Target release acidification to enhance performance

by Koen Schwarzer, Nutri-Ad, Hoogveld 93, 9200 Dendermonde, Belgium.

Changes in animal nutrition and livestock production by availability of raw materials, consumer concerns, regulatory issues and profit analysis have encouraged pig producers to review the composition of feed.

Unfortunately, there has also been a resultant return in intestinal diseases; enteritic, diarrhoea, dysentery, colibacillosis and salmonella that were less seen before.

Producers are now faced with new challenges; reformulations of the feed, developing an antibiotic free production system, while maintaining cost effective growth rates.

Understanding how antibiotic growth promoters (AGPs) work is not clear. It is widely assumed they mainly act through their effect on intestinal microflora. With less than 10% of intestinal microflora identified, there has been little chance of fully understanding the AGP's mode of action.

However, the intestinal microflora has important and differing effects on the pig, including regulation of epithelial cell turnover, competition for ingested nutrients, modification of digestion, competitive exclusion of pathogens and metabolism of mucus secretions and modulation of mucosal immunity.

A promising innovation is dietary supplementation with sodium butyrate (Na-butyrate), with positive effects found in piglets on both performance and health status.

Na-butyrate is a short chain fatty acid with very specific characteristics. Its uniqueness is that the active substance is miscible in both water and fat and it can pass the cell membrane of both Gram negative and Gram positive bacteria, but also has a positive influence on growth of good natured bacteria, such as Bifido and Lactobacillus bacteria and the regression of bad natured bacteria, such as, E. coli, salmonella and clostridia.

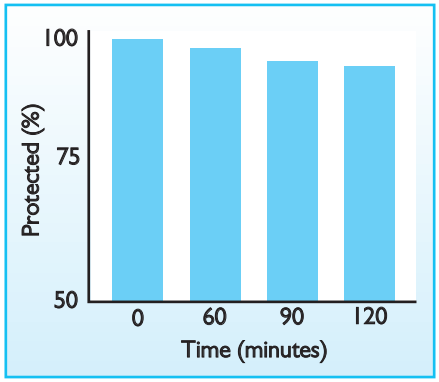

Fig. 1. The protection rate of the coating releasing sodium butyrate at 39°C at pH of 3.5.

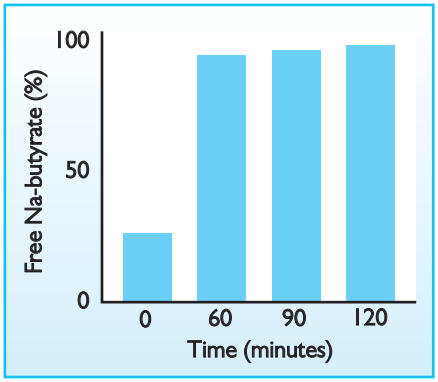

Fig. 2. The release of Na-butyrate in the presence of lipase at a pH of 7.0 and at 37°C.

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

Na-butyrate has various biological functions, such as positive influences on cell metabolism, the immune system and the selective action on bacterial microflora.

Inside the small intestine there is a system to maximise the surface for absorption (200-300m^2 for a four week old piglet). This system of intestinal folds, villi and microvilli also releases several important enzymes for carbohydrate and protein digestion.

Table 1. Mean ± SE of piglets from unsupplemented or Na-butyrate treatment on the number of pigs weaned and post weaning performance 0-20 days.

	Control	Na-butyrate	Significance
Total piglets day two	587	580	
Total piglets weaned	494	511	P+0.051 χ(3.84)
Piglet weight at weaning (kg)	8.6±0.12	8.7±0.12	NS
20 day weight (kg)	14.0±0.20	15.15±0.22	**
Rate of gain (g/d)	273±7.6	320±8.0	**
Feed conversion ratio (g feed/g gain)	1.45±0.021	1.34±0.022	**
Daily feed intake (g/d)	397±11	427±9	NS

***P<0.01; NS: P>0.05 mean values not significantly different within rows.*

Newly weaned piglets face a problem of damage of the villi, resulting in poor enzyme production and an enormous loss of surface for absorption of nutrients.

Na-butyrate is a 'source of energy for fast dividing cells' and stimulates the recovery of damaged villi through immediate cell renewal. It increases the length of intestinal villi in weaned piglets, thus improving their capacity to digest and absorb nutrients and limiting the growth of pathogenic bacteria, such as E. coli.

Supplementation with Na-butyrate can offer an effective and economically attractive solution to overcome post weaning problems. In piglets, the post weaning 'growth check' is characterised by villous shortening, crypt elongation and reduced enzyme activities. As a result, the digestive and absorptive capacity of the small intestine after weaning is strongly reduced.

Na-butyrate affects epithelial cell growth and differentiation and increases the proliferation index in the intestinal crypts and thereby reveals trophic effects on the gut mucosa. Galfi and Bokori (1990) were the first to show the positive influence of Na-butyrate on body weight gain, feed utilisation and composition of intestinal micro flora in piglets.

The aim of a trial in Australia was to determine if the supplementation of Na-butyrate in the diet of lactating sows and post weaning diets improves the litter viability and increases post weaning growth rates.

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Some 108 commercial F1 mixed parity sows (2.7±0.13; mean ± SE) were selected and individually housed in a farrowing shed. For three days prior to farrowing until 25 days of lactation the sows were fed either a standard lactating diet (Control) or a diet supplemented with 0.1% Na-butyrate in the form of Adimix C.

Litter size was standardised within two days of birth and was similar between litters (10.4 ± 0.1; mean ± SE). Weaned at 25 days of age, 120 male and 120 female weaners were randomly selected from each sow treatment, housed in pens of 10 piglets and continued on their respective dietary treatment from the day of weaning.

The weaning diets with Na-butyrate were supplemented with Adimix as follows: 0.2% until day seven post weaning, then 0.15% at 7-14 days and 0.1% at 14-21 days post weaning. The data was analysed by General Linear Model ANOVA with the exception of piglet populations at day two and at weaning (Chi square).

This trial showed a numerical increase in the number of pigs weaned per sow with the addition of Na-butyrate as Adimix C to the lactation diet of 0.4 piglets per sow but this was not statistically significant.

Group	Average daily gain (g)
Control No challenge	328
Adimix C No challenge	311.9
Adimix 30 coated No challenge	428.8
Control + challenge	191
Adimix C + challenge	266
Adimix 30 coated + challenge	373

Table 2. Average daily gain of non-challenged and challenged piglets with ETEC at end period.

There was no significant difference in weaning weight between treatments. Feeding Na-butyrate in the weaner diet significantly improved the growth rate and feed conversion, with a trend for improved average daily feed intake (p=0.068) 0-20 days post weaning. There were no treatment differences (P>0.05) in losses or ill thrift after weaning.

The use of Na-butyrate in the lactation diet and weaner diet increases the number of pigs weaned and improves the growth performance of pigs post-weaning most likely due to a better utilisation of nutrients.

Pig diseases cause pain and distress to the animal and also significantly reduce their profitability, either through reduced productivity or, in severe cases, through the premature death of the infected animals.

Enteric diseases, which affect the gut, cause lack of appetite, wasting and diarrhoea in affected pigs. Three significant enteric diseases affecting pigs are Ileitis, colitis and swine dysentery. Respiratory diseases affect the lungs, causing slow growth or even premature death of infected pigs.

The weaning of piglets is associated with profound changes in the structure and functions of the gastrointestinal tract. These perturbations can favour infection by enterotoxigenic strains of E. coli and lead to post weaning colibacillosis (PWC).

Although PWC can be controlled by the use of in feed antibiotics and minerals, such as zinc, antimicrobial resistance is increasing and concerns are being expressed about the routine use of antimicrobials in swine production. Post weaning colibacillosis is a multi-factorial disease and its expression is influenced by the diet.

The beneficial effect of free organic acids in piglet diets is well known throughout the last few decades; improving protein digestibility after weaning, bacterial control in feed and in the first part of the digestive tract.

As free organic acids are readily absorbed in the upper digestive tract they have to be protected to pass through the stomach to be able to play a role in the hind gut.

Therefore, an explicit production technique has been developed by which well selected organic acids are encapsulated, resulting in a slow release of the acids during transport throughout the hind gut.

Different organic acids are elected for particular functions; as energy source for the epithelial cells assuring nutrient absorption, as bacterial control to optimise intestinal microflora, to avoid adhesion of pathogens to the mucus and to avoid invasion of pathogens into the body.

Short chain fatty acids (SCFA), as well as lactic, citric and fumaric acid are readily absorbed in the upper digestive tract.

Therefore, specific production techniques have been developed in which short chain fatty acids are encapsulated in a vegetable fat matrix, resulting in a slow release of the acids during transport through the intestinal tract.

The coating with a melting point above body temperature is hydrolysed by lipases.

The enzymatic hydrolysis becomes more effective at a more neutral pH such as in the small and large intestines.

An 'in vitro' simulation is shown in Fig. 1 (stomach) and Fig. 2 (small and large intestines).

The coating matrix and the way of encapsulating the active molecules is essential for the target release. The active principles have to be liberated throughout the digestive tract where they are required.

The influence of the target released concept has been demonstrated in research facilities and under practical field conditions.

Challenge trial

The effect of free (Adimix C) or fat protected sodium butyrate (Adimix 30 coated) supplemented to the diet, on growth performance, health, immunity and gastrointestinal functionality, of Escherichia coli K88 challenged weaning pigs has been investigated at the University of Bologna.

Pigs were individually penned in cages, except for the two first days when they were kept in groups of four, to improve their adaptation and feed intake.

Some 54 piglets (three control groups of six animals and three challenged groups of 12 animals, balanced for litter and weight) weaned at 21-28 days were used (day 0 of the experiment), housed in weaning rooms with controlled temperature and ventilation.

Continuous access to feed and water was allowed throughout the trial.

Pigs were obtained from litters where at least one pig was sacrificed and found positive for susceptibility to Escherichia coli k88 (ETEC) intestinal adhesion, by in vitro test on the villi. This allowed most of the pigs prone to the ETEC intestinal adhesion to be obtained.

Piglets were fed the same base diet (standard prestarter diet) without antimicrobials, zinc oxide, or any kind of growth promoter.

Experimental diets were obtained with the addition of free or fat protected Na-butyrate.

Full factorial design of two factors (four diets x challenge – Yes/No).

Consequently the groups were:

- Base diet (six pigs).
- Base diet + 2kg/t Adimix C (Na-butyrate) (six pigs).
- Base diet + 2kg/t Adimix 30 coated (protected Na-butyrate) (six pigs).
- Base diet + challenge (12 pigs).
- Base diet + 2kg/t Adimix C (Na-butyrate) + challenge (12 pigs).
- Base diet + 2kg/t Adimix 30 coated (protected Na-butyrate) + challenge (12 pigs).

Experimental procedure

The groups were homogenised based on starting weight. All the pigs were supplemented for four days (day 0-3 morning) with colistin, just in order to ensure similar health conditions in the gut.

On day seven, each pig of groups 4-6 received an E. coli K88 oral dose of 5ml of a 3.109 CFU/ml solution.

Pigs of groups 1-3 received a placebo solution. Severity of diarrhoea was characterised by using the faecal consistency score system.

Samples of faeces were collected for the determination of total lactobacilli, E. coli and E. coli K88 plate counts at the start of the experiment and second, third and fourth day post challenge.

Pigs were sacrificed on days 13 + 1. The animals were deeply anaesthetised with sodium thiopenthal (10mg/kg body weight) and sacrificed by an intracardiac injection of Tanax (0.5ml/kg BW).

The procedures followed were carried out according to Italian law pertaining to experimental animals and approved by the Ethic-Scientific Committee for Experiments on Animals of the University of Bologna.

Pigs were weighed individually at the start of the trial and on day five and at sacrifice. Individual feed intake of each pig was registered. A sample of blood was obtained (to test anti k88-Immunoglobulin A levels) at start, at five days post challenge and at the end point. At sacrifice, the stomach and intestine were removed and weighed full and empty. The pH of the stomach, jejunum (at 75% of the small intestine) and colon were measured.

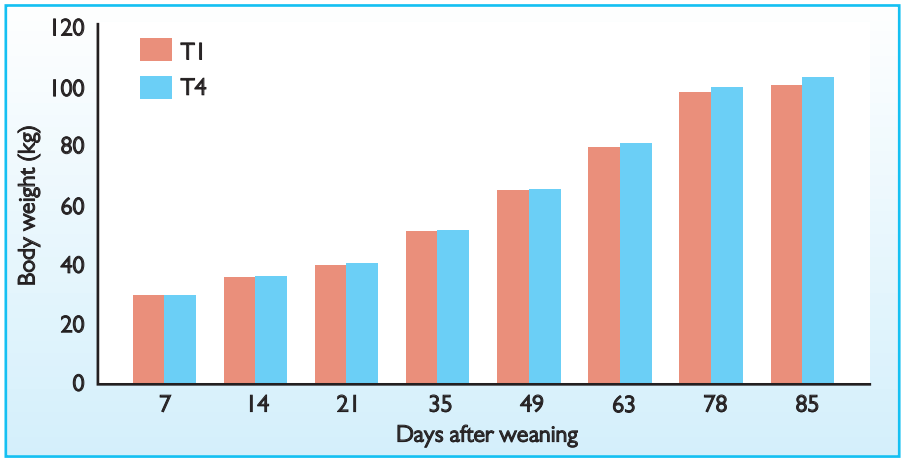

Fig. 3. Body weight days after weaning of pigs receiving organic acid combination (Product T1) in diet versus pigs recieving target released combination (Sanacore NE) in the diet.

Results

Mortality:

- 15% in the challenge control group, very high ETEC excretion before dead.
- 5% in the challenge + free Na-butyrate (Adimix C), high ETEC excretion before dead.
- 0% in the challenge + Adimix 30 coated group.

Performance:

The challenge with ETEC increased mortality in the control group certainly had an impact on the growth rate of the piglets.

The piglets receiving the free Na-butyrate in the diet showed a lower mortality rate and were to a lesser extent influenced in growth than the challenged control group.

In the group of piglets offered the target released Na-butyrate (Adimix 30 coated) in the diet none of the piglets died.

The growth rate was nearly influenced as it was still better than in the group of piglets, which were not challenged.

Trial with fattening pigs

The influence of diet supplementation of a free organic acid combination (Product T) and that of a target released combination of Na-butyrate/botanicals (Sanacore NE) was measured on the performance of pigs at a farm with historical dysentery problems.

Trial set-up:

- Eight replicates per treatment (two males and two females). Standard weaning diet: From weaning up to 30kg live weight. Grower diet: up to 60kg live weight. Finisher: from 60kg until slaughter.

Treatments:

- Standard weaning diet: T-1: Product T at 3kg/ton; T-4: Sanacore NE Dry at 2kg/ton.
- Grower feed: T-1: Product T at 2kg/ton; T-4: Sanacore NE Dry at 2kg/T.
- Finisher feed: T-1: Product T at 1kg/ton; T-4: Sanacore NE Dry at 1kg/T.

Results:

The liveweight of the pigs fed on a diet containing the target released product remained over the whole growing period superior towards the pigs recieving the diet with the free organic acid mix. The feed consumption in both treatments were very similar, which results in a slightly lower feed conversion ratio of the pigs receiving the target released product in the diet.

Conclusion

- Feed consumption in the Sanacore group had a steady increase over the whole period.
- The pigs supplemented with Sanacore showed the best growth rate during the whole period and yielded the highest weight at the end of the trial.
- The best overall performance was noticed in the Sanacore treatment.
- Best growth at low FCR.
- Reached similar weight (102.9kg) at 78 days post weaning as the other treatment (103.5) at 85 days post weaning, ie seven days earlier.

Changes in animal nutrition and livestock production by availability of raw materials, consumer concerns, regulatory issues, and profit analysis are common practice today.

Animal health can easily be challenged by a microbial intestinal disorder reducing animal performance as a consequence.

These target released concepts deliver the active principles where they have to function throughout the digestive tract to maintain a more optimal microbial balance and supporting nutrient digestion and uptake.

They assist in maintaining animal performance and animal health in a challenging and very competitive market. ■