Effect of Adding Astaxanthin to The Diet on The Physical and Chemical Traits of The Broiler Chickens

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Abstract

The aim of this study was conducted to add low levels of Astaxanthin to the feed on some physical and chemical traits of broiler carcasses raised at 42 days of age. 240 unsexed chicks, one day age, used the ROSS 308 strain, which was distributed randomly into five treatments by 48 chicks/treatment, and each treatment was divided into three replicates (16 chicks/replicate). The chicks were fed on three diets that included the initiator, growth, and final (23, 21.5, and 19.44% crude protein), respectively. Representative energy has amounted to 3000.5, 3100.7, and 3199.25 kcal/kg feed, respectively. Astaxanthin powder was added to the diet at levels 0, 10, 20, 30, and 40 mg/Kg of feed (T1, T2, T3, T4, and T5 treatments group), respectively. The results show the following: The treatments with Astaxanthin have recorded a significant improvement (P<0.01) in the percentages of liquids loss during cooking, drip and thawing loss, a significant increase in water holding capacity and pH in favor of the nutrient addition treatments compared to the control group. It, also, showed a significant improvement in the chemical traits of the Myoglobin and cholesterol concentration of minced chicken meat for the Astaxanthin treatments compared to the control group. It is concluded from the present study that the addition of low levels of Astaxanthin to broiler feed during the 42-day rearing period gave the best results in the physical and chemical traits of the carcass.

Keywords: Poultry meat, The physical traits of meat, Astaxanthin.

1.Introduction

Poultry meat and its products are one of the most important sources of animal protein with a high nutritional value. With the increase in population growth and the awareness of the importance of nutrition, meats were considered part of a healthy, balanced meal. This is because of their biological importance in building the body and maintaining human health. It is characterized by its ease of production and preparation and its low energy content. Its fibers are soft, easy to chew and digest, with a palatable flavor. Their proteins and fats include essential amino acids and fats that contribute to meet the requirements of human nutrition [1,2]. Despite the importance of meat processing, this sector faces challenges: it needs to improve quality traits and the most prominent such as bacterial spoilage, loss of meat color, and fat oxidation. They are among the main problems that are reflected in their impact on the organoleptic and qualitative traits and the nutritional and marketing value of meat, whether fresh or cooked, processed, or freeze-stored [3,4]. The physical traits of meat have a great impact on the quality including meat water holding capacity, which is important in the sense of juiciness and tenderness when tasting and which is affected by the pH of the meat [5,6]. Recent research and studies in this field, have tended towards finding alternatives and solutions to reduce these problems to reduce the trait of loss of important nutrients in meat (e.g. Drip loss during storage, loss during cooking, and to improve the ability of muscles). These are important to retain water WHC through the use of natural carotenoid materials in Poultry diets which are deposited within the tissues of the bird's body and contribute to improve the meat quality [7,8]. The drip loss represents the blood-like liquid that is excreted from fresh meat during storage or frozen meat during dissolving [9]. However, it is rich in protein and essential amino acids such as lysine and leucine, amounting to 4.4% in broiler chickens' meat. Also, it contains large quantities of vitamins, especially water-soluble B-Complex, as well as some mineral elements such as copper, potassium, iron and calcium [10]. Astaxanthin is a natural carotenoid. It considers an effective antioxidant with dark red color which has a clearance certificate from the European Food and Safety Authority (EFSA). This product is safe and valid for use in human and animal food supplements [11]. It is added to poultry, meat, and meat products safely [12,13]. It also works to reduce levels of LDL cholesterol, triglycerides, and oxidative stress due to its antioxidant properties. These properties come from its chemical composition by interaction with
biological membranes through its extension across the (double layer) cell membrane and improving the color values of meat [14,15]. Based on the foregoing, this study was conducted to investigate the effect of adding low levels of Astaxanthin to the broiler chickens' diet during the 42-day rearing period on some physical and chemical traits of the carcass.

2. Materials and Methods

The experiment was conducted in the poultry field, Department of Livestock, College of Agriculture, Al-Qasim Green University for the period from 4/27/2019 to 7/6/2019. The study was conducted to study the effect of adding a different level of Astaxanthin to the diet (0, 10, 20, 30, and 40 mg/kg feed) on the physical and chemical traits of broiler carcasses for 42 days. 240 unsexed ROSS 308 strain chickens were used for this study. Chicks were provided from a private hatchery starting weight 41g/chicken. The chicks were distributed randomly, one day age, into five treatments. Each treatment contained three replicates, at an average of 16 chicks/replicates, as follows: The first treatment (T1): a control treatment without any addition. The second treatment (T2): Adding 10 mg Astaxanthin/kg feed. Third treatment (T3): Adding 20 mg Astaxanthin/kg feed. Fourth treatment (T4): Adding 30 mg Astaxanthin/kg feed. Fifth treatment (T5): Adding 40 mg Astaxanthin/kg feed. The Astaxanthin powder used in the study was obtained from AstaPure® and sourced naturally from Haematococcus pluvialis. The chicks were raised in cages with dimensions 2x1.5 m and covered with sawdust (3-5 cm thickness). The replicates were distributed randomly to pens, and the temperature was automatically regulated using gas incubators and air pullers, then gradually reduced to 22-20°C until marketing age. Chicks were vaccinated against infectious bronchitis, Newcastle and Infectious bursal disease, and bird flu according to a vaccination program prepared for this purpose. The chicks were fed free feed Ad libitum with crushed feed during the period of the experiment. A standard starter diet was used for the period from 1-21 days of age. It contained 23% crude protein and 3000.5 kcal/kg energy feed represented according to the ROSS 308 chicks feeding guide to form the energy: protein ratio (C/P Ratio) of 130.45, followed by growth and final diet. It contained 21.5% and 19.44% crude protein and represented energy 3100.7 and 3199.25 kcal/kg feed. The energy to protein ratio was equal to 144,218 and 164.57, respectively, which lasted for up to 42 days. Six birds were taken from each group randomly. Birds were fasted 4 hours before slaughtering. They were scaled at 54° C for two minutes. Feathers were removed, and the internal evisceration was performed in an accurate anatomical manner from the beginning of the esophagus to the end of the exit according to the method [16]. They were washed and weighed. After completion of the cleaning and the removal of the process of the internal organs, 3 carcasses, were taken from each treatment for measurements including estimating the percentage of drip loss by the method of [17]. This method conducting by weighing the fresh carcasses hot and placing them in polyethylene bags and kept in the refrigerator at 5°C for 24 hours. The weight of the cold carcass was recorded after it was dried from the drip loss using filter paper, and the proportion of the drip loss was calculated according to the following equation:

\[
\text{Drip loss(%) = } \frac{\text{Hot carcass weight} - \text{cold carcass weight}}{\text{Hot carcass weight}} \times 100
\]

Then the percentage of losing weight when dissolving the treatment carcasses was estimated after freezing them at -18°C for 3 days according to the method [18]. The weight of the frozen carcass was taken for each treatment and then left in the refrigerator at 5°C for 24 hours to complete the dissolving process, then the drip loss was removed and returned. Weighed and then extracted the percentage of weight loss upon dissolving according to the following equation: - Weight loss when dissolving

\[
\text{Drip loss(%) = } \frac{\text{The weight of the frozen carcass} - \text{the weight of the carcass after thawing}}{\text{The weight of the frozen carcass}} \times 100
\]

The method of [19], was used to estimate the loss during cooking of the whole carcass by roasting in an electric oven at 160 °C for 6.5 minutes and by applying the following equation: -

\[
\text{Loss during cooking (%) = } \frac{\text{Weigh the carcass before cooking} - \text{Weigh the carcass after cooking}}{\text{Weigh the carcass before cooking}} \times 100
\]

The water retention capacity was estimated according to the method conducted by [20]. Briefly, ten g of meat was homogenizing with 30ml of distilled water at 4°C for one minute, then the mixture was centrifuged for 10 minutes at 3000 rpm, then the upper liquid was removed and stirred. The tubes went to the bottom and left for 5 minutes, then weighed and the WHC was estimated according to the following equation:

\[
\text{Water retention capacity (%) = } \frac{\text{Weight of water added} - \text{weight of water after centrifugation}}{\text{Sample weight}} \times 100
\]

The pH value was estimated by taking 1 g of the breast and thigh meat from each carcass, then mixing it with 10 ml of distilled water (pH=7), then mixing with water well and directly the pH was measured by a pH meter according to the method [21], the staining of Myoglobin was measured by homogenizing 10 g of meat with 90 ml of distilled water after adding 10 ml
of sodium phosphate (0.04 mol/liter) and placed in a centrifuge at 3000 rpm for 10 minutes. Filtering it and reading the absorbance over a wavelength (525 nm) and the Myoglobin concentration is calculated according to the following equation:

Myoglobin concentration = absorbance x 2.4 / sample weight x 0.452

Cholesterol concentration was measured based on [22] method, This test was performed as a result of the interaction of cholesterol with ferric chloride and concentrated sulfuric acid, which results in a dark brown color. It can be measured using a spectrophotometer in meat samples. The data were analyzed using the ready-made statistical program SAS (2012) and the application of complete random design in data analysis, and the Duncan test (1955) was used to test the differences between the multi-data treatments and compare the significant differences between the averages of the studied traits.

3. Results and Discussion

Table (1) indicates a significant improvement (P<0.01) in favor of the additional treatment T5 in the percentage of drip loss during storage compared to the rest of the experiment, followed by the two addition treatments T2 and T3, then T4, then T1. The thawing loss, the addition treatment T2, T3, T4, and T5 recorded a significant improvement compared to the control treatment (T1). The percentage of loss during cooking, the treatment T5 recorded a significant improvement compared to the rest of the experiment, followed by the effect T3, then T2 and T4, then T1, respectively. In the water holding capacity, the two addition treatments T3 and T5 recorded a significant increase compared to the other treatments, followed by the addition treatments T2 and T4 and then T1, respectively. As for the pH level, the addition treatment T5 recorded a significant increase compared to the rest of the experimental treatments, followed by the effect of treatment T4 which did not differ significantly from treatment T2 and which did not differ significantly from treatment T3 and then T1, which recorded the lowest values. Figure (1) shows a significant increase (P<0.01) in the concentration of Myoglobin pigment in T5 compared to the rest of the experimental treatments (T4, T3, T2, and T1), respectively. Figure (2) indicates a significant improvement (P<0.01) in the cholesterol concentration in T5 compared to T4, T3, T2, and T1. The reason for the low drip loss during storage may be due to the role and effect of Astaxanthin in preserving and providing stability to sarcoplasmic components, fluids, and membranes from oxidative damage resulting from the formation of free radicals, which results in a reduction in the drip loss [23,24]. While the lower values of thawing loss and increased water holding capacity are due to the treatments compared to the control treatment (T1). This is because of the natural antioxidant reaction pattern represented by the Astaxanthin in increasing the ability of meat tissues to retain water and reducing thawing loss through its association with protein inside the cell and this is what leads to the penetration of water from the outside into the cell. Thus, increasing the ability of protein in the meat to absorb water as a result of a decrease in its solubility [25,26]. As for the decrease in the percentage of loss during cooking in the treatments, it is due to the role of Astaxanthin added to the diets in increasing the rates of body weight and then an increase in the weight of the carcass, which reflected positively on the increase in the percentage of meat and then the increase of the sites of binding and holding water with the protein molecule. The main component of meat muscles Humidity leads to less waste during cooking [27,28]. In addition, the unique properties of Astaxanthin represented in its composition and structure as an effective antioxidant, contribute to protecting and stabilizing fats from oxidation and reducing and maintaining the tearing of the cell membranes surrounding muscle fibers. This will increase the ability and ability of the lean muscle to retain water [29,30]. Also, the high pH values of the meat may be due to the role of Astaxanthin, as an effective antioxidant, which has a major role in protecting cells, fats, proteins, and fats membranes. In addition, it protects tissues from damage by changing the water retention ability and increase the amount of water bound to the protein.
Table 1. Effect of adding Astaxanthin to the diet on the percentages of drip loss during storage, thawing loss, cooking loss, water holding capacity and pH (mean ± standard error) of carcass meat.

| Level of significant | T5   | T4   | T3   | T2   | T1   | Studied traits                      |
|----------------------|------|------|------|------|------|-------------------------------------|
| **                   | 1.25±0.020 | 1.41±0.006 | 1.33±0.015 | 1.35±0.012 | 2.07±0.026 | Drip loss during storage (%)        |
| **                   | 1.66±0.005 | 1.85±0.017 | 1.72±0.005 | 1.83±0.005 | 2.46±0.205 | Thawing loss (%)                    |
| **                   | 14.83±0.199 | 17.58±0.185 | 15.70±0.028 | 17.47±0.223 | 21.22±0.228 | Cooking loss (%)                    |
| **                   | 24.83±0.143 | 23.55±0.223 | 24.55±0.043 | 23.50±0.170 | 21.80±0.070 | Water holding capacity (%)          |
| **                   | 6.55±0.003 | 6.46±0.018 | 6.41±0.005 | 6.42±0.01 | 6.04±0.023 | pH                                  |
| **                   | a      | b      | c      | b     | a    |                                      |
| **                   | b      | d      | b      | a     | b    |                                      |
| **                   | d      | b      | c      | a     | b    |                                      |
| **                   | a      | b      | c      | b     | a    |                                      |

* The different letters within the same row mean that there are significant differences between the averages of the treatments.
** It means that there were significant differences at (P <0.01) in the ANOVA table.
*** The parameters include the following: - T1 control treatment without addition, T2, T3, T4, T5, and the addition of Astaxanthin at level 10, 20, 30, 40 mg/kg feed, respectively.

Figure 1. Effect of adding Astaxanthin to the diet on the concentration of Myoglobin pigment of carcasses.
Figure 2. Effect of adding Astaxanthin to the diet to a poultry diet on the cholesterol concentration of carcass meat.

This will be moving away from the electrical neutral point and improving the solubility and diffusion of proteins. All these data can be lead to the conclusion that Astaxanthin can be used as an antioxidant as a natural preservative alternative to industrial additives in meat preservation, where the integrity and protection of membranes and the reduction of their rupture contribute to preserving the cellular components of meat, leading to a lack of drip loss and an improvement in the ability of meat to Holding water during storage. The results of this study are consistent with [31,32].

The significant improvement in the Myoglobin pigment concentration for the treatments compared to the control group (T1) may be due to the color of the Astaxanthin pigment between red-orange. This color is deposited in the body tissues based on the percentage of Astaxanthin additive to the feed. The high effectiveness of Astaxanthin, as an antioxidant, protect poultry meat and its products from fast damage because it is fast sensitive to oxidation and spoilage. This is because they contain high levels of unsaturated fatty acids and low levels of natural antioxidants such as vitamin E, which protect it from the production of toxic compounds, including free radicals, hydroperoxides, and malondialdehyde [33,34].

The Astaxanthin additive protects the poultry meat color and kept the natural luster. This ability is due to the presence of Myoglobin pigment at the meat surface. Myoglobin pigment is less in poultry meat and it is increased by increasing Astaxanthin concentration which delaying the formation of the MetMb pigment thus extending the shelf life of meat [35,36].

The results of this study are in agrees with [37,38], who found that the use of Astaxanthin in poultry diets improves color values and provides protection for the natural color of meat that Astaxanthin prevented color oxidation because the two ends of the ring contain an oxygen molecule, which reduces according to [39,40]. Cholesterol is deposited in cell membranes which are sensitive to oxidation processes by the action of free radicals. Oxidized cholesterol products accumulate on stored meat as a result of the presence of free radicals formed from the oxidation of unsaturated fatty acids in these meats [41], studies have indicated the potential of Astaxanthin as a natural antioxidant and its unique composition represented by the different structures of the final groups. The number and the methylation groups and their physical and chemical interactions with the membranes from extending through the double-layer cell membrane and getting rid of free radicals inside and outside the cell by giving an atom. Hydrogen is from methane groups on both ends of the urine chain of the Astaxanthin molecule, which traps free radicals in cell membranes in which cholesterol is concentrated and which are sensitive to the oxidation process [42]. As indicated by some studies, [43], demonstrated the ability of Astaxanthin as an enzyme antioxidant to stimulate the nuclear factor associated with red factor-2 (Nrf2) Nuclear factor erythroid 2-related factor 2, which is a type of protein associated with DNA, which works to protect cell membranes and stimulate the antioxidant enzymes inside the cell that have a role in the elimination of types ROS reactive oxygenation [26], as Nrf2 activation stimulates the production of active proteins to reduce oxidative stress.


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