The beneficial effects of including L-selenomethionine in fish and shrimp diets on health and performance

Organic selenium has a wide range of effectiveness, including increased coping with stress during the production cycle and enhancing the immunity for fish. Additionally, its use can decrease both environmental selenium load and increase sustainability.

By Matthijs de Jong

In intensive aquaculture production, high growth rates and high feed efficiencies are essential. However, the required high growth performance is more often associated with increased levels of stress. Stress can be from various sources such as high stocking densities, pathogenic pressure, osmotic imbalance, other environmental factors and animal handling. When fish and shrimp experience stress, enhanced levels of reactive oxygen species (ROS) and a suboptimal antioxidant status and immunity are observed. Selenium (Se), an essential trace element, will support the animal during these stressful conditions. For example, it functions as a vital component of selenoenzymes, which play an important role in reducing ROS and maintaining a healthy antioxidant status.

Selenium contents in aquafeeds under pressure and in need for supplementation

Beneficial effects of Se in aquaculture diets are well-recognised. Nevertheless, due to increased usage of plant-based meals, to replace fishmeal and fish oil, the amount of Se in aquafeeds has been decreasing over the past decades. One of the consequences of these decreased Se levels in the feed is the decreased content of Se in fish, throughout the body and in the fillet (Betancor et al., 2016).

Decreased Se contents in the body are known to be unfavourable for animal health and performance. To counteract this trend, aquafeed producers and fish farmers have the possibility to include organic and inorganic Se sources in their diets. These chemical forms affect the Se bioavailability differently. In general, animals are unable to incorporate dietary inorganic Se sources in body protein, but this is possible for organic Se, in the form of L-selenomethionine (Figure 1). Next to that, it is commonly accepted that organic Se shows greater bioavailability compared to inorganic Se. This combination of high storage capacity and bioavailability is the reason that organic Se sources, in the form of L-selenomethionine (Excential Selenium 4000, Orffa Additives BV) are more functional compared to inorganic Se sources, for example sodium selenite.

Organic Se is involved in numerous biological processes which benefit the antioxidant and immune systems. These systems are negatively affected when Se levels are inadequate, showing the importance of maintaining sufficient Se levels in the diet. Additionally, Se is beneficial for health but decreasing Se concentrations in the fish body is problematic for humans, as fish fillet is one of the major sources of Se in the human diet. Supplementation of Se in the diet is thus a necessity - in order to maintain fish health and to maintain the health benefits of consuming fish and shrimp.

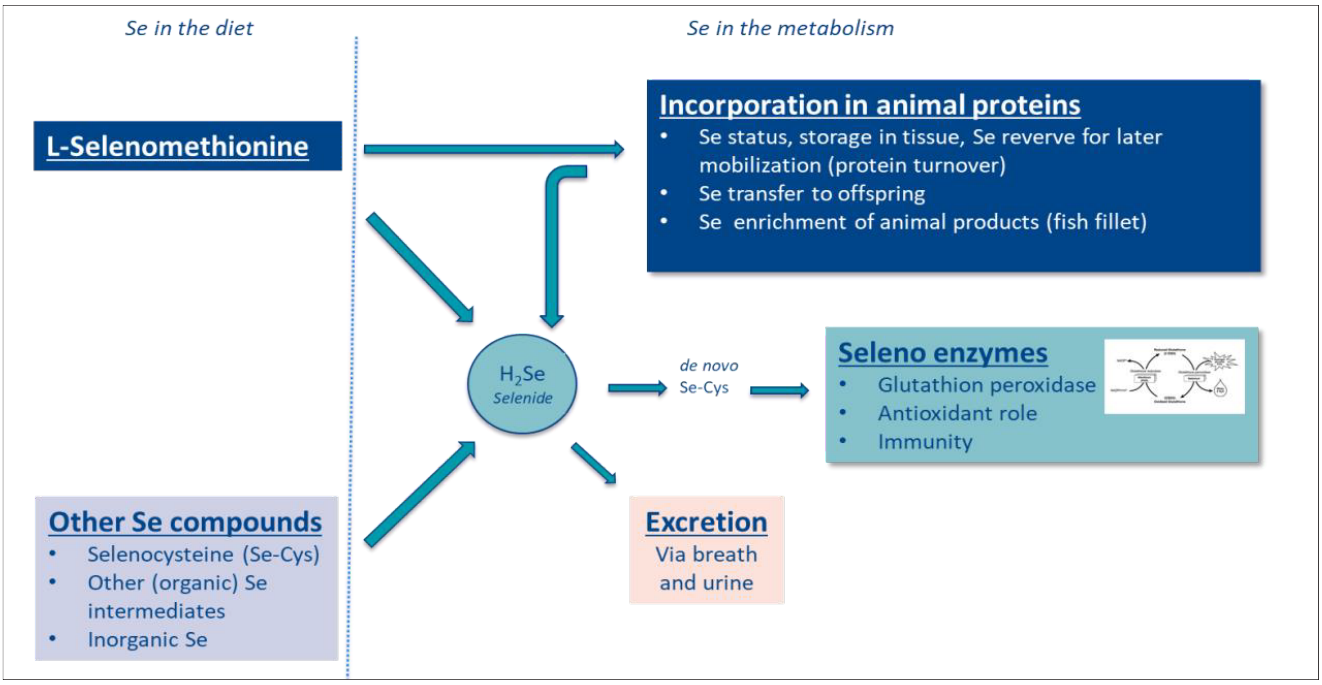


Figure 1. Metabolic pathway of L-selenomethionine and all other Se compounds (including inorganic selenium). adapted from Rayman (2004) and Combs (2001).

Selenium in salmon: Organic vs inorganic

The effect of feeding Se was examined in a trial by Prabhu et al. (2020) with post-smolt Atlantic salmon. During this experiment, different sources of Se (organic; L-selenomethionine Excential Selenium 4000- and inorganic; sodium selenite) and different levels of Se (0.15 to 1.1 mg Se/kg diet) were supplemented and evaluated on growth performance, fish antioxidant status, Se deposition and environmental impact.

It was hypothesised that L-selenomethionine, due to its high storage capacity in body protein, would be able to counteract decreasing Se contents in the fish diet. It was shown that the addition of any Se source increased fish growth performance slightly, but that the largest, numerical, weight gain and lowest, numerical, feed conversion (FCR) were observed in fish fed the diet with 0.4 mg Se addition from L-selenomethionine per kg of diet (Figure 2).

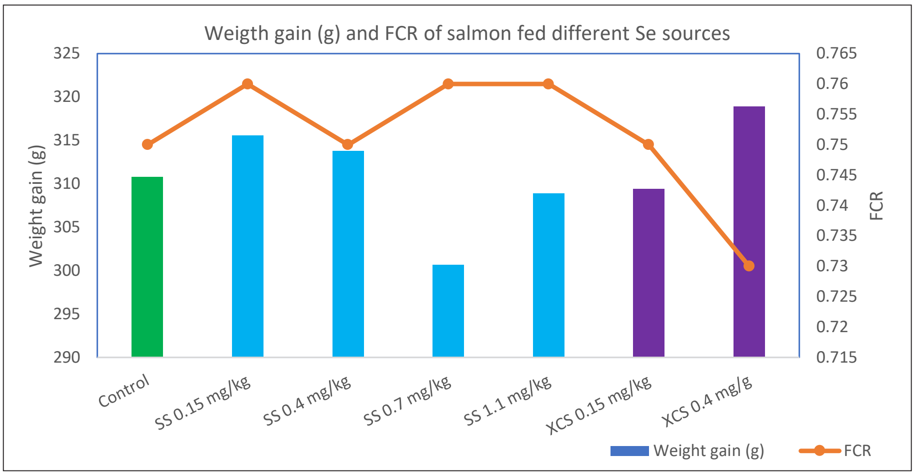


Figure 2. Weight gain (g) and feed conversion ratio (FCR) of post-smolt salmon fed different Se sources (SS=sodium selenite; XCS = Excential Selenium 4000), adapted from Prabhu et al. (2020).

Even more promising effects were seen on body Se deposition and immunity. Se concentration in whole body, liver, muscle, plasma, kidney and liver/kidney Se ratio significantly increased with increasing dietary Se compared to the control diet without added Se. Increased Se levels in several parts of the body act as a reserve (Figure 3) and indicate that Se is more available for salmon to cope with the stress periods during the production cycle and when dietary Se in raw materials is low. Another indicator that showed the increased antioxidant status is the level of oxidised glutathione (GSSG). Increased levels of GSSG indicate an increase in cellular oxidative stress in the fish. Similar to the previous observations, Se supplementation, regardless of source, was shown to significantly decrease the GSSG and thus decrease cellular oxidative stress.

However, when comparing different Se sources, it is shown that L-selenomethionine outperforms sodium selenite. The slope ratio shows that L-selenomethionine is more efficient in improving apparent availability, whole body or tissue Se status and Se retention (Figure 3).

These differences in slope ratio result in a lower requirement of L-selenomethionine compared to sodium selenite. In this study, the requirement of Se supplementation was 0.41mg/kg Se from sodium selenite, whilst for Se from L-selenomethionine, the requirement was only 0.17mg/kg. The existing EU limit of Se in salmon diets is 0.5mg Se/kg diet, with a maximum of 0.2mg organic Se/kg supplementation. Therefore, adding organic Se, in the form of L-selenomethionine, instead of inorganic Se sources like sodium selenite is favourable to meet minimal requirements for salmon and at the same time following the existing regulations.

Next to that, Prahbu et al. (2020) showed that inorganic Se is excreted to a higher extent when compared with organic Se. Replacing inorganic with organic Se supplementation therefore results in a decreased environmental Se load and increased sustainability.

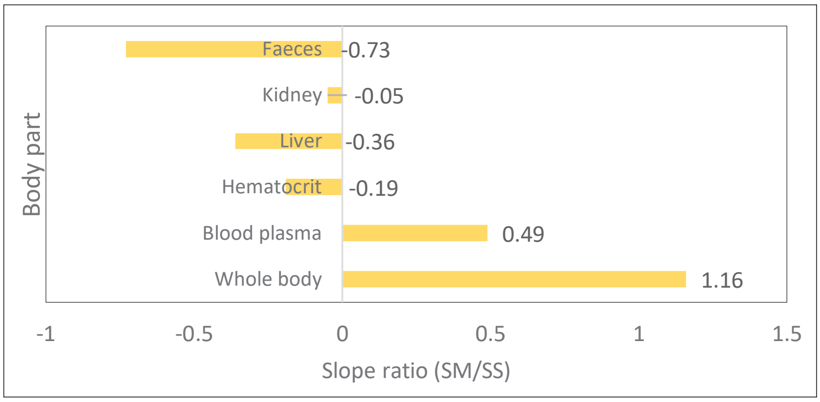


Figure 3. Relative differences of selenium concentrations in different parts of the body when L-selenomethionine is fed instead of sodium selenite (Adapted from Prabhu et al., 2020).

Selenium supplementation in tilapia: More of the same?

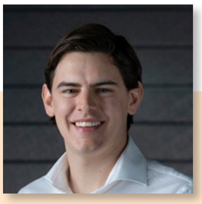
Salmon, a highly carnivorous species, is known to have a high Se requirement. However, when looking at species in lower trophic levels similar results regarding Se supplementation were observed as in salmon. A trial was conducted in Thailand with Nile tilapia to see the effect of various Se sources and levels on overall performance, antioxidative status and immunity. The trial, performed by Wangkahart (2022), showed that growth performance was significantly improved when L-selenomethionine (Excential Selenium 4000) was added at 1, 3 and 5mg Se/kg diet, whilst the growth did not improve and even slightly decreased when an inorganic Se source (sodium selenite) was added (Figure 4). An interesting note is that all supplementations are above the 0.5mg Se/kg diet that is allowed in EU regulations. Nevertheless, Prabhu (2020) mentioned that the actual requirement of Se in salmon is closer to 1mg/kg instead of 0.5mg/kg and this trial by Wangkahart underlined this statement: best growth was observed when an organic Se source was added at 1mg/kg inclusion rate. Important to note is that there was only a significant increase in growth observed when this organic Se, L-selenomethionine was added but with inorganic Se, both at higher and lower levels of inclusion no improvement of growth was observed. This again indicates that L-selenomethionine outperforms inorganic Se as a feed additive in aquaculture.

Based on these trials in salmon and Nile tilapia, we can conclude that this organic Se has a wide range of effectiveness. In other words, improvement of fish performance and health can already be achieved at lower inclusion levels but inclusion above the EU limit shows even more improvements.

Increased growth performance upon increasing dietary Se inclusion is linked to improved health of the animal. The tilapia trial showed that fish immunity improved when L-selenomethionine was added. Lysozyme activity, catalase activity, myeloperoxidase, superoxide dismutase and glutathione peroxidase, all indicators of antioxidant status, were improved when L-selenomethionine was added, while these were unaffected when sodium selenite was added. Again, this indicates that organic Se is a better source to feed fish compared to inorganic Se.

L-selenomethionine, an optimal selenium source in aquafeed

Increased stress accompanied by decreasing Se contents in feed is a serious challenge in the currently expanding aquaculture business. Demand for improved sustainability and increase of fishmeal prices have led to the need for alternative diets, which require supplementation of essential ingredients. Organic Se sources like Excential Selenium 4000 are proven to have higher bioavailability and less polluting effects compared to inorganic Se sources like sodium selenite, which makes it an optimal feed solution.



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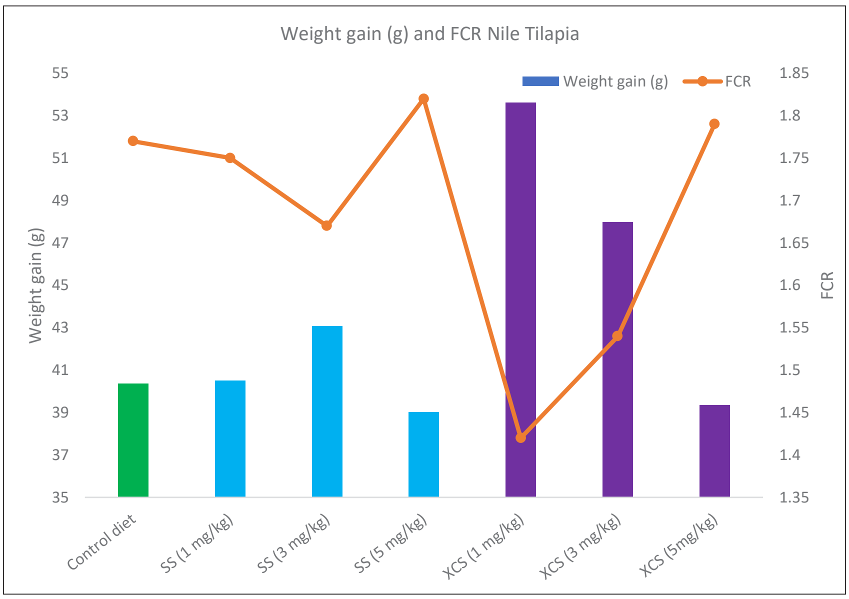

Figure 4. Weight gain and feed conversion ratio (FCR) of Nile tilapia fed different sources of selenium (XCS = L-selenomethionine; Excential Selenium 4000 and SS – sodium selenite) for 8 weeks. Adapted from Wangkahart et al. 2022.