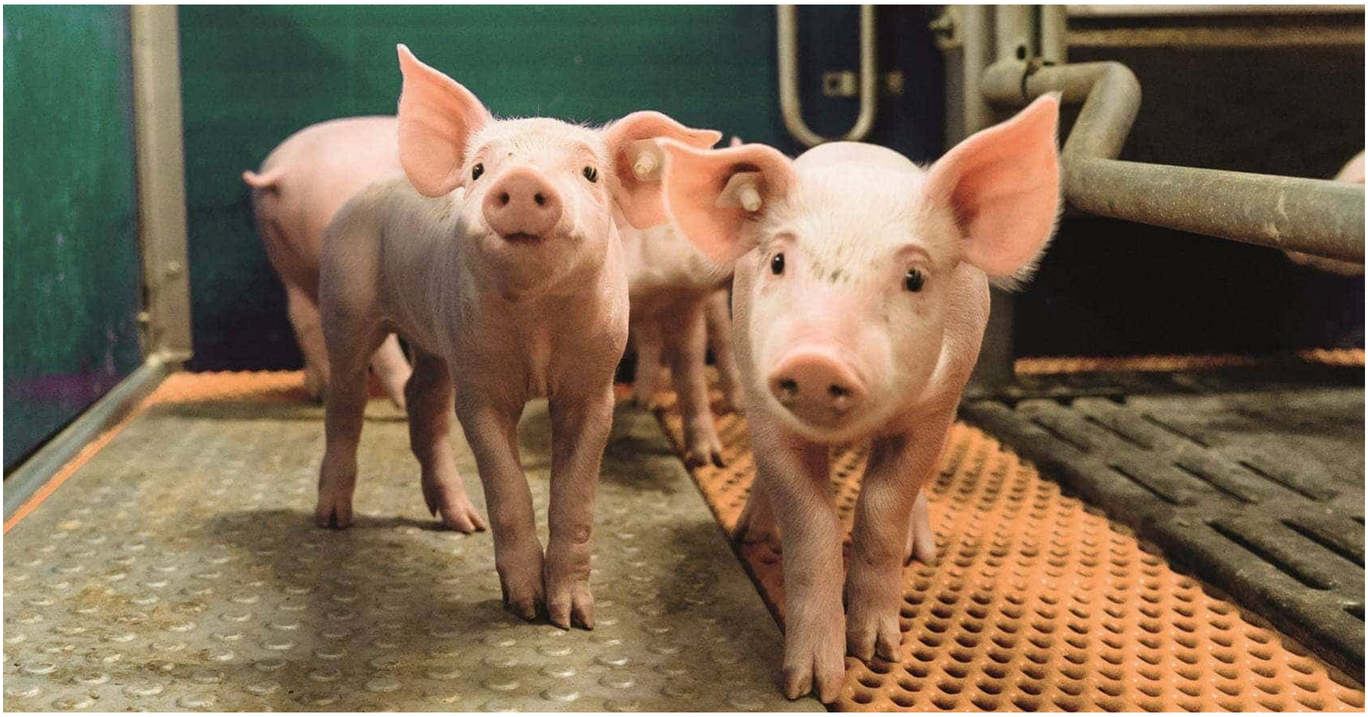
Acidifiers support piglets after weaning



*By **Dr. Inge Heinzl**, Editor, EW Nutrition*

In piglet production, high productivity, meaning high numbers of healthy and well-performing piglets weaned per sow and year, is the primary target. Diarrhea around weaning often gets in the way of achieving this goal.

Up to the ban of antibiotic growth promoters in 2006, antibiotics were often applied prophylactically to help piglets overcome this critical time. Zinc oxide (ZnO) application is another measure that cannot be used anymore to prevent piglet diarrhea. Effective alternatives are required.

Weaning – a critical point in piglets' life

Weaning stress is well-known to have a negative impact on the balance of the intestinal microflora and gastrointestinal functions (Miller et al., 1985). Suckling piglets have a limited ability to produce hydrochloric acid, but nature has a solution to compensate for this inadequacy. The lactobacilli present in the stomach can use the lactose in the sow's milk to produce lactic acid (Easter, 1988). In nature, the piglets would start to eat small amounts of solid feed at about three weeks when the sow's milk production no longer covers their nutrient demand. By increasing the feed intake, the piglets stimulate hydrogen chloride (HCl) production in their stomachs.

In piglet production, where weaning occurs at three or four weeks of age, the piglets are still not eating considerable amounts of solid feed. It is often the case that 50 % of the piglets take feed at the earliest after 24 h, and 10 % accept the first feed only after 48 h (Brooks, 2001). Additionally, hard grains in the diet can physically damage the small intestine wall, reducing villus height and crypt depth (Kim et al., 2005).

Only a minor production of HCl, no more lactose supply for the lactobacilli, varying feed intake, and high buffering capacity of the feed lead to a pH of >5 in the stomach.

The higher stomach pH is partly responsible for problems after weaning

A pH higher than 5, besides causing direct effects on the microflora in the stomach, has consequences for the whole digestive tract and digestion.

A high pH is favorable for certain microorganisms, including coliforms (Sissons, 1989) and other acid-sensitive bacteria such as Salmonella typhimurium, Salmonella typhi, Campylobacter jejuni, and V. cholerae (Smith, 2003).

1. **Lower activity of proteolytic enzymes**

   In the stomach, the conversion of pepsinogen to pepsin, which is responsible for protein digestion, is catalyzed under acid conditions (Sanny et al., 1975). Pepsin works optimally at two pH levels: pH 2 and pH 3.5 (Taylor, 1959). With increasing pH, the activity decreases; at pH 6, it stops. Therefore, a high pH can lead to poor digestion and undigested protein arriving in the intestine. There, it can be used as "feed" for harmful bacteria, leading to their proliferation. Barrow et al. (1977) found higher counts of coliforms in piglets' intestinal tract two days after weaning, while the number of lactobacilli was depressed.

   In the lower parts of the gastrointestinal tract (GIT), the final products of the pepsin protein digestion are needed to stimulate the secretion of pancreatic proteolytic enzymes. If no final products arrive, the enzymes are not activated, and the inadequate protein digestion continues. Additionally, gastric acid is the main stimulant for bicarbonate secretion in the pancreas, neutralizing gastric acid and providing an optimal pH environment for the digestive enzymes working in the duodenum.

2. **Expedited digesta transport**

   The stomach pH also influences the transport of digesta. The acidity of the chyme leaving the stomach and arriving in the small intestine is decisive for the amount of digesta being transferred from the stomach to the small intestine. Acid-sensitive receptors provide feedback regulation to prevent the stomach from emptying until the duodenal chyme can be neutralized by pancreatic or other secretions (Pohl et al., 2008). Therefore, a higher pH in the stomach leads to a faster transport of the digesta, resulting in worse feed digestion.

3. **Proliferation of microorganisms**

   A high pH is favorable for certain microorganisms, including coliforms (Sissons, 1989) and other acid-sensitive bacteria such as *Salmonella typhimurium, Salmonella typhi, Campylobacter jejuni*, and *V. cholerae* (Smith, 2003).

Elevated stomach pH + incomplete immune system = diarrhea

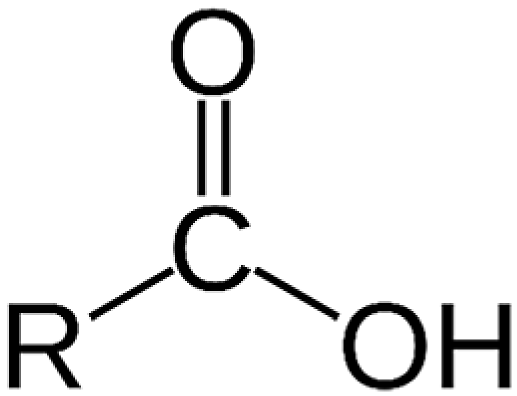
Acidifiers can mitigate the adverse effects of weaning on piglets

To overcome this critical time of weaning and maintain performance, acidifiers can be a helpful tool. They improve gut health, stimulate immunity, and serve as nutrient sources – while also positively affecting feed and water hygiene.

What are acidifiers?

Acidifiers' role in pig nutrition has evolved from feed preservatives to stomach pH stabilizers, compensating for young pigs' reduced digestive capacity (Ferronato and Prandini, 2020). They are now used to replace antibiotic growth promoters and ZnO, which were applied for a long time to mitigate the negative effects of weaning.

In general, both organic and inorganic acids and their salts feature in animal nutrition. They can be added to the feed or the water.



Organic acids: Commonly used with good results

Feed acidifiers are usually organic acids, including fatty and amino acids. Their carboxyl functional group is responsible for their acidic specificity as feed additives (Pearlin et al.,2019). Their pKa, the pH where 50 % of the acid occurs in a dissociated form, is decisive for their antimicrobial action. In animal nutrition, acids with pKa 3-5 are typically used (Kirchgeßner and Roth, 1991).

Organic acids used as feed additives can be divided into three groups:

- Simple monocarboxylic acids such as formic, acetic, propionic, and butyric acid
- Carboxylic acids with a hydroxyl group such as lactic, malic, tartaric, and citric acid
- Short-chain carboxylic acids with double bonds – fumaric and sorbic acid.

The primary acids for pig nutrition are acetic, fumaric, formic, lactic, benzoic, propionic, sorbic, and citric acids (Roth and Ettle, 2005).

Inorganic acids – the low-cost version

Inorganic acids are cheaper than organic acids, but their only effect is to decrease the pH. Additionally, they are extremely corrosive and dangerous liquids due to their strong acidity in a pure state (Kim et al., 2005).

Salts are easier to handle

The advantage of salts over free acids is that they are generally odorless and easier to handle in the feed manufacturing process due to their solid and less volatile form. Higher solubility in water is a further advantage compared to free acids (Huyghebaert and Van Immerseel, 2011; Roth and Ettle, 2005; Partanen and Mroz, 1999). The better handling and higher palatability make acid salts a more user-friendly method to apply acids to feed and water without compromising their efficacy (Luise et al., 2020).

The salts are mainly produced with calcium, potassium, and sodium. They include calcium formate, potassium diformate, sodium diformate, and sodium fumarate.

Blends

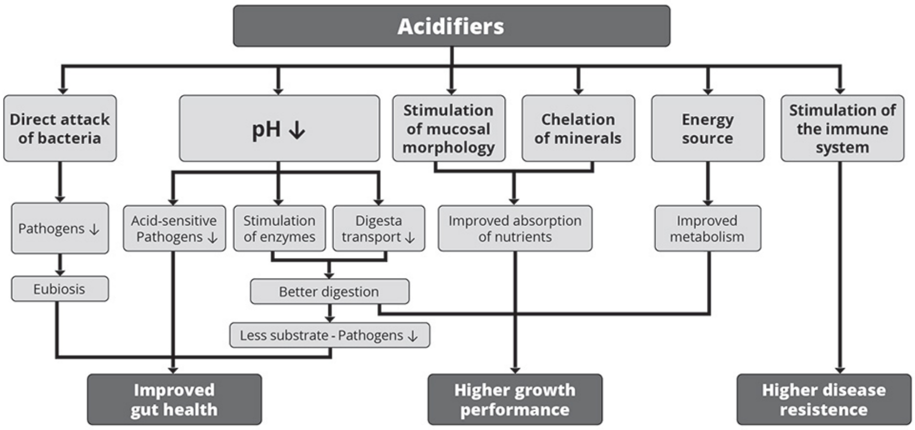
A mixture of diverse acidifiers combines the different characteristics of these substances. Perhaps, there may be synergistic effects. Acid blends are more and more used as feed additives. They have a widerranging action than single substances.

Roth et al. (1996) showed that a combination of formic acid with various formats is more effective than the application of formic acid alone.

The main effects of acidifiers

Acidifiers support piglets during the critical time after weaning through different modes of action. The final results are:

- Improvement in gut health
- Increase in growth performance
- Stabilization of the immune system.



1. Improvement in gut health

As shown in figure 1, the improvement in gut health relies on the antimicrobial effect of organic acids and the decrease in the stomach's pH.

1.1 Organic acids directly attack bacteria

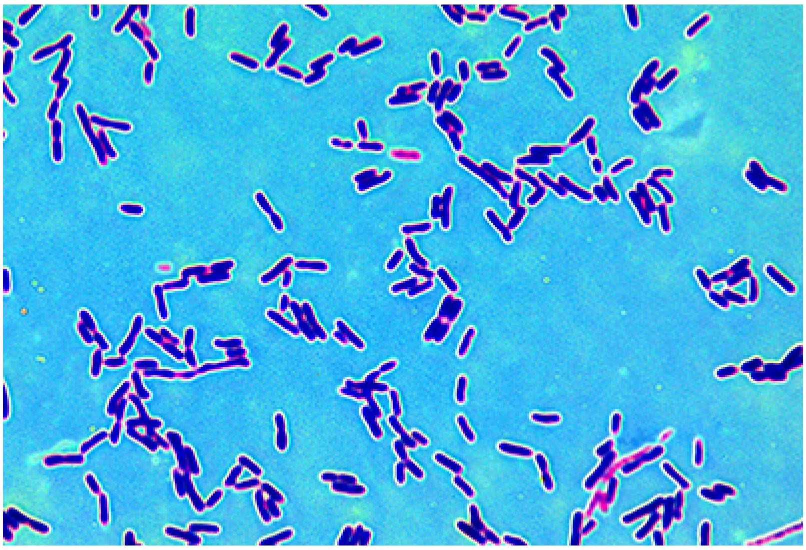
Organic acids not only act through their pH-decreasing effect but also directly attack pathogens. Due to their lipophilic character, organic acids can pass the bacterial cell membrane when they are in their undissociated form (Partanen in Piva et al., 2001). The lower the external pH, the more undissociated acid can pass the membrane.

Within the cell, the pH is higher. Hence, the organic acid dissociates and releases hydrogen ions, reducing the cytoplasmic pH from alkaline to acid. Cell metabolism is depressed at lower pH. Therefore, the bacterial cell needs to expel protons to get the cytoplasmic pH back to normal. As this is an energy-consuming process, more prolonged exposure to organic acids kills the bacterium. Additionally, the anions staying within the cell disturb the cell's metabolic processes and participate in killing the bacterium.

Studies from Van Immerseel et al. (2006) revealed that many fermentative bacteria could let their intracellular pH decline and prevent increased acid penetration. Bacteria with a neutrophil pH, however, react more sensitively.

1.1 Decreased pH reduces non-acid-tolerant pathogens

There is a direct effect of pH on the microflora. Some pathogenic bacteria are susceptible to low pH. The proliferation of, e.g., *E. coli*, *Salmonella*, and *Clostridium perfringens* is minimized at a pH<5. Acid-tolerant bacteria such as lactobacilli or bifidobacteria, however, survive. Many lactobacilli can produce hydrogen peroxide, which inhibits, e.g., *Staphylococcus aureus* or *Pseudomonas* spp. (Juven and Pierson, 1996).



Already Fuller (1977) showed in *in vitro* experiments that certain bacteria such as Streptococci, Salmonella, and *B. cereus* don't grow in an environment with pH 4.5 or even die (*Micrococcus*). In contrast, *Lactobacilli* are not so susceptible to this low pH. Using the same binding sites as harmful bacteria, they suppress coliforms, for example. Kirchgeßner et al. (1997) found a stronger reduction of *E. coli* than Lactobacilli and Bifidobacteria in different gut segments when exposed to 1.25 % formic acid.

1.2 Recovery of eubiosis through reduction of substrate

The reduction of the pH through organic acids maintains or stimulates the secretion of proteolytic enzymes in the stomach (pepsin) and pancreatic enzymes. Additionally, the acid leaving the stomach is partly responsible for regulating gastric emptying (Ravindran and Kornegay, 1993; Mayer, 1994). Both effects by improving protein digestion, reduce the fermentable substrates arriving in the hindgut. This decreases the quantity of fermentable substrate arriving in the intestine and, therefore, the growth of undesired pathogens.

2. Promotion of growth

2.1 Enhanced digestion of macronutrients

As explained above, the acidity in the stomach is responsible for the activation and stimulation of enzymes. Additionally, the lower pH keeps the feed in the stomach for longer. Both result in better digestion.

The improved utilization of nutrients leads to higher daily gain and better feed conversion. In pigs, the growth-promoting effect of organic acids is particularly pronounced during the first few weeks after weaning (Roth and Ettle, 2005). Some examples of the growth-promoting effect of formic and propionic acid feature in table 1.

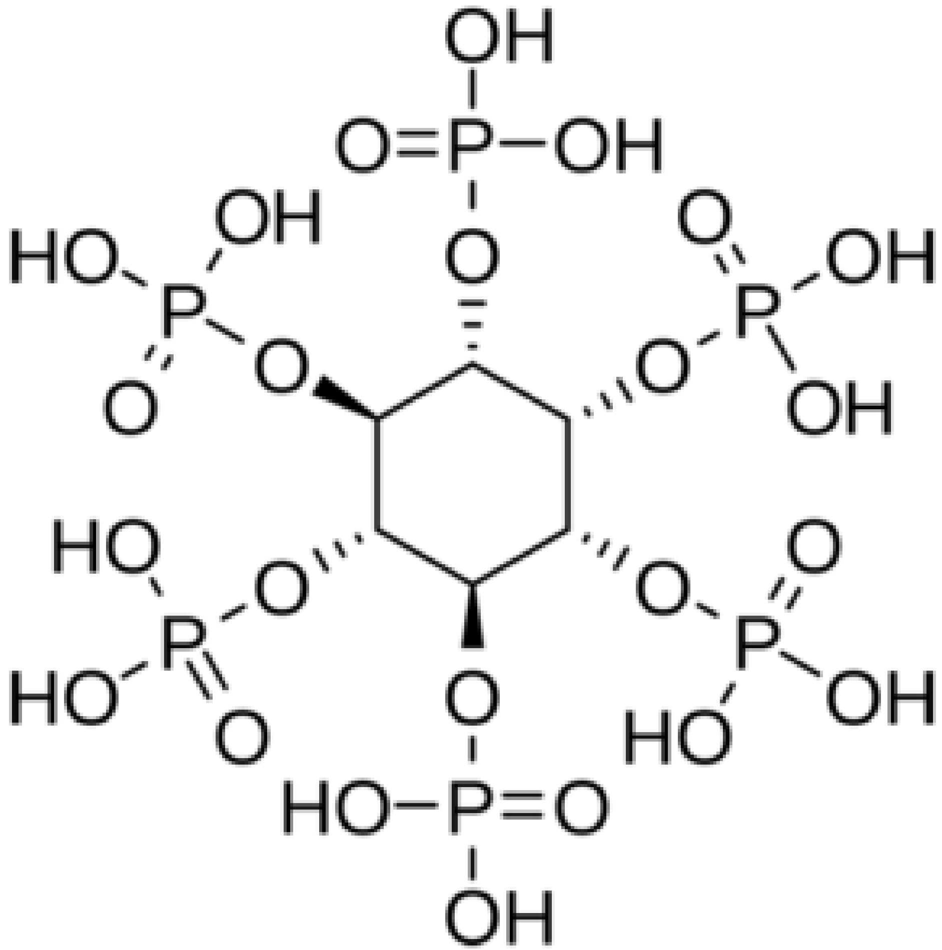
Acid	Inclusion	ADG	Feed intake	FCR	G/F	Reference
Formic acid	0.13 %	+ 6.0 %	+ 3.5 %	- 2 pts		Luise et al. (2017)
Formic acid	0.64 %	+ 5.0 %	+ 3.7 %	- 1 pt		Luise et al. (2017)
Propionic acid	2.00 %	- 4.4 %	- 11.0 %		+ 4 pts	Giesting and Easter (1985)

Table 1: Influence of two commonly used organic acids in animals on growth performance

Varying results are mainly due to the character of the organic acid, the dosage, the buffering capacity, and the possible reduction of feed intake in case of a high dosage (Roth and Ettle, 2005).

2.2 *Improved utilization of minerals*

Minerals are essential for metabolic processes and, thus, healthy growth. Chelated minerals show a higher digestibility. Acidic anions of the acidifiers form complexes (chelates) with cationic minerals such as Ca, Zn, P, and Mg. The resulting higher digestibility and absorption lead to decreased excretion of supplemented minerals and, therefore, to a lower environmental burden. Kirchgeßner and Roth (1982), e.g., reported an improved absorption and retention of Ca, P, and Zn with the addition of fumaric acid. However, there are also trials showing no effect of acidification of the diet on mineral balance (Radecki et al., 1988).



Phytic acid

Another factor influencing the absorption of minerals, mainly phosphorus, is the amount of intrinsic or microbial phytase in the diet (Rutherfurd et al., 2012). The enzyme phytase releases phosphorus out of phytic acid and increases its bioavailability. Partanen and Mroz (1999) showed that organic acids improve the performance of phytase and, therefore, the bioavailability of phosphorus in the diet.

Besides a better utilization by the animal, improved absorption of minerals means preserving the environment and direct cost-saving, as mineral supplements are expensive.

2.3 *Stimulation of gut and stomach mucosal morphology*

An intact gut mucosa with a preferably high surface is vital for efficient nutrient absorption. Many trials show that organic acids improve the condition of the mucosa:

Organic acids stimulate cell proliferation

In an *in vitro* trial with pig hindgut mucosa, butyric acid stimulated epithelial cell proliferation in a dose-dependent manner (Sakata et al., 1995).

Blank et al. reported that fumaric acid, being a readily available energy source, may have a local trophic effect on the small intestines' mucosa. Due to faster recovery of the gastrointestinal epithelial cells after weaning, this trophic effect may increase the absorptive surface and digestive capacity in the small intestines.

Organic acids influence villi length and crypt depth in the gut

Ferrara et al. (2016) observed a trend toward longer villi with a mixture of short-chain organic acids and mid-chain fatty acids, compared to the negative control.

The addition of Na-butyrate to the feed leads to increased crypt depth, villi length, and mucosa thickness in the distal jejunum and ileum, according to Kotunia et al. (2004). However, the villi length and mucosa thickness were reduced in the duodenum.

According to Gálfi and Bokori (1990), a diet with 0.17% sodium butyrate increased the length of ileal microvilli and the depth of caecal crypts in pigs weighing between 7 and 102 kg.

Organic acids strengthen stomach mucosa

Mazzoni et al. (2008) reported that sodium butyrate applied orally at a low dose influenced gastric morphology and function (thickening the mucosa), presumably due to its action on mucosal maturation and differentiation.

2.4 Pigs can use organic acids acid as an energy source

Organic acids are usually added to the feed in small doses. As some organic acids are intermediary products of the citric acid cycle, they are an energy source after being absorbed through the gut epithelium by passive diffusion. Their gross energy can be fully metabolized (Pearlin et al., 2019; Roth and Ettle, 2005; Suiryanrayna and Ramana, 2015).

The gross energy supply varies according to the acid. Roth and Ettle (2005) determined values between 6 kJ/g (formic acid) and 27 kJ/g (sorbic acid). Pearlin et al. (2019) calculated that 1 M of fumaric acid generates 1.340 kJ or 18 M ATP; this is comparable to the energy provision of glucose. Citric acid's energy provision is similar; acetic and propionic acid require 18 and 15 % more energy to generate 1 M ATP.

Acidifiers improve immune response

The immune system, especially at the sensitive life stage of weaning, plays an essential role for the piglet. Acidifiers have been shown to stimulate or support the immune system. Ahmed et al. (2014) showed that citric acid (0.5 %) and a blend of acidifiers composed of formic, propionic, lactic, phosphoric acid + SO2(0.4 %) significantly increased the level of serum IgG. IgG are part of the humoral immune system. They mark foreign substances to be eliminated by other defense systems.

In a trial conducted by Ren et al. (2019), piglets receiving a mixture of formic and propionic acid showed lower concentrations of plasma tumor necrosis factor-α, regulating the activity of diverse immune cells. Furthermore, interferon-γ and interleukin (Il)-1ß were lower than in the control group after the challenge with E. coli (ETEC). In this trial, the addition of organic acids to the feed alleviated the inflammatory response in a way comparable to antibiotics.

In a nutshell

Organic acids are no longer seen as pure acidifiers but as growth promoters and potential antibiotic substitutes due to their positive effect on the gastrointestinal tract. Their main effect, the decrease of pH, entails consequences from inhibiting pathogenic bacteria and improved digestion to enhanced health and growth.
Research indicates that acidifiers can be a viable alternative to antibiotic growth promoters and ZnO for ensuring healthy piglet production after weaning.

Piglet performance with fewer antimicrobials is possible

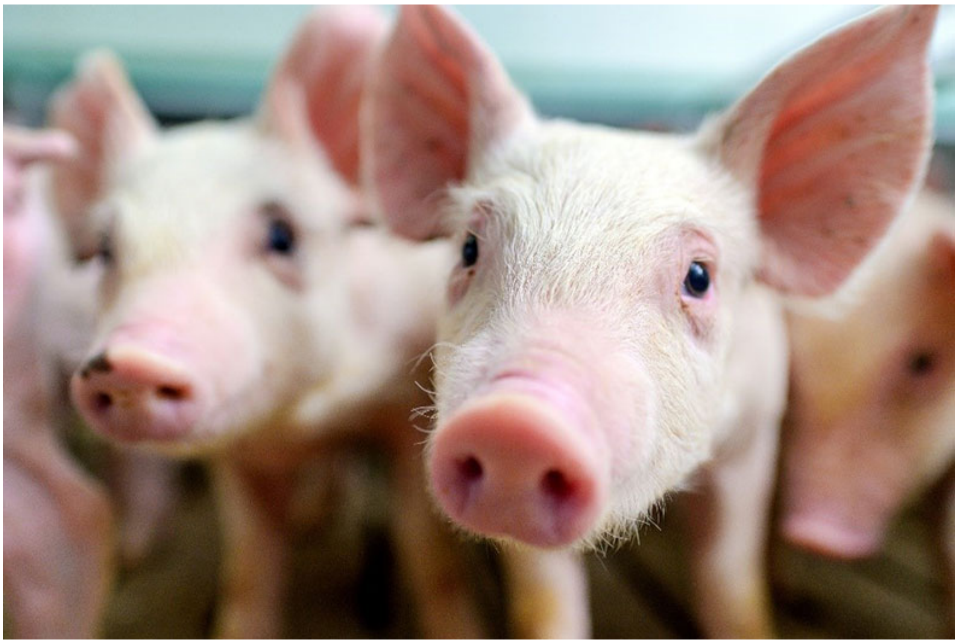
By Technical Team, EW Nutrition

A variety of stressors simultaneously occur at weaning, making this probably the most challenging period in pig production. During weaning, we commonly see altered gut development and gut microbiome, which increases piglets' vulnerability to diseases. The most classic clinical symptom resulting from these stressors is the occurrence of post-weaning diarrhea. It is a sign that something went wrong, and piglet development and overall performance may be compromised (Guevarra et al. 2019).

Besides weaning, an unavoidable practice in pig production, the swine industry has been facing other changes. Among them, the increased pressure to reduce the use of antimicrobials stands out. Antimicrobials are often associated with improved piglet performance and health. Their usage has been reduced worldwide, however, due to the threat of antimicrobial resistance that affects not just animal health but also human health (Cardinal et al., 2019).

Reduce antimicrobials and post-weaning diarrhea: can piglet nutrition achieve both?

With these drastic changes for the piglets and the global swine industry, producers must find solutions to keep their farms profitable — especially from a nutritional perspective. Our last article presented two feed additives that can be part of an antibiotic-free concept for post-weaning piglets. This article will highlight a few essential nutritional strategies that swine producers and nutritionists must consider when formulating post-weaning feed without or with reduced amounts of antimicrobials.



What makes weaning so stressful for piglets?

Producers, nutritionists, and veterinarians all agree that weaning is a tough time for piglets (Yu et al., 2019) and, therefore, a challenge to all those involved in the pig production chain. Although there is a global trend towards increasing weaning age, generally speaking, animals are still immature when going through the weaning process. They face several physiological, nutritional, and environmental changes (figure 1).

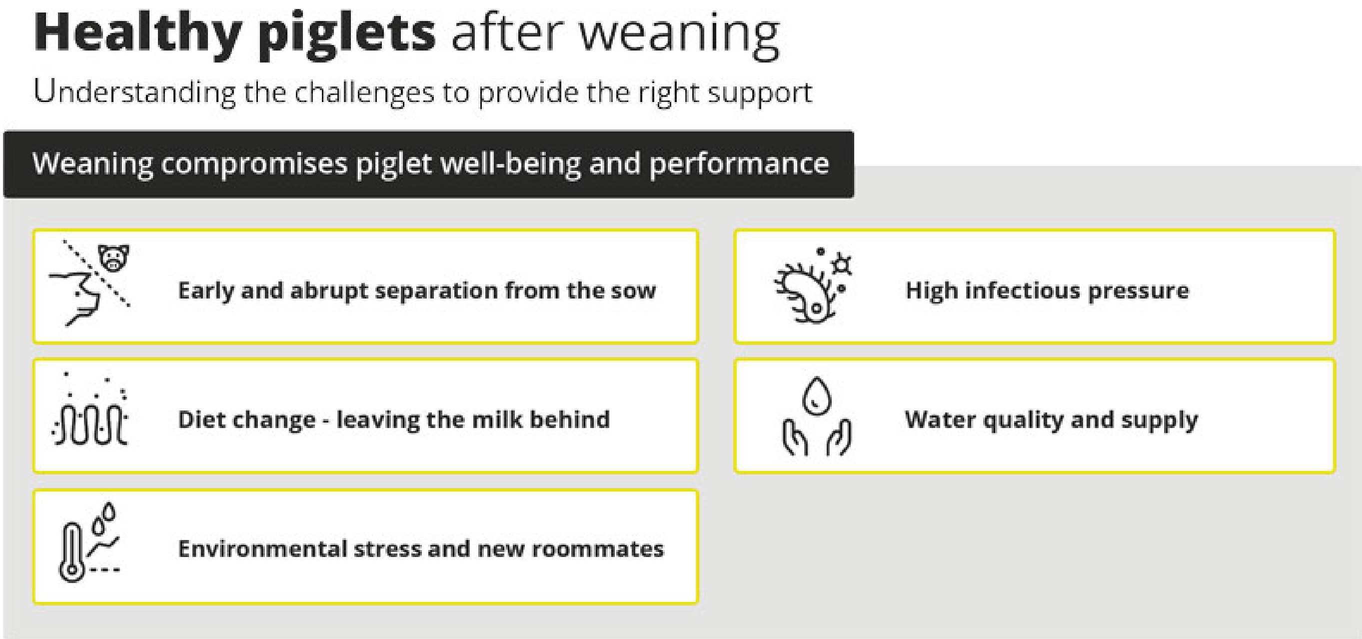


Figure 1. Factors associated with weaning can compromise piglet well-being and performance

Most of these changes become “stressors” that trigger a cascade of reactions affecting the balance and morphology of the intestinal microbiome (figure 2). The outcome is a decrease in the piglets’ well-being and, in most cases, performance. We need to clearly understand how these stressors affect pigs to develop effective strategies against post-weaning growth impairments, especially when no antimicrobials are allowed.

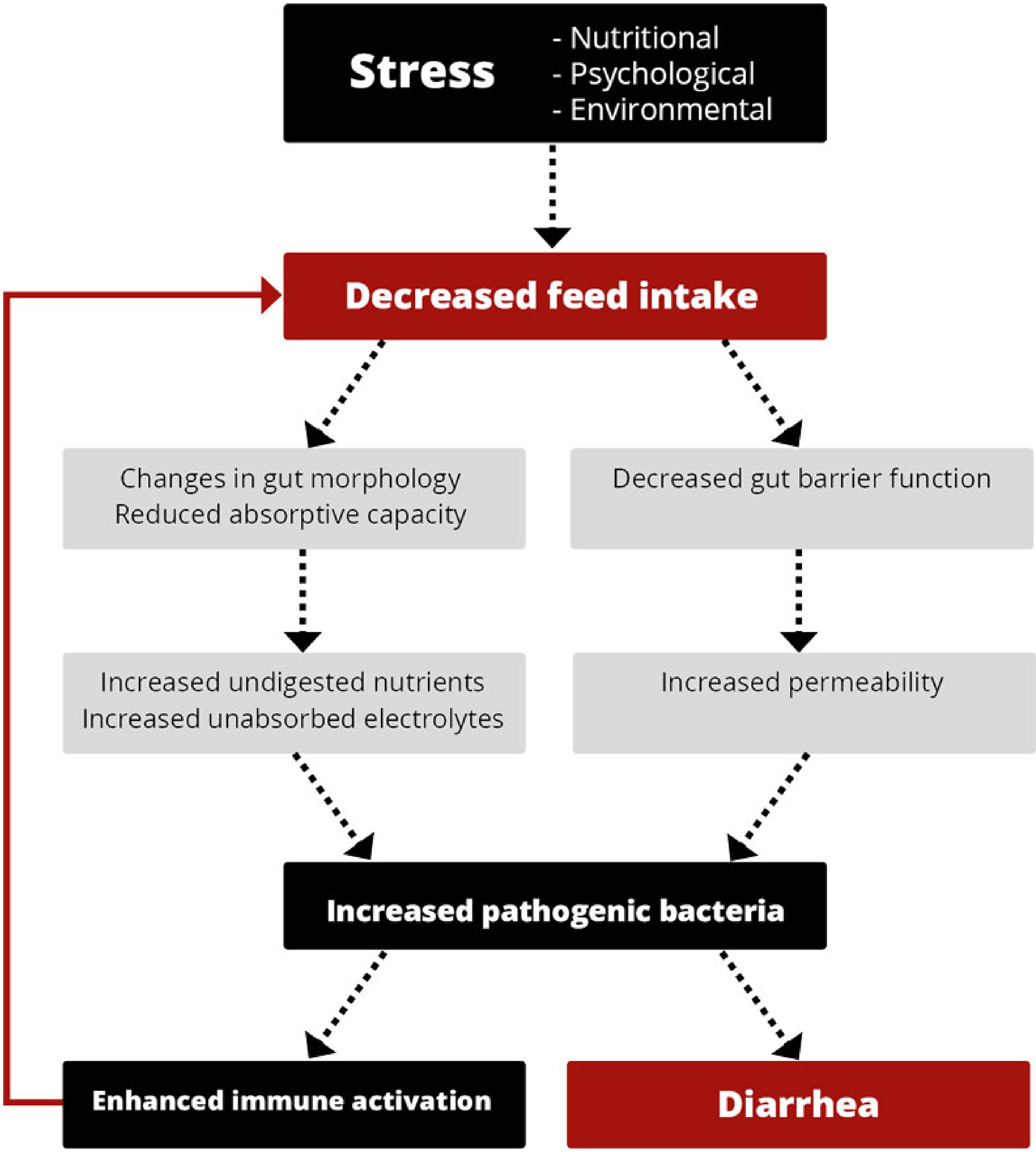


Figure 2. Schematic diagram illustrating the effects of stress in weaned piglets (adapted from Jayaraman and Nyachoti, 2017)

Weaning support starts before weaning

The use of creep feed has been evaluated and even criticized for many years. Some operations are still reluctant to use such a feed due to its high cost and amount of labor on the farm, with manually providing feed and cleaning feeding trays. In addition, some questions have been raised regarding the ideal composition of the creep feed – how much complexity should we add to this special diet?

Therefore, the benefits of creep feed are under re-evaluation, not only considering piglet physiology per se, but also feed characteristics and different feeding programs. Recent studies have questioned highly complex creep feed formulations. Creep feed is being called “transition feed” (Molist, 2021) – i.e., that meal which is complementary to sows' milk and not a replicate of it, helping piglets during the period of changing its main source of nutrients. We must, therefore, look at it as a way of making piglets familiar with solid feed, as highlighted by Mike Tokach during the 2020 KSU Swine Day. Dr. Tokach also mentioned that the presence of feeders in the lactation pen could stimulate the exploratory behaviors of the piglets. Combined, these practices can lead to a higher feed intake and performance during the nursery phase.

Towards a pragmatic stance on creep feed

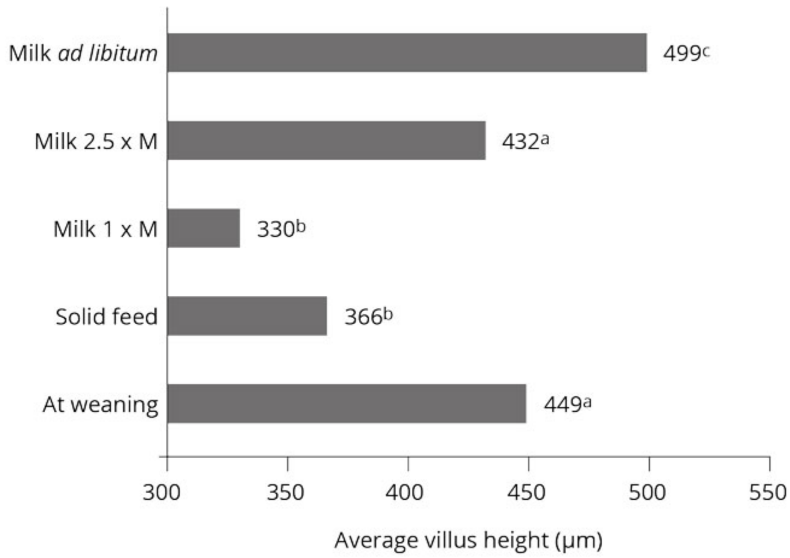
Heo et al. (2018) evaluated three different creep feed types: a highly digestible creep feed, weaning feed as creep feed, and sow feed as creep feed until weaning. Piglets receiving the highly digestible creep had higher feed intake during the second to the last week pre-weaning (14 to 21 days of age) and higher ADG during the last week pre-weaning (21 to 28 days of age). This resulted in a trend for higher weaning weight. However, these benefits did not persist after weaning when all piglets received the weaning feed.

Guevarra et al. (2019) also suggested that the abrupt transition in piglet nutrition to a more complex nutrient source can influence shifts in the gut microbiota, impacting the absorptive capacity of the small intestine. Yang et al. (2016) evaluated 40 piglets from eight litters during the first week after weaning. They found that the change in diet during weaning reduced the proliferation of intestinal epithelial cells. This indicates that this period affects cellular macromolecule organization and localization, in addition to energy and protein metabolism. These results suggest that "similarity" in feed pre- and post-weaning may contribute more to the continuity of nutrient intake post-weaning than a highly complex-nutrient dense creep feed.

Nutritional strategies without antibiotics: focus on pig physiology

As mentioned, it is crucial to avoid a drastic drop in feed/nutrient intake after weaning compared to pre-weaning levels. In a classic study, Pluske et al. (1996) showed the importance of high intake levels on villus weight (used as a reference for gut health, cf. graph 1). Although not desirable, the reduction should be considered "normal" behavior.

Imagine these recently weaned piglets, facing all these stressors, having to figure out within this new group of peers when it is time to eat, where to find food, why water and food now come from two distinct sources… Therefore, management, feeding, water quality, and other aspects play important roles in post-weaning feed intake (figure 3).



Graph 1. Villus height following different levels of feed intake (M = maintenance) post-weaning (a.b.c bars with unlike superscript letters are different at P<0.05). (From Pluske et al., 1996.)

From a nutritional perspective, piglets at weaning experience a transition from milk (a high-fat, low-carbohydrate liquid) to a plant-based diet (a solid, low-fat, and high-carbohydrate diet) (Guevarra et al., 2019). Even when previously introduced to solid feed, it is still difficult for their enzymatic system to cope with grains and beans.

One of the consequences of the lower digestibility capacity is an increase of undigested nutrients. Harmful bacteria thrive and cause diarrhea, reducing even further an already compromised feed intake. This cycle must be broken with the support of formulations based on piglet physiology.

Post-weaning feed must support digestion and nutrient absorption, including the largest possible share possible of high-quality, digestible ingredients, with low anti-nutritional factors. High-performing feed also integrates functional amino acids, functional carbohydrates, and additives to support the intestinal mucosa and gut microbiome.

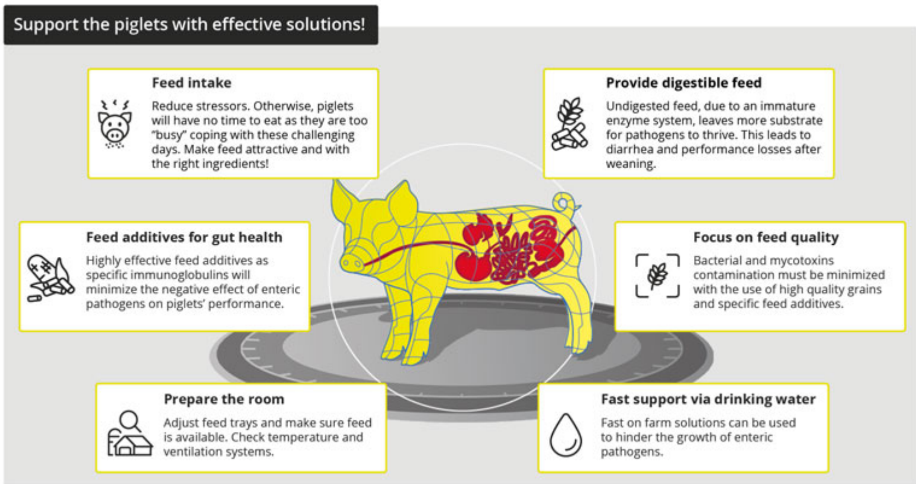


Figure 3. Supporting piglets with effective solutions

Crude protein – more of the same?

Levels of crude protein in piglet feed have been in the spotlight for quite some time. The topic can be very controversial where the exact percentage of crude protein in the final feed is concerned. Some nutritionists pragmatically recommend maximal levels of 20% in the weaner feed. Others go a bit lower, with some formulations reaching 17 to 18% total crude protein. Levels above 20% will incur high costs and may accentuate the growth of pathogenic bacteria due to a higher amount of undigested protein in the distal part of the small intestine (figure 4).

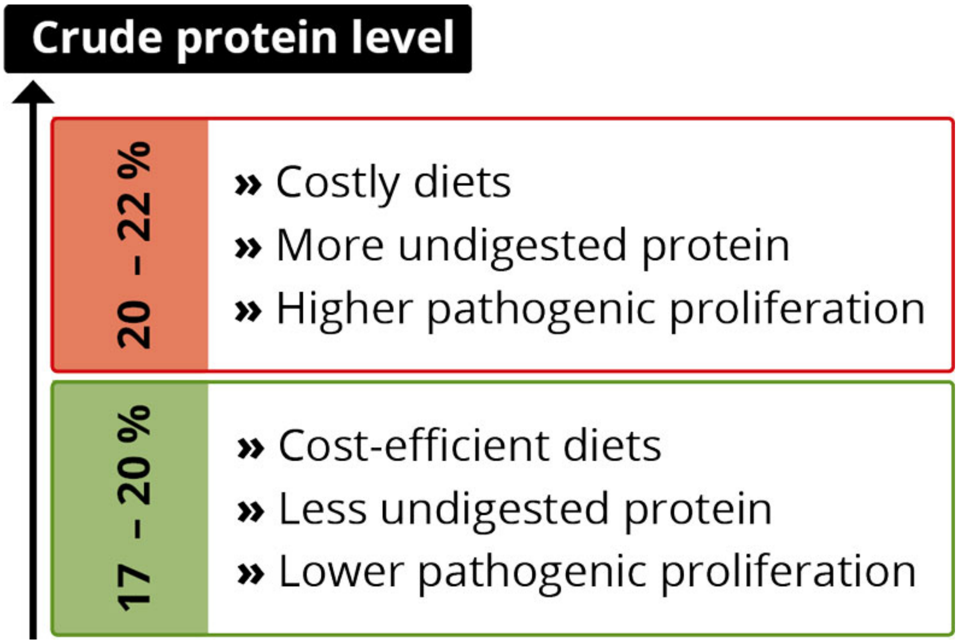


Figure 4. The dynamics of crude protein levels in piglet feed

What is not open for discussion, however, is the quality of the protein used, in terms of:

- digestibility,
- the total amount of anti-nutritional factors, and
- the correct supply of essential and non-essential amino acids (particularly lysine, methionine, threonine, tryptophane, isoleucine and valine).

The critical role of digestibility

High-digestibility ingredients for piglets need to deliver minimum 85% digestibility. In most cases, to reach high biological values (correlating to high digestibility), these ingredients typically undergo different processing steps, including heat, physical, and chemical treatments. Animal by-products (such as hydrolyzed mucosa, fish meal, spray-dried plasma) and processed vegetable sources (soy protein concentrate, extruded grains, potato protein) can be used in high amounts during this phase. They will notably reduce the total amount of undigested protein reaching the distal part of the intestine, with 2 main benefits:

- Less substrate for pathogenic bacteria proliferation (and therefore lower incidence of diarrhea)
- Lower nitrogen excretion to the environment

It is common knowledge that certain storage proteins from soybean meal (for instance, glycinin and B-conglycinin) can cause damage to piglets' intestinal morphology and trigger the activation of the immune system. However, it is normal practice to introduce this ingredient to piglets around weaning so that the animals can develop a certain level of tolerance to such compounds (Tokach et al., 2003). In Europe, where most diets are wheat-barley based, soybean meal is included in levels varying from 3 to 9% in the first 2 diets, with gradual increases during the nursery phase.

Amino acids and protein: manage the balance

When the supply and balance between essential and non-essential amino acids is concerned, reducing total crude protein brings indeed complexity to the formulations. The concept of ideal amino acid should be expanded, ideally, to all 9 essential amino acids (lysine, methionine, tryptophan, threonine, valine, isoleucine, leucine, histidine, and phenylalanine). In most cases, formulations go up to the 5th or 6th limiting amino acid. Lawor et al. (2020) suggest 2 practical approaches to avoid deficiencies when formulating low-protein piglet feed:

- Maintain a maximum total lysine to crude protein ratio in the diet of 7.1 to 7.4%
- Do not exceed the SID lysine to crude protein ratio of 6.4%

Some conditionally essential amino acids (e.g. arginine, proline, and glutamine) also play critical roles in diets with reduced crude protein levels. Glutamine is especially interesting. When supplemented in the feed, it can be used as a source of energy by the intestinal epithelium and, therefore, prevent atrophy and support nutrient absorption, resulting in better growth post-weaning (Hanczakowska and Niwińska, 2013; Watford et al., 2015)

The importance of the buffer capacity of the feed – supporting the enzymatic system

Given the move towards antibiotic reduction, this topic is more relevant than ever to nutritionists worldwide. The acid-binding capacity (also known as buffering capacity) of the feed directly affects the capacity of the stomach to digest protein. Hence, buffer capacity is of utmost importance in antimicrobial-free diets as it influences the growth of pathogenic bacteria (Lawlor et al., 2005).

In short, the acid-binding capacity is the resistance of an ingredient or complete feed to pH change. For piglet feed/feed ingredients, it is normally measured by the acid-binding capacity at pH4 (ABC-4). A higher ABC-4 equates to a higher buffering capacity. Feed with a high ABC-4 would require large amounts of gastric acid for the pH of the stomach to reach 4 and below. As the post-weaned piglet has limitations on producing and secreting acid, the stomach pH would stay high and, thus, less favorable for protein digestion.

The recommendation is to have a complete feed based on single ingredients with low ABC-4 values and to use additives that further reduce the ABC-4 value (such as organic acids). According to Molist (2020), post-weaning feed must have an ABC-4 that is lower than 250-300 meq/kg.

Talking about fiber

Dietary fibers are also known for regulating intestinal health in both humans and animals. Chen et al. (2020), for example, examined the effects of dietary soluble fibers (inulin) and insoluble fibers (lignocellulose) in weaned piglet diets for four weeks. Results showed that combining those fibers can positively influence nutrient digestibility, gut microbiota composition, intestinal barrier functions, and growth performance (table 1).

Items[1]	Control	IDF	SDF	CRMDF	MDF
Initial weight, kg	7.47 ± 0.16	7.47 ± 0.12	7.48 ± 0.09	7.48 ± 0.13	7.48 ± 0.12
2wk weight, kg	10.89 ± 0.26	11.20 ± 0.33	10.76 ± 0.26	11.23 ± 0.17	11.14 ± 0.21
Final weight, kg	16.93 ± 0.42	17.15 ± 0.77	16.69 ± 0.58	17.95 ± 0.44	17.41 ± 0.20
1-14 d					
ADFI, g/d	403 ± 19.13	410 ± 11.47	376 ± 15.49	409 ± 10.57	399 ± 10.55
ADG, g/d	238 ± 10.37	264 ± 17.04	230 ± 17.59	261 ± 5.84	264 ± 10.00
FG	1.70 ± 0.08^{a}	1.58 ± 0.08^{ab}	1.66 ± 0.07^{ab}	1.57 ± 0.01^{ab}	1.51 ± 0.02^{b}
Diarrhoea incidence %	21.42 ± 5.53	12.54 ± 4.19	17.86 ± 7.55	15.48 ± 4.29	15.48 ± 3.40
15-28 d					
ADFI, g/d	716 ± 34.86	732 ± 38.27	699 ± 30.97	756 ± 32.79	715 ± 24.96
ADG, g/d	431 ± 29.13	425 ± 37.50	424 ± 28.15	480 ± 24.13	448 ± 8.23
F/G	1.68 ± 0.06	1.68 ± 0.05	1.67 ± 0.07	1.58 ± 0.04	1.60 ± 0.05
Diarrhoea incidence %	16.67 ± 2.38^{a}	10.71 ± 2.92^{ab}	10.71 ± 3.03^{ab}	10.00 ± 1.23^{ab}	3.57 ± 0.60^{b}
0-28 d					
ADFI, g/d	560 ± 21.22	571 ± 24.41	537 ± 21.32	583 ± 19.25	557 ± 15.72
ADG, g/d	334 ± 12.20	345 ± 25.20	327 ± 19.24	371 ± 13.01	356 ± 6.98
F/G	1.68 ± 0.03^{a}	1.63 ± 0.03^{ab}	1.66 ± 0.05^{ab}	1.57 ± 0.03^{b}	1.56 ± 0.03^{b}
Diarrhoea incidence %	19.05 ± 2.71	11.43 ± 4.01	14.29 ± 5.03	15.48 ± 4.08	9.52 ± 1.99

$^{a-b}$ Means in the same row, different superscript letters show significant difference (P<0.05).
[1] **Control**: basal diet; **IDF:** 1% insoluble fiber; **SDF**: 1% soluble fiber; **CRMDF:** 0.75% insoluble fiber + 0.25% soluble fiber / 0.25% insoluble fiber + 0.75% soluble fiber; **MDF:** 0.5% insoluble fiber + 0.5% soluble fiber;
ADFI: average daily feed intake; ADG: average daily gain; F/G: feed/gain.

Table 1. Effects of dietary fiber supplementation on piglet growth performance (adapted from Chen et al., 2020*)*

How to reduce antimicrobials? Understand the

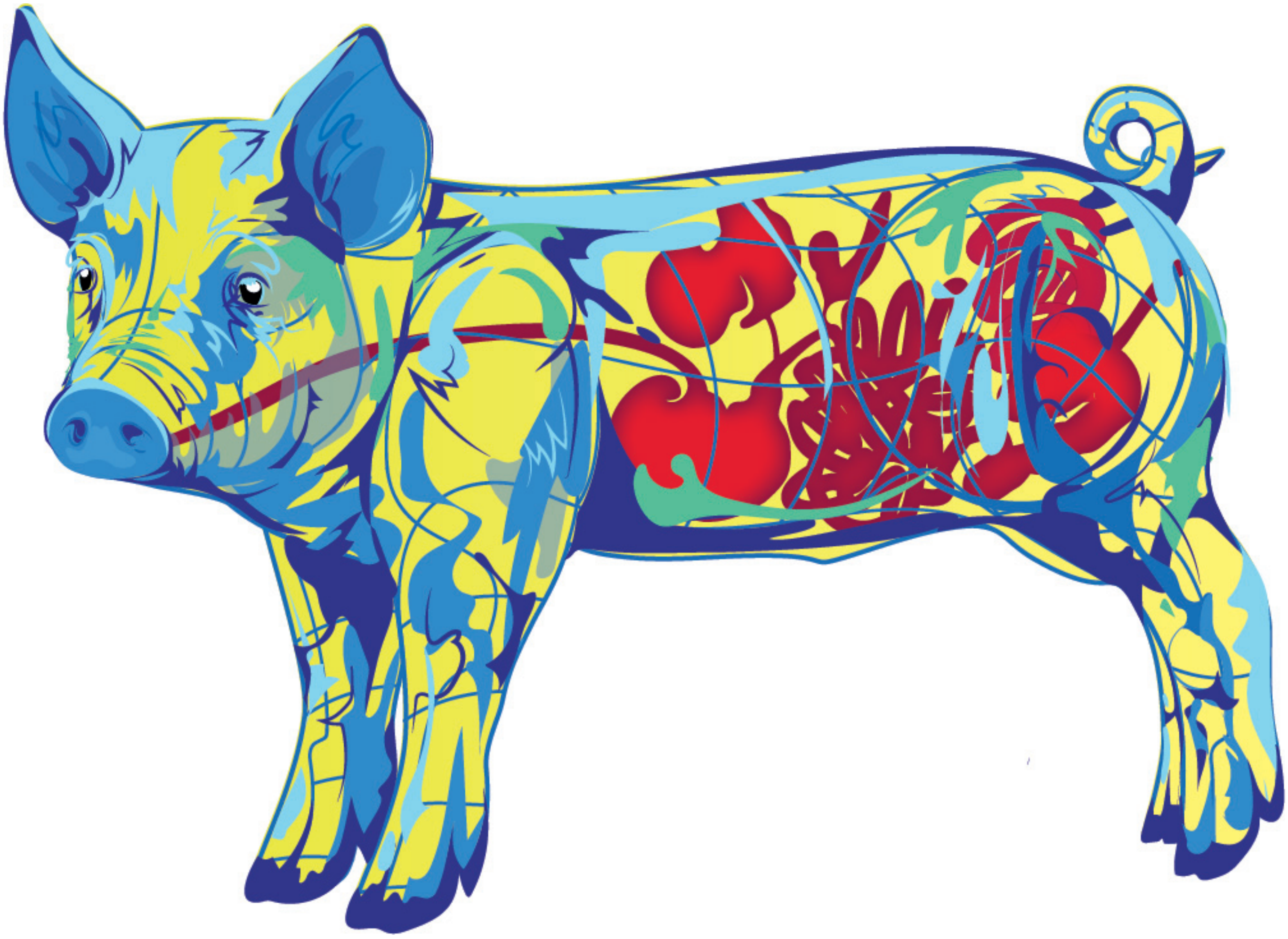
roles of piglet physiology and nutrition

Swine producers might think that “How can I reduce antimicrobial use on my farm?” and “How can I improve the performance of piglets at weaning?” are two separate questions. However, that is not always the case. Answers based on a deep understanding of physiology and nutrition dynamics help piglets overcome the challenges encountered during weaning – and, thus, lessen the need for antimicrobial interventions.

In this article, we have explored the basic principles that are the basis for ensuring the performance and health of the post-weaning piglet. Although we do not have a singular solution for eliminating antimicrobials on our pig farms, we can count on a group of robust and integrated nutritional strategies. By integrating factors ranging from management to feed additives, these solutions can improve piglet health and performance throughout their lives.

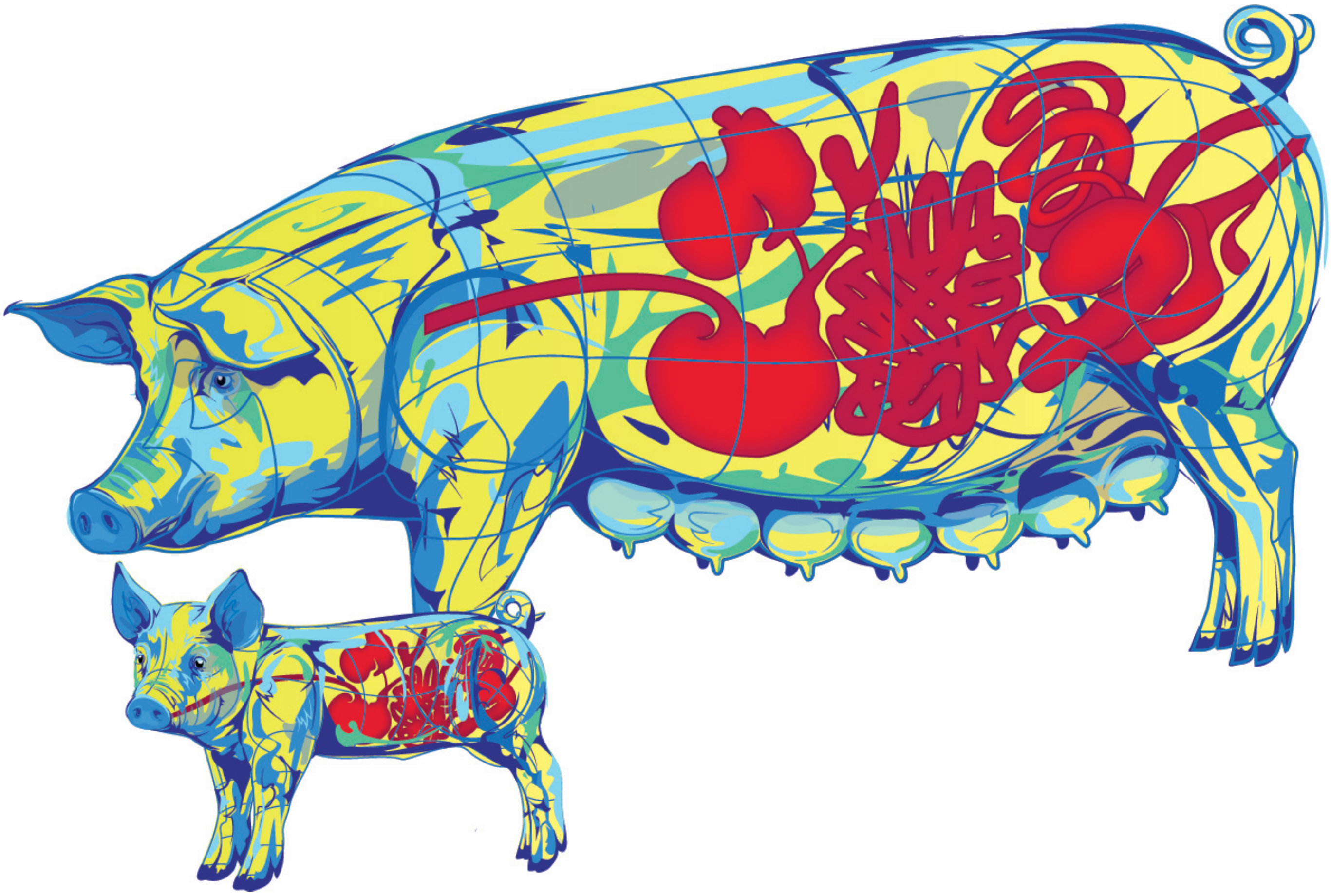
To know more about Gut health products click here.

INFOGRAPHIC: Healthy piglets after weaning



Piglet weaning is a critical period. When not properly managed, it leads to decreased performance, diarrhea, and sometimes mortality.
The six areas of intervention in our infographic will help pig producers manage these stressors, avoid diarrhea, and maintain piglet health and performance.

INFOGRAPHIC: Why large litters could mean higher mortality



The benefits imprinted by genetics with more piglets/sows can be lost along the way to weaning. What can decrease performance and increase mortality in such cases? Why do higher litter sizes so often correlate with higher mortality?

Optimal conditions in the farrowing unit put piglets in pole position

The most important parameters for a pig producer are the number of healthy pigs weaned/sow/year and their weaning weight. Due to improved genetics, it is possible today to find production systems that deliver more than 30 pigs weaned/sow/year. Strategies to increase sow productivity need to take into account the management, feeding, and health of both the piglets and the sows.

Pigs’ start in life – limited energy reserves and practically no immune protection

It is generally known that pigs are born physiologically immature. Their energy reserves are limited. They only possess 1-2 % fat, the main part of which is subcutaneous or structural fat protecting organs, joints and skin. Thus, the young pigs depend on the glucose of the glycogen deposits in the liver as main source of energy. This energy supply only meets their requirements for the first few hours.
Besides that, pigs cannot count on maternal antibodies. Unlike in humans, a sow’s placenta is not built to enable the transfer of these protective cells within the womb. At birth, the amount of protective cells in a pig’s intestine, the main site of pathogenic contamination, is therefore virtually zero. As they are born without any immune protection, new-born pigs rely on an early supply of antibodies from the maternal colostrum. During the first 24-36 hours after birth, antibodies are absorbed in the intestine and pass directly to the bloodstream. The intestinal barrier then closes. Importantly, the content of antibodies in the colostrum decreases with every hour after birth.

Prevention – the best way to protect the progeny!

Given this difficult situation in the early stages of life, it is clear that the farrowing unit should be as comfortable as possible for the young animals:

- It should be warm, as low temperatures contribute to hypoglycemia. The search for body heat at the sow additionally increases the risk of crushing, one of the main causes of pig losses. The problem arising here is that sows and the new-born pigs have different temperature requirements. One good solution is a heat lamp, installed specifically for the piglets.
- It should be clean, and pathogenic pressure should be as low as possible. Due to their poor immune status, young pigs are susceptible to diarrhea-causing pathogens like E. coli and Clostridium perfringens during their first days of life. In order to meet hygiene requirements, the first step is a careful cleaning and disinfection of the farrowing unit prior to placing the sows/gilts.

Sows’ manure – the first source of contamination

Cleaning both the farrowing unit and also the sows/gilts before placing them is helpful. Producers, however, have to understand that a sow is continuously shedding pathogens through her feces and that her young come into contact with them. In fact, sow manure is the first source of contamination for new-born pigs.
There are several methods to decrease pathogens within the sow’s gut. Feeding them natural substances such as probiotics or phytomolecules (also known as secondary plant compounds) in order to improve gut health is one possibility: beneficial microbes such as lactobacilli or bifidobacteria compete with pathogens such as E. coli or clostridia for nutrients and prevent their proliferation. Phytomolecules such as carvacrol and cinnamaldehyde, on the other hand, were found to have antimicrobial properties.
Could feeding them egg immunoglobulins be another possibility?

Egg immunoglobulins – the key to reduce pathogenic pressure?

Yokoyama et al. (1992 and 1997) already showed that immunoglobulins from eggs applied to piglets bind to pathogens within their intestinal tract. If they also bind pathogens in the sow’s gut – generating harmless complexes – this could be the key to reduce pathogenic pressure in the farrowing unit.

Trial

Method

To evaluate this possibility a trial was conducted in Japan. Two groups of eight sows were used. The sows of the control group received standard lactation feed. The trial group was also fed standard feed, but additionally received a supplement containing egg powder product (EPP) with immunoglobulins* at a dosage of 5g/sow twice daily during the last ten days before and the first seven days after delivery. The feces of the sows were obtained by rectal stimulation (in order to rule out contamination from the environment) on day 10 before and day 7 after delivery. The amount of colony-forming units (CFU) of total E. coli, E. coli O141 and Clostridium perfringens was determined.

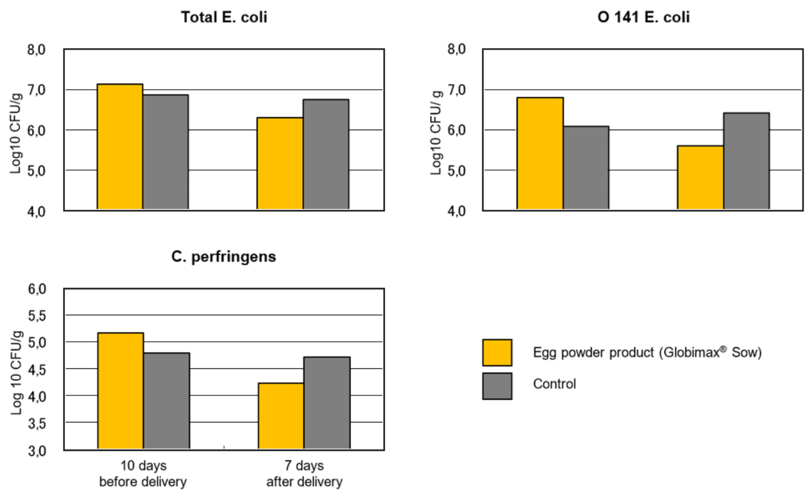
Results
The results are shown in figure 1. At the beginning of the trial, before the application of the EPP, both groups showed nearly the same level of the pathogens evaluated, with a slight disadvantage for the EPP group. After 17 days of using the EPP, the sows of the EPP group showed lower levels of pathogens in their excrements than the sows of the control group. A reduction in the colony-forming units of total Escherichia coli (from 107.12 to 106.3), Escherichia coli O141 (from 106.8 to 105.6) and of Clostridium perfringens (from 105.17 to 104.24) could be seen.

*The product used in this trial was Globimax® Sow, EW Nutrition.

Egg immunoglobulins – a tool to optimize conditions in the farrowing unit

It is important for pig producers to understand how they can combat adverse influences on their animals' performance. The results of this trial showed that supplementing the standard sows' diets with the EPP substantially reduced the amount of pathogenic colonies in sow's manure. Reducing pathogenic pressure in the farrowing unit is central to reducing the incidence of diarrhea and pre-weaning mortality. Giving young pigs the best possible start in life sets them up for delivering the best possible performance – and more healthy and heavy pigs weaned/sow/year means a more profitable farm.

Figure 1: Amounts of total E. coli, O 141 E. coli and Clostridium perfringens in the feces of sows 10 days before delivery (before the first application of EPP) and 7 days after delivery (after the last application of EPP)



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