E-ZINE OF BIOLOGICAL SCIENCES
ISSN: 2456-7264 | Issue – 18 | Published On 05/ 07/2021

Dietary Antioxidants and Their Effects on Broiler Oxidative Stress and Its Meat Oxidative Stability

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Introduction

Oxidative stress includes some important mechanisms responsible for biological damage in live animals affecting growth and performance. Oxidative rancidity is one of the major reasons behind meat deterioration (Morrisey *et al.*, 1997), which includes unpleasant odour, loss in flavour, texture, reduced nutritional value (Gray *et al.*, 1996). Both fish meal and oil are used as a source of energy and protein in the poultry diet. High amount of polyunsaturated fatty acid (PUFA) in these ingredients, specifically the omega 3, causes susceptibility of chicken meat to oxidative rancidity (Manilla and Husveth, 1999). This can be prevented by incorporating antioxidants into the diet (Morrisey *et al.*, 1997). Antioxidants are classified as synthetic or natural. Antioxidants are molecules present in the plants (Fruits, leaves, bark and seed). The most common natural antioxidants are tocopherols (vitamin E) and ascorbic acid (vitamin C). Some other natural antioxidants are carotene, zea-xanthine, cantha-xanthine, asta-xanthine, lycopene, flavonoids like quercitin, rutin, epigallocatechin, etc. and non-flavonoids like rosmanol, rosmaridiphenol and boldine, etc.

Synthetic antioxidants are most widely used in food for preservation due to their cost-effectiveness. Most of these antioxidants are derived from phenolic structures like butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), tert-butylhydroxyquinone (TBHQ) and propyl, dodecyl and octagallate. Ethoxyquin (ETOX) is a commonly used synthetic antioxidant in animal diets that has a non-phenolic structure (Bailey *et al.*, 1996). For use of antioxidants in humans and animals, the efficacy and safety margin of the antioxidant should be previously known. The extract of rosemary leaf (*Rosmarinus officinalis* L.) was first used for pigmentation and later for food preservation due to the presence of antioxidant components like carnosol, rosmanol, isorosanol and rosmaridiphenol. Reduced glutathione (GSH) with vitamin C and E reduces oxidative stress in living organisms. GSH releases hydrogen atoms and becomes oxidised glutathione (GSSG). GSH helps to stabilise free radicals and act as cofactor of glutathione peroxidise (GSHpx). This enzyme contains Selenium (Se) as prosthetic group, makes it dependant on the availability of this metal. It has been noticed that deficiency of dietary Se causes oxidative stress in poultry. It can be prevented by management of diet. For improving the immunity status in poultry, Surai (2002) gave practical recommendations. Superoxide dismutase (SOD) is another enzyme in the antioxidant defence. The presence of this enzyme in cell allows a fast dismutation of O_2^- to O_2 and H_2O_2. There are two types SOD in eukaryotic cells. The first one occurs mostly in cytosols and incorporates metals Copper (Cu) and Zinc (Zn) in its prosthetic group (Cu/Zn-SOD). The second one incorporates Manganese in its structure (Mn-SOD) and occurs in mitochondria (Fridovich, 1997). Supplementation of Cu in poultry diets causes increase in activity of Cu/ Zn dependent isoform (Ozturk-urek *et al.*, 2001), while Cu deficiency reduces the activity of Cu/Zn-SOD in chicken erythrocytes (Ozturk-Urek *et al.,* 2001).

Role of dietary antioxidants in prevention of oxidative stress in broilers

Supplementation of animal diet with antioxidant has more benefits other than food preservation as they are absorbed in the gut, so also perform systemic functions. Different studies have shown the advantages of supplementing animal diets with natural and/or synthetic antioxidants. Plasma GSHpx depicts the first antioxidant barrier for capillary cells, as it prevents attack of lipoperoxyl radical on the PUFA membrane (Noguchi *et al.,* 1973). Vitamin E present in the membrane represents the second antioxidant barrier by preventing the generation of the lipoperoxidative chain. In deficiency of Se and vitamin E, these antioxidant mechanisms would not occur, thereby allow lipoperoxidation and its disease consequences to occur. Encephalomalacia is one of such diseases that affects chicks, is associated with a peroxidative dysfunction caused by deficiency of vitamin E (Fuhrmann and Sallmann, 1995). Ozturk-Urek *et al.* (2001) observed that the supplementation of vitamin E in poultry diets is related to a lower lipoperoxidation basal level. This effect was noticed mainly in liver, brain and heart. Dietary administration of green tea catechins has been shown to reduce lipoperoxidation in muscle (both thigh and breast), liver and heart (Tang *et al.,* 2000). Apart from reducing the lipoperoxidation in chicken breast, inclusion of green tea in the diet decreased fat and cholesterol deposition in the carcass of the animal (Biswas and Wakita, 2001).

Role of dietary antioxidants in prevention of oxidative rancidity of broiler meat

The presence of fatty acid in the diet determines the lipid composition of broiler meat. The concentration of PUFA/saturated fatty acid balance in the carcass increases as the diet becomes richer in PUFA, assisting lipoperoxidation susceptibility in broiler meat (Grau *et al.*, 2001). It has been revealed that the systemic effect of some antioxidants is not confined to an *in vivo* effect, as it can endure in the tissues post-mortem, preserving the PUFA present in the meat. Bartov and Borstein (1977) analysed the relation between the unsaturation level of the diet and the effectiveness of antioxidants like vitamin E, ETOX and BHT on the oxidative stability of abdominal fat and oxidative (dark) and glycolytic (white) chicken muscle. They observed that (vitamin E, ETOX and BHT) had a positive impact on the oxidative stability of the abdominal fat of poultry fed on saturated or unsaturated fatty acids. Bartov and Bornstein (1981) examined the effect of ETOX and dietary BHT alone or in union with vitamin E. The single effect of ETOX and BHT reduced the oxidative rancidity of adipose tissue; however, the increase in the oxidative rancidity of dark muscle tissue was not significant. Also, significant increase in vitamin E deposition in the adipose tissue was observed, which the authors illustrated as a protective effect of synthetic antioxidants on dietary vitamin E, or to lower consumption of vitamin E (sparing effect). It has been observed that natural antioxidants can also impart a stabilizing effect on meat. Different authors have observed the effect of α-tocopherol supplementation on poultry diet showing that this antioxidant provides great protection against oxidation to broiler (Grau *et al.,* 2001) and turkey meat (Sheldon, 1997). Lopez-Bote *et al.* (1998) studied the effect of addition of rosemary and sage extracts and vitamin E into the broiler ration on the lipoperoxidation susceptibility of meat. They reported a significant reduction in the level of lipoperoxidation of the white muscle of poultry fed with the natural antioxidants, for different cold storage periods (up to 9 days; 4°C).

Conclusion

In view of various researches, supplementation of antioxidants in the broiler diet can be considered as a safe way of reducing oxidative stress and preventing oxidative rancidity in broiler meat. The use of natural antioxidants holds a great scope in future.

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