Coping with challenges in the pig's intestinal tract

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Many years of intensive research have considerably improved our understanding of the functional development of the digestive tract of the pig during the early stages of post-natal life. However, in commercial pig production the translation of this understanding into practical nutrition and feeding systems for weaner pigs remains a problematic issue.

Conventional wisdom suggests that if we provide weaners with a diet composed of highly digestible ingredients, we have the best chance of minimising bacterial challenge and maximising growth, especially if the piglets are adapted to such a diet by creep feeding before weaning. However, highly digestible diets are costly.

Furthermore, the more refined the starter diet the more problematic is the onward transition to a conventional grower diet. Giving the piglets too good a start may simply delay the onset of digestive upset and bacterial challenge and make them more vulnerable to subsequent diet changes.

As a way of ameliorating the dietary challenges, nutritional programs for young pigs have relied heavily on the inclusion of antimicrobial compounds, particularly antibiotics and zinc oxide, in piglet feeds. However, the prudence of using such compounds is increasingly challenged in all parts of the world, resulting in their prohibition in many countries, particularly those of the EU. There is a need therefore to search for improved feeding strategies and alternative products to assist piglets in the transition from suckling to grower diets.

One valuable line of approach focuses on the central importance of the intestinal microflora and its varied influences on the functionality of the digestive tract of the pig, including regulation of epithelial cell turnover, competition for ingested nutrients, modification of digestion, competitive exclusion of pathogens, as well as metabolism of mucus

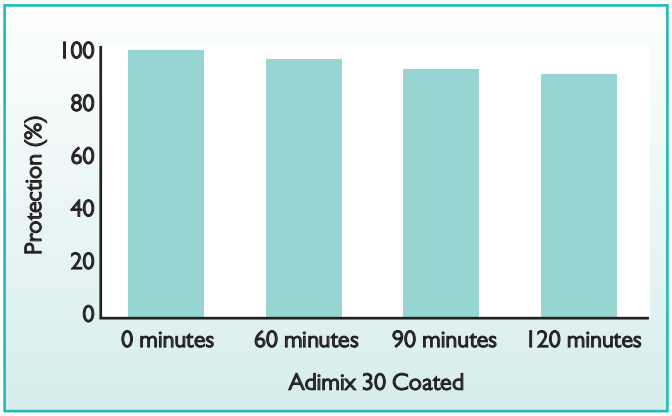

Fig. 1. Protection provided by coating, measured as the release of sodium butyrate at 39° whilst shaking in aqueous medium at pH 3.5.

secretions and modulation of mucosal immunity. There has been considerable work on the influence of short-chain fatty acids on the intestinal microflora.

A particularly promising innovation is dietary supplementation with sodium butyrate, with positive effects found in many animal species, including piglets, broilers, and layers, on both performance and health status. These effects appear to be mediated, partly at least, through effects on the intestinal bacterial population.

Sodium butyrate benefits

Sodium butyrate is a short-chain fatty acid with very specific characteristics. In particular, it is miscible in both water and fat and can pass the cell-membrane of both Gram negative and Gram positive bacteria.

Sodium butyrate has been found to have a positive influence on the growth of bacteria that have a beneficial effect on the gut environment, such as Bifidobacterium sp. and Lactobacillus sp., whilst causing regression of harmful bacteria, such as E. coli, salmonellae and clostridia.

Whereas most traditionally used organic acids function only in the animal's stomach or crop, sodium butyrate shows a strong anti-bacterial effect in the small intestine.

In addition to its selective action on intestinal bacteria, sodium butyrate also has positive influences on cell metabolism and the immune system.

The intestinal mucosa of the piglet has been much studied and it is well known that the integrity of the villi is the key to optimal mucosal enzyme secretion and nutrient absorption.

The post-weaning 'growth check' in piglets is characterised by villous shortening, crypt elongation and reduced enzyme activity. As a result, the digestive and absorptive capacity of the small intestine after weaning is much reduced.

Sodium butyrate enhances epithelial cell growth and differentiation, and increases the proliferation index in the intestinal crypts. The positive influence of sodium butyrate on body weight gain, feed utilisation and composition of intestinal microflora in piglets was first demonstrated by Galfi and Bokori (1990).

In a trial conducted in Australia, D. J. Henman and colleagues found that feeding sodium butyrate in the form of Adimix C in the weaner diet significantly improved growth rate and feed conversion.

This was most likely due to a better utilisation of nutrients, since there was only a slight trend for improved post-weaning feed intake.

Principle of target release

Butyric acid perhaps represents a special case but the beneficial effects of various free organic acids, including also fumaric, citric and lactic acids, in piglet diets is well recognised; improvements in protein digestibility after weaning, bacterial control in feed and in the first part of the digestive tract have been demonstrated.

However, as free organic acids are readily absorbed in the upper digestive tract they generally have little or no role to play beyond the upper small intestine.

With this limitation in mind, a specialised production technique has been developed by which appropriately selected organic acids are

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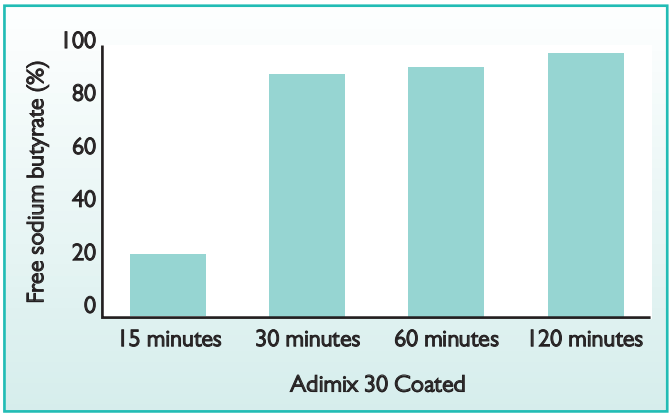
Fig. 2. The release of sodium butyrate in the presence of lipase at 37°C and pH 7.0.



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encapsulated, resulting in their slow release during passage to the more distal regions of the gut.

Different organic acids can be selected for specific functions; as an energy source for the epithelial cells to support nutrient absorption; for bacterial control to optimise intestinal micro-flora; to inhibit adhesion of pathogens to the mucus and to avoid invasion of pathogens into the body.

The production process involves encapsulation in a vegetable fat matrix. The coating has a melting point above body temperature and is hydrolysed by lipases. The enzymatic hydrolysis becomes more effective at the more neutral pH pertaining in the jejunum, ileum and the large intestines.

In vitro simulations are shown in Fig. 1 and Fig. 2, representing the stomach and the more distal regions of the gut, respectively.

The composition of the coating matrix and the method of encapsulating the active molecules are critical in ensuring the target release of the active principles throughout the digestive tract where they are required.

A trial was conducted at the University of Bologna and involved 54 21-day old weaned piglets which had been identified as susceptible to Escherichia coli k88 (ETEC) intestinal adhesion.

These were divided into two groups, one of which was challenged with ETEC, whilst the other group remained unchallenged.

Sub-groups of the challenged and unchallenged piglets were given a control diet or a diet supplemented with sodium butyrate (Adimix C) or a diet supplemented with fat-protected sodium butyrate (Adimix 30 Coated). Mortality rates in the challenged group were; 15% on the control diet, 5% with Adimix C and 0% with Adimix 30 Coated.

Whilst the growth performance of all three challenged groups was poorer than that of the unchallenged counterparts, those given the target release sodium butyrate (Adimix 30 Coated) grew 95% faster than the challenged controls, whilst those given the uncoated sodium butyrate (Adimix C) grew 39% faster.

This trial clearly demonstrated the beneficial effects of sodium butyrate and further demonstrated the enhanced effect due to its target release.

	First phase diet		Second phase diet	
	27-32 days	32-42 days	42-60 days	60-70 days
Negative control				
Zinc oxide (ppm)	3100			
Positive control				
Zinc oxide (ppm)	3100	3100	3100	3100
Treatment				
Zinc oxide (ppm)	3100			
Sanacore En (kg/tonne)	3.0	3.0	1.5	1.0

Table 2. Description of treatments in a trial comparing zinc oxide and a target release product containing sodium butyrate and botanicals (Sanacore En).

Table 1. Effects of replacement of antibiotics with a target release product containing sodium butyrate and botanicals in a piglet starter diet from 28-41 days.

	Control (antibiotics)	Treatment (Sanacore En)
Body weight at 28 days (kg)	7.34	7.34
Average daily feed (g)	349	346
Average daily gain (g)	313	288
Body weight at 41 days (kg)	11.87	11.35
Incidence of diarrhoea (%)	0	<0.5

Spanish trial

A second trial was done on a farm in Spain which had ongoing problems with dysentery. Pigs were given standard weaner, grower and finisher diets from weaning to slaughter, supplemented with either a free organic acid combination (Product T) or a target release combination of sodium butyrate and botanicals (Sanacore En).

The pigs given the target release

product grew consistently faster throughout the trial and reached slaughter weight (103kg) seven days earlier than those given the free organic acid mix. Feed intakes were similar so the faster growth resulted from more efficient use of feed.

Two further trials have been carried out demonstrating the effects of the target release combination of sodium butyrate and botanicals (Sanacore En).

The set-up of the first trial was as follows:

- Piglets weaned at 21 days.
- 2 x 456 piglets (12 pens of 38 piglets/treatment).
- First phase: 21-28 days; no medication; 5kg plasma powder per tonne of feed.
- Second phase: 28-41 days:

– Control (antibiotics): Colistine + chlortetracycline.
– Treatment (no antibiotics): 3kg/ton Sanacore En.

The results are shown in Table 1. In this trial the piglets given the target release sodium butyrate plus botanicals consumed slightly less feed and grew rather slower than the piglets given antibiotics.

Importantly though, the incidence of diarrhoea was very low in both groups: there was no diarrhoea in the control (antibiotic) pigs whilst only two of the treatment (Sanacore En) pigs exhibited diarrhoea.

It seems likely that both groups of pigs were somewhat challenged at 28 days since they had received no medications in the diet from weaning at 21 days until the start of treatments at 28 days. In this situation it is perhaps not surprising that antibiotic supplementation was somewhat superior to the non-antibiotic treatment. Nevertheless, it was shown that satisfactory health and performance can be achieved when antibiotics are replaced by Sanacore En.

Further testing

A further trial was conducted in Spain in early 2009, in which the effects of including either zinc oxide or a target release product containing sodium butyrate and botanicals (Sanacore En) were compared.

At 26 days of age a total of 165 piglets were housed in an environmentally controlled nursery in 12 pens each holding 13-14 animals. Each pen was allocated to one of three dietary treatments and the trial set-up was as shown in Table 2.

During the trial, several pigs showed signs of colibacillosis and were treated with enrofloxacin, including 16 piglets in the zinc oxide group and 29 piglets in the Sanacore En group.

The additional cost of this medication amounted to €0.13/piglet for the Sanacore En group and €0.07/piglet for the zinc oxide group.

The results of the trial are shown in Table 3. Sanacore En was considerably more effective than zinc oxide in terms of growth performance. Feed intake was 14% higher, growth rate 9% higher and FCR 4% better, resulting in pigs which were 1.6kg heavier at 70 days with Sanacore En, compared with zinc oxide.

Only small differences were seen between the zinc oxide treatment and the negative control in this trial. It appears that the role of zinc oxide has more to do with protecting health rather than growth enhancement. It was noted that the additional medication costs were lower with zinc oxide than with Sanacore En. Nevertheless, it can be calculated that the commercial benefit of Sanacore En was considerably higher than that of zinc oxide.

Taking into account the higher cost of Sanacore En compared with zinc oxide (+€0.12/piglet) and the higher cost of extra medication (+€0.06/piglet) the net profit with Sanacore En was €1.94/piglet higher than with zinc oxide, assuming a piglet price of €1.33/kg.

Table 3. The response of piglets from 27 to 70 days of age given diets supplemented with zinc oxide or sodium butyrate and botanicals (Sanacore En) compared with a negative control diet.

	Control	Zinc oxide	Sanacore En
Feed intake (g/day)	490	489	535
Growth rate (g/day)	254	264	301
Feed conversion (g feed/g gain)	1.93	1.85	1.77
Body weight at 70 days	18.09	18.50	20.12

Conclusions

Considerable advances are being made in the development of alternative strategies to cope with challenges in the intestinal tract of young pigs. Organic acids, particularly sodium butyrate, can be beneficial in regulating the balance of the intestinal microflora, maintaining the integrity of the villi and mucosa and improving nutrient absorption, thereby improving piglet performance. The effectiveness of sodium butyrate and other potential gut modulators can be enhanced by protecting them from absorption or degradation in the stomach and ensuring their progressive release in the more distal target regions of the tract. ■