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Ecophysiology of antioxidants in poultry diet

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ABSTRACT

This review was intended to elucidate the role of antioxidants in poultry feed formula on bird's ecophysiology. Naturally, many compounds have antioxidant features, including fat and water-soluble compounds, which can either be synthesized by the body or supplemented with a diet. The additive of antioxidants on poultry fodder is usually utilized in order to elevate the steadiness of feed. Nevertheless, some antioxidants are believed to have biological consequences in vivo. Oxidative stress clues to biological destruction, which in turn can disturb growth and production in farmstead animals. These Stressful factors are created reactive oxygen species. Therefore, the natural and synthetic antioxidants that add to animal feed are important to diminish the free radicals that are thought to unfavorably on growth, immune status, elevated lipid rancidity, and poor quality of meat. Supplementation of balanced feed with many ingredients including natural and synthetic antioxidants will improve the bird's performance and other physiological aspects by reducing the significant effects of free radicals. In conclusion, feed additive including antioxidants integrated with feed formula is beneficial and valuable to exclude and prevent the destructive effects of reactive oxygen species on physiological aspects of vital organs, maintenance of homeostasis, Repair and removal of harmed particles, activation of apoptosis and finally limit of mutagenesis.

Keywords: Ecophysiology, mutagenesis, physiological antioxidant, poultry diet.

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INTRODUCTION

No definition clarity of the term "stress" therefore, has several clarifications of stress. "Everybody knows what stress is and nobody knows what it is" and "a nonspecific response of the body to any demand made upon it" **(Selye, 1973).** Also, **(Moberg and Mench, 2000)** describe stress as a "threat to homeostasis" Vitally though, an incentive that creates considered positive stimuli like exercise, arousal, and excitement etc.…can trigger the hypothalamus-pituitary-adrenal axis (HPA-axis). And therefore construed as stress and thus included in the definitions mentioned above. While the thought debated by **Koolhaas *et al.*, (2011)** to understand stress and riposte is considered normal physiological processes and not regarded as stress. Physiological response to stress triggers four cascades of reactions as mentioned by **Love *et al.*, (2013)** firstly activate the autonomic nervous system, endocrine system, immune system and finally depend on behavioral effects. In mature chickens, when elevation the cortisol which affects alterations of many physiological parameters, like diminishing in body weight and relative of organ masses, the elevation of blood glucose, fat metabolite, and heterophil/lymphocyte ratio (stress index) (**Shini *et al.*, 2009).**

But in Japanese Quail**,** the physiological response to raises the cortisol has been unsuccessful in showing any later effects; therefore, we noticed the quail reached puberty earlier than other birds with a high response **(Marasco *et al.* 2012)**. Greatest biologically- pertinent are free radicals which originated from oxygen and nitrogen atoms have free electrons (unpaired electrons) in outer orbit, So-known as reactive oxygen species (ROS) and reactive nitrogen species (RNS). In normal circumstances, these two molecules have a vital role in the body but

can acquire the reactive capacity to become harmful to vital biological molecules **(Surai, 2002a).**

In poultry, the physiology of the gastrointestinal tract (GIT) has great ability to create reactive oxygen species (ROS) and reactive nitrogen species (RNS) that are generated by epithelial cells, either one from oxygen metabolism or by microbiota, to adjust gut healthiness. So, the possibility of oxidative stress is high by producing free radicals at higher than levels of antioxidants. Therefore, supplementation a diet has antioxidant properties to scavenger ROS and helpful in alleviating oxidative stress in the poultry gut **(Mishra and Jha, 2019)**.

In addition, the active oxygen species are also created from mitochondria and macrophages; it participate a vital role in damaging major biological particles comprising proteins, lipids, DNA, and RNA molecules that lead to generating stress reaction and activation groups of genes known as vintages that affect to redox equilibrium, stress resistance and adjustment suitable health, elevated immunity productive and reproductive performing in avian **(Surai *et al*., 2019).**

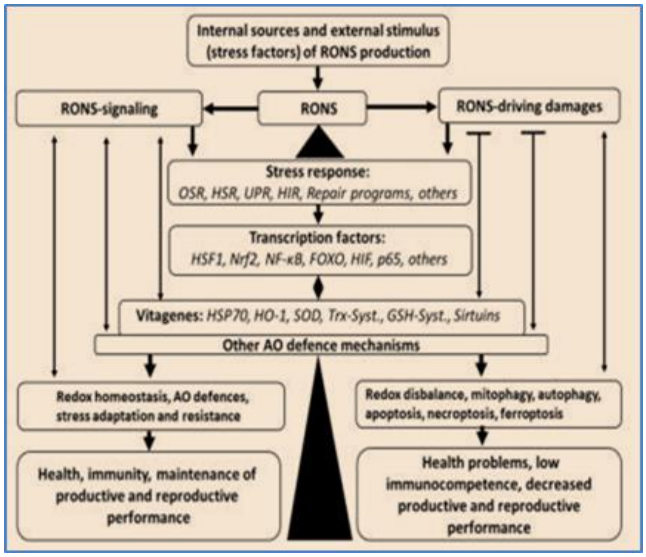

Fig. 1: The antioxidant defense system in poultry **(Surai *et al.*, 2019)**

The first system can combat against free radical production is digestive system as a general and the intestinal cells as a special, because the epithelial cells are unceasingly exposed to free radicals that physiological create from oxygen metabolism which are hydroxyl free radical, superoxide, and the hydrogen peroxide(H2O2), secondly endogenous antioxidant considered as second line to prevent peroxidation of lipids, nitration of protein, destruction of DNA and apoptosis which are glutathione peroxidase, superoxide dismutase, and catalase **(Estevez,2015)**. Superoxide dismutase either SOD1 or SOD2 can catalyzes to convert the superoxide anion (O^{-}_{2}) to hydrogen peroxide (H2O2), that cause disintegrated into water and oxygen molecules by enzyme known as catalase , But glutathione peroxidase (GPX) lessens lipid oxidation **(Fukai *et al.*, 2011)**. Also the absorption of nutrient impairment when elevated nitric oxide radical (NO•) which are production from arginine and citrulline that cause destructions of intestinal mucous. **(Sklyarov *et al.*, 2011).** Continuous exposure to stress losses the mucosa of intestine ability to digestion of nutrient and make inefficient absorption this is adversely redirected in adjustment normal growth of the animals **(Yara , 2013)**

Poultry industry, in the last decades has created marvelous advancement of quantity and property of chicken meat, production and quality of egg. However, it has associated with a variety of stresses involving physiological stress that affected by environmental factors, technological, diet, and the biological environment of the bird **(Surai and Fisinin, 2016).**Therefore, tremendous production of reactive oxygen species are public problems in poultry industry. Natural and synthetic antioxidants must be added to poultry diet.

living creatures have a specific antioxidant protective defensive, procedure to cope with reactive oxygen species which are steadily generated in the organism cells are termed generaly "antioxidant system" **(Surai, 2002a)**. naturally, there are thousands of composites having antioxidant features to fit counteract with free radicals, include fat-soluble vitamin and water-soluble vitamin, or synthesized endogenously such as ascorbic acid, glutathione, or maybe supplied via diet such as minerals, vitamin E, carotenoids. Additionally, the generation of mineral-related antioxidant enzymes can deal with reactive oxygen but at the same time need the feed-derived minerals to do so. (example) the selenium in the form of selenocysteine is an important part of the enzyme family named glutathione peroxidases (GSH-Px) and thioredoxin reductases (TR), dissimilarly depletion of those minerals which can result in oxidative stress and destroyed the biological molecules and membranes **(Surai *et al.*, 2019).** A gauge of the antioxidant of the body is also named equilibrium with oxidative materials and can be divided in natural antioxidants considered as an essential feature in poultry food.

Natural antioxidants:

Natural antioxidants in poultry feed are safer, inexpensive and can prevent oxidative responses in diet during storage also don't cause metabolic disorders in poultry body, are a good substitute to synthetic ones. The Enzymes with antioxidant activity are produced in the body and need co-factors for its stimulation; examples for these antioxidants include selenium, glutathione peroxidases (GSH-Px) and thioredoxin reductase (TR). Many Co factors as Zinc, copper and

manganese are form a basic portions for superoxide dismutases (SOD); while iron is a crucial element for catalase (an antioxidant enzymes). Balanced diet with sufficient amount of antioxidants like vitamin E is useful. Instead of that, an oxidative stress show remarkable elevation of free radicals especially with low supplemented feed additives with antioxidants. Thus undesirable effects will include injury and impairment of vital tissues. Therefore the supplement of natural antioxidants, especially vitamin E and selenium will help the nutritionists in the formulating of feed formula to challenge the deficient amount of antioxidant in feed and determined the feed additive quantity that is needed and cost - effectively validated **(Surai, 2002b)**.

There are three level of defending system with antioxidants, the 1st one is not adequate to provide a full protection from free radicals creation and lipid peroxidation, and the 2nd level act to prevent and restrict the series of free radical effects and this level is unable to protect the biological products and some lipids , proteins, carbohydrates and DNA. Hence the 3rd level of defending is depending on the action of particular enzymes such as (lipase, proteases, and repairing enzymes of DNA) which eliminate injured biological molecules **(Surai, 2002a)**.

Available natural antioxidants in poultry feed formula:

In general there are many natural compounds act as antioxidant that available and usually formulated with feed of poultry. Therefore this poultry diet comprises from a variety of several compounds that influence antioxidant actions **(Surai and Dvorska, 2002)**. Hence the followings compounds list are represent more popular antioxidants in poultry feed

Vitamin E:

It plays crucial effects in several biochemical and physiological activities, including antioxidant processes **(Litta *et al*., 2014)** . Many of studies showed that Vitamin E had beneficial effects in poultry by improving the oxidative stability of body tissues, growth performance and meat quality **(Niu *et al* ., 2018)**. Current data revealed that arise in supplementation of vitamin E is beneficial as anti-stressful compound for poultry (Surai and Dvorska, 2002b). Vitamin E performs its function by blocking lipid peroxidation with scavenging and diminishes the action of free radicals .

Vitamin C:

It acts mainly as anti-stress agent. It is proposed that the producing ability of birds may become inefficient under high thermal conditions, and the poultry performance is improved after exposure to high temperature conditions with Vitamin C supplement **(Attia *et al*., 2011),** therefore the antioxidant outcome of vitamin C might incompletely impede with oxidative protein denaturation and would enhance the feed and nutrients digestibility. In addition Vitamin C has a significant action in biosynthesis of corticosterone which is that improve of body function to overcome stressful condition **(Ahmadu *et al*., 2016)**

Carotenoids:

Attention for Appling of carotenoids as feed additives has been grown obviously due to their biological features. Carotenoids decrease the oxidative stress in pre and post hatching birds by different ways, including diminish of free radicals, and enhancing the antioxidant enzymes activity. Application of carotenoids in poultry diet provides an improvement of poultry health and with high quality products **(Nabi *et al*., 2020)**.

Selenium :

Selenium is available in 2 types: organic form that mainly found in any in feed component with variable concentrations and inorganic form which are usually used as dietary supplements. Selenium contributes in different biochemical and physiological roles as an essential element of a variety principle selenoproteins. A 26 chicken genes encoding for distinct selenocysteine (SeCys) -containing proteins have been recognized .Remarkably, more than half of selenoproteins are included as antioxidant effects and supporting the redox equilibrium of cells **(Zhao *et al*., 2017).**

Polyphenol:

They act by protecting the cells from free radicals by the different ways including firstly: impairment of pro oxidant enzymes such as xanthine oxidase, protein kinase C (PKC) and membrane-associated β-NADPH oxidase, secondly: activation of an antioxidant enzymes and immediate scavenging of reactive oxygen species ROS **(Procházková *et al.*, 2011)**, thirdly: inhibit hydroxyl radicals OH synthesis and finally: decrease of α-tocopherol radicals and improving the antioxidant action **(Lipiński *et al*., 2017).**

Synthetic antioxidants in poultry feed formula:

During stock pilling of animal diet, we need to stay the regimen of animals freshness as long time as possible, because numerous various processes may take place which modifies their chief natural proprieties. At beginning of all, lipids endure peroxidation, because the catalytic reaction of atmospheric oxygen leads to the continuous production of the free radicals and initiates peroxidation (food rancidity) manifests by strange taste, odor, and color as well as reduce the duration of storage the product **(Rumsey, 1980).** If the antioxidant not enough or absent the unsaturated fatty acids suffered from rancidity by this pathway including firstly the hydrogen is lost from unsaturated fatty acid

and as resulting of this pathway leads it produces free radicals, then speedily converted to a fatty acid peroxide and finally to hydroperoxide but when present antioxidant lead to provided hydrogen and inhibit peroxidation.

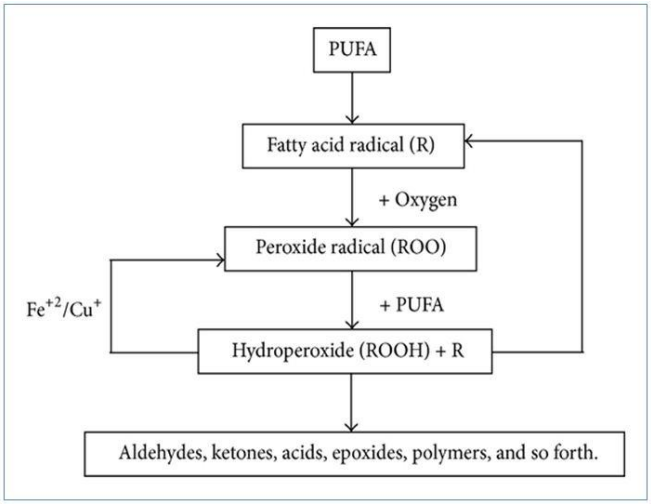

Fig. 2: Lipid peroxidation (**Castillo *et al.*, 2013**)

Alot's of natural antioxidants, as vitamin E, C, flavonoids affect for a limited period of preserving time, hence synthetic antioxidants are vastly used. The most popular synthetic antioxidant are BHT (butylated hydroxytoluene), BHA (butylated hydroxyanisole), TBHQ (tertiary-butyl hydroquinone) ,and EQ (ethoxyquin) (6-ethoxy-1,2-dihydro-2,2,4-trimethyl-quinoline) (EQ) are the most frequent used especially in processed poultry and fish feed **(Antony , 2017).**

Ethoxyquin:

It is widely handled because of its new technologies may drive production costs down and higher antioxidative effect as well as have benefit effect of to protect lipid from peroxidation, also uses to preserved pet food as well as farmed fish or poultry and even human **(Baszczyk *et al.*, 2013).** Ethoxyquin in a pure forms is a liquid and lightly yellowish in color, but it alterations to brown and polymerize when subjected to oxygen. It is merely soluble in organic solvents **(Koning, 2002)**. EQ has a critical role to safeguard lipids in food against rancidity . Delayed oxidation of vitamins A and E, xanthophylls, carotene, as well as add the ethoxyquin to animals' diet lead to elevate the level of vitamins A and E in the plasma higher than three-level was observed as well as allow the levels of vit-A storage in the liver is high.

Therefor, some researchers believed using EQ has high-efficiency than natural antioxidants **(Koning, 2002)**. Recently observe the ability of EQ to react with alkylperoxyl in the presence of oxygen which is also a strong antioxidant (**Taimr, 1994).** Antimutagenic action of EQ this antioxidant was noted in experimental animals such as hamsters, mice, and rats subjected to cyclophosphamide to produce reactive oxygen species that can cause damage to genetic material. the EQ can modify the effect of cyclophosphamide by decreasing the number of chromosome deviations, micronuclei, and leading to lethal mutations provoked by the anticancer medicine **(Ray *et al.*, 2010).**

Hernandez *et al*., (1993) detected influence of EQ on mechanism that generate energy in cells by constraining Na+, K+-ATPase pumping mechanism in renal and liver cells and then, interrelate with the respiratory chain of mitochondria caused in the restraining of oxygen consumption in the mitochondria. There are 9 analogs of EQ intended to compare their antioxidant activity. such as, hydroxyquin was 3.5 times as efficient as EQ, while hydroquin able to contest with EQ as an antioxidant. Hydroquin was previous discovered as an antioxidant in the animal diet in 1997, **(Koning, 2002).**

Butylated Hydroxyanisole (BHA) and Butylated Hydroxytoluene (BHT):

To highlight the remainder of the antioxidants that lowering the effect of polyunsaturated fatty acid from endogenous oxidation, including Butylated Hydroxyanisole “BHA”, Butylated Hydroxytoluene “BHT”, Propyl Gallate “PG” and Tert-Butylhydroquinone “TBHQ” have been usually used in the America and various countries to delay the expansion of rancidity of preserving diet. as well as these artificial antioxidants are professional also it is proportionately inexpensive **(Frankel , 2012)**. The effectiveness of these antioxidants employed two pathways: (BHA) and (BHT) react with peroxly radicals and prevent the development of it; while plentiful other antioxidants such as carotenoids turn off the reactivating singlet state of oxygen and modified it into a triplet state **(Frazier , 2010).** Electrospinning technology is of magnificent efficiency in food preservation, including production Nano fibers has different surface areas to raising the effectiveness of encapsulation synthetic antioxidant, BHA covered by a gelatinous capsule to act as an antibacterial and antifungal agent **(Chadha , 2021).**

The aim of the dealing poultry diet with antioxidants is to boost the steadiness of oxidation for a long time ago for a safe nutritional value of poultry meals **(Dozier , 2003).** Therefor Frankel et al. in 1994 classified antioxidant according their ability to compete with reactive oxygen species to Primary antioxidants, for example vitamin c, (BHT), (BHA), and (TBHQ), are peroxide stabilizers, while second classified of antioxidants lecithins prolong the progression of the beginning oxidation **(Frankel *et al.*, 1994)** . **Dassarma *et al.*, (2018**) proved the add BHA and BHT to preserving food formulations may be positive effect for liver cells.

CONCLUSIONS

Oxidative stress has an impact and adverse effect in poultry performance, therefore improving the antioxidants effects by supplementation of natural and synthetic antioxidants with poultry feed in balanced formula will help to alleviate the effect of stressful condition, reduction of lipid peroxidation and maintain the productivity trait.

Conflict of interest

The authors declare that there is no conflict of interest

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