Commentary

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Function of Selenium in Animal Nutrition

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Description

Selenium (Se) has been reported to be one of the essential trace elements influencing the physiological function and growth performance of animals. However, Se concentrations exceeding the biological requirements may lead to acute and chronic poisoning. Concerning livestock and poultry production, researchers have proposed that supplementation with appropriate Se doses not only plays a critical role in improving slaughter performance and the quality of livestock and poultry products but also promotes the enrichment of Se in animal tissues, thereby producing functional livestock products. Conversely, an overdose of Se generates oxygen radicals and results in apoptosis by inducing oxidation and cross-linking of protein thiol groups essential for cell survival.

Based on the mechanisms of absorption and metabolism, this paper focuses on the roles of Se compounds, both organic and inorganic forms, in the defense against oxidants as well as their potential pro-oxidant properties. Based on these contrasting roles, we further discuss the effect of Se on the quality of livestock and poultry meat, providing a reference for research on biological Se enrichment technology and the development of Se-rich products.

Selenium (Se), one of the indispensable nutrients for both human health and animal growth, participates in various physiological functions, such as antioxidant and immune responses and metabolism. The role of dietary Se, in its organic and inorganic forms, has been well documented in domestic animals. Furthermore, many feeding strategies for different animals have been developed to increase the Se concentration in animal products to address Se deficiency and even as a potential nutritional strategy to treat free radical-associated diseases.

Species of Selenium

Se additives in animal feed are divided into 2 main forms: organic Se and inorganic Se. The general consensus is that organic Se, in the form of both selenoamino acids and Se-enriched yeast (SY), is more effective than inorganic Se at increasing growth performance, antioxidant status, and tissue Se concentration, as well as in improving the meat quality of livestock, mainly due to its higher bioavailability and tissue retention. Inorganic Se exists in the form of Se compounds with diverse valence states, including selenite (SeO32−), selenate (SeO42−), selenium (Se) and selenide (Se2−) (Kieliszek, 2021). Se nanoparticles (SeNPs), inorganic Se molecules designed by regulating shape and size of the particle at the nanometer scale, have become an interesting topic of research in recent years. Compared with organic and traditional inorganic forms, SeNPs have been regarded as a promising feed additive to promote immune and antioxidant strength due to their novel properties, such as a large specific surface area, increased surface activity and reduced toxicity. However, SeNPs are still at the beginning of their development, and in animal and poultry nutrition, they are still a minor source of Se and are not legal or regulated in Europe and the USA. Some concerns have also been raised about the toxicity of SeNPs and the optimal dosage of additives, which need to be further studied

Nevertheless, studies on investigating the optimum addition of Se in feed, the long-term consequences of Se usage in food for animal nutrition, the mechanism of metallic Se nanoparticle (SeNP) transformation in vivo, and the nutritional effects of SeNPs on feed workers and the environment are urgently needed. Starting from the absorption and metabolism mechanism of Se, this review discusses the antioxidant role of Se in detail. Based on this characteristic, we further investigated the application of Se in animal health and described some unresolved issues and unanswered questions warranting further investigation. This review is expected to provide a theoretical reference for improving the quality of food animal meat as well as for the development of Se-based biological nutrition enhancement technology.

Improving Meat Color

The biomolecular interactions between myoglobin and other factors, such as lipid oxidation, are widely accepted to jointly govern meat color, and the autoxidation of myoglobin is the main reason for deviations from bright cherry-red to brown. Additionally, several studies have shown an underlying relationship between a change in meat color, lipid oxidation, and protein oxidation; the oxidation reactions occurring in the lipids and proteins are transferred to the myoglobin fraction, thereby affecting fresh meat color. In this case, strategies for supplementing Se to enhance the activity of antioxidant selenoproteins such as GPx and thioredoxin would be useful in preserving the color of fresh meat by disrupting the co-oxidation reactions of myoglobin, lipids, and proteins as well as promoting myoglobin synthesis.

After slaughter, the collapse of the endogenous antioxidant system and the biochemical changes that occur during the conversion of muscle to meat are considered responsible for deteriorating meat quality. These alterations remarkably influence the physical and chemical properties of proteins, including solubility, water-holding capacity, and meat tenderness. In addition, protein oxidation decreases the bioavailability of amino acid residues, thus negatively affecting the nutritional values of meat proteins. Lipid peroxidation is suggested to be responsible for the destruction of cell membrane integrity and pigment reduction systems, resulting in a reduced muscle water-holding capacity and meat discoloration along with an off-flavor. Furthermore, increasing evidence indicates that the interactions between protein and lipid oxidation concomitantly lead to further oxidation.

In contrast to inorganic Se, the absorption of selenomethionine (SeMet) and selenocysteine is mediated by an amino acid uptake mechanism. SeMet is likely transformed into the intermediate product Sec through the transsulfuration pathway and then subsequently decomposed into H2Se or undergoes transamination to demethylate into H2Se. Recently, a possible mechanism for the conversion of nano-Se to selenite has been proposed, suggesting that gut microbes convert nano-Se into selenite, Se-phosphate, or H2Se, leading to the synthesis of selenoproteins. As the branch point of 2 metabolic pathways, H2Se is ultimately converted into selenophosphate to supply Se in an active form for the synthesis of selenoproteins. On the other hand, some SeMet is incorporated into selenoenzymes or in place of Met to participate in the synthesis of selenoproteins, thereby increasing the total Se content in body tissues. Thus, differences in the degrees of improvement of livestock products and human health with the use of different Se sources may be clarified by determining their probable metabolic pathways and absorption processes.