Managing ABC-4: A KEY FACTOR IN PIGLET NUTRITION

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Managing the acid-binding capacity at pH 4 (ABC-4) is an overlooked but powerful tool to improve post-weaning piglet performance. Recent trials show that optimizing ABC-4 enhances growth, stabilizes gut health, and reduces diarrhea, providing a practical alternative to pharmacological ZnO.

Premature weaning of piglets in regions such as North America and Asia presents significant challenges due to the immaturity of the gastrointestinal tract. The transition from liquid to solid diets, low hydrochloric acid secretion, limited lactic acid fermentation, and irregular feeding patterns all contribute to heightened weaning stress. These factors raise stomach pH and increase susceptibility to digestive issues. As a result, piglets struggle to maintain the acidic gastric environment needed for optimal pepsin activity (pH 2.0–3.5), leading to protein indigestion, diarrhea, and greater risk of pathogen proliferation.

Traditionally, a particular strategy to address these challenges has been the use of antibiotics or pharmacological doses of zinc oxide (ZnO). Both approaches are known to reduce post-weaning diarrhea and improve growth performance, gut health, and microbiota balance. However, the extensive use of both antibiotics and ZnO has raised significant concerns, as both can contribute to the development of antimicrobial resistance, while high ZnO inclusion levels also lead to excessive mineral excretion and environmental pollution. These limitations have encouraged the search for alternative strategies that can address the underlying causes of post-weaning diarrhea.

One promising approach is managing the diet's acid-binding capacity to maintain gastric acidity. Ingredients with low buffering capacity help sustain acidic conditions, supporting digestion and piglet performance. This concept is quantified through Acid Binding Capacity at pH 4 (ABC-4), which measures the amount of acid (mEq HCl/kg feed) needed to lower feed pH to 4. Maintaining a pH below this threshold is critical, as it inhibits the growth of harmful organisms and optimizes protein digestion.

Ingredients vary widely in ABC-4 values (Figure 1). Protein-rich meals (soybean, rapeseed, fish) and mineral sources (calcium, sodium, zinc) tend to have high ABC,

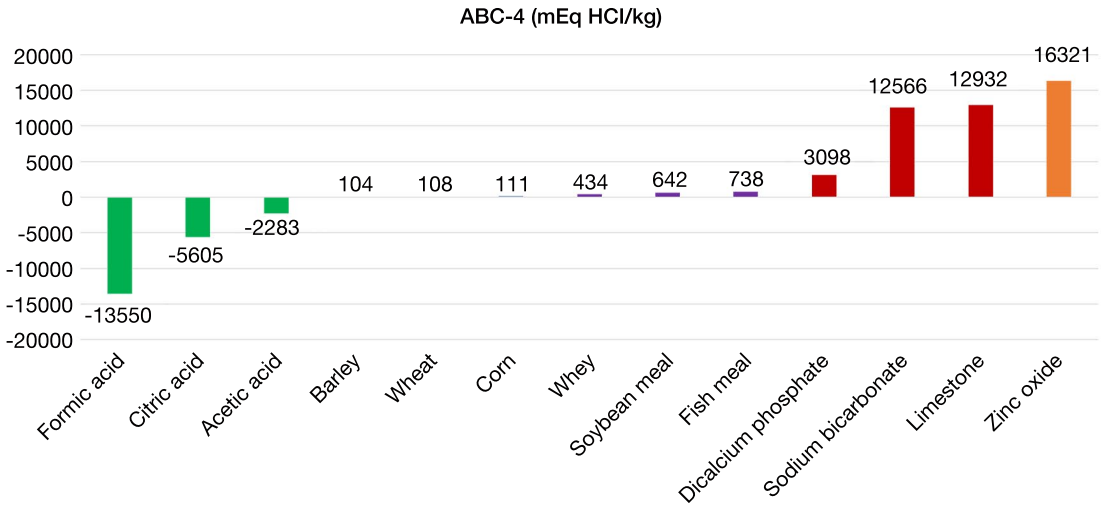

Figure 1. ABC-4 values of some commonly used feed ingredients Lawlor et al., 2005

absorbing large amounts of gastric acid and weakening the stomach's natural defense. In contrast, organic acids exhibit a negative acid-binding value and can offset the adverse effects of high ABC ingredients. Among mineral additives, ZnO is particularly notable, with one of the highest reported ABC-4 values (16,321 mEq HCl/kg). Consequently, inclusion of ZnO at pharmacological levels or the use of certain calcium sources can sharply increase the acid-binding capacity of the diet.

Managing the ABC-4 of the feed is being evaluated as an alternative to replace the pharmacological levels of ZnO. Kansas State University (KSU) has extensively evaluated the role of ABC-4 in weaned piglet diets. Their studies suggest an optimal range of 200–300 mEq HCl/kg, with phase-specific recommendations: 200–250 mEq for phase 1 (0–10 days) and 250–300 mEq for phase 2 (11–24 days) post-weaning. Staying within this window helps maintain gastric function and piglet performance, offering a viable alternative to pharmacological ZnO without compromising results (Stas et al., 2022).

A potentiated zinc oxide source (PZnO, Animine, France), supported by over 30 globally published papers, possesses unique physicochemical properties such as intermediate density, large particle size, and high specific surface area. These features enhance antibacterial activity and bioavailability, making it effective at much lower inclusion levels compared with standard ZnO doses of 3–4 kg/ton of feed. Building on this, KSU conducted a 24-day study in which low ABC-4 diets were combined with increasing doses of PZnO (Table 1), as a potential

Table 1. Zinc sources* at different dosages with the corresponding ABC-4 values

Treatment	Phase 1 (0 to 10 d)	Phase 2 (11 to 24 d)
	Zn, mg/kg / ABC4, mEq HCl/kg	Zn, mg/kg / ABC4, mEq HCl/kg
Positive control (ZnO)	3000 / 296	2000 / 306
PZnO 150/150	150 / 209	150 / 253
PZnO 500/300	500 / 221	300 / 258
PZnO 800/500	800 / 230	500 / 265

**Zinc sources : ZnO = Standard ZnO, PZnO = Potentiated Zinc Oxide (Animine, France)*

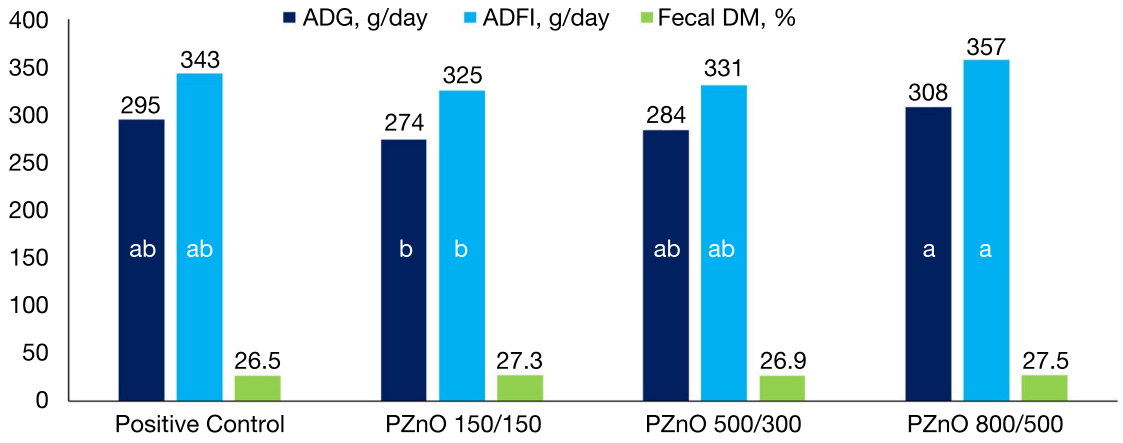

Figure 2. Production performance and fecal consistency of post-weaning piglets at day 24 (P-value < 0.05)

alternative to pharmacological levels of ZnO. The study aimed to evaluate the effect of these diets on the production performance and fecal consistency of weanling piglets.

The results were clear: increasing PZnO improved average daily gain and feed intake across the trial, while feed efficiency was particularly improved in phase 1. Importantly, piglets receiving either PZnO or high ZnO showed firm fecal consistency, with dry matter content above 26%, indicating good gut stability (Figure 2). These results demonstrate that lower doses of PZnO, even at European Union regulated inclusions, can achieve the same positive outcomes as pharmacological ZnO, in terms of feed intake, growth rate, feed efficiency, and diarrhea control, while managing diets within the optimal ABC-4 range of ~250 mEq HCl/kg.

To validate findings under commercial-like conditions, a complementary trial was conducted in Spain to further explore the effects of ABC-4 on piglet performance, and combining PZnO at EU-regulated level of 150 ppm, with the same range of dietary ABC-4 levels: 180/220, 253/280, 327/340, and 400/400 mEq HCl/kg (Phase 1/ Phase 2, mEq HCl/kg). Together with PZnO supplementation at an EU level, growth data revealed a clear linear effect of ABC-4 on piglet performance (Figure 3). Body weights and average daily gain (ADG) declined progressively as ABC-4 increased, with piglets on the lowest ABC-4 consistently gaining more weight compared with those fed high-buffering diets. Interestingly, feed intake (ADFI) showed the same pattern during Phase 2, with piglets consuming less feed as dietary ABC-4

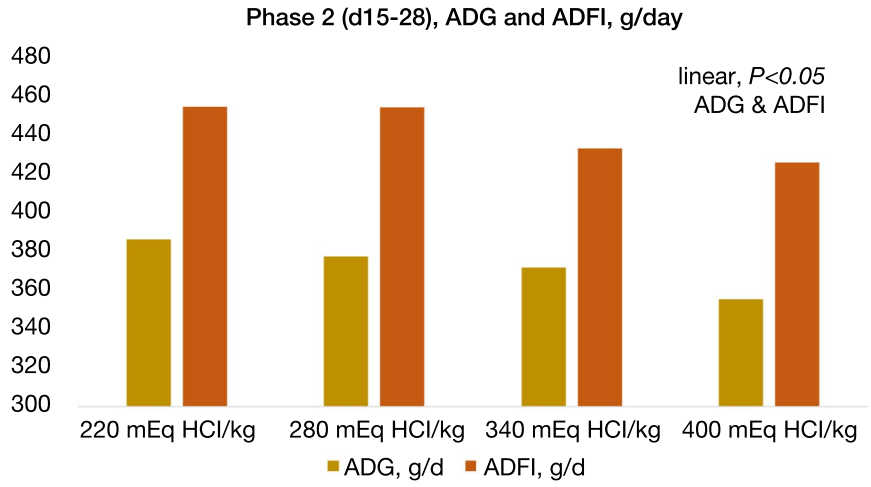

Figure 3. Production performance of post-weaning piglets with PZnO at 150ppm and increasing ABC-4 values at day 28 (linear, P-value < 0.05)

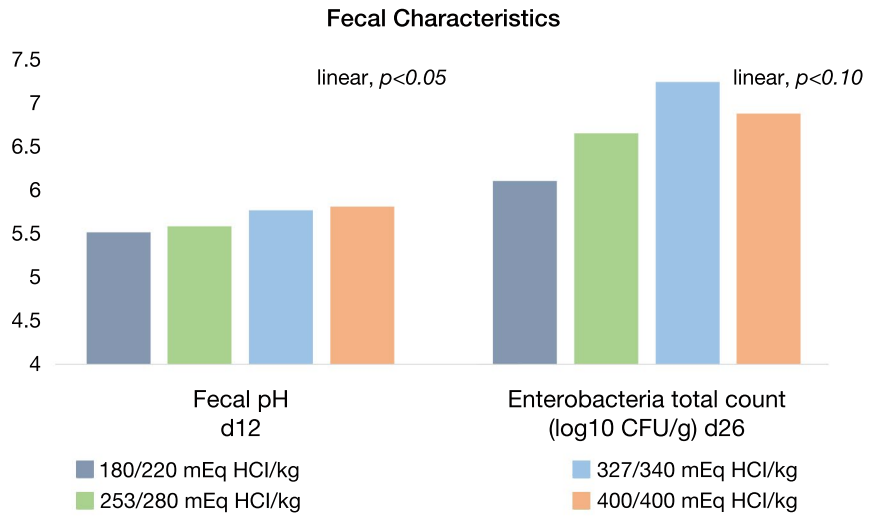

Figure 4. Fecal characteristics of piglets fed with increasing ABC-4 values (linear, P-value < 0.05; <0.10)

increased. This indicates that reduced performance was not only a matter of nutrient utilization but also of lower voluntary intake under high acid-binding conditions. Despite these differences in intake and growth, feed conversion ratio (FCR) remained statistically unaffected.

Fecal indicators highlighted the impact of high-buffering diets on gut health. During Phase 2, higher ABC-4 values increased fecal looseness and diarrhea frequency, with piglets on 400 mEq HCl/kg diets showing the highest incidence of diarrhea. While fecal dry matter was not consistently affected, increasing ABC-4 led to a linear increase in fecal pH (Figure 4). Higher fecal pH suggests reduced fermentation activity in the hindgut and can be an indirect measure of volatile fatty acid (VFA) concentration, where higher pH might indicate lower VFA production and inhibition of growth of pathogenic bacteria. By day 26, a linear tendency ($P < 0.10$) was observed for total enterobacteria counts, suggesting that higher ABC-4 levels may predispose to increased bacterial load. Although not statistically significant, this trend supports the observed increase in fecal pH and diarrhea frequency at 400 mEq HCl/kg, suggesting a potential destabilizing effect on gut microbiota at excessive buffering levels.

In summary, these studies confirm that ABC-4 is an important yet forgotten factor in piglet nutrition. Diets with excessively high acid-binding capacity compromise growth performance and gastric acidity, increasing diarrhea risk and microbial imbalance. Conversely, maintaining ABC-4 between 200–300 mEq HCl/kg supports digestion, growth, and gut stability. Practical implementation requires careful management of acid-binding ingredients and the strategic inclusion of mineral in the piglet diets. Producers can reduce reliance on antibiotics and ZnO while keeping piglets growing steadily. The use of potentiated zinc oxide at EU-regulated levels allows diets to reach these optimal ABC-4 values while maintaining growth and minimizing diarrhea, offering a sustainable alternative in the post-ZnO era.