Sel-Plex alleviates oxidative stress and improves performance

Oxidative stress is defined as a series of adaptive reactions caused by an imbalance in the dynamic balance system of generating and eradicating free radicals or reactive oxygen species (ROS). ROS — including superoxide anion (O^{2-}), hydroxyl radical (OH) and hydrogen peroxide (H_2O_2) — are produced during the biochemical processes that take place within an animal's body.

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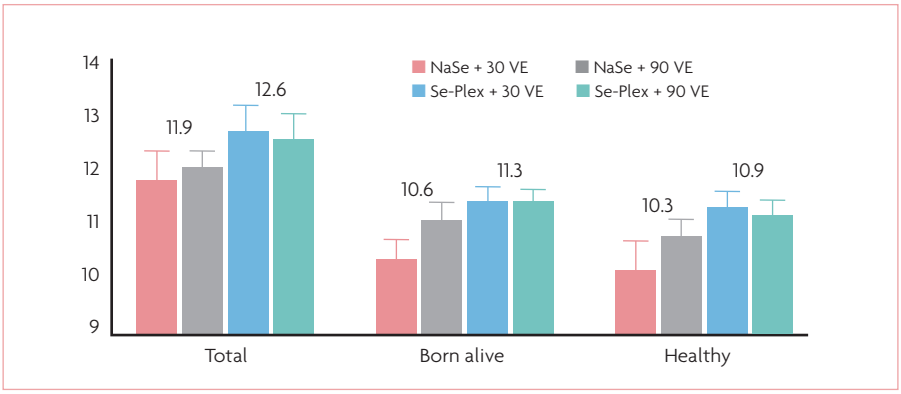

Fig. 1. Effect of Se source and vitamin E levels on the production performance of sows.

In the process of swine production, there are many stressors that lead to the production of excess ROS, such as high temperatures, vaccines, infections, diseases, feed anti-nutritional factors, mycotoxins, unbalanced nutrition levels, and a poor house environment.

In adapting to these internal and external stress factors, swine will mobilise their bodily resources to enhance their metabolism, resulting in increased levels of physiological hormones and blood sugar and significant changes in other physiological and biochemical indicators in their blood.

This adaptive functional state of the body will be accompanied by the production of a large amount of ROS and may exceed the threshold of the body's free-radical scavenging system. It also has a negative additive effect that weakens the body's antioxidant system. As a result, the antioxidant system cannot function properly, and the excess ROS continue to attack the biological macromolecules and tissues and organs of the body. This results in oxidative damage, which manifests as sub-par health and the decreased production performance of swine.

Oxidative stress status during gestation and lactation

Pregnancy consists of a series of temporary, complex and finely orchestrated events, which are accompanied by dramatic anatomical, physiological and metabolic changes to the maternal body.

There is a high energy demand and increased oxygen requirements during gestation — especially in the late gestational period, which is a crucial period for foetal growth. The maternal body undergoes substantial metabolic changes during late gestation, forcing sows to adapt from anabolic to catabolic metabolism.

Increased metabolic intensity may lead to low-level inflammation, progressive oxidative stress and insulin resistance. It has been proven in many previous studies that physiological pregnancy processes could lead to systemic oxidative stress and an inflammatory response due to higher amounts of circulating ROS.

Lactation is also one of the most challenging biological performance situations for sows, as their nutrition and energy demands are higher due to the extensive metabolism taking place in the mammary glands to produce milk during the lactation period.

It has been reported that 632 genes related to amino acids, fatty acids and glucose metabolism are differentially expressed in sows' livers during the lactation period. Increased metabolic burdens in lactating sows result in greater oxygen consumption and the excess production of ROS and lipid peroxides, further aggravating oxidative stress.

Berchieri-Ronchi et al. (2011) reported that oxidative DNA damage was higher throughout the gestational and lactational periods (between 38% and 47%) than during early gestation (G30; 21%) and that sows did not fully recover until the weaning period. Concentrations of antioxidant nutrients (for example retinol and a-tocopherol) in sow plasma also declined during the gestational period and began to normalise towards the end of the lactational period.

This research clearly showed that sows are under increased systemic oxidative stress throughout the late gestational and lactational periods. With this in mind, an increase in the inclusion of antioxidants in the gestation and lactation diets may be necessary in order to compensate for the substantial loss of antioxidative nutrients during this period and to alleviate oxidative stress in sows.

Antioxidants: Selenium

In recent decades, a number of antioxidants (for example minerals, vitamins, plant extracts) have been used widely to alleviate oxidative stress and improve swine production.

The beneficial effect of these antioxidants is attributed to their capacity for ROS detoxication to maintain the dynamic redox balance.

Selenium (Se), a well-known micronutrient for animals, is one of the essential components of GPx enzyme, which protects proteins and unsaturated fatty acids against free radicals, peroxides and lipid hydroperoxides as a potent antioxidant. Se is also involved in multiple biological functions, including maintaining growth, promoting reproduction, supporting muscle metabolism and regulating the immune system.

Se deficiencies have been shown to decrease animal health and performance in various animal species. The inclusion of Se has beneficial effects on pregnant sows and their offspring.

Organic Se Vs elevated vitamin E

Recent studies evaluated how providing two dietary selenium sources (sodium selenite vs. organic selenium, provided in the form of Sel-Plex at 0.30mg/kg) and two vitamin E levels (30 or 90 IU/kg) during gestation and lactation affected the antioxidant status and reproductive performance of multiparous sows.

The results showed that there were 0.7 more piglets, a 1.5kg higher litter weight and 0.5 more weaned piglets in the organic Se + vitamin E (Sel-Plex + 30 IU/kg vitamin E) group than in the group of sows fed inorganic Se + elevated vitamin E (sodium selenite + 90 IU/kg vitamin E). Additionally, the antioxidant status of the pregnant sows improved through the dietary addition of organic Se (Sel-Plex) over inorganic Se (sodium selenite), which was illustrated by higher activities of T-AOC, SOD, GSH-Px and GSH and a lower content of MDA in the serum of the sows.

It has been demonstrated that Se is present in at least 25 selenoproteins, most of which possess antioxidant properties. Therefore, an improved antioxidant status in sows may be closely associated with their Se status.

The results of the study mentioned previously showed that the serum content of Se was enhanced (between 15.15% and 24.5%) during the addition of organic Se (Sel-Plex) to the sows' diets throughout the gestation period. Similarly, the results also indicated increased levels of T-AOC, SOD, GSH-Px and GSH, a decreased MDA content and a higher Se content in the colostrum and milk of sows when they were fed organic Se (Sel-Plex).

However, antioxidant status and reproductive performance were not improved when vitamin E was added at 90 IU/kg vs 30 IU/kg, and no interaction between the Se source and vitamin E level was detected. This research indicates that dietary supplementation with organic Se (provided as Sel-Plex) was more effective at improving the antioxidant capacity and reproductive performance of sows than supplementing with elevated levels of vitamin E.

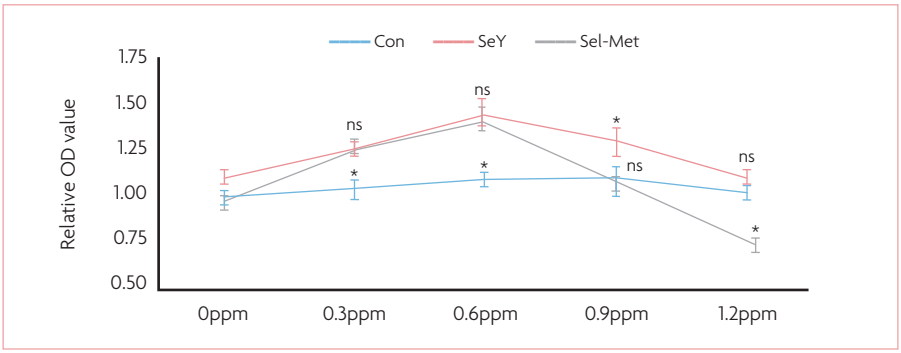

Fig. 2. Effects of Sel-Plex and Sel-Met supplementation on cell viability in PMECs.

Heat stress aggravates oxidative stress

In actual swine production, a high ambient temperature is another important environmental stressor that has a negative effect on the reproductive performance of sows, especially during the summer season. A high ambient temperature can lead to heat stress, which can affect sows negatively, resulting in issues like impaired embryonic development, reduced feed intake and milk production in sows, and delayed puberty in gilts.

Over the past few decades, genetic improvements in sows for higher reproductive performance have resulted in increased metabolic heat production, which makes sows more susceptible to a high-thermal environment. Zhao and Kim (2020) reported that plasma concentrations of malondialdehyde, protein carbonyl and 8-hydroxy-deoxyguanosine increased during late gestation when sows were exposed to a high-thermal environment.

Additionally, litter size and litter weight were found to be negatively correlated with these oxidative stress indicators.

The study suggested that a high-thermal environment can increase oxidative damage to lipids, proteins and DNA. Oxidative stress could be a contributing factor to reduced reproductive performance in sows.

This study also showed the importance of taking steps to regulate the oxidative stress status of sows under heat stress during gestation and lactation.

Benefits of high doses of Se

Recent research examined the effects of increasing the level of selenium (provided as Sel-Plex) supplemented to heat-stressed or actively cooled sows on sow productivity, colostrum and milk composition, as well as the selenium and antioxidant status and immunoglobulin levels of sows and nursing piglets.

Greater concentrations of protein, lactose and solids-not-fat in the colostrum and a greater fat concentration in the milk were reported in sows fed a higher dose of Se in a heat-stressed environment.

When nursing piglets received milk with a higher nutrient composition, they got more energy, which led to a greater pre-weaning survival rate for that group (96.3% vs. 90.4%). Regarding Se and antioxidant status, sows fed increased levels of Se (1.2mg/kg) had a greater plasma Se content than the group of sows fed 0.3mg/kg at farrowing and 21 days post-partum. The antioxidant status of sows improved when the amount of Se in the diet increased. Along with increased Se in the blood, more Se will be transferred to the mammary glands, leading to the production of colostrum and milk with a greater Se content.

Additionally, sows fed increased levels of dietary Se had higher GSH-Px activity and a smaller MDA concentration in both their colostrum and milk compared to sows fed the control diet (0.3mg/kg Se), which indicated that increasing dietary levels of Se can lead to an improved antioxidant status of the colostrum and milk.

The plasma Se content of nursing piglets at both birth and weaning was also found to be markedly improved via the colostrum and milk. Consistent with the improved antioxidant status and Se content in the

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Table 1. Effect of Sel-Plex on antioxidant status in the colostrum and milk of sows.

	Heat stress		Active cooling	
	0.3mg/kg Se	1.2mg/kg Se	0.3mg/kg Se	1.2mg/kg Se
Colostrum (g/kg)				
Se (μg/g)	0.107	0.215	0.101	0.224
GSH-Px (U/ml)	97.71	122.62	122.95	129.18
MDA (nmol/ml)	14.13	9.78	12.16	8.96
21-d milk				
Se (μg/g)	0.313	0.435	0.338	0.459
GSH-Px (U/ml)	78.96	80.69	77.59	87.59
MDA (nmol/ml)	10.21	8.13	8.29	6.04

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colostrum and milk, the antioxidant status of piglets born to sows that were fed higher doses of Se was also improved at both birth and weaning, providing piglets with antioxidant protection against the upcoming stress associated with weaning.

As for immunoglobulins, sows fed increased levels of Se had higher IgM levels in their colostrum and higher-IgA milk.

Also, piglets born to sows fed increased levels of Se had higher plasma IgA levels at 1 day of age and higher IgA and IgG levels at 21 days of age. When nursing piglets received higher immunoglobulin levels, they displayed improved immunity, which could also lead to higher preweaning survival rates.

All in all, increasing the Se supply for sows improved piglet preweaning survival rates and their colostrum and milk composition, as well as maternal selenium levels, antioxidant status and immunoglobulin transfer in a heat-stressed environment.

Differences between organic Se

Many studies have proven that organic Se is more beneficial than inorganic Se in swine production – but is there any difference between organic Se options from various sources? Choosing an organic Se source can be a real concern for swine producers. Wu et al. (2022) systemically compared the effects of two different types of organic Se – including selenium yeast (SeY, provided as Sel-Plex) and selenium methionine (Sel-Met) – on cell viability, selenoprotein transcriptome and antioxidant status in porcine mammary epithelial cells (PMECs).

Supplementation with SeY in the form of Sel-Plex resulted in higher cell viability, while a high level of Sel-Met actually led to lower cell viability, which suggests that excessive Sel-Met supplementation might be toxic to cells and could potentially induce cellular damage.

Se acts as an antioxidant regulating the cellular redox balance, mainly in the form of selenoprotein. Sel-Plex and an appropriate level of Sel-Met both significantly up-regulated the mRNA expression of most selenopreoteins, including DIOs, GPXs and the TrxRs family, et al., but Sel-Plex had a more beneficial effect than Sel-Met when the two were supplemented at the same level.

Se can repair damage caused by oxidative stress and can promote a greater cellular antioxidant capacity. Research has shown that Sel-Plex and Sel-Met can both greatly improve redox status, with higher levels of T-AOC, SOD and CAT and less MDA in PMECs. Similarly, a higher antioxidative capacity was observed in supplementation with Sel-Plex than when Sel-Met was supplemented at the same level.

Severe oxidative stress induced by excessive ROS has been shown to trigger cell apoptosis. Both SeY and Sel-Met supplementation significantly reduced the protein expression of cleaved-caspase-3 to mitigate cell apoptosis.

A lower ratio of p-p38/p38 and p-JNK/JNK was also found in the groups treated with Sel-Plex when compared to the groups treated with Sel-Met, which also indicated that Sel-Plex has a greater efficacy in preventing oxidative stress and apoptotic damage in cells. These findings provide a reference for the scientific utilisation of organic Se.

The special physiological metabolic process sows experience during gestation and lactation, along with the high-temperature environment, causes high-yielding sows to suffer from severe oxidative stress and leads to a decrease in their reproductive performance.

The reasonable selection of appropriate antioxidants can help improve the function of the antioxidant system in sows, ensuring better health and promoting the maximum reproductive potential of sows. SeY provided in the form of Sel-Plex can effectively alleviate the oxidative stress of sows during the late pregnancy and lactation stages and, as a result, can help improve their production performance. ■

References are available from the author on request