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THE ROLE OF ANTIOXIDANT VITAMINS ON PHYSIOLOGICAL PERFORMANCE OF POULTRY (Article Review)

Ghadeer A.M. Rahawi, Abdullah F. Abdul-Majeed, Saeb Y. Abdul-Rahman
Department of Animal Production, College of Agriculture and Forestry, University of Mosul, Iraq.

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Correspondence Email:
ghadeer_abd@uomosul.ed.iq

ABSTRACT

Animal health depends on multiple factors, and recently it has been shown that diet plays a major role in maintaining health and preventing various diseases. One of the most important nutritional factors is antioxidants, which occupy a special place because they play an important role in animal survival, maintaining animal health, and improving its physiological and productive performances and the immune state of the body. Antioxidants work to reduce the harmful effects of free radicals and toxic products of the metabolism. Therefore, the role of antioxidants, especially antioxidant vitamins (vitamin A, E, and C) is important in the growth stages of the bird's body, as well as in reducing the stress of birds as a result of their rapid growth requirements. Poultry products are considered one of the most protein sources in human nutrition in order to solve the problem of food shortage in the world, so the poultry industry is taking many ways to reduce the time period to reach the marketing weight such as: genetic selection, nutritional improvement, and other environmental factors, but unfortunately, all of that is associated with reduced immunity and the occurrence of oxidative stress. Therefore, the aim of this review is to clarify the role of antioxidants, which are: vitamin A, E, and C in the physiological and productive performance of broilers and their ability to prevent and/or reduce the oxidative stress effects in the body.

INTRODUCTION

Poultry farming is considered successful if it gives a high economic return in terms of converting the consumed feed materials to meat and/or egg production, this helps to reach the highest possible production performance in poultry (AL-Jubouri, 2000). Poultry products are considered one of the important food sources for humans (Cholore, 1996), including poultry meat, which is one of the most important sources of high-quality animal protein in human nutrition, as the global production rate of poultry products has increased, according to the report of the FAO (2022) which states: "The rate of global poultry meat production increased from 9-132 million tons between 1961-2019, and the egg production increased from 15-90 million tons".

The international humanitarian organizations stressed the need to find solutions to the problem of food shortage in the world, which has become increasing day by day, given the lack of food resources on one hand and the increasing population on the other (AOAD, 2006). The poultry industry tended to reduce the time period to

reach the marketing weight through genetic selection improving nutrition and other environmental factors (Cherian *et al.*, 2007), but this was accompanied by bad effects such as reduced immunity and increased cases of oxidative stress due to increased free radicals production reactive and effective oxygen species resulting from high rates of metabolic processes accompanying the rapid growth (Saif *et al.*, 2008). Poultry is also exposed to various stressful factors, including chemical ones, such as giving medicines, and physical factors such as climatic changes and lighting, in addition to stressful nervous factors such as sex and crowding (Sodhi *et al.*, 2008). Stressing factors usually lead to many disturbances in the physiological performance including the blood picture (Salah, 2008).

In order to study and understands the physiological changes that contributed to the improvement of health and productive performance of poultry by dietary supplementation which includes the addition of vitamins, trace mineral, and some active plant ingredients (Sabu & Kuttan, 2002; Al-Rahawi, 2010; Elagib & Omer, 2012). Recent studies have increased the interest in investigating the role of antioxidants in the prevention of oxidative stress that occurs in abnormal cases because the body has several defense mechanisms to control the production of free radicals, determine their risks, or rebuild damaged tissues (Surai, 2002; Sabu & Kuttan, 2002). Antioxidants play an important role in maintaining the health of birds (Surai, 2002).

Stress:

Stress is any action that changes the nature of an organism and results from a change in the external and internal environmental conditions of the animal. The reaction of an organism's body to the stressful factor is called stress. (Siegel, 1985).

Oxidative stress:

It is one of the types of stress, that occurs due to the increased production of reactive oxygen species (ROS) and lipid peroxides and the inability of the antioxidant systems in the cell to remove them or prevent their damaging effects (Beer–Ljubic *et al.*, 2012). Oxidative stress is accompanied by increased lipid peroxidation, causing damage to various body tissues (Betteridge, 2000; Noguchi *et al.*, 2000). Excessive production of free radicals that are generated as a result of the many vital activities in the body of the organism leads many damaged all components of the cell including protein, DNA, etc. which then leads to a gradual decrease in the physiological functions of the tissue or cells (Dalle-Donne *et al.*, 2006).

Reactive Oxygen species:

The Reactive oxygen species (ROS) are generally divided into two groups:

1-Radical R.O.S:

a- Super Oxide Anion Radical ($O_2^{\cdot -}$).
b-Hydroxyl Radical ($OH^{\cdot}$).
c- Aloxyl Radical ($RO^{\cdot}$).
d-Peroxyl Radical ($ROO^{\cdot}$).
e- Nitric oxide Radical ($NO^{\cdot}$).
f- Carbone dioxide Radical ($CO_2^{\cdot}$). (Maritim *et al.*, 2003).

2-Non-Radical R.O.S:

a-Single Oxygen (O_2^-).
b-Ozone (O_3).
c-Peroxy Nitrite ($ONOO^-$).
d-Hydrogen Peroxide (H_2O_2).
e-Nitrous Acid (HNO_2). (Maritim *et al.*, 2003).

Antioxidants:

Antioxidants are compounds or substances that protein the cells from oxidative damage and inhibit lipid peroxidation (Miquel, 2002). They are compounds of high reductive power capable of reducing free radicals and delaying or preventing their damage from reaching oxidative molecules and cellular components, they act as defense mechanisms against free radicals and reactive oxygen species (ROS) (Sanocka & Kurpisz, 2004). There are many compounds that have antioxidant properties in nature, including:

Antioxidants are classified into several classes; they may be classified according to their source to:

- **Exogenous Antioxidants:** that consist of food or any vegetable source.
- **Endogenous Antioxidants:** that the organism's body manufactures on its own (Noori, 2012).

It is also classified according to its chemical nature which is the common classification into:

1- **Enzymatic Antioxidants:** they are known as natural or primary antioxidants, and they generally need minerals such as selenium, manganese, copper, and zinc in order to complete their function and also need other auxiliary factors such as vitamins and folic acid (Yin & Chan, 2007). they include:
   a- Catalase (CAT).
   b- Superoxide Dismutase (SOD).
   c- Glutathione Peroxidase (GH-Px).
   d- Glutathione Reductase (GSH- rd).

2- **Non-Enzymatic Antioxidants:** they are known as manufactured antioxidants or nutritional supplements, their source is either from inside the body or from outside the body and is characterized by its low molecular weight (Karthikeyan & Rani, 2003), and is it includes:

Vitamins:

They are biological organic substances that the body needs in very small quantities to regulate biological activities its necessary for normal growth and normal physiological functions and for the activity of metabolic processes within the body, and because most vitamins can't be synthesized and manufactured in poultry, they must be available in the diet (Weber, 2009). In general, the antioxidant vitamins are classified into two parts based on their solubility:

1- **Fat-Soluble Vitamins:** such as vitamin E, A, D, K. Fat-soluble vitamins are stored in the liver and adipose tissue, thus allowing for accumulation and consumption over time.

2- **Water Soluble Vitamins:** such as B complex and vitamin C. Water-soluble vitamins are little retained in the body, they need a continuous supply, that is a regular replacement if their levels are determined mainly by processing them in food compared to fat-soluble vitamins (Prabhu *et al.,* 2010).

- Vitamin E:

Vitamin E is called tocopherol derived from the Greek word tokos which means childbirth, pherein means bring forth, and the ending "ol" for alcohol properties (Wagner *et al.,* 2004), it is one of the main antioxidants, it can be obtained easily from sources rich in the vitamin, such as wheat, corn, olive, soybeans and other natural sources (Khallouki *et al.,* 2020). Vitamin E consists of two groups of fat-soluble compounds, which are eight naturally occurring lipophilic compounds consisting of four tocopherols (α-, β-, γ- and δ-) and four tocotrienols (α-, β-, γ- and δ-) that fifer in their side chain saturation and degree of methylation of their chromanol heads, in addition to the factory form dissolved in water (Bansal & Bilaspuri, 2009). Vitamin E was discovered in 1922 and it was later recognized as an antioxidant (Khallouki *et al.,* 2020). Fat tissue is the main storage site for vitamin E, it is highly reactive with oxygen radicals but weak towards hydroxyl radicals (Matkovics, 2003). Vitamin E is a biological systemic antioxidant, and it is a fat–soluble that prevents the oxidation of long-chain fatty acids in cell membranes (Arslan *et al.,* 2001). Vitamin E is a major chain breaker in biological systems, as it settles in biological membranes and lipid droplets (Surai *et al.,* 2019; Avanzo *et al.,* 2001), and as free radicals are characterized by their ability to initiate a series of reactions that amplify their activity, which leads to the destruction of cell components and the oxidation of unsaturated fatty acids, causing a change in the composition of cell membranes and function (Cheng *et al.,* 2002, Surai *et al.,* 2003).

The richest sources of vitamin E are raw vegetable oils (Khallouki *et al.,* 2020). In conditions of stress, excessive doses of this vitamin are beneficial for the animal (Surai *et al.,* 2003). Vitamin E works to remove free hydroxyl radicals and thus is one of the antioxidants that provide protection for the liver during the oxidative processes that occur in it, especially the so-called lipid peroxidation (Duell, 1996).

Vitamin E is one of the biological antioxidants that breaks chains of free radical reactions to protect tissues from lipid peroxidation damage (Panda & Cherian, 2014). It is necessary for the safety and function of the reproductive, muscular, circulatory, nervous and immune systems (Leshchinsky & Klasing, 2001; Khan *et al.,* 2012). Vitamin E is added to the broiler breeder's diets to produce fertilized eggs (Rengaraj & Hong, 2015; Yaripour *et al.,* 2018), as it has proven its ability to improve fertility and hatchability in broiler flocks.In addition, it has a role in improving the characteristics of the sperms (Rakha *et al.,* 2015).

Many previous studies have shown that vitamin E reduces the effects of heat stress on birds. Both Arslan *et al.* (2001) and Sahin *et al.* (2001 & 2003) mentioned

that vitamin E protects the body cells from damage caused by the oxidative processes, which is positively reflected in improving body weight and the efficiency of feed conversion, also improving immune performance (Sell *et al.*, 1997). Abdul-Rahman & Alkatan (2009) showed that vitamin E improved the biochemical properties and antioxidant status of laying hens. Al-Rahawi (2010) revealed that the addition of vitamin E improved the biochemical characteristics in the blood serum of quail and improved immune response and the health status of the flock. Tawfeek's (2011) study indicated that adding different levels of vitamin E improved the productive performance of broiler chicks, as well as improved the general physiological condition of the birds, it regulates the biosynthesis of some molecules such as iron.

The action of vitamin E in somatic cells requires the presence of selenium and the enzyme glutathione peroxidase (Avanzo *et al.,* 2001), so both vitamin E and selenium protect living membranes, while the enzyme glutathione peroxidase (GSH-PX) destroys hydrogen peroxide (H_2O_2) and hydroxides in the plasma and cytoplasm of cells (Ajakaiye *et al.,* 2010). Younis (2019) showed that the vitamin E treatment improved the blood picture and the biochemical characteristics of the quail.

- Vitamin C:

It is one of the water–soluble vitamins called the anti-scurvy, it is required to maintain normal metabolic activities, it is manufactured in the bird's body to meet the physiological requirements of poultry (Leeson and Summers, 2001). Vitamin C is one of the most powerful natural antioxidants and is found in high concentrations in a number of tissues, especially in the brain, Vitamin C can be used to reduce the negative effects of stress (Sahin *et al.,* 2009). this is through its important effect in protecting birds from heat stress and improving their immune system (Lohakare *et al.,* 2005). Vitamin C acts as an inhibitor for the release of the stress hormone (Corticosterone) from the adrenal cortex (Elagib & Omer, 2012). Vitamin C plays an important role in the regeneration of the vitamin E cycle through a non-enzymatic reaction (Niki, 1987; AL-Musawi, 2009), also vitamin C regenerate vitamin E radicals formed when vitamin E scavenges the oxygen radicals (Niki, 1987).

Several studies were concerned with the impact of vitamin C in the different aspects of poultry production, Hammouda & Dabbagh (2018) noted that treatment with vitamin C led to an increase in the level of total protein and also lowered the level of cholesterol in the blood serum of broilers exposed to heat stress. Tayeb *et al* (2015) on this study on quail showed that vitamin C (300 mg/kg ratio) improve significantly HD%, egg mass and reduce serum Triglyceride (T.G), and cholesterol significantly. Also, Vitamin C treatment improve stress index in male quail by increasing lymphocyte % and decrease heterophil %. The study of Abdul-Rahman and Al-Rahawi, (2012) revealed that vitamin C (200mg/drinking water) enhance body weight of 4 week aged quail, also improve the stress index. . Abdul-Majeed *et al* (2013) study the impact of vitamin C (300mg/kg ratio) on the reproductive performance of quail. They revealed that vitamin C could prevent H_2O_2-induced oxidative stress and improve the maturity age, 50% egg production age and egg quality characters. . Abdul-Majeed *et al* (2012) also showed that vitamin C (300mg/kg ratio) improve stress index (H/L ratio), and overcome the passive effects of H_2O_2-induced oxidative stress on blood picture and increase significantly serum protein and globulin and reduce glucose, cholesterol and triglyceride. Abdul-Rahman and Alrahawi, (2012) showed

that addition of Vitamin C to quail drinking water (200mg/L) improve the immunity status as represented by the increase in serum, globulin and globulin/albumin ratio, also it reduce significantly the age of puberty (34 days: normal puberty age : 42 days) and the egg yolk cholesterol level.

. Taha and Abdulrahman (2011) revealed that the supplement of Arbor Acres ration with 450 mg vitamin C/kg enhance the antioxidant stress (increase GSH and reduce MDA) in testis tissue, Abdul-Rahman & Alkatan (2009) study the impact of vitamin C on hubbard laying hens, They showed that the addition of vitamin C to drinking water increase GSH and MDA in liver tissue and enhance the reproductive performance as the acceleration of maturity age and the egg weight. Abdul-Rahman and Alkattan *et al.* (2007) showed that vitamin C supplementation to the hubbard kaying hen ration reduce significantly the MDA in heart, kidney and pancreas tissue.

seminal plasma which was reflected in the improvement of semen quality characters. AL-Rahawi's (2010) results showed that the treatment with vitamin C improved some physiological and biochemical parameters, and this was reflected in some productive traits of quail and reduced cholesterol in egg yolk. Mohammed *et al.* (2013) explained that the treatment with vitamin C significantly improved the antioxidant status of the system against heat stress through a significant increase in the activity of the enzymes glutathione peroxidase and catalase in the plasma and the amount of bound iron and a decrease in the level of malondialdehyde and the value of peroxide and the percentage of free fatty in the liver tissue, and this indicates the role of treatment with vitamin C in protection from the effect of heat stress and its ability to improve physiological characteristics, health and immune status of laying hens (Puthpongsiriporn *et al.*, 2001).

- Vitamin A:

Vitamin A is one of the fat-soluble vitamins and has many functions in the animal body, it is necessary for animal growth and reproduction, vision and the integrity of the mucous membranes in the body (Yuan *et al.*, 2014). However, a fat-soluble compound can be stored in the liver in large quantities and may lead to poisoning symptoms (Engelking, 2015). Studies have shown that vitamin A is important in improving the resistance of broilers to coccidiosis, as its deficiency in the diet leads to a weakening of the body's immune defense against coccidiosis (Dalloul *et al.*, 2002). Taha and Abdul-Rahman, (2013), study the effects of vitamin A 915mg/kg ration) on Arbor Acres broiler breeder males, results status through enhancing GSH and the reduction of MDA in testis tissue and seminal plasma, and they revealed that the antioxidant status improvement was reflected on the improvement of semen quality and fertility and hatchability %.

There is a relationship between vitamin E and vitamin A, as vitamin E has an important role in absorbing vitamin A inside the animal's body and protecting it from oxidation (Reboul, 2017). Vitamin A also increases the bird's ability to resist diseases by increasing the effectiveness of the immune system (Semba, 1999).

Salah (2008) indicated that the treatment with antioxidants such as vitamin A led to an improvement in blood as it is pointed in the reduction of stress index (H/L ratio).

Vitamin A is one of the most important vitamins in the poultry diet, and it is necessary for growth and production, as well as to maintain the integrity of the mucous membranes that line most of the body's systems, importance this vitamin has not limited to the safety of looking in birds (Al-Sheikhly, 2003). The presence of vitamin A in the diet leads to an increase in IgG, IgM, IgA antibodies from mothers to chicks through eggs, which work to enhance the immune response (Yuan *et al.*, 2014), vitamin A acts asan antioxidant by neutralizing free radicals before they phagocytosis (Sinbad *et al.*, 2019). Also, inhibits the breakdown of lipids and proteins, acts as a detoxifier, and reduces the load on the immune system (Surai *et al.*, 2000).

CONCLUSIONS

In conclusion from this review, the antioxidants can be used with the basal diet of poultry to obtain the best results in the physiological and productive performance of poultry. The antioxidant defense system which is represented by the antioxidant vitamins (A, E, and C) has an important effect in most of the physiological, productive, and immune properties, can to interact freely with the free radicals, thus reducing their amounts and preventing or/and reducing the occurrence of lipid peroxidation in birds.

Also, this study showed that there are synergistic effects of the antioxidant vitamins among them so that they can be used to relieve oxidative stress and enhance the antioxidant status of the birds and improve their immune system.

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CONFLICT TO INTEREST

There is no conflict of interest between the authors for publishing this manuscript.

دور الفيتامينات المضادة للأكسدة في الأداء الفسلجي للدواجن: بحث مراجعة

غدير عبد المنعم محمد رحاوي عبدالله فتحي عبد المجيد صائب يونس عبد الرحمن

قسم الإنتاج الحيواني، كلية الزراعة والغابات، جامعة الموصل، العراق

الخلاصة

تعتمد صحة الحيوان على العديد من العوامل، وقد تبين مؤخراً أن النظام الغذائي يلعب دوراً رئيساً في الحفاظ على الصحة ومنع الأمراض المختلفة. أحد أهم العوامل الغذائية هي مضادات الأكسدة، التي تحتل مكانةً خاصةً لأنها تلعب دوراً مهماً في بقاء الحيوان والحفاظ على صحته وتحسين أدائه الفسيولوجي والإنتاجي والحالة المناعية للجسم. إذ تعمل مضادات الأكسدة على تقليل الآثار الضارة للجذور الحرة والمنتجات السامة لعملية التمثيل الغذائي، لذلك فإن دور مضادات الأكسدة ولاسيما الفيتامينات المضادة للأكسدة (فيتامين أ، هـ، ج) مهم

في مراحل نمو جسم الطائر، وكذلك في تقليل إجهاد الطيور نتيجة لمتطلبات نموها السريع. تعد منتجات الدواجن من أكثر مصادر البروتين في تغذية الإنسان من أجل حل مشكلة نقص الغذاء في العالم، إذ تتخذ صناعة الدواجن العديد من الطرق لتقليل الفترة الزمنية للوصول إلى الوزن التسويقي مثل الانتخاب الجيني وتحسين التغذية وعوامل بيئية أخرى، ولكن لسوء الحظ كل ذلك كان مصحوباً بانخفاض المناعة وحدوث الإجهاد التأكسدي. لذلك فإن الهدف من هذه المراجعة هو توضيح دور مضادات الأكسدة وهي: فيتامين أ وهـ وج في الأداء الفسيولوجي والإنتاجي لدجاج التسمين وقدرتها في منع و/ أو تقليل تأثيرات الإجهاد التأكسدي في الجسم.

الكلمات الدالة: الفيتامينات، مضادات الأكسدة، الإجهاد التأكسدي، أصناف الأوكسجين الفعالة، توكوفيرول

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