Immunomodulation in weaned piglets: a plant-based approach

It is a unique trait in a mammal's life that it must go through a transition from being milk-fed to eating solid diets. In nature, weaning is a gradual process where the young animal slowly increases the intake of solid food and decreases the intake of milk.

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Piglets in the wild are completely weaned at around 12-16 weeks of age but start rummaging for food with their dam already well before that. In livestock production this process is sped up, not only when it comes to age of weaning but also in regards to the duration of the weaning process

In commercial pig production, the separation from the sow is abrupt and usually occurs around 21-28 days of age

This sudden change in life has a great impact on the physiology of the piglet.

First, there is the transition from the easily digested liquid milk diet to a solid diet with high amounts of carbohydrates.

Secondly, the separation from the mother combined with a new environment and new litter mates, causes social stress.

For both situations the piglet is not yet well adapted and needs to quickly adjust.

Digestive enzymes

Already at birth, the intestinal tract of piglets shows a high activity of lactase, enabling the young pig to digest milk. In contrast to that, enzymatic activity required to breakdown the more complex carbohydrates such as starch and proteins found in solid, cereal-based diets only slowly increases (Fig. 1).

At 3-4 weeks of age, the activity especially of amylases and pepsin and trypsin is still quite limited. Amylase activity can be 'trained' by introducing piglets as early as possible to solid feed, for example with a creep feed. To avoid only partial digestion and consequent transfer of undigested protein and starch to the hindgut, where it is fermented by bacteria, weaner diets should only include high quality, highly digestible ingredients, ideally also including some dairy-based products. Furthermore, a low pH and buffering capacity of the diet additionally supports protein digestion and helps to maintain gut health.

Fig. 1. The development of digestive enzyme production in piglets during the first seven weeks of life (adapted from Kirchgessner, 2014).

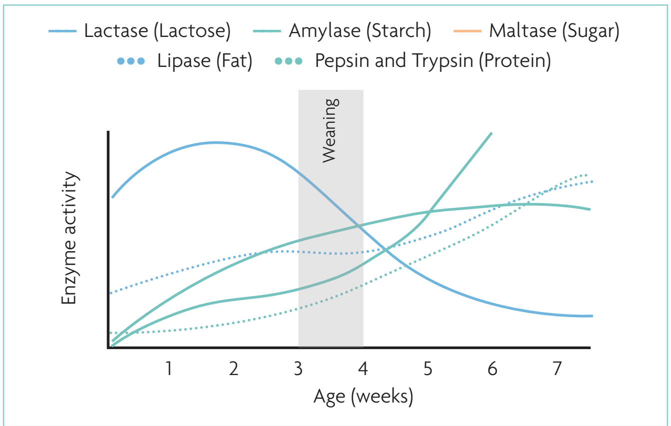
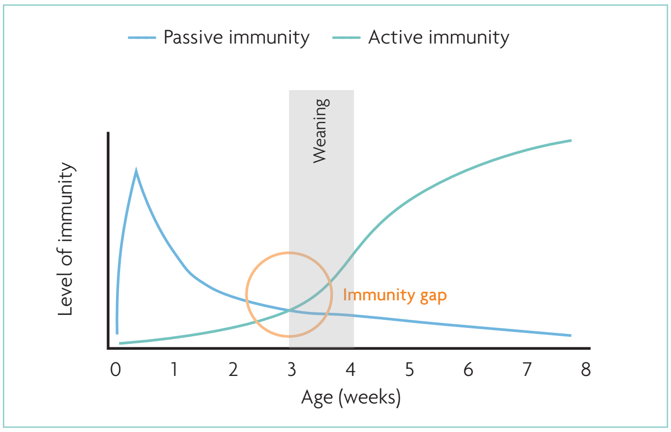


Fig. 2. Post-weaning immunity gap (adapted from Coffey et al, 2000).



Immune system

Unlike in humans, there is no passage of maternal antibodies through the placenta in sows. Therefore, piglets are born with a naive immune system and rely on sufficient colostrum intake to obtain the necessary immunoglobulins, cytokines and other immune relevant molecules for passive immunity from their mother.

The gut of the piglet becomes impenetrable to immunoglobulins within 12-48 hours after being born. This highlights the importance of fast access to high quality colostrum with a high immunoglobulin concentration.

As shown in Fig. 2, the passive immunity provided by the mother gradually disappears until 4-6 weeks of age. At the same time, the active immune system, where the piglet builds up its own set of immune cells and antibodies, only starts around 3-4 weeks after farrowing.

This process takes time and is not yet fully completed when the passive immunity weakens.

During this time, which in modern pig production falls into the weaning period, the immune system of the piglet is compromised, making it intrinsically more susceptible to disease.

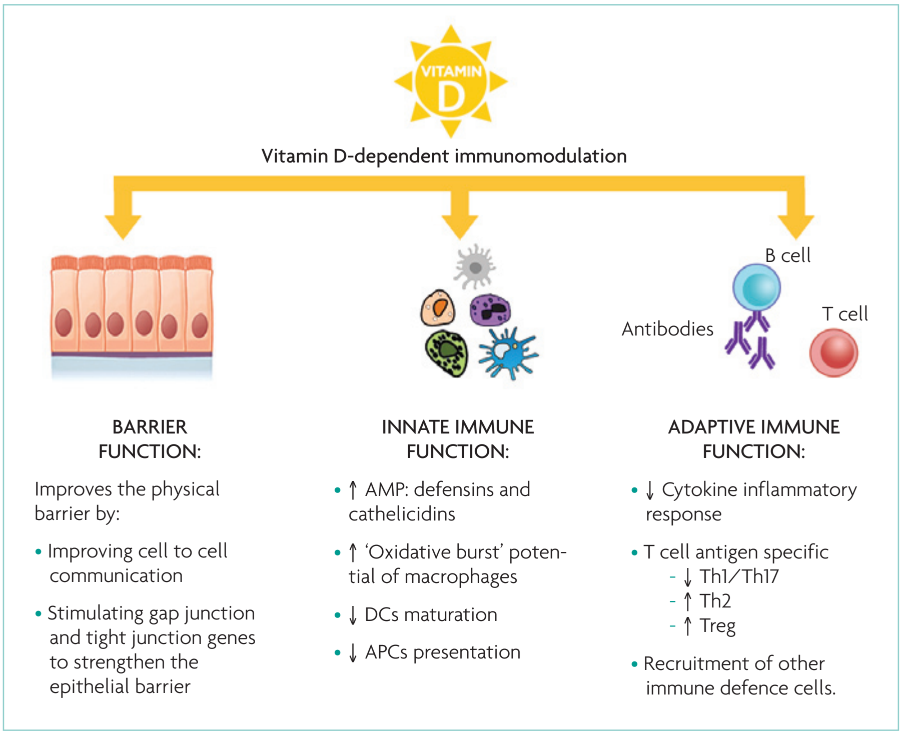


Fig. 3. Vitamin D-dependent immunomodulation. AMP, antimicrobial peptides; APCs, antigen presenting cells; DC, dendritic cells; Th1, type 1 T helper cells; Th2, type 2 helper cells; Th17, type 17 T helper cells; Treg, regulatory T cells (adapted from Briceno Noriega, D., and H. F. J. Savelkoul, 2022).

Reducing weaning stress

The social, environmental and nutritional stress encountered by the piglet at weaning exacerbate the physiological challenges and the immune gap. After weaning, piglets often stop eating for a few days, either because of the changed environment and/or the novelty of the feed.

This leads to atrophy of the intestinal villi and dysbiosis, especially when the piglets are overfeeding after the anorectic phase.

On the other side, stress is further reducing the already lowered immunity, increasing even more the risk of diarrhoea and other diseases such as respiratory disease or edema disease.

There is a variety of nutritional and management tools to prepare the piglet for weaning, to reduce weaning-associated stress and to improve the immunity of the piglets.

A rather surprising candidate for the latter is vitamin D and its metabolites.

Although the role of Vitamin D on the immune system has been known for quite some time, it has recently received a lot of renewed attention in the context of Covid-19. The effects of vitamin D and its metabolites on the immune system are diverse (Fig. 3).

They have been described to act as inflammatory modulators, to increase the production of antimicrobial peptides in blood, which act as 'self-made' antimicrobials, as well as to have beneficial effects on epithelial integrity.

Even though pig diets are supplemented with vitamin D, a topping of the diet with 1,25(OH)2D3 can give the piglet an additional edge on coping with weaning stress.

A natural source of 1,25(OH)2D3 is the plant Solanum glaucophyllum (SG), which contains high amounts of the glycosylated form of 1,25(OH)2D3.

In a Spanish trial the supplementation of SG to weaned piglets for 60 days was tested. In total 252 pure Iberian piglets, weaned at four weeks of age, either received a commercial control diet (CON) or the control diet supplemented with 100g Panbonis (commercial product based on SG, containing 10μg 1,25(OH)2D3/kg as glycosides) per ton of feed (PAN).

Average daily weight gain from start to end of trial was 30g higher in the PAN group and FCR was improved. Furthermore, piglet homogeneity was clearly increased (Table 1).

Additional blood and gut analysis showed a significantly reduced neutrophil and basophile count, indicating a reduced inflammatory state in the PAN pigs, which is corroborated by the increased expression of FOXP3 in the duodenum. This protein plays a role in the differentiation of regulatory Th2, type 2 T helper cells and thus on downregulating the immune response.

The effects were more pronounced at 60 days after weaning than at 30 days after weaning, encouraging the supplementation of PAN for longer periods.

Gut morphology was analysed in three piglets at 30 and 60 days post-weaning.

This pilot assessment indicated improved mucosal thickness in the duodenum. In jejunum, villus length was increased 30 days post-weaning while villus length/crypt depth ratio was higher at both time points.

These findings indicate an overall improved gut physiology.

Further studies are planned in high performing breeds and with a larger number of animals to confirm the results.

Including SG in the diets for weaned piglets is thus an additional tool to combat post-weaning health issues in piglets. ■

Table 1. Performance of Iberian piglets either fed a control diet or a diet supplemented with Panbonis 60 days after weaning.

	DWG (g/d) day 1-60	FCR day 30-60	CV* (%) day 60
Control	407	3.02	26.2
Panbonis	432	2.30	13.2

*Coefficient of variation. The lower the figure, the higher the homogeneity of the piglets

References are available from the author on request