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Review article

Supplemental antioxidants in rabbit nutrition: A review

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ABSTRACT

Dietary antioxidants protect tissues against oxidative damage. There are a variety of stress factors that can disturb normal cell functions, initiating chain reactions that can compromise cell integrity and induce excessive production of reactive oxygen species. These active metabolites could result in damage to the cell structures, including proteins, lipids, and DNA, and induce physiological and pathological changes in the animal resulting in poor performance and worsening its meat quality. Alpha-tocopheryl acetate (TOH) and vitamin C are the most widely used dietary antioxidants in practical rabbit nutrition. The effect of selenium as antioxidant in most rabbit studies is doubtful. There is a growing interest on the use of natural supplements with antioxidant properties in growing rabbit feeding that could protect against oxidative damage, while providing the meat with a valuable source of antioxidants and other beneficial biological substances. TOH supplementation at the rate of 200 mg/kg diet could increase α-tocopherol content of L. dorsi and L. lumborum muscles about three times (r=0.894) and of thigh muscle about two and half times (r=0.716) compared to no TOH supplementation. Also, the same level of TOH could minimize the oxidative rancidity of L. dorsi and L. lumborum muscles by about 48% (r=0.632). Other effects of supplemental antioxidants related to growth performance and meat quality traits reveal no clear trend.

This review underlines the role of supplementary dietary antioxidants on performance of growing rabbits and on improving the functionality and protection against oxidative rancidity of the meat.

Contents

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1. Introduction

Oxidative stress results when formation of reactive oxygen species (ROS) exceeds the capacity of cellular antioxidant defenses to remove these toxic species. Excessive production of ROS initiates chain reactions that can compromise cell integrity (Lykkesfeldt and Svendsen, 2007). The damage affects different building blocks of cell structures (proteins, lipids or DNA) in the animal (Limón-Pacheco and Gonsebatt, 2009) and also affects the carcass quality and acceptability of meat products (Morrissey et al., 1998). In the rabbit, environmental conditions, mainly heat stress and feeding diets enriched with poly-unsaturated fatty acids (PUFA), especially of $n-3$ PUFA series to produce high quality meat are the most studied stress factors in the production chain.

To reduce the negative impacts of ROS, several mechanisms have to be integrated. Endogenous and exogenous antioxidants work synergistically to neutralize the action of ROS. The endogenous antioxidant network includes enzymatic and non-enzymatic mechanisms. Antioxidant enzymes convert superoxide anion radicals, through H_2O_2 to H_2O, thereby minimizing the production of hydroxyl radicals which are the most potent ROS in biological systems (Halliwell et al., 1995). Nutrient antioxidants (belonging to exogenous antioxidants) cannot be produced in the animal body and must be provided from an external sources, such as α-tocopheryl acetate (TOH) (the most widely available source of vitamin E for supplementation), vitamin C (almost all the domestic species have the ability to produce it), carotenoids and the trace metals Se, Mn and Zn (Rice-Evans, 1995). Nutrient antioxidants work either as chain-breaking antioxidants (TOH, vitamin C and β-carotene) or, as in the case of selenium, manganese and zinc, as constituents of endogenous antioxidant enzymes (Morrissey et al., 1998).

There are a variety of supplemental antioxidants employed in practical rabbit nutrition of which TOH and vitamin C are the most widely used. TOH protects cellular membranes against oxidative damage. It reacts or functions as a chain-breaking antioxidant, thereby neutralizing free radicals and preventing oxidation of lipids within membranes (Morrissey et al., 1994; McDowell, 2000). Vitamin C can reduce the generation of ROS and might regenerate α-tocopherol from its oxidized form (Reed, 1992).

Supplemental TOH or vitamin C has a limited role in improving the growth performance of the rabbit and few research works have proven the growth promoting effect, possibly because most studies have been carried out without oxidative stress conditions. Intensive studies proved the positive correlation between supplemental TOH and vitamin C and meat quality. Also, some additional feed components with antioxidant properties have been used in rabbit feeding with promising results. These include olive oil (Lopez-Bote et al., 1997), oats (Lopez-Bote et al., 1998), soy-isoflavones (Yousef et al., 2004), oregano-essential oil (Botsoglou et al., 2004), grape polyphenols (Sgorlon et al., 2005), grape pomace (Eid, 2008), alfalfa polysaccharides (Liu et al., 2010) and green tea (Eid et al., 2011). However, the response to these phytoderivative antioxidants is not as efficient as in case of supplemental TOH or vitamin C.

This review summarizes and correlates relationships between supplemental antioxidants and growth performance and meat quality of the rabbit.

2. Antioxidants levels in feed, blood and tissues of rabbit meat

Tocopherols are extremely resistant to heat but are readily oxidized. Natural vitamin E is subject to destruction by oxidation, which is accelerated by heat, moisture, rancid fat, light, alkali, and certain trace minerals (*e.g.*, copper and iron). Since esterification of the vitamin improves its stability, commercial supplements usually contain D-α-tocopheryl acetate (also called RRR-tocopheryl acetate) or DL-α-tocopheryl acetate (also called all-rac-α-tocopheryl acetate). The acetate ester is very stable to *in vitro* oxidation and has no activity as an *in vitro* antioxidant. However, it is readily hydrolyzed in the intestine to non-esterified or free tocopherol, which is the potent *in vivo* antioxidant (McDowell, 2000). Vitamin C is more easily destroyed by oxidation, especially under moist conditions and when exposed to oxygen, Cu, Fe and other minerals (McDowell, 2000). Currently, there are forms of vitamin C that can withstand high temperatures during the feed pelleting process such as the ethylcellulose-coated and ascorbyl phosphate products.

Data in Table 1 illustrate the relationship between dietary supplemental antioxidant levels and their respective deposition in plasma and tissues of rabbit. All studies reported that an increase in supplemental TOH resulted in an increase in tissue level; regardless of the supplemental TOH level (40–500 mg/kg), method of supplementation (feed or water), ingredient composition of the diet (without or with oil in diet), tissue analyzed (plasma, thigh, loin, liver or kidneys), storage conditions (storage period and temperature) and length of feeding. The percentage increase in α-tocopherol content of the meat muscles following TOH supplementation in the diet varied between 23% in loin meat (Selim et al., 2008b) and 466% in L. dorsi (Oriani et al., 2001). The differences in the experimental protocols followed in these studies may explain the wide range in results obtained. Also, the extent of α-tocopherol deposition in different organs differs as a function of their metabolic type. Lo Fiego et al. (2004) found that liver exhibited the greatest concentration of α-tocopherol, followed by kidneys, then thigh and L. dorsi. Results presented in Table 1 indicate that in many studies L. dorsi muscle was able to reserve a higher α-tocopherol level than thigh muscle. However, it is hypothesized that thigh muscle as a heterogeneous combination of glycolytic and oxidative fibers has to contain more α-tocopherol reserves than L. dorsi muscle (glycolytic fibers) (Lo Fiego et al., 2004).

Means from several studies included in this review (Botsoglou et al., 2004; Castellini et al., 1998, 2000; Dal Bosco et al., 2001; Oriani et al., 2001; Lopez-Bote et al., 1997; Lo Fiego et al., 2004) were used for regression analysis to evaluate the relationship of α-tocopherol deposition in L. dorsi muscles and dietary TOH levels ($r=0.894$). Similarly, means from the reports of Bielanski et al. (2007), Kowalska and Bielanski (2009), Kowalska et al. (2011), Lo Fiego et al. (2004), and Zsédely et al. (2008)were used for regression analysis to evaluate the relationship of α-tocopherol