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Review

Selenium in poultry breeder nutrition: An update

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ABSTRACT

Selenium (Se) is shown to be an essential element for poultry nutrition and a great deal of information has been accumulated for the last 20 years indicating that dietary form of Se is a major determinant of its efficiency. Generally speaking, there are two major Se sources for poultry, namely inorganic selenium (mainly selenite or selenate) and organic selenium in the form of selenomethionine (SeMet; mainly as Se-Yeast or SeMet preparations). In this review two main areas are considered in relation to the Se nutrition of breeders. Firstly, it is Se important roles in the maintenance of semen quality and optimal Se status of poultry males and Se is considered to be an important factor in ensuring the fertility of breeding stock. Secondly, Se status of the eggs from breeding birds is of great importance for the maintenance of the antioxidant system of the developing embryo. It is generally accepted that the hatching process is an oxidative stress and improvement in antioxidant defences of the embryo can increase hatchability. It is quite clear that the roles of Se in poultry nutrition and reproduction need new consideration in light of our recent knowledge on the molecular mechanisms of Se action at the cellular and sub-cellular levels. In particular, the discovery and characterisation of a range of new selenoproteins and a better understanding of the relationships between different antioxidants, as important parts of integrated antioxidant system with possibilities for antioxidant recycling *in vivo*, have yielded new insights in this area. In particular, it should be mentioned that increased levels of Se supplementation are not always beneficial, since selenoprotein synthesis is under the gene control and it reflects the need in these active molecules to deal with various stresses. However, to give a body a chance to affectively respond to environmental challenges by modulating selenoprotein synthesis there should be enough Se reserves available and this an ability of building Se reserves in the body is considered to be the main point in advantages of organic selenium in poultry and farm animal nutrition. A comprehensive analysis of the effects of various forms of dietary Se on its egg concentration, its transfer to the embryonic tissues and physiological consequences of the improved Se status of the progeny chicks are considered.

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Abbreviations: BD, basic diet; DHT, dihydrotestosterone; FCR, feed conversion ratio; GSH-Px, glutathione peroxidase; HMSeBA, 2-hydroxy-4-methylselenobutanoic acid; MDA, malonedialdehyde; Met, methionine; OS, organic selenium; PC, phosphatidylcholine; PE, phosphatidylethanolamine; PS, phosphatidylserine; PUFAs, polyunsaturated fatty acids; SeMet, selenomethionine; SeCys, selenocysteine; SOD, superoxide dismutase; SS, sodium selenite; Se-Yeast, selenium-enriched yeast; Sph, sphingomyelin; T, testosterone; TBARS, thiobarbituric acid reactive substances; ZSM, Zn-SeMet.

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1. Introduction

Selenium is shown to be an essential element for poultry nutrition. Indeed, severe Se deficiency is related to the decreased production and reproduction performance of poultry. It is well known that commercial poultry production is associated with various stresses and Se as a part of various selenoproteins can help maintain antioxidant defences preventing damages to tissues. Selenium has important applications in poultry nutrition, particularly as commercial poultry production uses modern chicken genetics characterised by high egg production and high growth rate. However, the price for such improvements in performance is that the birds are highly sensitive to various stresses. Therefore, in the modern poultry production there is an important move from preventing Se deficiency to meeting Se requirement and optimising performance. In fact, [NRC \(1994\)](#) requirements for Se are quite low, varying from 0.06 ppm (laying hen) up to 0.2 ppm (turkey, duck). However in commercial conditions, with their associated stresses, the Se requirement increases substantially. Since the process of Se transfer from feed to egg and subsequently to embryonic tissues has received limited attention ([Cantor, 1997](#); [Surai, 2000](#); [Paton et al., 2002](#)), there is no clear answer as to which level of Se supplementation is optimal for broiler breeders. However, an analysis of published research and commercial data indicates that 0.2–0.3 ppm of selenium in organic form would be the recommended level for supplementation in breeders ([Surai, 2006](#)).

It is quite clear that the roles of Se in poultry nutrition and reproduction need new consideration in light of our recent knowledge on the molecular mechanisms of Se action at the cellular and sub-cellular levels. In particular, the discovery and characterisation of a range of new selenoproteins and a better understanding of the relationships between different antioxidants, as important parts of integrated antioxidant system with possibilities for antioxidant recycling *in vivo*, have yielded new insights in this area. In particular, it should be mentioned that increased levels of Se supplementation are not always beneficial, since selenoprotein synthesis is under the gene control and it reflects the need in these active molecules to deal with various stresses. However, to give a body a chance to affectively respond to environmental changes by modulating selenoprotein synthesis there should be enough Se reserves available and this is the main point in advantages of organic selenium in poultry and farm animal nutrition. More than ten years past since our previous review on Se in poultry was published ([Surai, 2002b,c](#)) and the concept of organic Se found its way to poultry industry, but effective sources of organic selenium for poultry and farm animals need further detailed consideration and we feel that time has come to update the knowledge in this exciting area.

2. Selenium for breeders

Two main areas should be considered in relation to the Se nutrition of breeders. Firstly, it has been proven that Se plays an important role in the maintenance of semen quality and optimal Se status of poultry males is considered to be an important factor in ensuring the fertility of breeding stock ([Surai, 2006](#)). Secondly, Se status of the eggs from breeding birds is of great importance for the maintenance of the antioxidant system of the developing embryo. It is generally accepted that the hatching process is an oxidative stress and improvement in antioxidant defences of the embryo can increase hatchability ([Surai, 2002a, 2006](#); [Fisinin et al., 2008](#)).

2.1. Selenium and semen quality

The importance of Se nutrition of poultry males is related to the high proportion of polyunsaturated fatty acids (PUFAs) in avian semen and its susceptibility to lipid peroxidation ([Surai et al., 1998a](#)). In particular, it has been shown that during sperm storage, lipid peroxidation is associated with a significant decrease in PUFA concentration in spermatozoa. In particular, the main PUFA in the chicken semen (22:4n-6) was most susceptible to peroxidation. Its proportion in the phospholipid fraction was significantly decreased as a result of incubation of chicken sperm for 12 h at 20°C ([Surai et al., 1998b](#)). The confirmation of the suggestion that the loss of PUFA was due to peroxidation came from the data

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