Producing Pigs without Antibiotic Growth Promoters

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▪ Introduction

The growth-promoting properties of anti-microbial agents for farm animals were discovered in the late 1940s. The practice of feeding sub-therapeutic doses was very successfully adopted and became an integral part of developing nutritional strategies for all farm livestock. However, following the publication of the Swann Report in 1968, attention was drawn to the risk of bacterial resistance to certain antibiotics and the potential harm to both human and animal health. Since then, there has been increasing concern about the transmission of resistant bacteria and this has lead to a re-appraisal of the use of antibacterial agents in animal feeds and even their withdrawal. Indeed, the EU has suspended the licence for several major antibiotics used in animal feeds in July 1999. This will have an effect on performance and will almost certainly necessitate the development of new feeding, management and healthcare strategies.

The primary effects associated with the inclusion of anti-microbial feed additives are: prevention of digestive disturbances, improved feed utilisation and improved animal performance. Secondary effects include reduced nutrient waste, diminished environmental impact and reduced production costs. Indeed, in terms of the improved animal performance alone, the economic return of including these products is in the order of 5-10 : 1 and this has made them very cost-effective and economical to use. The major benefits associated with the use of in-feed antibiotics appear to result from a reduction in the microbial population within the gastro-intestinal tract, as well as a change from pathogenic towards beneficial bacteria. This results in better nutrient absorption, less substrate for the proliferation of pathogenic organisms and an improvement in the health status and integrity of the gastro-intestinal tract. In general, there is a 3-5% improvement in nutrient utilisation, a 3-8 %

improvement in growth rate, with a 2-5% improvement in feed conversion efficiency in growing-finishing pigs, with higher responses in piglets.

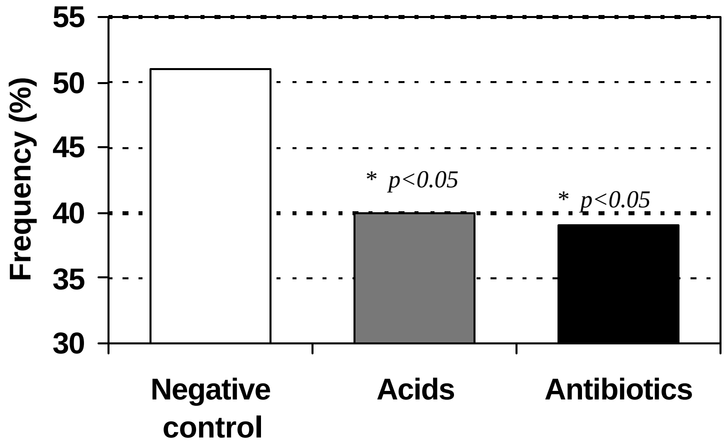
This paper considers the consequences of the removal of antibiotic growth enhancers in pig diets and examines alternative strategies that are available as replacement products. Alternative strategies include:

- Diet Acidification
- Oligosaccharides
- Enzymes
- Herbs/Flavours
- Minerals
- Probiotics/Yeasts
- Non-starch Polysaccharides (NSP)
- Protein and Amino Acids
- Dietary Ingredients & Feed Presentation
- Management & Husbandry Techniques

▪ Diet Acidification

Both organic and inorganic acids have been included in pig diets for several years (Easter, 1988). The addition of acids generally lowers the pH and buffering capacity of the diet, reduces pH within the stomach, increases both gastric proteolysis and nutrient digestibility, promotes beneficial bacteria at the expense of pathogenic organisms and decreases intestinal bacterial growth. As a consequence there is an improvement in gastro-intestinal health, resulting in enhanced growth performance and improved feed efficiency. The growth-promoting effects of acids are most prominent in the first few weeks after weaning, when the gastro-intestinal tract of the piglet is not fully developed and is most vulnerable to infection. Several individual acids, or a mix of acids may be used. The role of acids in pig nutrition has recently been reviewed by Roth and Kirchgessner (1998) and Partanen and Mroz (1999). Overall, the application of acids to pig feeds can be a viable alternative to the use of antibiotic growth enhancers and, compared with a negative control, improvements in growth rate as high as 23% have been obtained in some trials (Paulicks *et al*, 1996). There is also a considerable decrease in the frequency of diarrhoea; comparable to that found in piglets fed antibiotic growth enhancers (Figure 1).

Figure 1. Effect of acid products on the frequency of treatments for diarrhoea in piglets (Callesen *et al, 1999)*



▪ Oligosaccharides

The binding of pathogenic bacteria to the intestinal mucosa of the intestines is an essential step in the development of infection and the onset of pathological conditions. In this respect, cell recognition is important and specific carbohydrates and sugars are fundamental to this process. For example, bacteria have glycoproteins (lectin/fimbriae) on the surface of cells which can recognise and combine rapidly and selectively with the sugars on the surface of the gut wall. However, if they attach to a sugar or oligosaccharide which is not part of the gut wall, but is an indigestible component of the feed, then they pass out with the digesta without causing the animal any digestive problems. This 'competitive exclusion' principle is now being applied in pig nutrition and both mannose and fructose oligosaccharides have been used.

Mul and Perry (1994) reported that the inclusion of fructo-oligosaccharides improved the growth rate of weaned piglets (7-18 kg body weight) by 5.1% and reduced the FCR value by 2%. More recently, Van der Beke (1997), fed a mannose-oligosaccharide yeast to piglets (body weight 7kg) over a 4 week period and recorded a 7.4% improvement in growth rate, with a 5.2% better efficiency of feed utilisation. Interestingly, the number of piglets which scoured was also reduced. In addition to their 'competitive exclusion' properties, mannan-oligosaccharides have been shown to enhance the immuno-competence of the animal. They increase the release of cytokines which play an important role in the immune response by co-ordinating the actions of the immune system and by enhancing immuno-stimulating activity (Spring and Privulescu, 1998). Thus, both piglet health and performance are improved.

▪ Enzymes

At weaning, piglets often suffer a growth check because of changes in their nutrition, environment and immune status. Sow's milk is replaced by a diet containing complex carbohydrates which necessitates a dramatic change in endogenous enzyme secretion. A rapid development in the digestive tract has to take place and the combined effects of these changes can result in a temporary reduction in digestive competence, pre-disposing the young animal to malabsorption, which may lead to scouring.

The addition of specific enzymes, such as proteases, amylases and lipases can augment and complement those secreted endogenously. Their inclusion has been shown to improve nutrient digestion and absorption and hence growth rate for a range of diets (Partridge and Hazzledine, 1997). Incidence of scouring is also reduced, since less undigested material passes into the large intestine, thereby reducing the substrate available for the bacterial growth. In addition, enzymes, such as α-galactosidases, pentosanases and proteases, can specifically target anti-nutritional factors, which impair digestion and therefore provoke digestive disturbances. It is also interesting to note that following the ban of routine in-feed antibiotics in Sweden, the use of feed enzymes became established as an alternative feeding strategy.

▪ Herbs / Flavours

Herbs have been widely used as alternative therapies in both human and animal medicine. Certain herbs contain a sophisticated composition of organic elements that are known to have specific therapeutic effects. Herbs have been found to enhance anti-microbial activity, have anti-viral and anti-oxidative properties and are said to stimulate the endocrine and immune system. They promote a higher metabolic and immune status within the animal, as well as enhancing welfare. Their inclusion in the diet has also been shown to stimulate appetite by improving palatability.

Although a wide range of herbs, spices and oils are available for inclusion in animal feeds, one which has been most widely investigated is garlic. Garlic contains the amino acid L Alliin and the enzyme Allinase and these are its active ingredients. In humans, garlic reduces the production of free radical and lipid peroxides, as well as blood lipid content. In pigs, Jost (1996) has shown that the inclusion of 0.05% garlic in the diet maintained the efficiency of feed utilisation, reduced the incidence of scouring and number of piglets that died, when compared against an anti-microbial growth enhancer (Table 1).

Table 1. Effect of garlic on the performance of weaned piglets, 11-24 kg. (Jost, 1996)

Treatment	***0 % garlic***	***0.05% garlic***	***0.25% garlic***	***50 ppm Mecadox***
Feed intake (g/d)	710	736	691	825
Growth rate (g/d)	382	414	376	465
Feed : Gain (g/d)	1.88	1.77	1.83	1.77
Losses (%)	15.6	-	3.1	9.4
Treatment for diarrhoea (%)	6.3	6.2	9.4	21.9

▪ Minerals

The role of copper sulphate as a growth enhancing agent is well established and in many countries it is customary to add 175 ppm Cu to the diets of pigs up to 12 weeks of age and 100 ppm thereafter. Similarly, the inclusion of zinc oxide at pharmacological levels in piglet diets is purported to have therapeutic effects that improve performance and considerably reduce the incidence and intensity of diarrhoea/colitis in the post-weaned piglet. However, there is concern about the high rate of excretion of these elements into the environment and, in this respect, there is growing interest in the potential role of organic minerals which are both more biologically active and bio-available. Because more is utilised by the animal, there is a significant decrease in the levels excreted and hence less risk of potential environmental pollution.

Organic elements may utilise peptide or amino acid pathways, rather than the normal mineral ion uptake pathways in the small intestine. They are more stable, do not react adversely with other dietary nutrients and do not compete with other minerals for the same uptake mechanisms or sites. This provides a metabolic advantage to the animal, with consequential effects upon performance. The role of organic minerals in pig production has recently been reviewed by Close (1998).

▪ Probiotics / Yeasts

Probiotics have been widely promoted as alternatives to the use of antibiotics in pig diets. Unlike antibiotics, probiotics introduce live beneficial bacteria into the intestinal tract. Many strains of bacteria have been used commercially to produce direct-fed microbials, but the most common are *Lactobacilli, Bacillus subtilis, Bifidobacteria* and *Streptococci* species. Yeasts may also be used to manipulate the conditions within the gut and both *Saccharomyces cerevisae* and *Aspergillus spec.* have been most commonly included in the diet of monogastric animals.

Current probiotic research at the University of Alberta (see paper by McMullen, pg. 165 these proceedings) on genetically improved lactic acid bacteria holds considerable promise. These enhanced probiotics can be used to specifically target and inhibit intestinal pathogens such as *E. coli*.

Several authors have assessed the efficacy of probiotics as growth promoters for pigs. Most concluded that when results are averaged over several trials, there is an improvement in growth rate and in the efficiency of feed utilisation, but that the results are highly variable. Pollmann (quoted by Chesson, 1994) suggested a 2.5% (range -8.5 to +10.5) improvement in growth rate and 6.8% (range -1.4 to +21.4) improvement in feed efficiency. The variability of the results may be associated with strain differences, dose level, storage condition, diet composition, feeding strategy and interactions with drugs (Chesson, 1994). The effects of the probiotics appear to be more consistent and positive in piglets than in growing / finishing animal.

▪ Non-Starch Polysaccharides (NSP)

Bolduan (1988) showed that the addition of 5% straw to a piglet starter diet reduced the transit time of digesta through the gut, increased the proportion of digesta in the hindgut and reduced the percentage of days with diarrhoea from 6.0 to 3.5. Since then, work with other sources of digestible fibre, or non-starch polysaccharides, such as sugar beet feed, have shown an improved overall NSP digestibility of the diet (Longland *et al*, 1991) and reduced incidence of post-weaning diarrhoea (Göransson *et al*, 1995) (Table 2).

Table 2. The effect of sugarbeet pulp (SBP) on the frequency of diarrhoea (Göransson *et al*, 1995)

	Control	*Control + SBP*
No. of herds	7	7
No. of litters	71	71
No. of piglets at weaning	678	650
Mortality (%)	4.3	4.3
PWD (% of litters)	36	21

▪ Protein and Amino Acids

Commercial experience suggests that the incidence of post-weaning diarrhoea is higher, the higher the level of crude protein in the diet. Thus, providing the correct level of protein in the diet is important if both the health and performance of the piglets is to be maintained post weaning. Danish experience (Kjeldsen *et al*, 1999) suggests that in some herds it was necessary to lower the protein content of the diet to 110-120 g digestible crude protein per feed unit (10.5-11.5 g CP/MJ DE) to reduce the incidence of diarrhoea in grow/finish pigs following the removal of antibiotic growth enhancers in the feed.

Although protein content may need to be reduced, the level and balance of essential amino acids must be maintained if performance is not to be further compromised. This may necessitate more reliance on synthetic amino acid supplementation.

Ensuring the correct balance of certain non-essential amino acids may be required to ensure optimal gut function. For example, L-glutamine, which is the principal fuel for the gut epithelium, may increase intestinal immune response (see Abstract #6). Arginine is also involved in immune function and gut development and may have an additional role to play (see Abstract #7).

▪ Dietary Ingredients and Feed Presentation

In-feed antibiotics prevented proliferation of harmful bacteria in the gut, even when the necessary substrate for their growth was in plentiful supply. Now that they have been withdrawn it is more important than ever to balance the diets carefully and possibly restrict intake of nutrients that may promote the growth of pathogenic bacteria. Thus, restricted, rather than *ad libitum* feeding for a 3-4 week period may be recommended, following a change in feed, until a new microbial balance within the gut becomes established.

In addition, certain dietary ingredients are better suited than others to meet the metabolic and physiological needs of the pig at the different stages of growth. It is important that the feed contains no ingredients that have anti-nutritional properties, such as lectins, tannins and protease inhibitors. For example, in the post-weaned piglet, the use of products such as spray-dried or blood plasma protein, immunoglobulins, antibodies, egg or milk products, biopeptides, anti-secretory proteins (ASP) and rice starch offer potential as a means of reducing antibiotic use and have been shown to improve the performance in the post-weaning period. (For example, see Abstract #5 in these proceedings.) There is also considerable interest in the use of liquid feed as it appears to be more sympathetic to the gastro-intestinal structures and microbial milieu within the gut than dry feed. In general, improvements in post-weaning growth rates have been reported in most of the investigations with piglets fed liquid, compared with dry feed (Jensen & Mikkelsen, 1998, Brooks, 1999).

Similar benefits have been established with fermented liquid feed, where the feed is soured until a pH of <4.0 is achieved. This results in a proliferation of the beneficial and naturally-occurring lactic acid bacteria and yeast species which produce lactic acid, acetic acid and ethanol.

▪ Management and Husbandry Techniques

The development of proper management and husbandry practices are all-important, in that they provide and safeguard the correct environment in which the pig can grow and develop and be allowed to express its true genetic potential. Certain practices may need to be re-considered, including weaning age, segregated/medicated early weaning (SEW/MEW), all-in/all-out systems, the appropriate environmental conditions, good air quality and appropriate ventilation rates, pen design and space allocation within the pen, as well as water supply. The latter is especially important in the period immediately after weaning, as the piglet quickly becomes dehydrated and this reduces feed intake and limits growth and development. To minimise disease challenges and guarantee biosecurity, proper hygiene practices, cleaning and sanitation procedures must be followed. The quality of the piglet at weaning must also be considered; the stronger and healthier the piglet, the better able it is to overcome the stress of weaning.

▪ Conclusions

Antibiotic growth promoters have proven to be very cost-effective and efficient in improving pig performance and health. However, if their routine use in animal feed is abruptly stopped and no alternative strategy put in place, it is possible that the therapeutic administration of antibiotics at pharmacological levels will increase, because of large-scale herd infections and increased incidences and severity of diarrhoea.

Alternative strategies can be used effectively to replace antibiotics in pig diets without loss of performance. It is likely that a combination of the alternatives discussed in this paper, as well as changes in husbandry and management, will be the best strategy to adopt to efficiently reduce or replace the use of antibiotic growth promoters and to meet the ever-increasing needs of the modern pig genotypes.

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