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Research Article

Effect of Astaxanthin Addition to Diets of Laying Hens on Egg quality Characteristics

Shahla Jabar Hussan[1], Sabah Kadhum Al-hummod[2], Majid Hassan Al-asadi[2]
[1]*Department of Animal Production, College of Agriculture, University of Misan, Misan Iraq*
[2]*Department of Animal Production, College of Agriculture, University of Basrah, Basrah Iraq*
*Corresponding Author: **Shahla Jabar Hussan**

Abstract: In this study, six pure strains of maize were used: H (1), A (2), I (3), T (4), E (5) and M (6) in a half cross cross. Seeds of single parents and crosses were sown in an experiment using a randomized complete block design (R.C.B.D) with three replications in the field of the Agricultural Technical College in the fall season (2023). Parents and crosses of the first generation differed significantly at the level of probability 1% for the characteristics of the number of days for male and female flowering, plant height, ear diameter, and individual plant yield. Some crosses showed significant and desirable The averages of the general and specific ability to coalesce were significant at the level of 1% for all the studied traits. The additive and dominance genetic variance differed from zero for all the traits. The heritability values in the broad sense were high for all traits, and in the narrow sense were medium for male flowering date, plant height and ear diameter, and low for female flowering and individual plant yield. The average degree of dominance was greater than the correct one for all traits.

Keywords: combinability - degree of dominance - genetic variation - heritability - genetic improvement

INTRODUCTION

The poultry industry is one of the most important agricultural sectors that contribute to meeting the needs of humans for animal protein. Raising laying hens is an important part of this industry, as egg production is one of the most important products provided by these birds, and improving the productive and qualitative qualities of eggs is vital to maintain the strength of this industry and increase profits for breeders (FAO, 2022). The type and quality of eggs produced depends on a few factors, including breeding and feeding conditions. The use of various food additives is vital in facing environmental challenges, because of their positive roles in enhancing the immunity and productivity of birds (Abbas, and Al-Subaihawi, 2022). Among these additions comes astaxanthin, which is one of the safe alternatives to industrial food additives and has a potential impact in improving the tolerance of laying hens to heat stress, improving the productive and qualitative qualities of eggs, and reducing their harmful effects. It may be an effective strategy and one potential solution to improve tolerance to extreme thermal conditions and enhance the ability of chickens to adapt to environmental challenges (Yu, *et al*., 2019). Astaxanthin is a natural compound belonging to the carotenoid family and is found in some foods and plants, mainly produced from the aquatic algae *Haematococcus pluvialis*, which is widespread around the world (Ding *et al*., 2023). It has antioxidant properties that contribute to protecting cells from the harmful effects of free radicals formed during heat stress and inhibits their action, as well as its various roles and uses in therapeutic, medical, immunological, and nutritional preparations (Henke and Wendisch, 2019). Astaxanthin is believed to contribute to improving the color of the yolk, which enhances the attractiveness of the product to consumers and reflects better egg quality. Some studies suggest that the use of astaxanthin in chicken diets may lead to an increased content of omega-3 fatty acids in egg yolk, a beneficial compound for human health (Takahashi, *et al.*, 2023). To achieve these benefits and effects, the use of astaxanthin in the diets of laying hens exposed to heat stress represents a promising potential for improving productive qualities. Adding astaxanthin to chicken diets may be an effective strategy to improve tolerance to extreme thermal conditions and enhance chickens' adaptability to environmental challenges (Magnuson, *et al.*, 2018).

The experiment aims to find out the effect of astaxanthin addition to the diet of laying hens (ISA Brown) on some qualitative characteristics (external and internal) of eggs produced at advanced ages

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MATERIALS AND METHODS

This experiment was conducted in the poultry field of the Department of Animal Production / College of Agriculture / University of Basra, where it extended to 8 weeks from 22/11/2022 to 21/1/2023 and used 60 laying hens aged 60 weeks from the ISA Brown hybrid. The birds were randomly distributed to five Transactions and by 3 repeaters/ transaction, where each transaction consisted of 12 chickens and (4) chickens / repeater. Males were placed in individual cages with dimensions of (41×41×45) cm, distributed the transactions are as follows:

1. First transaction T1: control group (no addition).
2-Second treatment T2: a group taking a control diet with astaxanthin at a concentration of 3 mg/kg feed.
3- Third treatment T3: a group taking the control diet with astaxanthin at a concentration of 6 g / kg feed.
4- Forth Treatment T4: a group taking a control diet with astaxanthin at a concentration of 9 mg/kg feed.
5-Fifth treatment T5: a group taking a control diet with astaxanthin at a concentration of 12 mg/kg feed.

Water was prepared freely throughout the study period; the birds were fed on the diet of laying hens (Table 1) and the amount of feed provided per day was (112) g / bird/ day.

According to the chemical composition of feed materials according to the feed material analysis tables contained in the reports of the National World Research Council (NRC, 1994).

Table (1) shows the chemical analysis of the diets.

Croud protein %	17.4
Energy Metabolic (kcal/kg feed)	2753.2
Fat %	5.21
Ash %	3.64
Fibber %	3.13
Lysine	0.89
Methionine	0.28
Methionine + Cysteine	0.72
calcium	4.09
Phosphorus available	0.459

Qualitative qualities of eggs

Eggs were collected daily, and the following tests were conducted the qualitative characteristics of eggs were measured according to the method indicated by Al-Fayyad, et al., (2011). Calculating the weight of the egg, yolk, white and shell using a sensitive scale.

Characteristics of yolk

Yolk color: The color of yolk was measured by means of a hand-held plastic fan.

Yolk weight (gm): based on a sensitive scale's measurement of the yolk's weight.

the Relative weight of the yolk (%) is as follows: The following equation states.

$$Relative\ weight\ of\ yolk\ \% = \frac{\text{Yolk weight}}{Egg\ weight} \times 100$$

Yolk height (m): The height of the yolk was measured using a three-base micrometer.

Yolk diameter (m): I measured the yolk's diameter using a digital Vernia measuring device.

Yolk index: The yolk index and the white index were calculated according to the treatment mentioned by Naji et al., (2008)

$$Yolk\ index = \frac{\text{Yolk height (m)}}{Yolk\ diameter\ (m)}$$

Characteristics of albumin

The weight of the egg albumin (gm): according to the weight of the egg white, by applying the following equation:

albumin weight (gm) = egg weight (gm) – (yolk weight + shell weight)

The relative weight of the egg white, %: according to the following equation

$$Relative\ weight\ of\ albumin\ \% = \frac{\text{albumin weight}}{Egg\ weight} \times 100$$

The Haugh Units

This was measured according to equation mentioned by Nesheim et al. (1979).

Haugh Units= 100x log (H- 1.7 W0.37 +7.57)

H= the height of thick albumen.

W= the egg weight.

0.37 are constants.

Characteristics of Eggshell

Eggshell weight (gm): according to the weight of the eggshell using a sensitive scale,

the relative weight of the eggshell (%): according to the following equation:

$$Relative\ weight\ of\ eggshell\ \% = \frac{\text{Eggshell weight}}{Egg\ weight} \times 100$$

Eggshell thickness (mm): The thickness of the shell was measured from the pointed and convex ends of each egg (after lifting the membranes of the eggshell) and left to dry for a period of more than 24 hours by a micrometer and took an average of two readings for the ends of each egg.

The study data was analyzed to a Completely Randomized Design (CRD) analysis of variance to analyze the results using the completed program SPSS (2019). Duncan (1955) multiples test was applied to separate means at a significant level ($P \leq 0.05$).

RESULTS AND DISCUSSION:

Qualitative qualities of eggs

Specification of yolk:

Table (2) indicates the effect of the use of astaxanthin in the diets of laying hens in the specifications of the yolk, shown from Table (2) on the qualitative characteristics of the yolk (yolk weight, relative weight of the yolk, yolk height, yolk diameter and yolk index).

The use of astaxanthin in laying hens diets at a concentration of 3.6, 9.12 mg / kg feed did not have a significant effect on the yolk weight and percentage compared to eggs taken from chickens who were fed on a diet free of astaxanthin control treatment (T1) where the yolk weight was 18.25 g and its percentage was 29.95%, while the value of these two traits when adding astaxanthin at a concentration of 3, 6 , 9 12 mg/kg feed 19.11 g, 30.03%, 18.75 g, 29.91%, 18.55 g, 30.07%, 18.47 g and 29.94% respectively, and no significant differences were observed in the yolk index as a result of the use of astaxanthin by 3, 6, 9, 12 mg / kg as it reached 0.48 , 0.48 and 0.50 and 0.50 respectively compared to the control coefficient of 0.49.

Since the yolk index represents the product of dividing the height of the yolk by a drop, and therefore we note in Table (2) that there is no significant effect of the use of astaxanthin on the height of the yolk as well as a drop in concentrations.

Table (2) Effect of Astaxanthin Use in Diets of Laying hens on Egg Yolk Specification (Mean± SE.)

[1]Treatments	Control T1	T2	T3	T4	T5	P value
Yolk weight (g)	18.25± 0.21	19.11 ± 0.04	18.75± 0.24	18.55± 0.54	18.47± 0.34	.438
Relative weight of the yolk (%)	29.95± 0.28	30.03± 0.34	29.91 ± 0.35	30.07± 0.30	29.94± 0.13	.992
Yolk height (mm)	16.80± 0.15	16.68± 0.12	16.69 ± 0.16	16.75 ± 0.15	16.79± 0.16	.967
Yolks diameter (mm)	34.33 ± 0.88	34.67 ± 0.88	34.67 ± 1.20	33.67 ± 0.88	33.67 ± 1.20	.906
Yolk Index	0.49± 0.02	0.48± 0.01	0.48± 0.01	0.50± 0.01	0.50± 0.02	.768

T1 [1] control diet (no additive) and T2, T3, T4, T5: astaxanthin use coefficients 3, 6, 9, 12 g/kg feed respectively.

mentioned above as the average increase was 16.80, 16.68, 16.69, 16.75, 16.79, and the drop rate was 34.33, 34.67, 34.67, 33.67 mm in the coefficients T1, T2, T3, T4, T5 respectively. These results are consistent with the findings of (Heng et al., 2020) who did not record a significant effect of astaxanthin level in laying hens' diets in yolk specifications.

The color of the yolk

From the results of Figure (1), it is clear that there are significant differences at the level ($P \leq 0.05$) in the degree of color of the yolk between the different experimental treatments, as the average readings when using 12 mg/kg feed of astaxanthin were recorded, the highest rates amounted to 12.33 degrees, followed by the effect of the treatment that used 9 mg/kg feed of 10.67 degrees, then the treatment of 6 mg/kg feed, which recorded 8.33 degrees, while the treatment of 3 mg/kg feed did not differ with the control treatment (without addition), as they recorded 6.33 and 5.67 degrees respectively.

The color of the yolk is an important indicator of egg quality, the addition of astaxanthin to the diets of laying hens led to a gradual rise in the color of the yolk by increasing its concentration, as astaxanthin is considered a carotenoid and is the main pigment in animals (Magnuson, *et al*., 2018*).* Astaxanthin can be stored in tissues without alteration or biochemical transformation after absorption by birds (Lim, *et al*., 2019), which makes the yolk of bird eggs appear golden yellow or reddish, however, adding astaxanthin to the diet of laying hens can affect the color of the yolk and make it redder. It may be because of astaxanthin in increasing the content of unsaturated fatty acids in egg yolk (Tolba, *et al*., 2020). These

results are consistent with Reached by Zhu, *et al.* (2021) who noticed a significant increase in the color of the yolk gradually with the level of astaxanthin added to the diet of laying hens.

Albumin Specifications

Table (3) indicates the effect of astaxanthin use in laying hen diets on laying hens' specification. It is clear from Table (3) that there is no significant effect of the use of astaxanthin on the albumin and percentage of whiteness, as the weight of albumin was 36.50, 38.09, 37.58, 36.93 and 36.99 gm, and the percentage of albumin was 59.90, 59.83, 60.75, 60.17 and 60.99% in the treatments T1, T2, T3, T4, T5 respectively. Also, no significant effect of the use of astaxanthin in different concentrations in the diets of laying hens was found in the rate of elevation of albumin, as it reached 8.79, 8.82, 8.87, 8.84 and 8.77 mm in the coefficients T1, T2, T3, T4, T5 respectively.

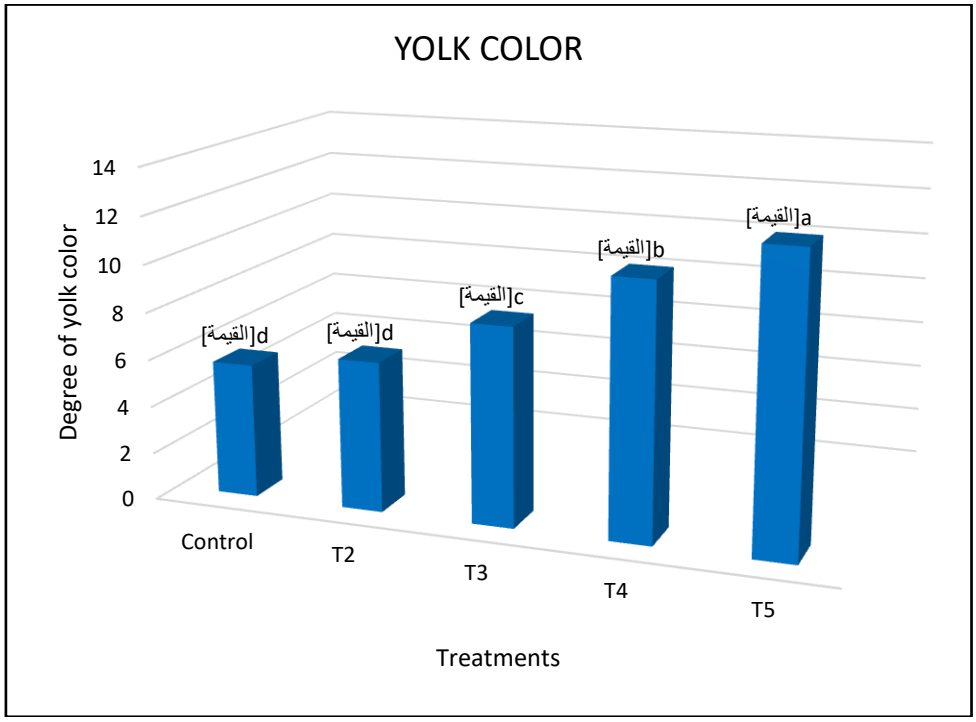

Figure (1) Effect of Astaxanthin Use in Diets of Laying hens on Egg Yolk Color

The use of astaxanthin at concentrations 0, 3, 6, 9 ,12 mg/kg feed did not significantly effect on Hough Unit, reaching 91.23, 90.68, 91.22, 91.34 and 90.96 respectively. The absence of significant differences in Hough Unit is because these measures depend in its calculation on two measurements, namely egg weight and egg height.

These results are consistent with his statement Honda *et al*. (2020); Yang, *et al*. (2006) Who did not observe a significant effect of the addition of different concentrations of astaxanthin 0, 7, 9, 11 mg/kg feed in the specification of albumin.

Eggshell Specifications

Table (4) indicates the effect of the use of astaxanthin in laying hens' diets in the specifications of the shell, and it is noted from the data of Table (4) that there is no significant effect of the use of astaxanthin in the thickness of the shell at concentrations of 0, 0.33, 0.31, 0.32, 0.33 and 0.34 mm. The results shown in Table (13) showed no significant differences in the weight and percentage of eggshell when feeding laying hens on diets containing astaxanthin at concentrations of 0, 3, 6, 9 and 12 mg/kg feed if the rate of the weight of the shell is 6.19, 10.15, 6.46, 10.14, 6.34, 10.12, 6.19, 10.04, 6.22 g and 10.08%, respectively. These results are consistent with those obtained by Shevchenko, *et al.* (2021) who indicated.

Table (3) Effect of Astaxanthin Use in Diets of Laying Hens on albumin Specifications (Mean± SE.)

[1]Treatments	Control T1	T2	T3	T4	T5	P value
Albumin weight (g)	36.50± 0.34	38.09 ± 0.34	37.58± 0.27	36.93± 0.61	36.99± 0.39	.177
Relative weight of the albumin (%)	59.90± 0.67	59.83± 0.82	60.75± 0.90	60.17± 0.87	60.99± 0.73	.972

Albumin height (mm)	8.79± 0.10	8.82± 0.13	8.87± 0.07	8.84 ± 0.08	8.77± 0.12	.958
Hough Unit	91.23± 0.37	90.68± 0.85	91.22± 0.32	91.34± 0.13	90.96± 0.46	.871

[1]T1 control diet (no additive) and 2T, T3, T4, T5: astaxanthin use coefficients 3, 6, 9, 12 g/kg feed respectively.

that there were no significant differences in shell characteristics when astaxanthin was added to laying hens' diets at concentrations of 10, 20 and 30 mg/kg feed.

Table (4) Effect of Astaxanthin Use in Diets of Laying Hens on Egg Shell Specifications (Mean± SE.)

[1]Treatments	Control T1	T2	T3	T4	T5	P value
Shell thickness (mm)	0.33± 0.019	0.31± 0.007	0.32± 0.020	0.33± 0.017	0.34± 0.017	.869
Shell weight (gm)	6.19± 0.089	6.46± 0.161	6.34± 0.098	6.19± 0.055	6.22± 0.160	.451
Relative weight of the (%)	10.15± 0.04	10.14± 0.14	10.12± 0.16	10.04± 0.13	10.08± 0.12	.963

[1]T1 control diet (no additive) and 2T, T3, T4, T5: astaxanthin use coefficients 3, 6, 9, 12 g/kg feed respectively.

CONCLUSIONS

The current study showed that by adding different levels of astaxanthin in the diet of laying hens, it led to an improvement in the color characteristic of the yolk in order to increase the concentration of astaxanthin in the eggs, so adding it at a concentration of 6, 9 and 12 mg / kg feed in the diet of laying hens leads to the production of healthy eggs and that eating such type of eggs has beneficial health benefits, and we can also conclude that the qualities of yolk, albumin and egg shell are not affected by the addition of astaxanthin in the concentrations used in the study.

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