Assessing the effect of L-selenomethionine in pig production

In intensive pig production daily weight gain and feed efficiency are high. However, high performance is associated with increased levels of stress. When stress occurs during the production cycle it can negatively impact embryonic development, increase the number of stillbirths, lower the litter size and affect growth of piglets.

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Stress (productive, social, heat, etc) is associated with enhanced levels of reactive oxygen species (ROS) and linked to suboptimal antioxidant status. Selenium (Se), in this respect, is a very important essential trace element. It is a vital component of selenoenzymes (glutathione peroxidase, GPx) which play a role in reducing ROS and therefore helps maintain a healthy antioxidant status.

A disruption of this steady state causes tissue damage due to interaction of ROS with lipids, proteins and DNA. These negative interactions reduce their metabolic activity. In order to maintain this steady state a continuous, optimal selenium supply is essential.

However, this can be difficult to achieve when uptake from the diet is impaired when stress (sickness) is present.

At that moment selenium is in high demand, to produce selenoenzymes and combat ROS. Selenium storage inside the animal, in that respect, would be beneficial.

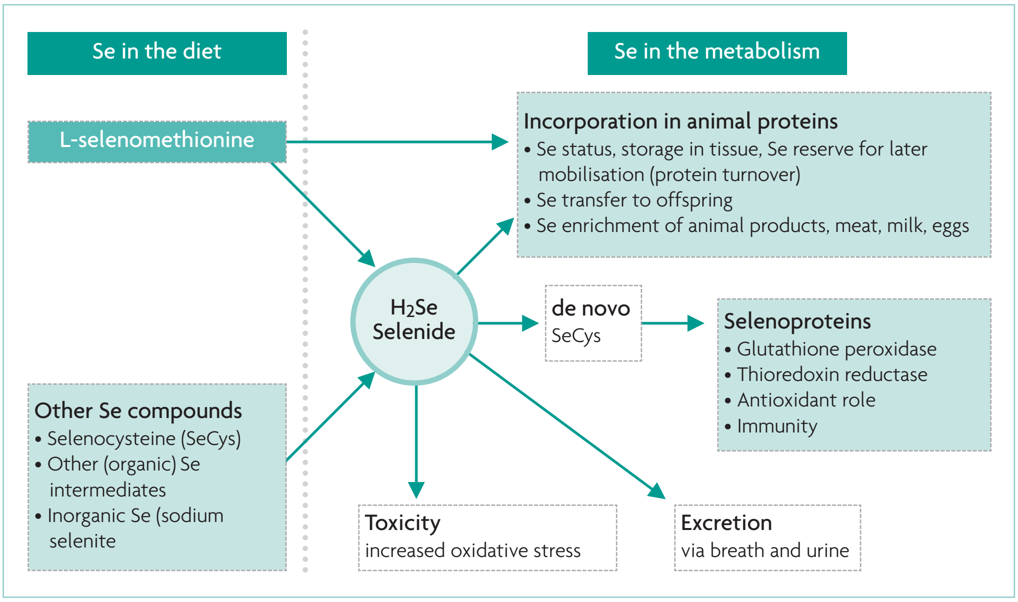

Fig. 1. The metabolism of L-selenomethionine and other selenium compounds (adapted from Rayman, 2004; and Combs, 2001).

A nutritional solution

Selenium can be added to the diet in either inorganic or organic forms (Fig. 1).

The advantage of using organic selenium (L-selenomethionine, L-SeMet) over inorganic sources (sodium selenite or selenate) is its ability to be incorporated directly, without conversion, into general body proteins as a methionine source, and this in every cell of the body.

L-selenomethionine is the only selenium compound that has this ability.

The incorporated selenium, in the form of L-selenomethionine, acts as a storage of selenium inside the animal. This stored selenium ensures optimal supply, even during stressful periods. If necessary, the stored selenium gets metabolised to selenide (H2Se) then to de novo selenocysteine (SeCys).

This molecule will be incorporated, as the active site, in selenoproteins. Other selenium compounds, such as SeCys and inorganic selenium, are not storable but will be metabolised to de novo SeCys.

The body maintains an equilibrium of circulating selenium, and excess selenium from SeCys or inorganic forms will be quickly excreted by which the availability of selenium at stressful times might be limited.

L-selenomethionine will only be metabolised to selenide when there is a need. This form is therefore less prone to excretion and toxicity reactions.

The success of L-selenomethionine in swine

The depletion of selenium reserves, with advancing parity, is exacerbated with greater productivity. Mahan and Peters (2004) showed a direct correlation between parity, selenium source (inorganic and organic) and selenium level on milk selenium concentration at weaning.

As parities progressed, sow milk selenium concentration decreased when sows were fed either the basal diet (no added selenium) or the inorganic selenium supplemented diet. In contrast, the selenium content of milk of sows fed the organic selenium source remained relatively constant between parities.

L-selenomethionine supplementation also increased the selenium body reserves through non-specific incorporation in general body protein.

Sows fed organic selenium had significantly ($p<0.05$) greater concentrations of selenium in the liver, loin and pancreas compared to sows fed the inorganic selenium source. The subsequent reproductive data indicated a greater number of stillbirths ($p<0.05$) when inorganic selenium was fed.

The milk selenium data agrees with the findings of Falk et al. (2019) which showed that L-seleno-methionine supplementation, initiated 30 days prepartum and continued throughout the lactation period, significantly increased total selenium levels in colostrum (x2) and in milk (x3) compared to the sodium selenite supplemented diet (Fig. 2).

Feeding of diets supplemented with L-selenomethionine led to higher concentrations of selenoprotein P (SelP) and selenoalbumin (SeAlb) at farrowing.

These selenoproteins are involved in selenium transport from extra-mammary tissue to colostrum and milk. Interestingly, in this trial, higher average daily feed intake (ADFI) was observed during the lactation period.

From day 13 post-partum until the end of the study, the ADFI was significantly higher in the L-selenomethionine supplemented group.

This can be interesting for high yielding sows where adequate feed intake can be challenging.

A higher amount of selenium

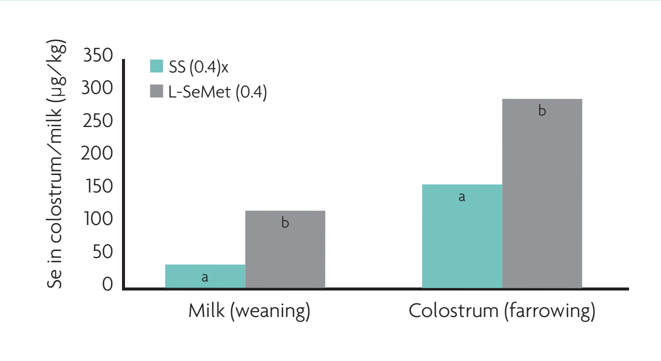

Fig. 2. Level of total selenium in colostrum and milk (n=7). Bars at one time point without a common subscript differ significantly (P<0.05).

deposited in the sow, in the form of L-selenomethionine, provides an effective transport of selenium from dam to foetus and newly born piglet via placenta, colostrum and milk. This will strengthen the piglets' antioxidative system, passive immunity and improve their weight gain.

Inherited selenium

Zhan et al. (2011) reported that the elevated selenium level found in the organs of weaned pigs could be attributed to higher inherited selenium at birth and higher transfer of selenium in colostrum and milk when sows were fed with selenomethionine.

Significantly ($p<0.05$) improved antioxidant status (total antioxidant capability, GPx) was observed in serum and organs of the weaned piglets (28 days postpartum).

Thyroid hormone ratio (T4/T3) was also investigated and seen to be significantly ($p<0.05$) increased, meaning that more active thyroid hormone (T3) was produced under high body selenium levels.

A selenoprotein is involved in the conversion of T4 to T3. An increase in body selenium reserve could therefore have had a beneficial effect on this conversion. In this trial average daily gain of piglets was also investigated. From birth to weaning, maternal selenomethionine increased the average weight gain of piglets by a magnitude of 12.20% ($p<0.05$). Besides beneficial effects in sows and their piglets, L-selenomethionine addition is also able to alleviate oxidative stress in the fast-growing fattening pig.

Falk et al. (2018) evaluated the expression of specific genes in female finisher pigs. L-selenomethionine was seen to positively influence the finisher pigs' immune and antioxidant genes. Sodium selenite, on the other hand, induced additional oxidative stress.

This study was conducted based on the presence of Mulberry Heart Disease (MHD) and nutritional myopathy (skeletal muscle degeneration, NMD) in Norwegian pig production and their link with selenium and vitamin E deficiency. The capacity of L-selenomethionine to be incorporated in general body proteins led to higher muscle-Se-concentrations (Fig. 3).

This can improve meat quality by protecting myoglobin against oxidation, enhancing the integrity of cell membranes and decreasing drip loss while stabilising meat colour.

Zhan et al. (2007) showed slightly increased pH value, elevated activity of GPx ($p<0.05$) and decreased malondialdehyde (MDA) concentration of the loin muscle ($p<0.05$) in the L-selenomethionine treated group compared to control.

These results might have contributed to the observed, significantly ($p<0.05$) decreased drip loss. L-selenomethionine also had a higher ($p<0.05$) ability to stabilise the redness (Hunter a value) of the meat than sodium selenite.

Silva et al. (2019) observed similar results when studying the effect of four levels of L-selenomethionine (0.3, 0.4, 0.5 and 0.6ppm) in finishing pigs. The L-selenomethionine presented best results for meat quality compared to the other tested source (sodium selenite).

The use of L-selenomethionine at any level promoted higher oxidation stability of the meat ($p<0.05$). The supplementation of L-selenomethionine at a level of 0.4ppm promoted better physicochemical characteristics and higher selenium deposition in swine meat. Increased L-selenomethionine levels also showed a positive linear effect on carcase yield ($p<0.05$).

Selenium is also tightly linked with fertility. It became apparent in the early 1980s that selenium is essential for male fertility. Important components of mammalian semen are lipids as they are both structural compounds, precursors, and used for energy production.

In boar semen, docosahexaenoic acid (DHA) and n-3 polyunsaturated fatty acids (PUFA) are positively correlated with sperm motility, viability and normal morphology and plasma membrane. Long chain PUFAs, however, are prone to lipid oxidation and therefore limit spermatozoan membrane and fertilising integrity.

Antioxidant protection in this respect plays a crucial role. Major antioxidants (vitamin E and C) in boar semen are low and the antioxidant enzymes containing selenium could therefore become very critical, especially in stressful commercial conditions.

L-selenomethionine, as it is built into general body protein, could therefore improve antioxidant status of testes and semen. Jacyno et al. (2002) measured the reproductive performance of young boars receiving inorganic or organic selenium and vitamin E. The total spermatozoa produced was higher in boars fed the diets containing the organic selenium and a lower percentage of sperm with minor or major morphological abnormalities was observed.

Selenium also plays a role in immunity. Namely, selenoproteins influence immunity through many mechanisms, such as cellular activation and differentiation. A deficiency in selenium may therefore lead to a less responsive immune system.

One of the most important roles of selenoproteins is the protection of host cells from damage caused by the production of ROS by immune cells. Many phagocytic cells rely on the production of ROS for their bactericidal activities during inflammation.

To prevent damage to host epithelium, ROS must be combatted by a well-functioning antioxidant system. Immunological related studies have focused on the importance of disease resistance in weanling pigs. Selenium transfer from the sow was, in this respect, studied to a high extent. Although higher selenium deposition can be achieved by supplementing L-selenomethionine, there seems to be no effect on immunoglobin concentration in colostrum and milk.

Conclusion

Inorganic selenium sources have been widely used in animal feed since the 1970s. After years of usage the limitations of this form of selenium become more and more known. Inorganic selenium is known to have a low efficiency of transfer to milk, meat and eggs and its inability to build and maintain reserves in the body. Next to that inorganic sources are more acutely toxic than organic forms.

In contrast, L-selenomethionine, due to its molecular structure, can be built into general body proteins in a non-specific way and build up selenium reserves in every cell of the body.

It can therefore be considered as an important element in increasing adaptive ability of animals to various stresses. L-selenomethionine has the ability to promote enhanced production in sows, piglets and swine which are subject to (oxidative) stress. ■

References are available from the author on request

Fig. 3. Effect of time and diet on selenium concentration in M. longissimus dorsi (LD, mg/kg DM). Different letters denote significant differences in selenium concentration in LD between groups and time point (p<0.05 for the linear model (R lm)).