SELENIUM, A CRUCIAL ELEMENT IN PET FOOD FORMULATION

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Selenium is an essential trace element. The narrow margin between the minimum requirement and the maximal legal limits of selenium, variation of selenium levels in raw materials, and influences of production processes, makes pet food formulation challenging. By making use of natural body reserves, L-selenomethionine can provide a solution for a safe and continuous supply of selenium to dogs and cats!

Selenium is an essential trace element, and dietary supplementation is common practice in food for dogs and cats. However, formulating pet food with the right levels of selenium is challenging. There is a narrow margin between meeting the daily selenium requirements of pets and not exceeding legal limits set by the European Union (EU). The wide variation of selenium in raw materials further complicates maintaining optimum levels. Additionally, the pet food production process (e.g. canning diets) can have a significant effect on the bioavailability of selenium in pet food. This complexity underscores the need to delve deeper into the topic of selenium, with a special focus on differences between plant- and animal-based raw materials and solutions to ensure more reliable selenium availability for our dear four-legged friends.

SELENIUM IN MEAT- OR PLANT-BASED DIETS

Selenium is an essential nutrient in pet nutrition and is crucial for an optimal antioxidant status, thyroid function, and immune defense. The growing popularity of vegetarian pet diets, prompts further exploration into the application of selenium in various pet foods. In scientific studies evaluating essential nutrients in commercial plant-based pet foods, selenium is often not recorded[1].When looking at the essentiality of selenium in plant-based diets for omnivores, human studies show the importance of selenium supplementation of vegetarian or vegan diets.

In a recent nutritional evaluation study in humans, selenium was identified as a critical nutrient for vegetarians and vegans[2]. Examined biomarkers, serum selenium and enzymatic activity of glutathione peroxidase (GPX activity), were significantly lower in participants without meat in their diet (Figure 1). While almost none of the omnivores (2.5%) and flexitarians had selenium values below the limit of 50 µg/L, this occurred relatively frequent in people on a vegetarian (33%) or vegan (40%) diet. Selenium concentrations below the reference range, indicates that these participants would have a higher risk for developing health impairments.

VARIATION OF SELENIUM IN RAW MATERIALS

The above mentioned study of Klein et al (2023) highlights the large difference of selenium availabil-

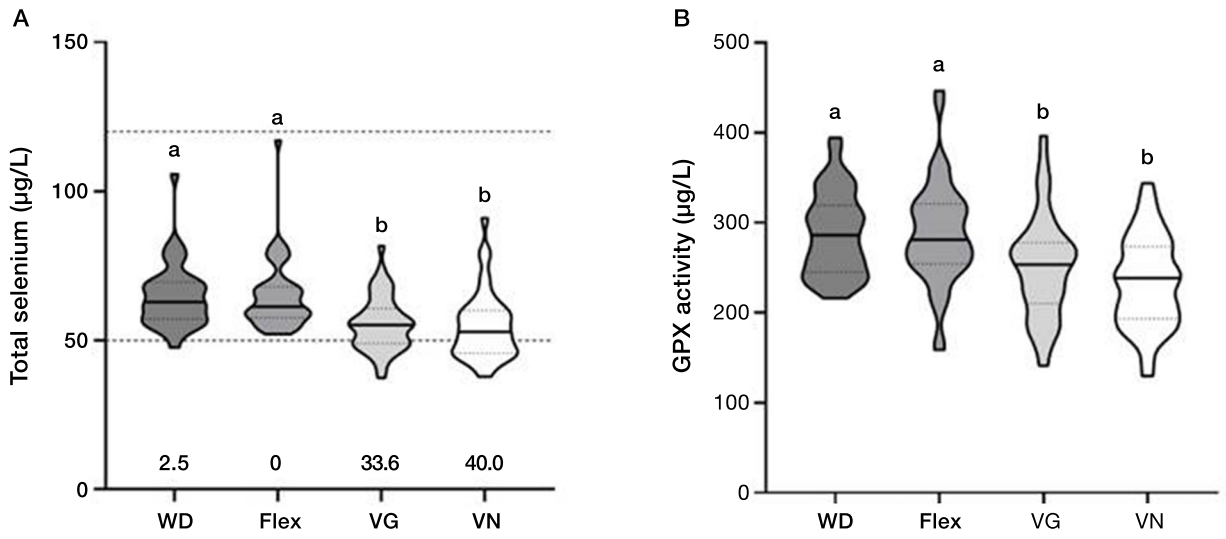

*Figure 1. In a nutritional evaluation study, the selenium biomarkers in serum of people without meat in their diet are substantially lower, and relatively frequent below the limit of 50 µg/L (Klein, et al., 2023). (**WD** = omnivores; **Flex** = flexitarians; **VG** = vegetarians; **VN** = vegans)*

ity from plant- and animal-derived food diets. Generally, animal-based ingredients are rich in selenium, whereas selenium levels in raw materials from vegetable origin are low. This can be explained, as selenium is not essential for plants. The selenium level in plant-derived ingredients depends on the selenium level of soil where the plant was grown, and can be very low and is highly variable between batches. Additionally, the bioavailability of trace elements from plant-based raw materials is often lower[3].

In contrast to plants, selenium is essential for animals, and meat-derived ingredients always contain a minimum amount of selenium. The selenium content varies depending on the part of the animal, with organs; such as the liver and kidneys containing higher levels compared to skeletal muscle tissue. Additionally, the animal's origin impacts the selenium concentration, as fish-based ingredients usually contain higher amounts of selenium compared to products derived from land-based animals[3].

Pet food products containing more plant-based ingredients require additional selenium supplementation to meet the daily requirements of the animal and prevent selenium deficiency. Conversely, pet diets that are mostly based on organ-based or fish derived raw materials can fulfill the daily requirements, or even exceed the maximum levels, without additional selenium supplementation. The wide variation of selenium in raw materials makes it complicated to stay between minimum and maximum levels. But what are exactly the boundaries within which a pet nutritionist must adhere?

WHAT ABOUT SELENIUM REQUIREMENTS

The FEDIAF (2024) provides the minimum recommendations for selenium in growing and adult dogs and cats (Figure 2). In adults, the FEDIAF recommends nutrient levels based on the activity level of the animal. Less active animals have lower maintenance energy requirements (MER), and consequently a lower daily food intake. In order to meet the daily requirements, the selenium content in food for less active animals is higher. Although FEDIAF don't specifically provide requirements for overweight animals, it can be seen that the MER for overweight dogs and cats is even below 95 kcal/$kg^{0.75}$ and 75 kcal/$kg^{0.67}$ respectively. While weight loss diets often have a lower energy density, the daily amount of food provided to these animals is still less compared to normal sized pets. To reach the minimum daily recommendation, the level of selenium in a diet for overweight pets will become very

Figure 2. Selenium recommendations in pet food (FEDIAF, 2024)

Stage	Activity level / age	Min. recommendation (mg Se/kg DM)		EU legal limit (mg Se/kg DM)*
Early growth (< 14 weeks)		0.400		0.568
Late growth (≥ 14 weeks)		0.400		
Adult dogs (MER of 110 kcal/kg$^{0.75}$)	Moderate activity	0.180 (dry diet)	0.230 (wet diet)	
Adult dogs (MER of 95 kcal/kg$^{0.75}$)	Low activity / senior	0.200 (dry diet)	0.270 (wet diet)	

Stage	Activity level / age	Min. recommendation (mg Se/kg DM)		EU legal limit (mg Se/kg DM)*
Growth & reproduction		0.300		0.568
Adult cats (MER of 100 kcal/kg$^{0.67}$)	Active cats / senior	0.210 (dry diet)	0.260 (wet diet)	
Adult cats (MER of 75 kcal/kg$^{0.67}$)	Neutered / indoor cats	0.280 (dry diet)	0.350 (wet diet)	

**In the EU, for organic selenium a maximum supplementation level of 0.2273 ppm mg/kg DM (=0.2 mg/kg complete feed with 12% moisture) applies*

close to the European legal limit of 0.568 mg selenium per kg dry matter (DM).

In young animals, the selenium recommendation is relatively high and close to the EU legal limit. These levels are higher as the FEDIAF incorporates an additional safety margin due to the potentially low availability of selenium in pet food. The pet food production process can have a significant effect on the bioavailability of selenium in pet food[5], which likely explains why an explicit distinction is made in the minimum requirements for selenium in both dry and wet diets for adult pets. In canned diets, the sterilization process can strongly decrease the digestibility of selenium[6,7].

SELENIUM IN COMMERCIALLY AVAILABLE DIETS

The limited available information on selenium levels in vegetarian pet diets compared to traditional meat-based diets sparked our curiosity about the application of selenium in commercially available pet foods. In a small practical trial, 12 dry kibble diets for adult dogs, from 6 different brands, were bought in (online) pet stores. A brand was selected when it had both a vegetarian and lamb-based diet in the assortment. In order to keep the origin of the meat the same, lamb-based diets were chosen, as both vegetarian and lamb-based diets are often promoted for dogs sensitive to specific nutrients. On the pet food labels, the amount and source of supplemented selenium was declared. Total selenium analysis was performed by the University of Ghent, Belgium. Based on these results and the label information, an estimation of the selenium content from the raw materials was made.

The total amount of selenium in lamb-based diets was numerically higher compared to the vegetarian

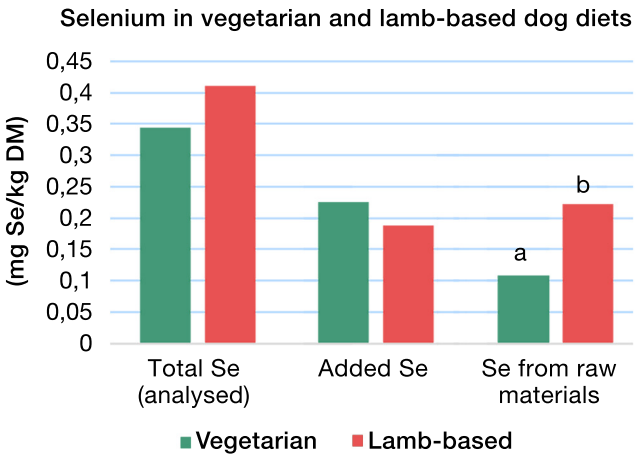

Figure 3. Average selenium levels of 12 commercially available vegetarian and lamb-based dog diets, from 6 different brands.

diets (Figure 3). All diets remained within the minimum (0.220 mg/kg DM) and maximum (0.568 mg/kg DM) levels of selenium for adult dogs. Of the vegetarian foods, 4 out of 6 diets barely exceeded the minimum requirements, where all lamb-based diets were above the 0.3 mg/kg DM.

Sodium selenite was the most used source of supplemental selenium, only one diet was enriched with a selenized yeast. Within each brand, the vegetarian diet contained a (slightly) higher level of additional selenium, with only one exception.

In line with earlier publications[3], selenium derived from the raw materials is significantly lower in plant-based diets compared to the meat-based variants. In all diets, the amount of selenium from the raw materials was low (≤ 0.300 mg/kg DM). In two-third of the diets, the amount of selenium from raw materials did not exceed the minimum levels to fulfill in the requirements of dogs. Selenium supplementation of pet diets is therefore essential. However, what is a rational choice when we look at the different selenium sources that are commercially available?

DIFFERENCE OF SELENIUM SOURCES IN THE METABOLISM

Both plant-based and animal-based ingredients contain selenium, predominantly in the natural, organic form of L-selenomethionine. Supplemented selenium can be either inorganic (often sodium selenite) or organic (selenized yeast or L-selenomethionine).

In the metabolism of the animal, there is a difference between L-selenomethionine and other forms of selenium (Figure 4). All selenium compounds are recognized for the supply of selenium, and all can be used for the synthesis of selenoproteins (selenoenzymes). It is the selenoenzymes that play a vital role in antioxidant defense, regulation of the thyroid function, and immune system support. Beside this general pathway to selenoenzymes, L-selenome-

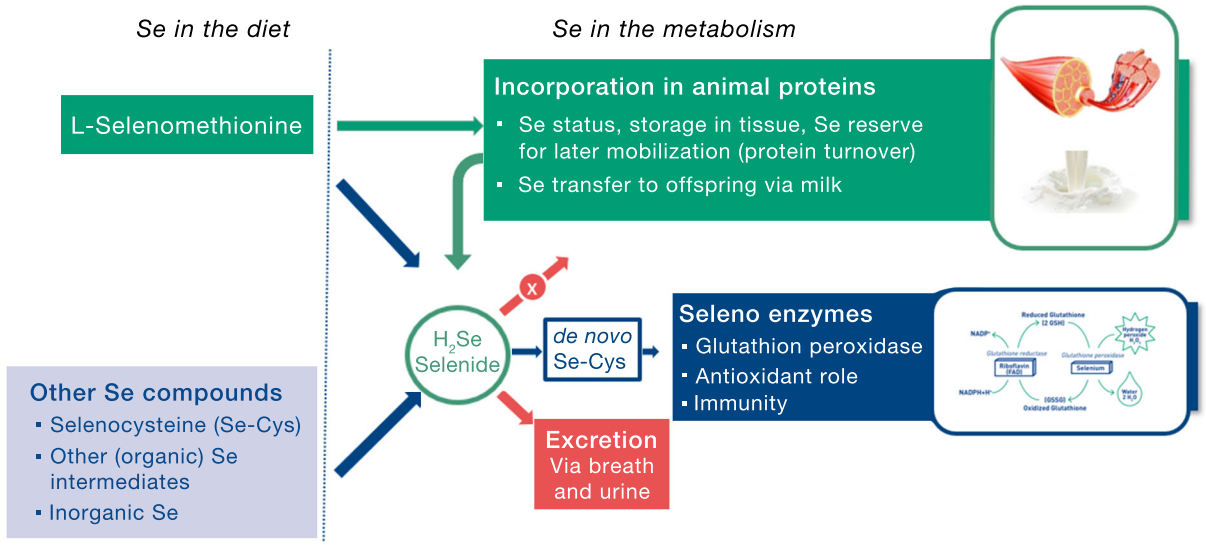

Figure 4. Dietary selenium sources in the metabolism

thionine is utilized in the body as an amino acid and can be incorporated into body proteins in place of methionine. Through this specific pathway, L-selenomethionine is able to build up selenium reserves in the body, and efficiently transfer selenium to the offspring through colostrum and milk.

The greater retention of L-selenomethionine in animal protein, provides a safe reserve of selenium in the animals' body which ensures the future selenium supply. During protein turnover, stored L-selenomethionine will be released and can be used for selenoenzyme synthesis at any time. Use of L-selenomethionine can be the solution to mitigate the risk for lower selenium availability in the animal, especially when selenium (bio)availability from the diet is low due to variation in the raw materials and/or influenced by the production process.

L-SELENOMETHIONINE FROM ORGANIC SOURCES

Both selenized yeast and pure L-selenomethionine sources contain L-selenomethionine, however they differ in concentration of L-selenomethionine within the product. Selenium yeast consists of up to 98% organic selenium, though not all of this organic selenium is in the form of L-selenomethionine. According to EU legislation, 63% of the selenium in selenized yeast should be in the form of L-selenomethionine. The remaining part of the selenium is in the form of selenocysteine, other (organic) intermediates or inorganic selenium.

In the metabolism (Figure 4), selenocysteine and other (organic) selenium intermediates are reduced to hydrogen selenide and then utilized for the novo- selenocysteine and selenoenzyme biosynthesis. Thus, the remaining selenium in the selenized yeast (<37%) follows the same pathway as inorganic sodium selenite. In contrast, 100% of a pure L-selenomethionine source can be used for both pathways in the metabolism.

Selenium deposition, and thereby the difference between dietary selenium sources, can be measured in milk and muscle tissue. Although no comparative

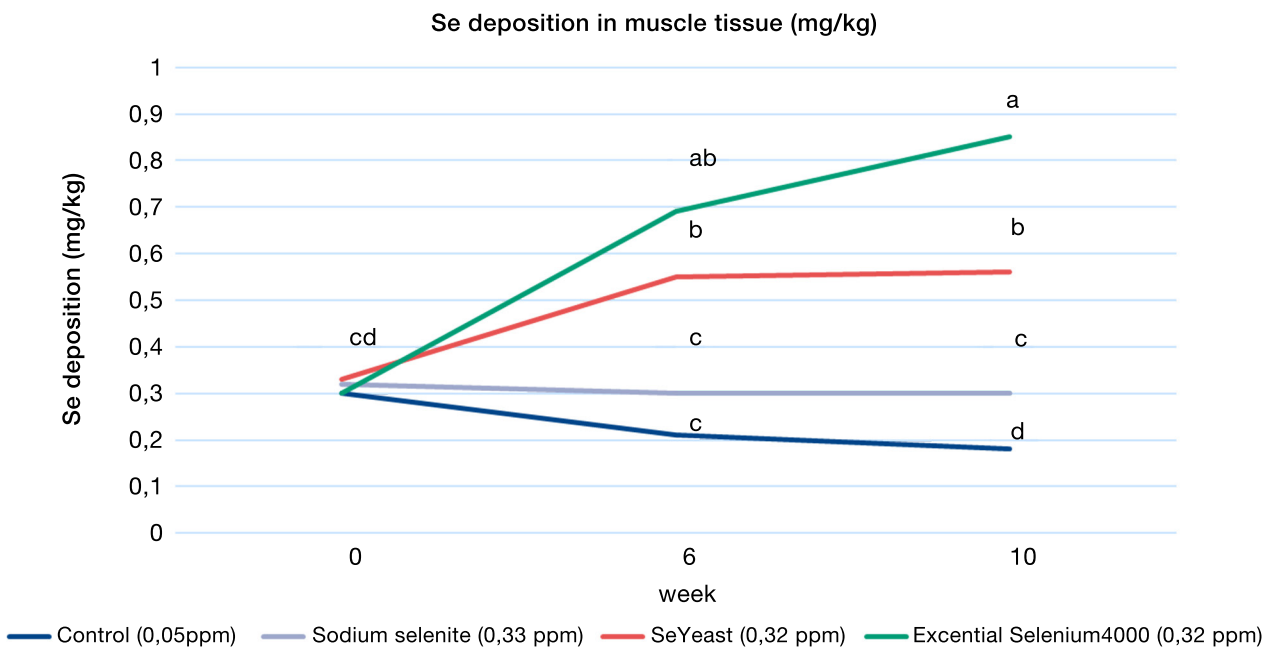

Figure 5. The safe deposit of selenium in the animal depends on the dietary selenium source (adapted from Falk et al, 2018)

studies with more than 2 different dietary sources of selenium are performed in cats and dogs, there is sufficient information available from other animal species. The results on Figure 5, adapted from the Norwegian University of Life Sciences, clearly show the difference in selenium deposition in swine muscle tissue, when animals receive different selenium sources in their diet[8].

Although the dietary selenium levels of the supplemented diets were equal, selenium deposition was significantly higher for the organic sources, with the highest observed levels in animals fed the pure L-selenomethionine source (Excential Selenium4000, Orffa Additives). These results highlight why L-selenomethionine is well-known as the natural and safe source of selenium in animal nutrition.

CONCLUSION

The wide variation of selenium levels in raw materials, diet composition (meat- or plant-based), and the effects of heat during production processes on selenium bioavailability, often necessitate selenium supplementation to ensure a sufficient selenium supply to dogs and cats. The narrow margin between the minimum requirement and the maximal legal limits of selenium, makes pet food formulation challenging. By using L-selenomethionine to create a safe reserve of selenium in the body, you will have a solution to safeguard the future selenium supply in dogs and cats.

References available on request via orffa@info.com

About Pauline Rovers-Paap

In 2008, Pauline Rovers-Paap graduated from the University of Wageningen, the Netherlands. In her master's thesis, she already explored the opportunities for Orffa to approach the pet food market with specialty-type feed additives. This meant a successful start to her career at Orffa, where she likes to translate scientific research into practically useful information. With her passion for companion animal nutrition, Pauline Rovers-Paap has been the technical support and driving force to bring new nutritional solutions to the pet food market!