Hypozincemia and second weaning syndrome in piglets

Weaning is a stressful event for the piglets, with a separation from the dam, a change of social environment and an abrupt transition from milk to solid feed. Consequently, 40-50% of piglets do not ingest any feed in the first 24 hours after weaning, and about 10% take 48 hours before eating their first meal. For all the piglets, the feed intake is initially low.

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Feed intake and energy balance after weaning

According to the NRC (2012), the feed intake recommendation for a piglet with a body weight ranging from 7 to 11kg is estimated to 493g per day. However, the observed average feed intake is commonly 50g during the first days after weaning, and not more than 200g during the following week, which can lead to an insufficient supply of nutrients.

Energy requirements, for example, are thus not achieved during this critical period and piglets usually face a negative energy balance. Nevertheless, the body has mechanisms to compensate this temporary negative nutrient supply, such as mobilising body storages. Some micro nutrients like zinc (Zn) are quickly depleted.

Zn supply after weaning

Considering the NRC (2012) recommendations, Zn for a weaned piglet is 100ppm Zn in the diet. With an ideal daily feed intake around 500g, piglets are supposed to ingest 50mg Zn per day. Nevertheless, immediately after weaning, when feed intake is low, Zn supply is compromised.

A study performed at Universitat Autonoma de Barcelona showed an alteration of the Zn status in weaned piglets, compared to unweaned piglets of the same age or to weaned piglets fed with a pharmacological dose of ZnO (2,000ppm of Zn as ZnO). One week after weaning, Zn concentration decreased significantly in plasma, as seen in Fig. 1, and numerically in blood cells.

The European Commission (Regulation (EC) No. 1334/2003) has now limited the Zn concentration in pig diets to 150ppm Zn due to environmental concerns. However, considering an average daily feed intake of 150g per day, Zn intake of piglets during the first week post-weaning is around 22mg per day.

In order to achieve animal requirement for Zn the diet should contain at least 330ppm of the mineral in the diet, and the maintenance of the Zn status after weaning could require higher doses.

In a study performed at Aarhus University with a dose-response of Zn between 150 and 2,500ppm from standard ZnO, the Zn level in the serum of piglets seven days after weaning was below the Zn level in serum at weaning when the Zn concentration in the diet was less than 1,000ppm.

The Zn status and the diarrhoea rate were correlated: the number of days with diarrhoea was significantly higher in the group showing hypozincemia (serum Zn below the Zn level at weaning).

In addition, according to this trial, the dose of Zn that is required to maintain an

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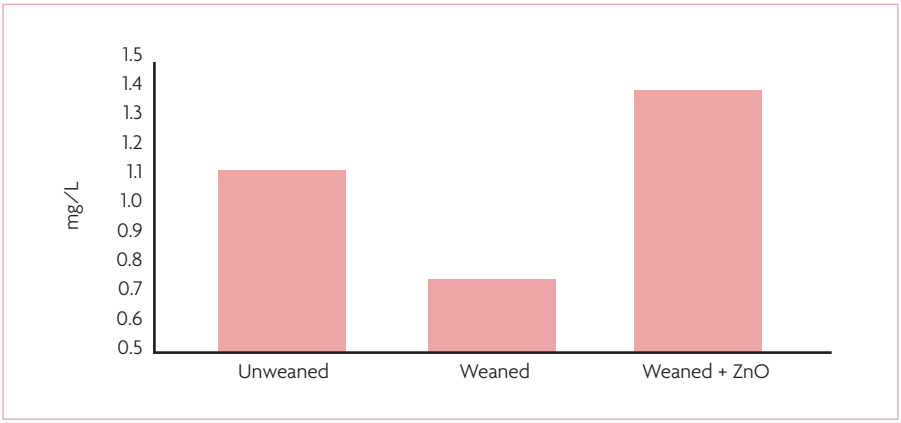
Fig. 1. Zn status of piglets of the same age (suckling, weaned or weaned with ZnO)



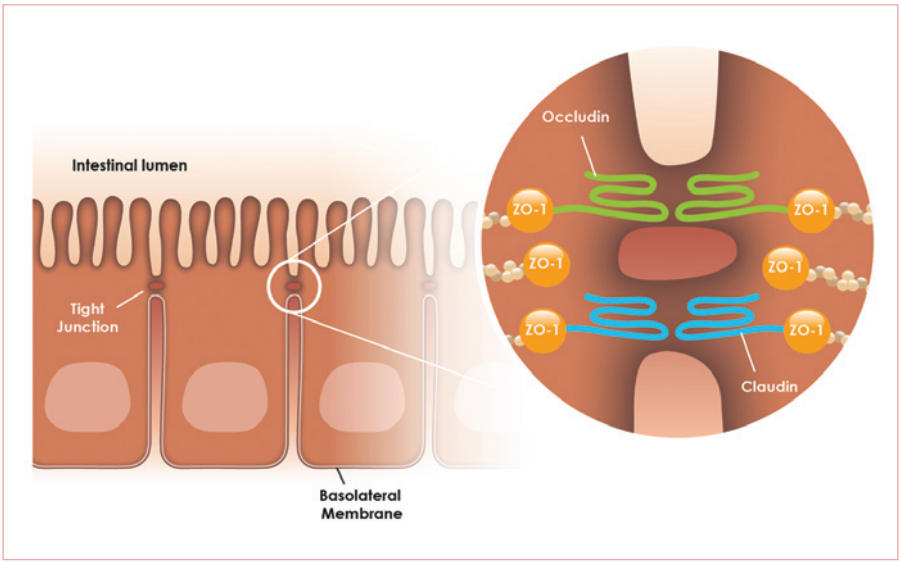


Fig. 2. Mains Zn dependent tight junctions' proteins: Occludins, Claudins and Zona Occludens-1 (ZO-1).

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optimal serum Zn level after the pre-starter phase would be around 450ppm.

In case of Zn deficiency, the health and the performance of the animals can be affected. Indeed, Zn is an essential nutrient, implied in many physiological processes.

For example, some Zn metalloenzymes show antioxidant properties, like Zn-SOD. This trace element is associated to the immune status of the animal, and to the maintenance of epithelial barrier and function integrity, through improving mucosal repair and paracellular permeability.

Some specific zinc forms such as zinc oxide also display antibacterial properties that can play a role in the gut microbiota regulation.

Zn and intestinal barrier function

The gastrointestinal epithelium is a selective permeable barrier that regulates the passage of nutrients and water, limiting the transfer of pathogens, toxins and antigens. The integrity of the intestinal barrier is mainly governed by tight junctions, illustrated on Fig. 2.

These tight junctions form a narrow paracellular ion channel, water and solutes can pass through them.

Some factors can decrease tight junctions' gene expression. As example, a gut microbiota alteration and an intestinal inflammation are observed after the weaning, with the production of proinflammatory cytokines as tumor necrosis factor-α (TNF-α) and IL-6.

This inflammation is associated to an increasing epithelial permeability, which allows the indiscriminate entry of extracellular antigens and pathogenic micro-organisms.

Cytokines are cell signaling proteins, responsible for communicating and stimulating immune responses and movements of cells towards sites of inflammation, infection or trauma.

The involvement of TNF-α in the impairment of intestinal barrier function is given to cytoskeletal rearrangement and a decrease in ZO-1 expression, increasing paracellular permeability through enhanced flux across the non-restrictive class of pores, allowing big molecules to easily leak into the lumen.

IL-6 and IL-13 increase paracellular permeability through an enhanced expression of pore-forming claudin-2, being selective to cations but not to macromolecules.

The 'second weaning' syndrome

The hypozincemia leads to tight junctions' disruption and neutrophil migration that release proinflammatory cytokines. This suggests that not only the supplementation of Zn has a positive effect, but the lack of Zn seems to also compromise barrier function.

In addition, some Zn forms are well-known for their antibacterial properties and can regulate the composition of the gut microbiota, including the Escherichia coli population, often involved in diarrhoea.

In some countries, Zn is still supplemented at high dosage in piglets' diets (2,000-2,500ppm Zn as ZnO) during the pre-starter phase.

The shift between the pre-starter and the starter diets can lead once again to a disruption of the microbiota balance, leaving the animal susceptible to harmful bacteria to proliferate and once again causing diarrhoea. This disturbance is known as dysbiosis.

A survey done in Denmark looking into causes of diarrhoea in piglets between 12-63 days post weaning has reported a high frequency in diarrhoea that seem to occur between 3-7 weeks after weaning. The study, performed in 20 Danish herds, noticed as a consequence in these situations an increased use of antibiotics.

Interestingly, 10% of the diarrhoea was not related to a certain bacterial infection. So, this case could be feed related dysbiosis caused by a change in the diet.

In a word, supplementing a bioavailable zinc source, efficient at nutritional dosage, during all the post-weaning phases is the best nutritional strategy.

The unavoidable need to supplement zinc in piglets

Zn concentration is generally low in plant-based raw materials and including a high variability depending on the species or the soil type.

In Europe, the dietary native Zn level in a standard feed for weaning piglets without mineral premix is estimated around 30-40ppm, and below the Zn requirements of piglets.

Consequently, Zn supplementation is necessary. Many sources are available for animal nutrition, including zinc oxide, zinc sulphate and chelated zinc, but all these sources are not equal. Some of them show positive results at nutritional level, like the potentiated zinc source HiZox.

Compared to a standard ZnO at the same dosage, it can decrease significantly the coliform population in small intestine of weaned piglets and improved gut integrity, through the increased expression of proteins of tight junctions and the modulation of the inflammatory status of the gut (via alkaline phosphatase expression).

In addition, potentiated zinc HiZox also displays an excellent bioavailability due to its slow dissolution kinetics. ■

Conclusion

Zn plays an important role in many physiological pathways, including the immune system. In the first days after weaning, the feed intake and consequently the Zn intake are low (below requirements). Zn storage being limited, and homeostasis being tightly controlled, a daily supply is needed to maintain proper levels of Zn.

In the EU where zinc levels in feed are now restricted, the selection of a proper source like potentiated zinc is important.

In countries outside the EU, where pharmacological ZnO is still allowed, its removal needs to be accompanied during all weaning phases with such nutritional solutions too to avoid the 'second weaning' syndrome.