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THE EFFECTIVENESS OF ASTAXANTHIN ADDED TO THE DIET FOR IMPROVING PRODUCTIVE EFFICIENCY, TRAITS FOR BROILER CHICKENS EXPOSED TO OXIDATIVE STRESS

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Abstract

This experiment was conducted in the field of poultry in Al-Anwar Company in Babylon province, Al-Mouradia region for the period from 18/9/2019 to 23/10/2019, then it was followed by laboratory work with the aim of studying the effectiveness of added astaxanthin to the diet in improving the productive efficiency of broilers chickens. In this experiment, 240 unsexed Ross 308 broiler chicks were used One day-age. The chicks were raised on a ground bed, and the chickens were fed from 1-35 days old, and they were distributed into five treatments with three replicates per treatment (16 birds/ replicate), And oxidative stress was induced by adding H_2O_2 to drinking water, and the treatments included: T1 negative control treatment (Basal diet + water free from H_2O_2), T2 positive control treatment (Basal diet + drinking water containing 0.05% H_2O_2), T3, T4 and T5 addition of astaxanthin at a concentration of 40, 50 and 60 mg/ kg, respectively, from the Basal diet + drinking water containing 0.05% hydrogen peroxide (H_2O_2). The results showed that the addition of astaxanthin to the diet of birds at a concentration of 50 mg/ kg exposed to oxidative stress induced by H_2O_2 in the fourth treatment resulted in a significant excelled ($P < 0.01$) in the rate of body weight and weight gain, as well as the rate of feed consumption and feed conversion efficiency in the additional treatment. Compared to the control treatment. The results showed that the adding of astaxanthin to the bird's diet at a concentration of 50 mg/kg exposed to oxidative stress induced by H_2O_2 in the fourth treatment resulted in a significant excelled ($P < 0.01$) in the rate of body weight and weight gain, as well as the rate of feed consumption and feed conversion efficiency in the addition treatments. Compared to the control treatment.

Keywords: Astaxanthin, productive efficiency, oxidative stress

Introduction

The poultry industry is an important element in the development of livestock and one of the most important foundations for the economy of many countries, so producers and researchers have made their efforts to contribute to their prosperity and development and work to increase production and health efficiency and eliminate problems that are exposed to them, including the problem of the so-called exposure of birds to oxidative stress, a situation that occurs, as a result, An increase Oxidizing substances in the cell (Bahorun *et al*., 2006) It is one of the most important reasons that cause economic losses is that it causes a decrease in growth and production performance, the deterioration of immunity and the high Mortality rate, which is the main reason for increasing the free radical formation of Reactive oxygen species (ROS) (Mohammad, 2013). Increased free radicals in the body lead to this condition, which is associated with an increased rate of cellular breakdown and damage (Sikka, 1996). Therefore, recent studies have tended to investigate the role of antioxidants that have a role in improving metabolic processes and physiological functioning of the body (Habsah *et al*., 2000). Which constitutes a defensive line against the destructive activity of free radicals for the purpose of protecting cells from damage resulting from free radical reactions and eliminating diseases and thereby preserving body tissue (Diplock *et al*., 1998). This prompted researchers and producers to use antioxidants by adding them to the diet, because of its important role in improving the productive traits for poultry and enhancing the immune status as well as its antioxidant effect caused by free radicals (Sahin *et al*., 2006).So this study aimed to use antioxidants to prevent the effect of oxidative stress, the most important of which is Astaxanthin, where it has been described as the king of all antioxidants, with its distinctive and unique chemical properties because it contains effective groups of both O_2 and OH at the end of the molecule chain at each aromatic ring, which is The largest polarity of the rest of the carotenoids (Jiang *et al*., 2019). The primary advantage of astaxanthin is its high ability to capture free radicals and the Reactive oxygen species (ROS) found in biological systems (Birben *et al*., 2012). It is found mostly in marine organisms, shrimp, salmon, and some types of microalgae and yeasts, which are among its best natural sources (Nguyen *et al*., 2013). Given the importance of this pigment where an anti-oxidant and the lack of research that addressed this effect on the productive performance of broiler chickens, this experiment was conducted with the aim of knowing the ability of astaxanthin added by three different levels to the bush to protect the broiler body from damage caused by oxidative damage caused by hydrogen peroxide to drinking water, as well as determining the best level addition.

Materials and Methods

This experiment was conducted in the fields of Al-Anwar Company in Babylon province in Al-Mouradia region for the period from 18/9/2019 to 23/10/2019 in order to study the effect of adding three different levels of astaxanthin pigment to broiler chickens diets in protecting from oxidative stress induced by hydrogen peroxide through performance And production efficiency. In this study, 240 unsexed Ross 308 broiler chicks were used One day age, with an average weight of 45 g. They were prepared from Al-Anwar Company in Babylon province. They were divided into 5 treatments and by 3 replicates per treatment and each replicate of 16 chicks. It was randomly distributed within pens of dimensions 1 x 1.5 m. And hydrogen peroxide was added to drinking water for experimental treatments except

for the negative control treatment that was given normal drinking water free of addition. The treatments included the following:

T1 negative control treatment (Basal diet + water free from H_2O_2), T2 positive control treatment (Basal diet + drinking water containing 0.05% H_2O_2), T3 T3, T4 and T5 addition of astaxanthin at a concentration of 40, 50 and 60 mg / kg, respectively, from the Basal diet + drinking water containing 0.05% hydrogen peroxide (H_2O_2).

The birds were fed free nutrition on two types of diets, which are the starting feed (protein ratio 23% and energy amount 3027 kilocalories/kg feed) from the one day age until the third week of the age of the birds after that they were replaced by the growth diet (protein ratio 20% and the amount of energy 3195.3 km Calories / kg feed) until the end of the fifth week, as shown in Table (1).

Table 1 : The percentages of diet components used in the study and their chemical composition

Final diet% (22-35 day)	Starter diet% (1-21 day)	Feeding Materials
40	30	yellow corn
24	28.25	wheat
24.8	31.75	Soybean meal (48% protein)
5	5	protein concentrate * (1)
4.4	2.9	Sunflower oil
0.6	0.9	limestone
0.9	0.7	DCP Calcium Diphosphate
0.1	0.3	Table salt
0.2	0.2	Mix vitamins and minerals
100	100	Total
Calculated Chemical Analysis (2)		
20	23	Crude protein (%)
3195.3	3027	Calculated represented energy (kilo calories / kg feed)
1.1	1.2	Lysine (%)
0.46	0.49	Methionine (%)
0.32	0.36	Cystine (%)
0.78	0.85	Methaionine + cysteine (%)
0.76	0.85	Calcium (%)
0.49	0.45	Available phosphorus (%)
159.77	131.61	C / P%

BROCON-5 SPECIAL W protein concentrate : Chinese origin, each kg contains: 40% crude protein, 3.5% fat, 1% fiber, 6% calcium, 3% phosphorous available, 3.25% lysine, 3.90% methionine + cysteine 2.2% sodium, 2100 kcal / kg energy represented, 20,000 IU vitamin A, 40000 IU vitamin D3, 500 mg vitamin E, 30 mg vitamin K3, 15 mg vitamin B1 + B2, 150 mg B3, 20 mg B6, 300 B12 mg, 10 mg folic acid, 100 mcg biotin, 1 mg iron, 100 mg copper, 1.2 mg manganese, 800 mg zinc, 15 mg iodine, 2 mg selenium, 6 mg cobalt, 900 mg antioxidant (BHT).According to the chemical analysis of the diet according to NRC (1994).

The studied productive traits:

1. Live body weight and weight gain (g / bird)

The chicks were weighed at the one day age, and all birds were weighed weekly for each replicate of treatments during the experiment period (35) days using an electronic balance. The following formula was applied to find the average live weight within one replicate, where indicated by Al-Fayyad and Naji (1989):

Average live weight (g / bird)=

$$\frac{\text{Total live weight of replicate birds at the end of the week (g)}}{\text{The number of birds for replicate at the end of the week}}$$

As for the weight gain rate achieved per week, according to the following equation (Al-Fayyad and Naji, 1989):

Average weekly weight gain (g / replicate) = average body weight at the end of the week (g) - average body weight at the beginning of the week (g).

2. The feed consumption (g)

It is calculated according to the average weekly feed consumption for birds of one replicate and for weeks (1-5) by the weight of the feed provided to it during the week minus the weight of the feed remaining at its end (Al-Fayyad and Naji, 1989).

The Feed conversion ratio

The feed conversion ratio for each replicate is calculated weekly according to what indicated in (Al-Zubaidi, 1986) according to the following formula: -

Weekly feed conversion ratio (g feed/g weight gain)=

$$\frac{\text{The average amount of feed consumption (g) within a week}}{\text{The average weight gain (g) within a week}}$$

The Statistical Analysis System -SAS (2012) was used in data analysis to study the effect of different treatments on the studied traits according to a completely randomized design (CRD), and the mean differences between the averages were compared to the Duncan (1955) polynomial test.

Results

Live body weight (g / bird)

The results in Table (2) shown indicate the effect of adding different levels of astaxanthin to the broiler diets exposed to oxidative stress in the weekly live body weight rate (g/bird) at ages 1-5 weeks. Statistical analysis indicated that there were significant differences between treatments in some experiment weeks for different ages, In the first week, a significant difference (P <0.01) was observed in treatment T1, T3, T4 and T5 compared to the treatment T2 where it was 213.00 g / bird, while there were no significant differences between T1, T3, T4 and T5 treatments, respectively. In the second week, there were no significant differences between all treatments. As for the third week of the experiment, the highly significant T5 treatment (0.01> 0.01) excelled the T1, T2 and T3 treatment. It recorded 1054.00 g/bird, and it was noticed a highly significant excelled of treatment T2 and T4 (0.01> P) on the treatment T1 and T3 in the same week where it recorded 1033.00 and 1043.00 g/bird, respectively, while there were no significant differences between T2, T4 and T5, As was observed a highly significant excelled (P <0.01) for treatment T3 while treatment T1, which amounted to 1019.00 g / bird. In the fourth week, treatment T2, T3 and T4 were significantly excelled (T> 0.01) on treatment T1 and T5, but there were no significant differences between treatment T2, T3 and T4, and we note the excelled of treatment T5 highly (P <0.01) on T1 where it reached 1506.00 g / bird compared to 1464.00 g / bird. Upon reaching the last week of the experiment, a significant difference (P <0.01) was observed for the treatment T2 on the rest of the treatment where it recorded 2157.00 g / bird. The treatment T3 and T4 significantly excelled (P <0.01) on the treatments T1 and T5 which it reached 2116.00 and 2119.00 g / bird , In contrast, 2029.00 and 2098.00 g / bird, respectively. The highly significant T5 treatment P (<0.01) also excelled the negative control treatment where it reached 2098.00 g / bird.

Table 2 : Effect of adding different levels of astaxanthin to diets of broiler chickens exposed to oxidative stress on weekly live body weight (g / bird)

Average treatment ± Standard error (g / bird)						Treatments
The fifth week	The fourth week	The third week	The second week	The first week	Weight at one day	
d 0.57± 2029.00	c 2.30± 1464.00	d 6.98± 984.67	a 1.76± 513.33	a 0.88± 224.67	a 1.20± 45.33	T1
a 1.15± 2157.00	a 2.88± 1520.00	b 1.73± 1033.00	a 1.73± 513.00	b 1.73± 213.00	a 0.33± 45.67	T2
b 1.73± 2116.00	a 3.46± 1521.00	c 1.15± 1019.00	a 1.15± 516.00	a 2.30± 222.00	a 0.00± 46.00	T3
b 0.57± 2119.00	a 2.30± 1519.00	ab 1.73± 1043.00	a 0.57± 511.00	a 1.15± 221.00	a 0.66± 46.33	T4
c 2.30± 2098.00	b 1.73± 1506.00	a 2.30± 1054.00	a 1.73± 512.00	a 3.48± 224.33	a 0.67± 46.33	T5
**	**	**	N.S	**	N.S	Level of significance

The averages that have different letters within one column differ significantly among themselves.* * (P <0.01) highly significant, N.S: non-significant.T1 negative control treatment (Basal feed + water free from H_2O_2), T2 positive control treatment (Basal feed + drinking water containing 0.05% H_2O_2), T3, T4 and T5 addition of astaxanthin at a concentration of 40, 50 and 60 mg / kg, respectively, from the Basal diet + drinking water containing 0.05% of Hydrogen peroxide (H_2O_2).

Weight gain rate g / bird:

Table (3) shows that adding different levels of astaxanthin to the broiler chickens diets exposed to oxidative stress has led to the presence of highly significant differences (P <0.01) in the weight gain rate for the weeks of the experiment. In the first week, A significant increase (P <0.01) was observed in favor of the negative control treatment on treatment T2 and T3 where it recorded 179.33 g / bird, While there were no significant differences between T1, T4 and T5 treatments, but the highly significant T3 treatment (P <0.01) was excelled to the T2 treatment as it recorded 173.00 g / bird. In the second week, the T2 treatment was highly significant (P <0.01>) compared to the rest of the treatments where it recorded 301.00 g / bird, but there were no significant differences between T1, T3 and T4 treatment. T5, In the third week, a significant increase (P <0.01) was obtained in favor of the T4 and T5 treatment compared to the rest of the treatment, as it recorded 532.00 and 542.00 g / bird, respectively. As for the T2 and T3 treatments, it significantly increased (P <0.01) on the negative control treatment as it recorded 520.00 and 519.00 g / bird Against 471.00 g / bird, but for the fourth week, a significant difference (P <0.01) was observed for the T1, T2, T3 and T4 treatments against the T5 treatment, and the T1, T2, T3 and T4 treatments did not differ significantly, but there are mathematical differences between them. Upon reaching the last week, the T2 treatment obtained a highly significant excelled (P <0.01) on the rest of the treatments, as it reached 636.00 g / bird, while the T3, T4 and T5 treatments were a significantly higher (P <0.01) excelled to the T1 treatment as it reached 595.00 and 599.00 And 592.00 g / bird, respectively, as well with respect to the rate of cumulative significant increase, treatment T2 recorded the highest rate of high weight increase significantly (P <0.01) on the rest of the treatments, which amounted to 210.00 g / bird. As for the T4 treatment, it was highly significant (P <0.01) compared to the T1 and T5 treatment, which amounted to 2080.00 g / bird, and there were no significant differences between T3, T4 and T5 treatments, but there were mathematical differences between them. The fifth treatment was highly significant (P <0.01>) compared to the negative control treatment It recorded 2050.00 g / bird.

Table 3 : The effect of adding different levels of astaxanthin to the diets of broilers exposed to oxidative stress in the rate of weight gain (g / brid)

Average treatment ± Standard error (g / bird)						Treatments
Total weight gain	The fifth week	The fourth week	The third week	The second week	The first week	
d 10.03± 1982.33	c 2.88± 565.00	a 4.61± 479.00	c 1.73± 471.00	bc 3.46± 288.00	a 45.± 179.33	T1
a 5.03± 2109.00	a 3.46± 636.00	a 2.30± 487.00	b 5.19± 520.00	a 1.15± 301.00	c 2.88± 165.00	T2
bc 11.71± 2066.00	b 2.30± 595.00	a 2.88± 485.00	b 4.62± 519.00	bc 2.30± 294.00	b 0.57± 173.00	T3
b 5.19± 2080.00	b 0.57± 599.00	a 2.30± 484.00	a 2.30± 532.00	bc 0.57± 290.00	ab 0.57± 175.00	T4
c 2.51± 2050.00	b 0.57± 592.00	b 1.15± 451.00	a 1.15± 542.00	c 1.15± 287.00	ab 1.15± 178.00	T5
**	**	**	**	**	**	Level of significance

The averages that have different letters within one column differ significantly among themselves.* * (P <0.01) highly significant, N.S: non-significant.T1 negative control treatment (Basal feed + water free from H_2O_2), T2 positive control treatment (Basal feed + drinking water containing 0.05% H_2O_2), T3, T4 and T5 addition of astaxanthin at a concentration of 40, 50 and 60 mg / kg, respectively, from the Basal diet + drinking water containing 0.05% of Hydrogen peroxide (H_2O_2).

Feed consumption rate

It is clear from Table (4) that adding different levels of astaxanthin to diets of broilers exposed to oxidative stress have led to significant differences in feed consumption during the experiment weeks in the third, fourth and fifth weeks, where there were no significant differences between all treatments in the first two weeks and the second. In the third week, a significant difference (P <0.01) was observed for the treatment T2, T4 and T5 compared to the treatment T1 and T3 where it recorded 700.67, 705.00 and 709.00 g / bird, and therefore we did not notice significant differences between T2, T4 and T5 treatments in the same week, and no significant differences appeared between T1 and T3 treatments, however, there were mathematical differences between them, which were 691.00 and 688.00 g / bird, respectively. As for the fourth week, the treatment T2 was highly significant (P <0.01) compared to the rest of the treatment, as it recorded 962.00 g / bird, and then came with a significantly excelled ranking, treatment T1 against the treatment T3 and T5 as it reached 905.00 g / bird, whereas the T4 treatment was highly significant (P <0.01) On T5 treatment it recorded 902.00 g / bird. As for the last week, the T2 treatment was significantly higher (S = 0.01) than the rest of the treatments, and its value was 1055.00 g / bird, and the T3 and T4 treatments were significantly excelled (P <0.01) on the T1 and T5, where it recorded 1029.00 and 1038.00 g / bird, respectively.

However, the T5 treatment recorded a highly significant (P <0.01) excelled on the T1 treatment as it recorded 995.00 g / bird. As for the results of the cumulative feed consumption rate, it was found that there were significant differences. The T2 treatment was highly significant (P <0.01) excelled to the rest of the treatments with a value of 3255.67 g / bird, followed by the T4 treatment with significant excelled (P <0.01) over the T1 and T3 treatments as it reached 3186.33 and there were no significant differences between the T1, T3 and T5 treatments but there were mathematical differences between them and they were Treating the addition of astaxanthin at a concentration of 40 mg / kg is the best treatment, due to its low feed consumption and superior production.

Table 4 : The effect of adding different levels of astaxanthin to diets of broiler chickens exposed to oxidative stress in the Feed consumption rate per week (g / bird)

Average treatment ± Standard error (g/ bird)						Treatments
The total Feed consumption	The fifth week	The fourth week	The third week	The second week	The first week	
d 5.56± 3122.00	d 1.73± 983.00	b 4.04± 905.00	b 4.04± 691.00	a 0.57± 374.00	a 0.57± 169.00	T1
a 12.91± 3255.67	a 2.88± 1055.00	a 1.15± 962.00	a 2.60± 700.67	a 2.88± 376.00	a 4.62± 162.00	T2
c 11.40± 3156.67	b 5.19± 1029.00	cd 1.73± 895.00	b 2.30± 688.00	a 1.15± 376.00	a 2.02± 168.67	T3
b 2.96± 3186.33	b 4.61± 1038.00	bc 1.15± 902.00	a 1.52± 705.00	a 2.30± 374.00	a 5.23± 167.33	T4
cd 8.08± 3134.00	c 2.30± 995.00	d 1.73± 893.00	a 1.73± 709.00	a 3.46± 369.00	a 1.15± 168.00	T5
**	**	**	**	N.S	N.S	Level of significance

The averages that have different letters within one column differ significantly among themselves.* * (P <0.01) highly significant, N.S: non-significant.T1 negative control treatment (Basal feed + water free from H_2O_2), T2 positive control treatment (Basal feed + drinking water containing 0.05% H_2O_2), T3, T4 and T5 addition of astaxanthin at a concentration of 40, 50 and 60 mg / kg, respectively, from the Basal diet + drinking water containing 0.05% of Hydrogen peroxide (H_2O_2).

The Feed conversion ratio

Table (5) showed that the effect of adding astaxanthin to the feed conversion ratio in the second, fourth and fifth week did not show any significant differences between the treatments and the period of giving the pigment was not significant effect on the feed conversion ratio but in the first week the table indicates the presence of significant differences between treatments Experiment in the of food conversion rate . The addition of astaxanthin led to a significant improvement (P <0.01) in the value of the food conversion factor in favor of the T5 treatment, which recorded 0.947 g feed / g weight gain compared to the T2, T3 and T4 treatments. Between treatment T1 and T5, no significant differences were found. The T4 treatment then appeared to a highly significant improvement (P <0.01) as it reached 0.955 g feed / weight gain compared to the T2 and

T3 treatments. Then it came with the T3 treatment rank and the T2 control treatment was the lowest treatment in the significant improvement in the rate of feed conversion efficiency as it recorded 0.979 g feed / g weight gain compared to the rest of the treatments. As for the third week, the T1 treatment recorded a highly significant excelled (P <0.01) on the rest of the treatments and its value was 1.460 g feed/weight gain and the lowest treatments were the improvement in the rate of food transfer efficiency. As for the rest of the treatments, no significant differences occurred between them and the T5 treatment was the highest significant improvement (P <0.01) in the average feed conversion efficiency rate from all other treatments, as it recorded 1.303 g feed / g weight gain and when studying the cumulative average of the efficiency of the food conversion rate, there were no significant differences between the treatments along the Experiment days, and there were mathematical differences between them.

Table 5 : Effect of adding different levels of astaxanthin to broiler diets exposed to oxidative stress on average feed conversion rate(feed g/ weight gain)

Average ± standard error (kg feed / kg meat / bird)						Tretments
Average	The fifth week	The fourth week	The third week	The second week	The first week	
a 0.011± 1.468	a 0.04± 1.740	a 0.017± 1.910	a 0.017± 1.460	a 0.005± 1.290	d 0.001± 0.941	T1
a 0.004± 1.437	a 0.03± 1.653	a 0.02± 1.970	b 0.02± 1.340	a 0.013± 1.243	a 0.001± 0.979	T2
a 0.012± 1.433	a 0.02± 1.730	a 0.05± 1.850	b 0.027± 1.336	a 0.024± 1.276	b 0.001± 0.972	T3
a 0.011± 1.431	a 0.023± 1.720	a 0.03± 1.870	b 0.02± 1.323	a 0.016± 1.286	c 0.002± 0.955	T4
a 0.05± 1.484	a 0.03± 1.680	a 0.24± 2.210	b 0.023± 1.303	a 0.005± 1.280	d 0.002± 0.947	T5
N.S	N.S	N.S	**	N.S	**	Level of significance

The averages that have different letters within one column differ significantly among themselves.* * (P <0.01) highly significant, N.S: non-significant. T1 negative control treatment (Basal feed + water free from H_2O_2), T2 positive control treatment (Basal feed + drinking water containing 0.05% H_2O_2), T3, T4 and T5 addition of astaxanthin at a concentration of 40, 50 and 60 mg / kg, respectively, from the Basal diet + drinking water containing 0.05% of Hydrogen peroxide (H_2O_2).

Discussion

It can be inferred from these results that the addition of astaxanthin to the broiler chickens diets exposed to oxidative stress by H_2O_2 had a positive role in reducing the negative effects of free radicals, which in turn was reflected in the increase in live body weight in comparison with the control treatment of free addition, and a decrease in the bird's body weight was observed in treatment of positive control due to the increase in the formation of free radicals as a result of adding hydrogen peroxide in drinking water, Which works to Lipid oxidation in the plasma membrane of cells, causing tissue damage and demolition (Rice and Mcmurray, 1984; Combs, 1997), and the positive effect of astaxanthin on body weight may come through the role it plays as an effective antioxidant that removes free radicals Formed inside the body before entering the reaction chain (Combs, 2008). With this feature, it is able to protect cells, fats and lipoproteins against oxidative stress and prevent various disturbances (Guerin *et al*., 2003; Kidd *et al*., 2011). Also, astaxanthin protects all parts of the cell and has better biological activity than other antioxidants (Yang *et al*., 2013; Ekpe, *et al*. 2018), and the nature of the pigment is more polar than other carotenoids, which improves the extent and rate of absorption of being a soluble compound in the fat (Ranga *et al*., 2013; Kidd, 2011)

All of these roles can lead to a live body weight of broiler chickens, which enables birds to resist oxidative stress and eliminate toxic effects from the oxidation of free radicals. As for the feed consumption rate, a significant decrease was observed due to the use of H_2O_2 in drinking water for broiler chickens, due to the ability of this substance to cause a state of oxidative stress (Abdel Majeed, 2013), as it works to raise the molecular pressure of oxygen inside the stomach, which leads to an increase in the molecular pressure of oxygen Intra-tissue (Loven and Oberley, 1985) This increases the chance of oxidative harm in the tissues of the liver and pancreas, which may affect the secretion of insulin by inhibiting the work of the body cells, including beta cells of the pancreas, and thus works to inhibit the hormone insulin (Al-Qattan, 2006), and this leads to an increase in the level of sugar in the blood that One of the factors inhibiting feed intake (Sturkei, 1976; Al-Husseini, 2000).

Conclusions

It was noted that the addition of astaxanthin to the flock of broiler chickens at a concentration of 50 mg / kg exposed to oxidative stress resulted in an improvement in the average body weight and the weight increase and the amount of feed consumed, as well as an improvement in the food conversion rate compared to the control treatment free from any addition.

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