



Mineral Nutrition: AN OFTEN-OVERLOOKED SOLUTION TOWARDS IMPROVING SUSTAINABILITY

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Mineral nutrition plays a crucial role in sustainable livestock production, influencing both environmental excretions and animal performance. Choosing highly bioavailable mineral sources can reduce dosages, minimize waste, and limit eutrophication, while different trace elements and their forms show varying efficacy. Social sustainability also matters, as dust exposure affects workers. Exploring these approaches can reveal how feed strategies impact efficiency, animal health, and broader environmental outcomes.

With the global population expected to reach 9.7 billion people in 2050, demand for animal protein (meat, milk, eggs) is rising rapidly. While animal production is widely recognized as a major source of greenhouse gas emissions, it also results in the excretion of minerals into the environment. This raises a critical question of how can we meet this growing demand for animal protein in a sustainable way?

Nutrition can play a key role when considering sustainable livestock production, as the production of feed plays a big role in total emissions and environmental excretions. Major contributors are grains, fats and premixes. When selecting a premix, the choice of mineral source is crucial, as bioavailability can vary significantly. Products with low bioavailability are generally associated with high environmental excretion and are added in high dosages to ensure the desired effects. The high excretion to the environment is related to increased eutrophication (process of enriching water bodies with too much nutrients). Eutrophication causes an overgrowth of algae and certain plants which can disturb the

natural balance in oxygen in the water and affect the organisms that live in the water. By reducing the excretion of minerals into the environment, the addition of nutrients in the water can be limited, reducing the danger of eutrophication.

When a product with better bioavailability is chosen, both environmental excretion as well as the dosage can be reduced, minimizing input while still achieving the same output. This can offer significant improvements in both environment (less resources needed, reduced eutrophication) as well as economic (cost reduction) sustainability. On top, trace mineral sources with low dust levels will have social impact, improving the working conditions in premix factories and feed mills.

SELENIUM: IT IS ALL ABOUT L-SELENOMETHIONINE

Selenium is an essential trace element, with fundamental importance for animal health and performance. In animal nutrition, it is generally supplemented in inorganic (e.g. sodium selenite) or organic form. When

differentiating available selenium sources, it is important to note that only L-selenomethionine (L-SeMet) can be incorporated into animal protein and therefore can provide a safe deposit of selenium inside the body. L-SeMet is a methionine molecule, but instead of sulphur, the sulphur in the molecule is replaced by selenium. Thereby, L-SeMet can be incorporated as an amino acid in animal tissue. All other forms of selenium cannot be stored and can only be used for the synthesis of selenoproteins used in the animal metabolism. Due to the ability to create a selenium reserve in the body, L-SeMet is the most effective form of selenium, contributing to an optimal selenium status.

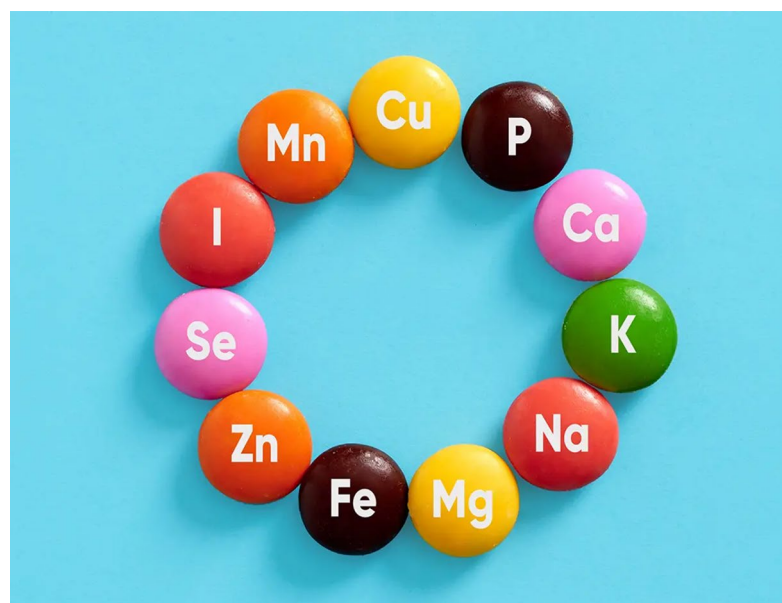
Several commercial selenium products contain L-SeMet, like selenized yeast, OH-Selenomethionine (OH-SeMet) and pure L-selenomethionine (L-SeMet). However, the content and bioavailability of L-selenomethionine for these different products varies significantly and therefore it is important to carefully consider this, as to make sure you are using the most bioavailable, and therefore sustainable form of selenium. Selenized yeast products are produced by culturing yeast on a high-selenium media. This causes the selenium to be incorporated into the yeast, partly as L-SeMet. Not all selenium will be incorporated as L-SeMet, part will be incorporated in other forms such as selenocysteine. In Europe, selenized yeast products should contain at least 63% of their selenium as L-SeMet (EFSA) but in practice, these contents can sometimes be even lower. An important consideration on the L-SeMet in selenized yeast, is that this is incorporated into the yeast protein. Before L-SeMet can be absorbed, the yeast protein first needs to be digested and split up into peptides and amino acids. Digestibility of yeast protein is around 80%, and taking that into account, the average selenized yeast product will contain $63\% \text{ SeMet} \times 80\% \text{ digestibility} = 50\%$ digestible L-SeMet. The remaining selenium in the product is present in other forms, which cannot be used for creating selenium deposits in the animal.

OH-SeMet on the other hand is a synthetically produced molecule which must be converted into L-selenomethionine before it can be used by the animal.

This conversion takes place by two enzymatic steps in the liver and kidney. This conversion causes the product to 'lose' some of its efficacy ($\pm 20\%$) and results in a bioavailability of around 80%. Bioavailability of OH-SeMet is often explained by considering the relative utilization of different methionine isomers, where L-methionine is considered at 100% utilization and OH-methionine at 80% (in monogastric animals).

Pure L-SeMet sources are also produced by chemical synthesis, but these products contain all selenium in the form of L-SeMet and are considered to have 100% bioavailable L-SeMet. Because of the 100% bioavailable L-SeMet content, these products are considered to allow for the most optimal selenium status of animals.

The evidence for optimal efficacy of L-SeMet vs other organic selenium sources has been confirmed by Van Beirendonck et al. (2018) in an *in vivo* broiler trial. In total, 140-day-old chicks were divided over 7 treatments; Control: no added selenium (Se), T1: control + 0.20 ppm Se (sodium selenite), T2: control + 0.20 ppm Se (L-SeMet), 0.16 ppm Se (L-SeMet), 0.20 ppm Se (OH-SeMet), 0.20 ppm Se (selenized yeast; 45% L-SeMet), 0.20 ppm Se (selenized yeast; 29% L-SeMet). Treatment 2 and 3 have L-selenomethionine from Excential Selenium 4000; Orffa Additives BV.



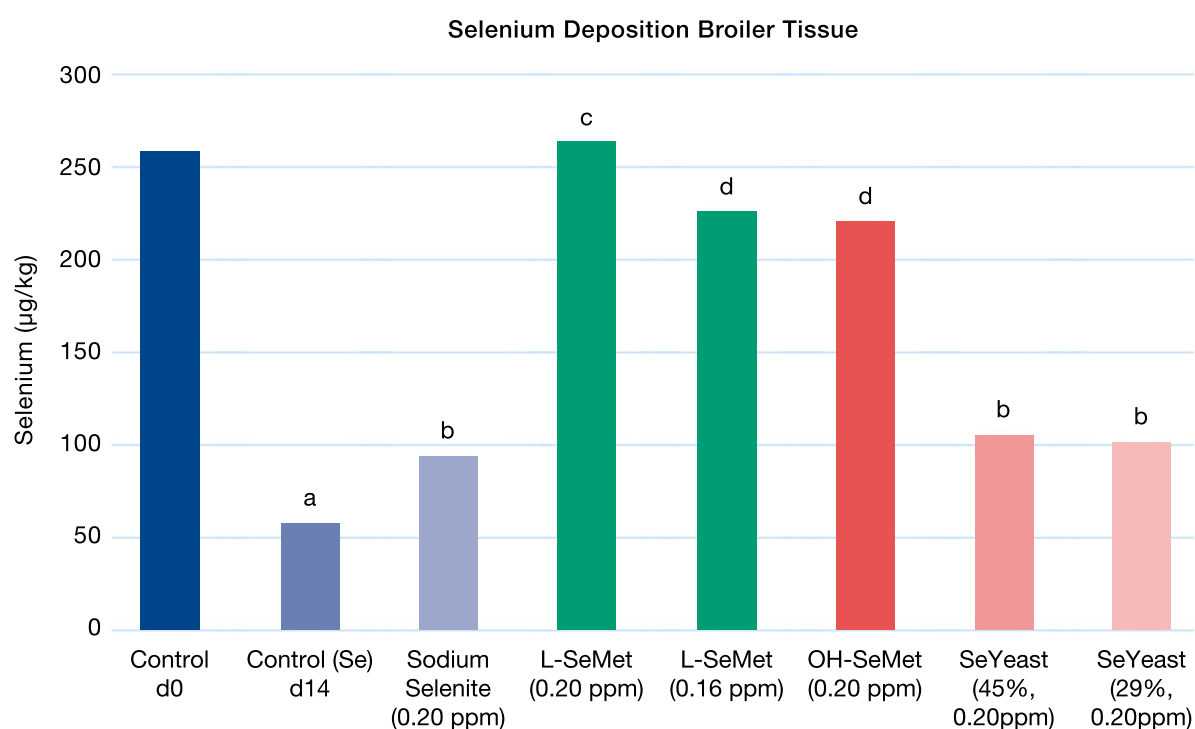


Figure 1. Selenium (Se) deposition in broiler muscle tissue on day 14 ($P < 0.05$)
(adapted from Van Beirendonck et al. 2018)

After two weeks of feeding, breast muscle samples were collected from three birds per replicate to analyze selenium deposition. For comparison, the same sampling and analysis were performed on the control group on day 0. The results (Figure 1) show that on day 0 (d0), birds have a good selenium deposition in their muscles, but when not supplementing any selenium for the first two weeks of life (control group), this storage is exhausted. Supplementing sodium selenite or selenized yeast with low L-SeMet levels (45 and 29% respectively), allows for slight compensation in the selenium that is stored in the muscle. When comparing L-SeMet and OH-SeMet, the results showed similar selenium deposition in muscle tissue between the lower dosage of L-SeMet (0.16 ppm) and OH-SeMet (0.20 ppm). However, the higher dosage of L-SeMet (0.20 ppm) resulted in significantly higher selenium deposition ($P < 0.05$) in the broiler muscle tissue, with a 17% increase compared to OH-SeMet (0.20 ppm).

By choosing L-SeMet, an optimal selenium status can be created. L-SeMet has been shown to be more efficient compared to other (organic) selenium

sources. This can contribute to improving sustainability, as the added selenium is used in the most effective way, and excretion is minimized. At the same time, it is possible to reduce the dosage while maintaining the same outputs. Besides the lower environmental pressure, reducing dosage can allow for a cost reduction and economic sustainability.

WHAT ABOUT COPPER, ZINC AND MANGANESE?

Copper, zinc and manganese are essential trace elements that are commonly included in animal nutrition. Different forms of these trace elements are available, which are generally categorized under three generations of products. The first generation, traditional, inorganic minerals (oxides and sulphates) are known for their ionic bonds and low bioavailability. Oxides can be compared to a stone; almost insoluble and therefore the trace element hardly becomes available for absorption. Sulphates on the other hand are more comparable to sugar cubes; quickly soluble and therefore at risk of forming insoluble complexes and causing reactivity already in the feed. The second-gen-

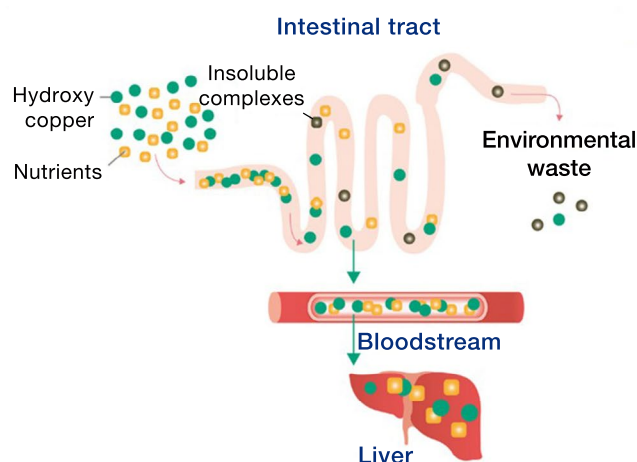
eration trace minerals include organic minerals, with a strong covalent bond and a carbon ligand. There is a high variety in possible ligands (proteins, fats, single amino acids etc.) which creates some uncertainty as to the specific bond strength (differs per ligand). However, it is generally assumed that these organic minerals have high bioavailability. The third-generation products contain hydroxy trace minerals, with a strong covalent bond and hydroxy (non-carbon) ligand. Due to the low molecular weight of the hydroxy ligand, these products can contain high concentrations of trace elements which allow for low dosages in premixtures. The strong covalent bonds ensure optimal bioavailability of these minerals, and they can be compared to lollipops, allowing for a slow release. Because of this slow release, the product will not interact with other nutrients and ensure stability in the feed. In contrast to sulphates for example, which are known for reducing the bioavailability of other nutrients such as vitamins or enzymes (phytase).

Solubility affects how minerals interact with other nutrients in feed. Since feed generally consists of around 88% dry matter and 12% moisture, products with high solubility will already interact with other nutrients in the feed. Figure 2 shows the differences between hydroxy copper and copper sulphate,

where copper sulphate has high solubility, and will cause formation of insoluble complexes that will be excreted as environmental waste to a high extent. Hydroxy trace minerals have a slow release, therefore allowing for at the right time, at the right place, the trace element to be taken up by transporters in the small intestine with less competition for transporters at the beginning of the small intestine and optimal absorption. This reduces the excretion of environmental waste, reducing eutrophication and contributing to environmental sustainability.

As mentioned before, mineral sources with high bioavailability are important when talking about optimizing feed sustainability. When replacing the first-generation trace minerals, bioavailability can be improved, which allows for lower dosages of the product while still achieving similar (or better) results. In broilers, a study with 870 Ross-308-day-old chicks compared the bioavailability of zinc and copper sulphate with hydroxy forms (Excential SMART Z + C, Orffa Additives BV), when the latter was supplemented at a lower dosage. The animals were divided over two treatments; 1. Control diet + 120 ppm zinc (zinc sulphate) + 15 ppm copper (copper sulphate) and 2: Control diet + 80 ppm zinc (hydroxy zinc) + 10 ppm copper (hydroxy copper). After

Smart Hydroxy Copper



Copper Sulphate

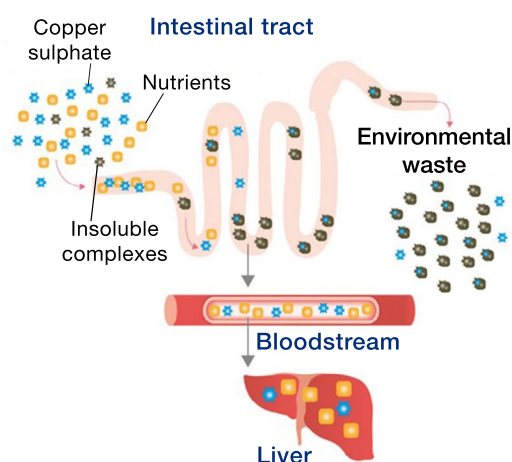
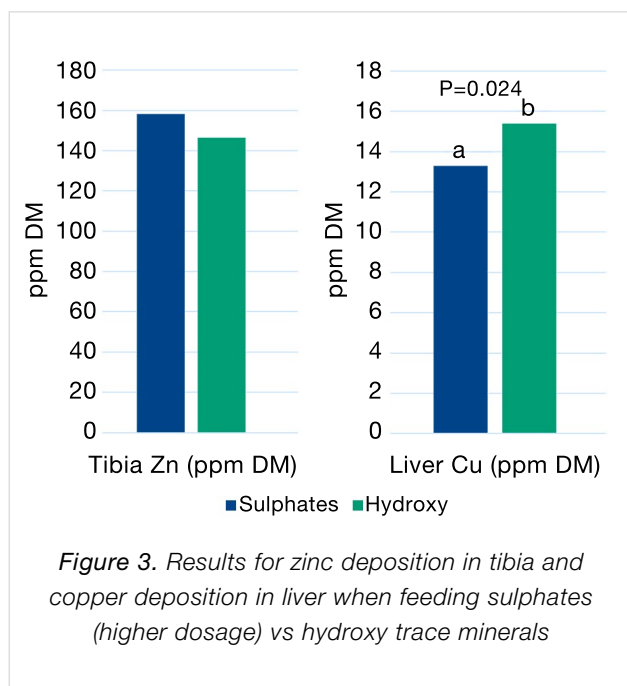


Figure 2. Hydroxy copper (Excential SMART, Orffa Additives BV) vs copper sulphate in the gastrointestinal tract



the 42-day feeding trial, the zinc content in the tibia was analyzed, as well as the amount of copper in the liver (Figure 3). The results show that there are no significant differences in zinc deposition in the tibia. Even though the hydroxy zinc was added at a lower zinc dosage (10 ppm), the effects on deposition are comparable to results for the zinc sulphate at higher dosage (15 ppm). For the copper deposition in the liver, it was shown that the hydroxy copper at lower dosage (80 ppm) resulted in higher liver copper levels compared to the copper sulphate at a lower dosage (120 ppm). The results of this trial very nicely show how the hydroxy zinc and copper have higher bioavailability compared to the zinc and copper sulphate and therefore allow for a reduction in zinc and copper levels in feed, while achieving similar/better zinc and copper levels in the target animal. Similar results on bioavailability can be found for other species (e.g. swine, ruminants).

SOCIAL SUSTAINABILITY:

CONSIDERING DUST IN THE WORKPLACE

Besides environmental and economic sustainability, it is also important to consider social sustainability, which focuses on maintaining and improving the welfare of people and future generations. Good working conditions play a big role, especially the health of employees. Feed additives, especially min-

erals, can be quite dusty products. Workers in feed and premix factories are exposed to this dust, which can pose a serious hazard to their health. Long-term exposure to mineral dust can lead to several occupational exposure diseases such as asthma, lung irritation and even cancer. Therefore, it is important to minimize the dusting potential of these additive and safeguard the health of the people working with these products. In Europe, EFSA has implemented Occupational Exposure Limits (OEL's), which indicate the maximum allowed dusting potential, which is still considered to be safe. The dust potential can be measured by using the Stauber-Heubach dust meter, which quantifies dust particles in powder materials. When choosing a mineral solution, it is important to take the dusting potential into account. Orffa offers several dust free mineral solutions. The L-SeMet product (Excential Selenium 4000) is dust free and in line with the OEL of $<0.2 \text{ mg Se/m}^3 \text{ air}$. But also, the Elovital Miku range offers dust free solutions for iodine, cobalt and selenium. By choosing a dust free mineral product, a contribution is made towards better social sustainability.

HOW TO CHOOSE SUSTAINABLE MINERAL SOLUTIONS?

When summarizing how to choose a sustainable mineral solution, it is important to consider different aspects of sustainability; environmental (minimize resources + waste), economic (reduce costs) and social (workers' safety). For both environmental and economic sustainability, it is important to choose the most bioavailable mineral solution, which allows you to reduce the dosage while maintaining optimal mineral levels in the animal. For selenium, L-selenomethionine is considered as the selenium source with the most optimal bioavailability, for copper, zinc and manganese the third-generation hydroxy trace minerals are considered an excellent source. When focusing on social sustainability, it is important to consider dust levels of different mineral sources and choose a dust free or low dust product. By choosing such sustainable mineral solutions, you can contribute to a more sustainable livestock industry and a healthy planet for future generations!