treatments 0.12,0.17,0.22 % chlorine chloride and the control in some blood parameters. The result agrees with Zaki *et al.* (2023) when they added 0.5% choline chloride to the diet.

Table 10: Effects of choline chloride ration supplementation on some blood parameters.

Treatments / Traits	T1	T2	T3	T4
Glucose mg/dl	163.0±9.56a	151.3±10.08a	149.40±8.60a	156.2±12.01a
Total protein gm/dl	5.26± 0.33 a	5.94±0.09 a	5.87±0.07 a	6.70 ±0.07 a
Albumin gm/dl	3.11± 0.05 a	4.08±0.08 a	3.65± 0.05 a	3.18 ±0.06 a
Globulin gm/dl	2.15 ±0.13 a	1.86 ±0.08 a	2.22 ± 0.06 a	3.52 ± 0.1 a
Cholesterol mg/dl	125.7± 8.12 a	121.30±10.3 a	124.0±7.13 a	117.7±7.66 a
Triglycerides mg/dl	314.43±19.5 a	273.67±14.48a	321.71±14.67a	315.07±12.01a
LDL mg/dl	128.40 ±9.56 a	118.55±11.0 a	115.71±14.17a	112.45±8.01a
HDL mg/dl	18.77±1.06 a	21.88±1.48 a	21.73±4.07 a	22.35 ±2.11a

- the differences in the letters horizontally indicates significance between the means (P≤ 0.05)
- T1: without added chlorine chloride. T2: Added of 0.12% chlorine chloride.
-T3: Added of chlorine chloride 0.17%. T4: Added of chlorine chloride 0.22%.

CONCLUSIONS

Supplementing the diet of laying hens with choline chloride, Particularly, during the last weeks of their production, various parameters have been improved. Adding choline chloride at concentrations of 0.12, 0.17, and 0.22% significantly improved egg production and quality. Therefore, it is an effective and essential nutritional supplement to be added to the diet of laying hens.

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CONFLICT OF INTEREST

The authors stated that there are no conflicts of interest with the publication of this work.

تأثير إضافة كلورايد الكولين إلى عليقة الدجاج البياض على الأداء الإنتاجي

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قسم الإنتاج الحيواني / كلية الزراعة والغابات / جامعة الموصل / الموصل / العراق [1]

الخلاصة

تم استخدام قطيع من الدجاج البياض من نوع دجاج لوهمان البني الكلاسيكي بعمر 57 اسبوع ، وتمت تربيته في حقول الدواجن التابعة لقسم الإنتاج الحيواني في كلية الزراعة والغابات جامعة الموصل، في قاعة نصف مغلقة مقسمة إلى حجرات ذات تربية ارضية، غذي الدجاج الخاضع للتجربة على عليقة متوازنة مضاف اليها كلورايد الكولين بنسب (0.0%، 0.12%، 0.17%، 0.22%) والتي تمثل أربع معاملات بواقع أربع مكررات لكل معاملة ، لمعرفة تأثير استخدام كلورايد الكولين كمكمل غذائي في تحسين الأداء الإنتاجي للدجاج البياض في المراحل المتأخرة من الانتاج . استمرت فترة التربية سبعة أسابيع تم خلالها أخذ بعض الصفات الإنتاجية وخصائص جودة البيض والصفة التشريحية للجهاز التناسلي وبعض معايير الدم. وكانت نتائج التحليل الاحصائي للبيانات المتحصلة كالاتي: زاد معنويا متوسط وزن البيض الأسبوعي والإنتاج اليومي للبيض وكتلة البيض مع تحسن معامل التحويل الغذائي، وتحسن سمك القشرة ووزن القشرة وقطرها ووزن وارتفاع الصفار بشكل معنوي. لم تتأثر جميع مقاييس الدم المدروسة معنويا بإضافة كلورايد الكولين للعليقة، وكنتيجة فان إضافة كلوريد الكولين إلى العليقة أدى الى تحسين خصائص الإنتاج، وخاصة في المرحلة العمرية المتأخرة من الإنتاج للدجاج البياض.

الكلمات المفتاحية: جودة البيض، مرحلة الإنتاج، مكملات غذائية، معايير الدم.

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