Acidifiers in Animal Nutrition

A Guide for Feed Preservation and Acidification to Promote Animal Performance

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CONTEXT

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ORGANIC ACIDS AND SALTS PROMOTE PERFORMANCE AND HEALTH IN ANIMAL HUSBANDRY

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Introduction

Organic acids, such as propionic acid, have been used for more than 30 years to reduce bacterial growth and mould in feedstuffs and thus preserve hygienic quality. In feed legislation they are registered as preservatives, but their positive effects on animal health and performance, if they are added to feed in sufficient amounts, are also well documented. Acids used as feed additives are predominantly compounds that naturally occur in cell metabolism, thus they are natural products with low toxicity (Kirchgessner and Roth, 1988).

Health and performance promoting effects have been demonstrated for a number of organic acids, including formic, fumaric, citric and lactic acid and their salts. Besides improvement in hygiene and a corresponding reduction of pathogen intake, effects on feed digestion and absorption and on stabilisation of gut flora eubiosis have been demonstrated in a number of investigations. In animal husbandry, higher feed conversion rates and improved daily gain, as well as reduced incidence of diarrhoea, enhance economic return by lower feed costs and shorter time to market.

The greatest response to supplementation with acids has been recorded in piglets, especially during the weaning period. In the first three to four weeks of life gastric hydrochloric formation and pancreatic enzyme secretion is poor in the digestive tract. Moreover, piglets can be subject to stressed due to separation from the sow, and feed intake may be low for some days post-weaning. After recovery, high amounts of feed are consumed in compensation, and these volumes cannot always be acidified and digested properly, leading to diarrhoea and oedema. These problems are reduced in older pigs but the growth promoting effects of organic acids can still be achieved, though to a lower extent (Baustadt, 1993; Meyer *et al.*, 2006). However, a literature survey reveals considerable variation in effects between trials (Freitag *et al.,* 1998) that can be caused by differences in feeding, housing or hygienic conditions.

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POSSIBILITIES OF E. COLI CONTROL BY USING ACIDIFIER IN LIVESTOCK PRODUCTION

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Escherichia coli is a gram-negative bacillus. Important strains of *E. coli* in animal production are K88, K99, 987P and F41. Infection in neonates is commonly caused by K88 and 987P strains, whereas post weaning colibacillosis is nearly always due to the impact of K88 strains.

E. coli is an important cause of enteric diseases in the piglet, from birth until after weaning. Immunization of sows using commercially available vaccines may effectively control neonatal diarrhoea but not the post weaning diarrhoea or oedema disease. In the past, *E. coli* has been traditionally associated with severe, watery diarrhoea, dehydration, and often death in piglets during the first week of life. These *pathogens* colonize the intestinal epithelium by means of various fimbrial adhesins including F4 (also known as K88), F5, F6, and F41. They produce enterotoxins which induce an influx of water and electrolytes into the intestine, resulting in the characteristic clinical symptoms. Certain combinations of adhesins and enterotoxins (pathotypes) have been associated more frequently with neonatal diarrhoea, and these may vary from one geographical region to another.

Most commercially available vaccines for *E. coli* diarrhoea are directed against the fimbrial adhesins. Immunization of sows near the end of gestation with such vaccines results in the production of specific antibodies which are passed to the piglets via colostrum, and effectively block intestinal colonization by the pathogenic *E. coli*; hence preventing the development of the more severe form of the disease observed in piglets during the first week of life. However, this type of immunization does not usually stimulate a high level of specific lactogenic antibodies which would be present in the sow's milk until weaning. Occasionally, immunization of the sow with a commercial *E. coli* vaccine does not appear to effectively protect piglets against the development of neonatal diarrhoea. It is important to realize that *E. coli* diarrhoea may be clinically indistinguishable from diarrhoea of other causes or may be present as a mixed infection with other organisms. Hence, a thorough and accurate diagnosis should be made following submission of intestinal samples from autopsied piglets or rectal swabs from live piglets. Diagnostic tests based on the detection of fimbrial

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THE USE OF DIFFERENT DOSAGES OF ACIDIFIER BASED ON INORGANIC ACIDS IN POST-WEANING PIGLETS

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Introduction

It is well known that the swine industry has been interested in reducing piglet weaning age in order to maximize the annual sow productivity, saving costs and improving the economics of pig production on farm. However, weaning at an earlier age exposes the piglet to a wide variety of problems, including nutritional and environmental stresses, which can result in depressed growth, diarrhoea and high mortalities (Ravindran and Kornegay, 1993). During the last few decades, diets for weaning piglets have been supplemented with various antibiotics in prophylactic doses, to prevent gastrointestinal disorders and improve growth rates (4 to 15%) and feed efficiency (2 to 6%; Mroz, 2003), thereby maximising the economics of production. However, in more recent years, public concern has increased regarding the use of antibiotics in animal agriculture and the risk of developing cross-resistance of pathogens to antibiotics used in human therapy, especially in European countries. This has prompted the pig industry to look for alternatives to antibiotic growth promoters, which will maintain pig performance and control gastric disorders.

Acidifiers in animal feed were initially used in piglets to compliment their limited capacity to maintain a low gastric pH, which is linked to problems with digestion (Easter, 1988). Antibiotics inhibit all microbial growth (Cromwell, 1990), whereas acidifiers are more selective in their activity – they can reduce harmful micro organisms and promote beneficial microflora colonisation of the gastrointestinal tract (Mathew *et al*., 1991). The most widespread benefit from acidification of weaner pig diets has been seen with organic forms of acids (Kim *et al*. 2005). Research to date has been primarily focussed on types and levels of applied organic acids (Cole *et al*., 1968; Giesting and Easter, 1991; Eckel *et al.*, 1992).

The use of acidifiers containing inorganic acids in-feed has become popular due to their relatively cheaper costs compared to organic forms, and weaner diets including these acids are considered a low cost option. To examine the relative efficacy of inorganic acids, studies were carried out using hydrochloric acid, sulphuric acid and

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EFFECTS OF ORGANIC ACIDS ON GROWTH PERFORMANCE AND NUTRIENT DIGESTIBILITIES IN PIGS

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Introduction

As in-feed antibiotics have been completely banned in the EU, the beginning of 2006 saw intensified research to find suitable replacements. Organic acids and their salts have received much attention as potential alternatives in order to improve the performance and health of weaning and fattening pigs. It is generally accepted that organic acids and their salts lower gastric pH, resulting in increased activity of proteolysis and consequent improved amino acid and protein digestion. Additionally, organic acids selectively inhibit the growth of potential harmful bacteria, like *Escherichia coli*. However, growth-promoting and microbial effects depend on type and inclusion level of the acid used, the buffering capacity of the diet and age of animals. In general, the response to supplementation with organic acids is more pronounced in the young pig, especially around weaning when the digestive system is still immature.

At weaning, pigs are exposed to physiological and environmental stress, which often results in reduced feed intake and little or no weight gain. In some instances diarrhoea, morbidity and even fatalities may occur. The transition from liquid to solid feed and abrupt changes in feed intake (Aumaître *et al.*, 1995) have been identified as major stressors after weaning. At this time, piglets have a limited digestive and absorptive capacity due to an insufficient secretion of hydrochloric acid (HCl) required maintaining a low pH of approximately 3.5 in the stomach (Cranwell and Titchen, 1974). They also have inadequate secretion of pancreatic and brush border enzymes. It takes 3–4 weeks after weaning before the acid secretion in the stomach of piglets is sufficient to reduce gastric pH to a suitable level. In particular, diets with a high buffering capacity exert a negative effect on pepsin activity in the stomach, which, in turn, may have adverse effects on performance (Eidelsburger *et al.*, 1992a). Additionally, during the fattening period, digestive disorders associated with poor performance may also occur, particularly when pigs from different rearing compartments or farms are transferred to other production units and feeding regimes

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IMPROVING THE PERFORMANCE OF WEANED PIGS WITH NATURAL PRODUCTS

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Introduction

Mortality, morbidity and depressed pig performance associated with disease during the early post-weaning period continue to be major problems facing the swine industry (Cutler *et al.*, 1992). Although there are many managerial and environmental factors that can contribute to these losses, increased susceptibility of young pigs to disease is a direct reflection of their relatively poor immunological competence (Kelly *et al.*, 1993). For the newly weaned pig, poor immune status, in combination with other stresses associated with high-intensity pig production systems, and the concomitant suppression of feed intake and immune responsiveness are major contributors to enhanced disease susceptibility (Westley and Kelly, 1984; Hennessy and Jackson, 1987; Brown-Borg *et al.*, 1993). These issues are exacerbated in nurseries, where pigs of multiple origins provide an increased chance of pathogen exposure and consequent disease (Boeckman, 1996).

Currently, the majority of the U.S. swine industry relies on the inclusion of sub-therapeutic concentrations of antibiotics in the diets of young pigs to promote growth and mitigate disease problems. Increasing concerns regarding the development of antibiotic-resistant bacteria, and its potential implications for human health, have created public concern worldwide regarding such management practices (Liem, 2004). The development of alternatives to the use of antibiotics is therefore a priority for the industry.

The research discussed in this chapter was conducted to assess the use of natural products, designed to enhance feed intake and reduce disease susceptibility, versus antibiotics used at sub-therapeutic growth promoting doses (AGP's) on the performance of pigs from weaning to the grower phase. At present, acidifiers consisting of organic and/or inorganic acids are considered a promising option for replacing AGPs in livestock production (Steiner, 2006).

Successful application of organic acids in the diets for pigs requires an understanding of their modes of action. It is generally considered that dietary organic acids or their salts lower gastric pH, which results in increased activity of proteolytic enzymes and gastric retention time, thus improving protein digestion (Partanen and Mroz, 1999).

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EFFECT OF ORGANIC ACID CONTAINING ADDITIVES IN WORLDWIDE AQUACULTURE - SUSTAINABLE PRODUCTION THE NON-ANTIBIOTIC WAY

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Introduction

The current situation in world food supplies calls for supreme efforts to ensure the increasing requirements of the growing world population for staple diets and high-quality food. Additionally, bridging the widening gap between food demand and supply is required, especially in developing areas. Setbacks in any food production sector places greater pressure on other areas for supplying the increasing urban and rural populations, particularly in less developed countries.

Around one billion people are dependent on fish as their main protein source, and this number is likely to increase further (Becker and Focken, 1998), as the world population is increasing at an estimated annual rate of 2%. Aquaculture now provides more than 22% of all consumable aquatic products (Guillaume *et al*., 2001). Between 1987 and 1996, aquaculture production of food fish increased by 148% (Tomasso and New, 1999). In comparison, livestock meat and fisheries have grown yearly only by 3% and 1.6% respectively. Aquaculture is, at present, the only enlarging sector within the fishing industry and is also reputed to be the fastest growing food production sector in the world.

Since the early 1980s, yearly growth rates of around 10% have been reported for aquaculture business. Because of this situation, global production of farmed fish and shellfish has more than doubled in both volume and value in the past 15 years (Naylor *et al*., 2000). If products from aquaculture that are not directly used for human consumption are included (e.g. seaweed), then the world's aquaculture production more than tripled by weight and value between 1984 and 1996 (Dagoon, 2000). The contribution of aquaculture to total fish production directly consumed by humans is currently more than 25%.

Aquaculture production differs greatly between countries due to different retail opportunities, climatic zones and local conditions as well as the types of farmed animals, leading to diverse production practices and a variety of impacts on the ecosystem. Williams *et al*. (2000) described certain targets required for the aquaculture industry if

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THE USE OF ACIDS TO PRESERVE FEEDSTUFFS

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Introduction

To secure health and a good growth performance, animals need a constant supply of high quality nutrients throughout the year. A primary objective in any profitable farming operation should be the use and production of good quality feedstuffs. Preservation of forage feedstuffs is of key importance for maintaining nutritive value and avoiding the losses caused by undesirable microorganisms and the contamination with toxins such as fungal mycotoxins.

According to the presence or absence of oxygen, feedstuffs can be stored under aerobic or anaerobic conditions respectively. Anaerobic procedures (without oxygen) include the age-old practice known as ensiling. The practice of ensiling was originally a management tool to fulfill feed demand for ruminants in seasons where forage was scarcer, by storing and preserving the excess forage resources during periods of overproduction or abundance, e.g. spring grass 'flush'. In more recent times its importance has extended, especially for high input systems utilizing so called "zero-grazing" strategies, with the accompanying benefits derived from increased productivity per animal and per area unit (Ogle, 1990; Muller and Botha, 1997; Klein and Ledgard, 2001). Ensiling is also less dependent on weather and can be used to preserve a great variety of forage crops and regionally available byproducts (Schroeder, 2004).

Over the last few years, silage additives have been utilised more and more by silage producers (Knický, 2005). Their main purpose for inclusion in silage is to increase its nutritional value, improve fermentation (so that storage losses are reduced) and increase aerobic stability of the finished silage after the opening of the silo (Jones *et al*., 2004). Responses to additives depend not only on what type of forage is used, but also dry matter (DM) content, for example (Burns *et al*., 2005).

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