ROBUST PIGLETS: FEED SOLUTIONS TO SUPPORT PIGLETS' HEALTH AND PERFORMANCE

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Early life is considered as a challenging period for all livestock species, including swine. Proper health and growth during this phase are essential to achieve optimal performance later in life. The early life period of piglets consists of many different stressors such as change from milk to solid feed, weaning, and pathogen pressure.

For piglets, antimicrobials were commonly used to deal with these challenges, and allow for growth promotion, and pathogen control. However, over recent years, due to the high use of antimicrobials in livestock nutrition, microbial resistance has been on the rise. This has led to pressure to reduce the use of antibiotics. Another approach for antimicrobials to improve intestinal health in piglets, and reduce the incidence of post-weaning diarrhoea, is the use of dietary zinc oxide or high copper levels. In addition to the reduction of antibiotics, several countries are also restricting the use of such high mineral solutions. The European Union has already decided to ban the usage of pharmacological levels of zinc oxide and addition of copper only on low levels to fulfil the animal's requirements. This leaves the industry with a major challenge to find alternative solutions.

Generally, the term 'robust piglet' is considered important since we have to ensure that the animals have a higher resilience to stress. This allows them to be less sensitive to pathogens and other challenges, ensuring a better resistance of the young animals. Feed additives play a crucial role in improving this animal resilience. This article will describe three different feed solution areas that can contribute to more robust piglets with optimal health and performance.

MINERAL NUTRITION

Essential trace minerals play an important role in various physiological processes, contributing to optimal animal health and performance. One of such trace elements is selenium, which is involved (among others) in the antioxidant response and immune functioning, via its incorporation into selenoenzymes. Selenium is naturally present in plant based raw materials, but the selenium level depends on the level of selenium in the soil. This makes the natural selenium levels in raw materials variable and in most cases quite low. Therefore, it is recommended to add additional selenium to the diet to fulfil in the animals' requirements. When considering different selenium feed additives,

it is important to make a differentiation between L-selenomethionine (organic selenium) and all other sources of selenium. L-selenomethionine can directly be used for the synthesis of selenoenzymes and, another part, allows for an incorporation of selenium into animal proteins (e.g. animal tissue, colostrum and milk) by following the same pathways as regular methionine. This ensures a safe deposit of selenium which can be used later on, ensuring a continuous selenium supply, and a more efficient selenium supply to suckling piglets. All other sources of selenium cannot be incorporated into proteins, and only follow the pathway of selenoenzyme synthesis. For high performing sows, selenium nutrition is essential to ensure a proper antioxidant status, and reduce the negative effects of stress on piglets during gestation. On top of that, after farrow, the transfer of selenium (when feeding L-selenomethionine) into colostrum and milk contributes to a higher selenium intake of the piglets. In turn, by having piglets with an optimal selenium status, they have a better antioxidant response which improves resilience in early life.

The Norwegian University of Life Sciences has published two papers on this topic (Falk et al. 2019, Falk et al. 2020), comparing the effects of different dietary selenium sources on sows and piglets. In the first study, a total of 32 sows were divided over four treatments:

1. Basal diet + sodium selenite (0.40 mg/kg)
2. Basal diet + sodium selenite (0.60 mg/kg)
3. Basal diet + L-selenomethionine (0.26 mg/kg)
4. Basal diet + L-selenomethionine (0.43 mg/kg)

The L-selenomethionine used in this study was Excential Selenium 4000 from Orffa Additives B.V. When evaluating the results, it was shown that the levels in colostrum and milk for total selenium (Figure 1), selenoP (SelP), selenoalbumin (SeAlb) and selenomethionine (SeMet) were significantly higher ($P<0.05$) for the L-selenomethionine supplemented sows. The higher levels of inorganic sodium selenite did not increase the selenium transfer into milk.

The follow-up study (Falk et al. 2020) continued with the piglets born from the sows mentioned above.

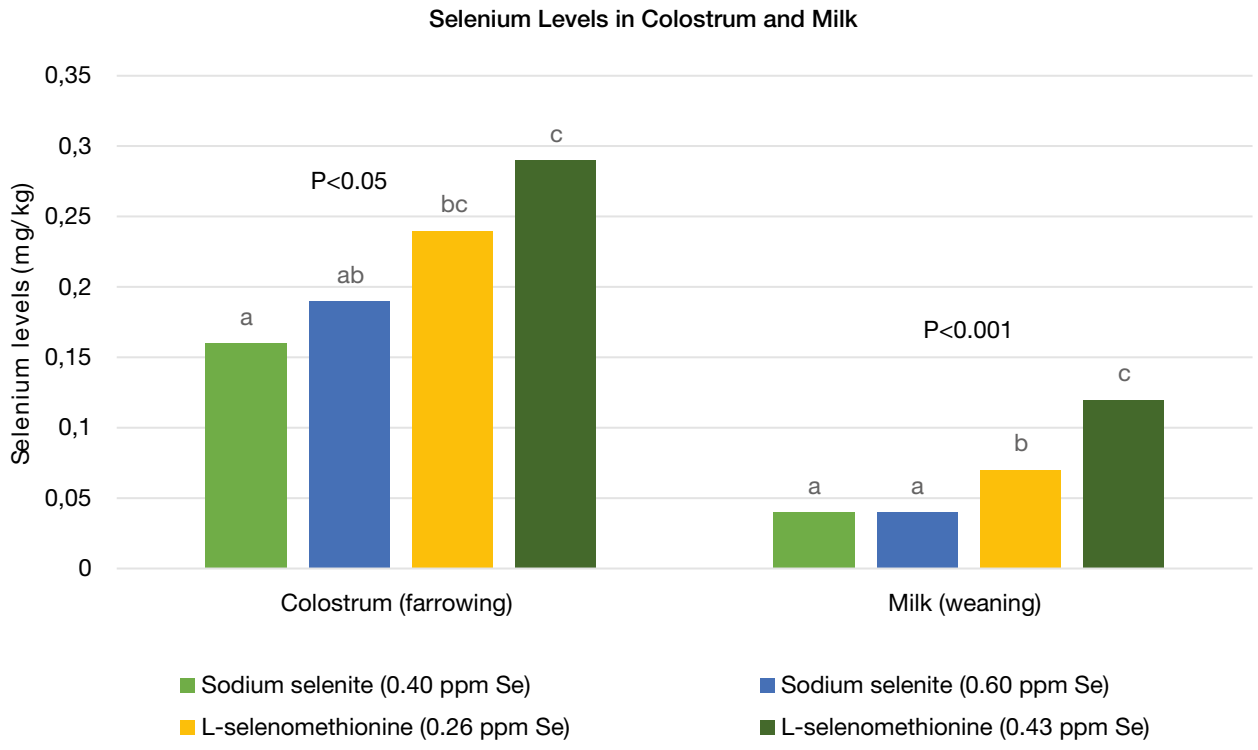

Figure 1. Total selenium levels (µg/L) in colostrum (farrowing) and milk (weaning) of sows fed different sources of selenium (sodium selenite and L-selenomethionine) at different dosages.

These piglets received pelleted compound feed, which was supplemented with the same selenium sources and levels as the sow diet, from one week of age onwards. The results show that the piglets from the L-selenomethionine supplemented groups had higher (and dose-dependent) selenium levels in plasma ($P<0.01$). Also glutathione peroxidase 3 (GPx3) in plasma, which indicates protection against oxidative stress, was significantly improved ($P<0.01$) in piglets from the L-selenomethionine groups. These results indicated an improved antioxidant status in piglets, thanks to the higher selenium levels in colostrum and milk in L-selenomethionine supplemented sows, in addition to feeding L-selenomethionine directly to the piglets. This improved antioxidant status of the piglets allowed the animal to better deal with early life stressors.

Overall, these studies nicely show the importance of selenium nutrition for young animals, where it is important to consider both the maternal selenium source, as well as the selenium in the offspring diet. By supplementing L-selenomethionine, an optimal selenium and antioxidant status in piglets can be achieved. This will allow for better resilience and more robust young animals.

FEED EFFICIENCY

Proper growth and development of piglets requires good digestion and utilization of nutrients. Over time, the gastrointestinal tract will further develop and adapt from liquid to solid feed. In the meantime, early in life, it can be observed that digestion and absorption of nutrients is limited. One reason could be for example that the production of bile salts is still limited. These bile salts function as natural emulsifiers and support the digestion of fats. By inclusion of a nutritional emulsifier in the piglet diets, the digestion of nutrients can be supported.

A recent trial at a commercial farm in Argentina, with coordination from the National Scientific and Technical Research Counsil (CONICET), investigated the effects of a nutritional emulsifier in young piglets. In the period before farrowing (days 90-112 of gestation), 30 sows were followed and divided over two treatments receiving either a basal diet or a basal diet supplemented with 350 g/ton Excential Energy Plus (nutritional emulsifier by Orffa Additives B.V.). Farrowing was induced at day 114 of gestation, after which litter sizes were adapted to 13-14 piglets to ensure comparable treatments.

The weaning at 22 days indicated the start of the trial. 380 piglets were selected and divided over four treatments, after which results were monitored for a 15-day period:

1. Basal diets for sows, and basal diet for piglets

2. Basal diets for sows, and basal diet for piglets + 350 g/ton nutritional emulsifier

3. Basal diets for sows + 350 g/ton nutritional emulsifier, and basal diet for piglets

4. Basal diets for sows + 350 g/ton nutritional emulsifier, and basal diet for piglets + 350 g/ton nutritional emulsifier

The results showed an effect on citrulline levels, which functions as marker for metabolic activity and functional mass of the enterocytes. The inclusion of nutritional emulsifier in the piglet diet significantly increased ($P<0.05$) citrulline levels, regardless of the diet fed to the sows (Figure 2). This indicates that the emulsifier can improve the metabolism in piglets after weaning.

In addition, the intestinal maltase activity, an enzyme involved in the carbohydrate metabolism, was significantly higher ($P<0.05$) for piglets receiving the nutritional emulsifier, with no effects from the

sow treatments. This could have allowed for higher energy levels which can be used for growth and development. The volatile fatty acids (VFA) levels in the caecum, specifically valeric acid and propionic acid were analysed and shown to be significantly higher (P<0.05) when both sows and piglets were fed with the emulsifier. Higher valeric acid levels hint towards improved intestinal barrier function and higher propionic acid levels suggest a better energy source for the liver.

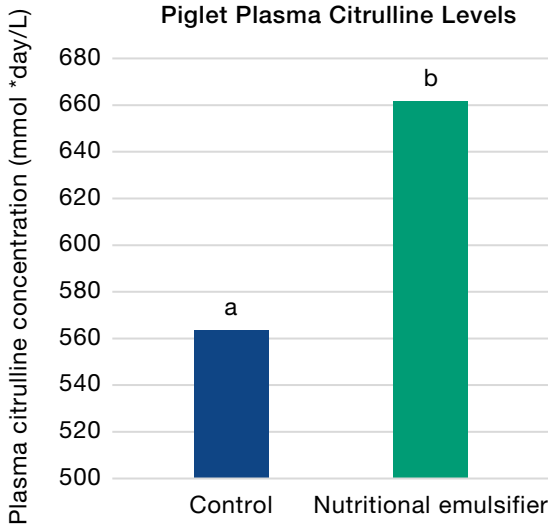

Figure 2. Plasma citrulline levels in piglets from control and nutritional emulsifier treatment

Some intestinal morphology parameters in the ileum and jejunum were also monitored during the trial. It was shown that villus height, villi/crypt ratio and intestinal absorption surface were significantly improved (P<0.05) for the piglets receiving the nutritional emulsifier, regardless of the sow diet. This indicated improved gut health and nutrient absorption, which is expected to contribute to better growth performance. To confirm this hypothesis, also growth performance (body weight and feed conversion ratio) was recorded and shown to be numerically improved in the piglets that received the emulsifier diet.

Significant differences on piglet growth performance were found in a follow-up trial. A total of 47 weaned piglets were divided over two treatments and monitored for a week; basal diet or basal diet with the nutritional emulsifier (Excential Energy Plus, Orffa Additives B.V.). The nutritional emulsifier group showed significantly improved body weight and feed conversion ratio (P<0.05).

To summarize, by including a high-quality nutritional emulsifier, the digestion and absorption of nutrients can be improved. In turn, this supports the metabolism and allows for a better health and growth of piglets especially during the stressful period post-weaning.

GUT HEALTH AND IMMUNITY

The early life stressors for piglets, including the transition from milk to solid feed, puts a severe challenge on gut health and immunity. Maintaining a healthy gut is essential for proper growth and development since the gut is involved in many processes including nutrient absorption, secretion of mucin and immunoglobulins, and the barrier function to prevent entry of pathogens. Recently, the feed industry has been focusing more on the use of probiotics to support gut health. Probiotics are beneficial, live bacteria, which can be added to animal feed, to allow for a wide range of health benefits. They will colonize the microbial community of the gut, reducing the chances for opportunistic pathogens to colonize, since they work via competitive exclusion (colonization only possible on 'free spaces'). In piglets, use of in feed-probiotics can support gut health and immunity during challenging periods, for example around weaning.

A recent trial at Kangwon National University (KNU) in South Korea included 150 weaning piglets that were divided over two treatments:

1. Basal diet
2. Basal diet + 500g/ton probiotic (Excential ProDi-G 10%, Orffa Additives B.V.)

The inclusion of the probiotic showed a significantly higher (P<0.05) final body weight at day 42. When considering the bacterial count in faecal samples, *E. coli* counts were significantly lower in the probiotic supplemented group compared to the basal diet. Numerically, the probiotic also improved the digestibility of crude protein.

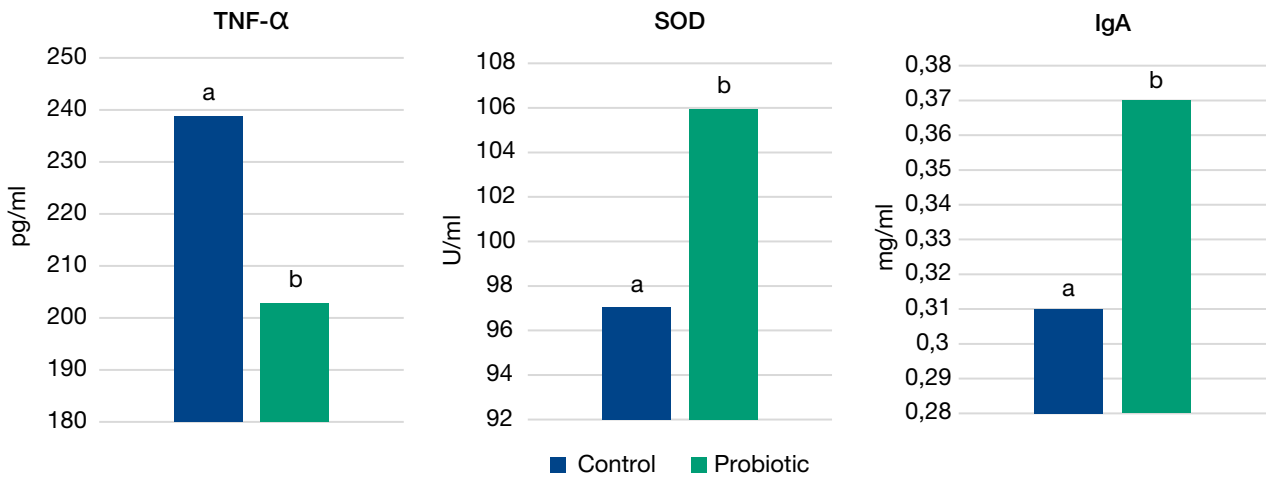

Figure 3. Results blood analysis for markers of inflammation (TNF-α), oxidative stress (SOD) and immunity (IgA) in the probiotic or basal diet

On day 42 of the trial, blood samples were collected and analysed for 10 piglets per treatment. This analysis showed significantly higher immunoglobulin A (IgA) levels and superoxide dismutase (SOD) activity, and significantly lower TNF-α levels ($P<0.05$) for the probiotic supplemented group (Figure 3). Improved IgA levels indicate a better immune response, since IgA functions as antibody involved in the protection of mucous membranes. The higher SOD activity indicated an improved antioxidant status since SOD is an enzyme involved in catalysing the conversion of oxygen radicals into non-radical species. TNF-α is a pro-inflammatory cytokine and lower levels indicate reduced inflammation and inflammation-induced damage.

In conclusion, it can be stated that the inclusion of a probiotic in the feed can improve gut health and immunity of weaning piglets. Lower pathogen pressure and better immune -and antioxidant status result in improved growth. This will provide the piglets with a healthy start to sustain good growth and development also later in life.

THREE COMPLEMENTARY FEED SOLUTION AREAS FOR ROBUST PIGLETS

When considering the challenging period of early life in piglets, good nutrition plays a key role to optimize health and performance. Nutrition should go further than just meeting the nutrient requirements and should be focussed on providing solutions for the industry. Different types of solutions can be implemented in the form of feed additives. There are three feed solution areas that have been shown to be essential as part of the solution to increase resilience in piglets. Mineral nutrition, especially with a focus on selenium, is key towards improving robustness. Not only the dosage is important, but also the source of selenium should be considered, where L-selenomethionine is shown to give the best results. Another feed solution area of interest for piglets is feed efficiency. Due to ongoing changes of the gastrointestinal tract, it is essential to support digestion and absorption of nutrients. This can be achieved by inclusion of a high-quality nutritional emulsifier. Finally, gut health and immunity solutions contribute to reducing the problem of post-weaning diarrhoea and pathogen pressure. Here, probiotics can improve the intestinal health and immune response, which supports a healthy growth and development.

Overall, feed additives can support the industry to face challenges associated with the reduction of antibiotics and high copper or zinc oxide in young animals.