

Accumulation of selenium

its antioxidant properties in plants, animals and humans

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Selenium is essential for humans and animals by virtue of its antioxidant properties, which form part of a sequence of chemical reactions. In actuality, Se is considered as one of the most important trace elements for human- and animal-health as it is considered as individual antioxidant that can cooperate with other antioxidants, such as C and E vitamins and in operation protecting the cells from free radicals. In such manner selenium protects a body from development of cancer, cardiovascular diseases and masculine sterility. Selenium is not considered essential for plants but due to its chemical properties similar to sulphur (S), selenium is absorbed and metabolized by plants in the same assimilation pathway as Sulphur (S). Uptake of selenium by plants and its total amount in plant tissues are influenced with many factors, including the content of selenium in a soil, its form, soil reaction, soil redox potential, mineral structure of soils, mineral fertilizers and rain precipitation. Recommended Se content in grains used as fodder and feed are 0.2 to 0.3 mg/kg and 0.1 to 0.2 mg/kg, respectively. Toxicosis occurs when an animal diet contains more than 3–8 mg/kg Selenium.

Key words: Accumulation, Animals, Antioxidant, Humans, Plants, Selenium

SELENIUM (Se) is an important trace element in animal and human nutrition but known as a non-essential element in plants, although its beneficial roles in plants capable of accumulating large amount of the element is found. Plants which are capable of accumulating high amounts of selenium without any toxic effects can be used for bioremediation of selenium-contaminated soils and water. Excessive levels of selenium can cause adverse effects in most of selenium-sensitive crop plants, and the metabolic pathway and regulation of selenium toxicity in these plants are poorly understood. High antioxidant activities scavenge the reactive oxygen species produced during stress in plants, hence increasing their tolerance to environmental stress. Because of the importance of selenium in human health and the strong deficiency of this element worldwide, it is pre-requisite to find

out strategies to increase its content in foods. Accordingly, for rice, wheat varieties, and lettuce, showed that the Se content in these cultures increased with the introduction of this element through fertilization, which enables increased selenium intake by the population. Recommended selenium content in grains which used as fodder and feed are 0.2 to 0.3 mg/kg and 0.1 to 0.2 mg/kg, respectively. Toxicosis occurs when an animals diet contains more than 3 to 8 mg/kg Se.

Importance of selenium

Selenium is essential for humans and animals by virtue of its antioxidant properties, which form part of a sequence of chemical reactions. In deed, selenium is considered as one of the most important trace elements for human- and animal-health. The deficiency of this element is related with the occurrence of serious diseases like disease cardiac and many types of

cancer. Unlike the case for humans and animals, for plants selenium is not considered essential because of its chemical properties similar to sulphur (S), selenium is absorbed and metabolized by plants in the same assimilation pathway as sulphur, which is present in sulphur amino acids such as selenomethionine and selenocysteine. Depending on the selenium concentration used, it may exert a double effect on plant growth. Se acts as an antioxidant and can stimulate plant growth and production at low concentrations, whereas it favours cell oxidation, leading to a reduction in yield at high concentrations.

Selenium in plants

Uptake of selenium by plants and its total amount in plant tissues are influenced with many factors, including the content of selenium in a soil, its form, soil redox potential, soil reaction, mineral structure of soils,

mineral fertilizers and rain precipitation. Another factor participating in total uptake of selenium is the atmosphere. In terms of availability, the form of selenium is more important factor than the total amount of selenium in a soil. Selenium can be absorbed by a plant in inorganic form as a selenate (SeO_4^{--}) or selenite (SeO_3^{--}) or in organic form as Se-amino acid, for example as Selenomethionine (Se-met). SeO_4^{--} is well soluble and for plants easily available form of selenium. It is found that the plants contained the highest amount of selenium after treatment with SeO_4^{--} , furthermore Se-met α - SeO_3^{--} . Cauliflower (*Brassica oleracea* var. *botrytis* L.) and cabbage (*Brassica oleracea* convar. *capitata* L.) contained 10 higher amount of selenium after treatment with 4.5 mg $\text{SeO}_4^{--}\text{-kg}^{-1}$ of soil in comparison with variants treated with 4.5 mg $\text{SeO}_3^{--}\text{-kg}^{-1}$ of soil. Other forms of selenium Se - selenides (Se^{--}) and elementary selenium ($\text{Se } 0$) are usually located in reduction condition of an environment and are not available for the plants.

SELENIUM AND PLANT GROWTH

Owing to its physiological and toxicological significance, selenium has become an element of interest to many plant scientists. Enhances growth of plants, reduces damage caused by UV-induced oxidative stress, enhances chlorophyll content under light stress, stimulates senescing plants to produce antioxidants and improves plant tolerance to drought stress by regulating water status. Selenium is recognized to increase superoxide dismutase and GPX activities, thus activating the protective mechanisms against oxidative stress. It is also revealed to exert an antioxidant effect directed towards a decreased concentration of intracellular active oxygen species by inducing the biosynthesis of proline and peroxidase production.

In plants, selenium uptake and translocation take place through sulphate transporters (STs) and phosphate transporters (PiTs). Once absorbed by the plants, the inorganic

selenium is converted into more bioavailable organic forms such as selenomethionine (SeMet). It is presumed that STs located in root cell membranes are involved in the uptake of selenite, while PiTs are generally accepted to be involved in selenite uptake. A large number of enzymes such as APS reductase (APSR), ATP sulphurylase (ATPS) and sulphite reductase (SiR) take part in sulphate assimilatory pathway to incorporate selenate or selenite into selenocysteine (SeCys) and selenomethionine (SeMet). Selenium uptake may be controlled by genetic factors and cultivars may differ in their Se content.

Selenium in human body

For human body selenium is essential element playing significant role in body anti-oxidation system; it is considered individual antioxidant that can cooperate with other antioxidants, such as vitamins C and E and in processes protecting the cells from free radicals. In such way selenium protects a body from development of cancer, cardiovascular diseases and masculine sterility. Selenium participates in thyroid hormone metabolism, immune system, inhibits virulence, slows down the development of AIDS by decreasing the speed of HIV development. Furthermore, it can reduce the risk of spontaneous abortions as well. Balanced content of selenium in human food helps in case of complications connected with diabetes, and affects also the prevention of asthma. Through free radicals inhibition selenium moderates harmful effects of radiation, important for proper function of cerebral neurotransmitters and reduces epileptic waves at children. Selenium deficiency is connected with acceleration of senility and development of Alzheimer's disease. Selenium affects in a positive manner human mind and mental wellness.

Recommended intake of selenium, its deficiency and toxicity

Recommended daily intake of selenium for adult men and women is 55 µg per day. Recommended intakes

for other age groups and for pregnant and lactating women are given in Table 1. In Europe, Asia and part of Africa the intake of selenium from food doesn't reach recommended daily intake; the deficiency of selenium in Europe is commonly known. Low intake of selenium endangers mostly the people with reduced intake of food (seniors) and people with higher need of this essential element, including pregnant and lactating women, growing and developing children, sportsmen and hardworking people.

Table 1. Recommended daily intake of selenium by individual age categories

Life stage	Age	µg Se.day ⁻¹
Infants	0-6 months	15
	7-12 months	20
Children	1-3 years	20
	4-8 years	30
	9-13 years	40
Adults	14 < years	55
Pregnants	—	60
Lactation	—	70

Source: Food and Nutrition Board, Institute of Medicine, 2008.

Deficiency of selenium in human nutrition affects biological functions being in relationship with function of Se-proteins and metabolism of selenium. The risk of occurrence of degenerative diseases (especially cancer, cirrhosis, cardiovascular diseases, diabetes etc.) increases. In China, in areas with critical deficiency of selenium two killer diseases are epidemiologically spread: 'Keshan disease' characterized with failures of myocardium function – the so-called 'cardiomyopathy' and 'Kashin-Beck disease' – the osteoarthropathy, that means a disease characterized with damage of cartilages causing the deformation of bone-structures.

As for intake of selenium in the sense of improvement of nutritive value of food, it is important to know its safe upper limit of daily intake separating positive and potential negative effects on human beings. Maximum safe daily intake of selenium for men and women (pregnant, as well as lactating) older than 14 years is 400 µg per day. Maximum safe daily intake of

Table 2. Maximum safe daily intake of selenium for particular age categories

Life stage	Age	µg Se.day-1
Infants	0 - 6 months	45
	7 - 12 months	60
Children	1 - 3 years	90
	4 - 8 years	150
	9 - 13 years	280
Adults*	> 14 years	400

*including pregnant and lactation

Source: Food and Nutrition Board, Institute of Medicine, 2008.

selenium for particular age groups is discussed in Table 2. Chronically over limit daily intake of selenium can have negative and (depending on

doses) even toxic effects. In chronic intake the toxic effects of organic and inorganic forms are similar. At immediate overdose the symptoms of toxicity are more intensive at inorganic forms of selenium (Se).

SUMMARY

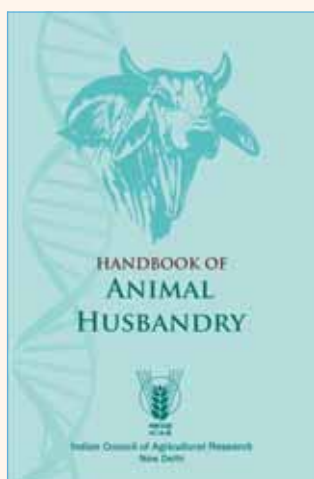
Drought results in production of reactive oxygen species in stressed plants, which causes oxidative damage to the cellular constituents such as carbohydrates, lipids, nucleic acids and proteins, ultimately reducing plant growth, respiration and photosynthesis. Application of selenium reduces the oxidative damage by production of compatible

solutes. The accumulation of these organic solutes prevents cellular dehydration and helps the plants to retain water in cells. Another role of selenium is to improve drought tolerance in crop plants and protect them from oxidative stress by stimulating senescence to produce ROS-scavenging enzymes. Selenium increases SOD and GPX activities, thus activating the protective mechanisms against oxidative stress.

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Livestock sector has created a significant impact on equity in terms of employment and poverty alleviation. After staple crops, livestock sector is the second most important contributor to the agricultural economy. The



producer prices of meat, eggs and milk, in India appear to be highly competitive as the domestic producer prices of these products are quite low compared to the ex-farm gate prices of major exporters in the world markets. A knowledge resource is essential to harness the potential of animal production. The Indian Council of Agricultural Research brought out first edition of *Handbook of Animal Husbandry* in 1962 for serving the end-users ranging from livestock owners to academicians. This is the Fourth revised and enlarged edition of *Handbook of Animal Husbandry* which includes 48 chapters under nine sections, such as Animal Genetics and Breeding; Animal Nutrition and Feed Technologies; Animal Management; Animal Reproduction; Animal Health Management; Animal Biotechnology; Animal Products, Technology and Machineries; Economics and Trade of Livestock and Poultry Enterprise; and Social Sciences. It has 19 new chapters like Impact of Biotechnology, Nanotechnology: Applications in Animal Sciences; Carbon Trading: Mechanisms and Opportunities in Livestock Sector; Intellectual Property Rights Regime; Indigenous Technical Knowledge etc.; and old chapters were revised holistically. The fourth revised and enlarged edition of *Handbook of Animal Husbandry* will prove useful to the students, teachers, livestock/poultry farmers, and to especially those who visualize the economic growth of country with the support of livestock sector.

TECHNICAL SPECIFICATIONS

No. of pages : i-x + 1550 • Price : ` 1500 • Postage : Rs 300 • ISBN No. : 978-81-7164-086-7

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