Selenium

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Selenium is a microelement which intake is essential for correct function of the metabolism. In a dog's body, it is important, for example, for its antioxidant function, its role in thyroid metabolism, synthesis of DNA, or reproduction. It seems that it also plays an important role in prevention and treatment of cancer.

Keywords: blood ; serum ; Se biomarkers ; dog ; nutrition

1. Introduction

Selenium (Se) is a metalloid discovered by Jöns Jacob Berzelius in 1817. It first came into focus in the 1930s, when it was discovered to cause "alkali disease"—a chronic selenium poisoning, appearing in South Dakota and Wyoming, causing horses, hogs, and cattle to shed hooves and lose hair. In chicken, it caused high mortality at hatching and deformities [1]. In 1961, an endemic disease was discovered in China, of which the cause was determined to be selenium intoxication. Symptoms were loss of hair and nails, and in affected villages, it had morbidity up to 50% [2]. On that account, it is not surprising that selenium was looked upon solely as a toxic element for a long time. However, other aspects of selenium slowly started to appear. Schwarz and Foltz [3] proved the essentiality of selenium in experiments on rats—its deficiency caused liver necrosis. Following research showed that offspring of Se deprived rats were almost hairless, grew more slowly, and were unable to reproduce [4]. These discoveries were the start of extensive research about selenium and its importance for health. At present, this research still continues, although it mainly focuses on humans and farm animals. Only a limited amount of information is still available for different species, including dogs, cats, and other carnivores.

Generally, in a mammal's body, selenium is important for its antioxidant function, its role in thyroid metabolism, synthesis of DNA, and also reproduction. It is a component of selenoproteins such as glutathione peroxidase (GPx), deiodinases, thioredoxin reductase, and many others [5]. In farm animals, selenium is known to have a narrow window between deficiency and excess, but in dogs, there are no naturally occurring cases of poisoning described. That may be caused by the fact that carnivores preserve higher selenium levels than other species of animals, such as horses, cattle, sheep, or goats [6].

2. Metabolism of Selenium

As most of the research concerning selenium metabolism is focused on humans and farm animals, there is a very limited amount of information regarding Se in canine's metabolism. Generally, the most significant difference is that dogs as carnivores retain more Se than herbivore and omnivore species as they maintain higher serum levels of selenium [6]. The selenium can enter the body with food in two different forms—organic and inorganic. Organic selenium, mainly in a form of selenomethionine, is received from meat and other "natural" food sources, like viscera or eggs. In contrast, inorganic selenium, usually sodium selenite, is the most frequent form of supplementation used in commercial dog food. Depending on the form, the way of resorption in the small intestine differs. It is believed that while organic selenium has an active transport mechanism (using the pathway of methionine), the inorganic form is absorbed by simple diffusion, and thus more slowly [7]. The bioavailability of sources is frequently discussed, but it just may be that it is not too different in dogs as animals fed high levels of selenium given in form of sodium selenite and organic source had similar fecal absorption [8]. A bigger difference might be made by processing of the diet [9], but the matter will be discussed further in the next chapter.

Selenium is excreted from a dog's body mainly by the kidneys and can be measured by selenium:creatinine (Se:Crea) ratio. Canines are able to adapt to changes in selenium intake rapidly—in dogs suddenly shifted to low selenium diet (0.11 mg/kg dry matter), Se:Crea ratio decreased by 84% during the first week [10], and dogs supplemented with high doses of both organic and inorganic forms of selenium (8 to 9 mg/kg dry matter) increased their urinary excretion thirty times in 21 days [8]. Some selenium can also be excreted by bile, although the exact amount that can be eliminated this way is unknown.

3. The use of Selenium in Prevention and Therapy

Different studies were carried out to cast a light on the importance of selenium, its potential therapeutic effects, and the impact of subclinical Se deficiency. One of the researched fields was a reproduction. For example, supplementation with selenium and vitamin E improved sperm quality in dogs with lowered fertility [11] and helped four infertile dogs to mate successfully [12]. Moreover, in normospermic dogs of different breeds, supplementation with selenium, zinc, vitamin E, and folic acid improved multiple sperm parameters [13]. On the other hand, Kirchhoff et al. [14] found no improvement in normospermic Cairn Terriers after supplementation with selenium and vitamin E. It may have been caused by the supplemented doses of both nutrients—in the latest study mentioned, doses per body weight of dogs were way higher, and so instead of having a beneficial effect, could have reached subclinical toxic levels and thus not improving any reproduction parameters.

Most of the attention is probably focused on cancer research, as selenium might be able to play a role in prevention of cancer. In experiments on cell cultures, selenium inhibited the growth of neoplastic cells and induced apoptosis of different tumor cell lines isolated from dogs [15][16][17]. In a mouse model of transplanted canine mammary tumor cells, it also inhibits angiogenesis [18]. Since elderly dogs, unlike most other species, can develop prostate cancer spontaneously similarly to humans, they can be used as a model for preventive programs. Supplementing with selenium causes a lower percentage of extensively damaged prostate cells and increases apoptosis [19]. Moreover, dogs diagnosed with malignant tumors have significantly lower serum Se concentrations than healthy dogs and dogs with different pathologies [20]. In a different study, though, there was no difference between dogs with tumors of the mammary gland, healthy dogs, and dogs with different pathologies [21]. However, this study did not differ between malignant and benign cases of tumors. The most important thing in cancer prevention seems to be the right dose of supplemented selenium. When dogs are over-supplemented selenium then loses its protective role, and there is no additional decrease of prostate cancer risk [22][23]. The theory of human and dog prostate cancer and its “U-shaped dose-response” between selenium and prostatic DNA damage was more profoundly reviewed by Waters and Chiang [24].

Liu et al. [25] studied the effect of Se supplementation of dogs with ethylene glycol-induced calcium oxalate renal calculi. They found out that the supplemented dogs (either with the organic or the inorganic form of Se) have lower urinary calcium levels and milder renal changes. The selenium status also seems to affect progress of parasitical diseases. Dogs supplemented with vitamin E and selenium had better recovery from Sarcoptes infection [26]. In dogs naturally infected with leishmaniosis, plasma Se was lower in infected dogs in comparison to healthy dogs. Moreover, it was lower in symptomatic dogs compared to infected asymptomatic dogs [27].

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