Water acidification in swine production systems

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Recently there has been increased interest in water quality and the potential benefits of a water acidification program for swine. Water is the most essential element for swine and poultry production and is required more than any other nutrient. Inadequate intake of water will have a negative effect on feed intake and animal performance.

Much of the water in Canada is very alkaline, containing high pH levels ranging from 7.5 to 8.5. Water with elevated pH levels tends to contain high levels of minerals, particularly calcium and magnesium. Difficulties with high pH water include the build-up of lime scale in pipelines resulting in leaky nipple drinkers, reduced effectiveness of antibiotics and reduced availability of chlorine and other sanitizing agents. The addition of acids to water and the subsequent reduction in pH can provide overall water quality improvements while enhancing performance and health for sows, nursery and grow-finish pigs.

The addition of acids to feed and water in swine production systems is not a new concept. The acidification of swine diets has been looked at over the last 20 years as a means of improving health and performance in weaned pigs. Water acidification with the addition of lactic acid was studied in the late 1960's for improved growth and feed efficiency in nursery pigs. The livestock and poultry industry has focused on water acidification as a means of reducing the growth of pathogenic bacteria, particularly *Salmonella.* Also, Ontario veterinarians, nutritionists and swine specialists have been reducing water pH for years as a means of reducing the negative effects of post-weaning scours in pigs.

Generally, research has shown that combinations of acids will out perform single acids. The benefit arises from the synergy achieved by combining acids. The enhanced spectrum of activity makes them more effective at killing bacteria and reducing water pH.

There are two main types of acids used to reduce water pH; inorganic and organic acids. Inorganic acids such as phosphoric acid and hydrochloric acid are very efficient at reducing water pH and are very cost effective. Comparatively, the organic acids are much more bactericidal in nature - that is they have the ability to kill bacteria in a similar fashion to

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antibiotics. Research has shown the organic acids with the best bacteria killing effect are lactic, formic and proprionic acids.

There are a number of mechanisms of action when acids are added to swine water systems:

1. Lowering gastric pH and increasing the activity of digestive enzymes in the gastro-intestinal tract.
2. Lowering gastric pH, which helps to reduce the growth of pathogenic bacteria.
3. Improvements in the utilization of oral antibiotics.
4. Prevention of build-up of lime scale in water lines.
5. Improvement in the availability of chlorine.

Lower gastric pH

Of these mechanisms, the reduction in pH is very likely the most important aspect of acid activity. Pepsin is the major enzyme breaking down protein, however it has an optimum pH activity in the range of 1-2. Research has shown that the addition of acids to weaner diets will reduce the pH of the stomach, duodenum and jejunum versus control diets (Table 1). Therefore any decrease in the pH of the gastro-intestinal (GI) tract should have a positive effect on the activity of pepsin and improve feed digestibility. A reduction in pH should result in the increased activation of pepsinogen, the pro-enzyme of pepsin for the digestion of protein.

Table 1: Effect of fumaric acid, malic acid and citric acid on the pH of the intestinal tract of starter pigs

Citric acid (%)	–	1.0	–	–
Fumaric acid (%)	-	-	0.7	-
Malic acid (%)	-	-	-	0.9
	pH of gastrointestinal tract			
Stomach	4.55	3.50	4.17	4.33
Duodenum	5.30	4.55	5.07	5.45
Jejunum	6.57	6.43	6.23	6.43

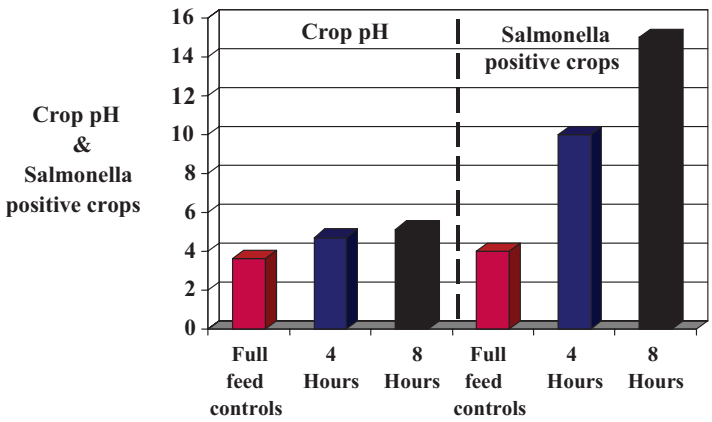
From: Scipioni, R. et al., (1978) Zootechnica and Nutricone Animale 4, 201-218

Reduced growth of pathogenic bacteria

Another benefit of reduced GI tract pH from the addition of acids to water is the reduced growth of pathogenic bacteria. *Salmonella, Escherichia coli* and *Clostridium* all colonize and multiply more efficiently in a more alkaline environment.

In poultry a number of studies have shown crop contamination increases during pre-slaughter feed withdrawal of broiler chickens and contaminated crop contents may serve as an important source of *Salmonella* entry into poultry processing plants. The Department of Veterinary Pathobiology and Poultry Science, Texas Agricultural Experiment Station evaluated the effect of pre-slaughter feed withdrawal on crop pH and crop contamination with *Salmonella*. The results showed crop pH increased significantly from pH 3.64 before feed removal to pH 5.14 after 8 hours of feed removal (Figure 1).

Figure 1: Effect of experimental feed withdrawal on crop pH & Salmonella +ve crops in market age broiler chickens



From: Dept. of Veterinary Pathobiology & Poultry Science, Texas College of Vet Medicine -98

This increase in crop pH allowed for a clear increase in pathogenic bacteria growth as indicated by the dramatic increase in *Salmonella* positive crops from 3.3 % before feed removal to

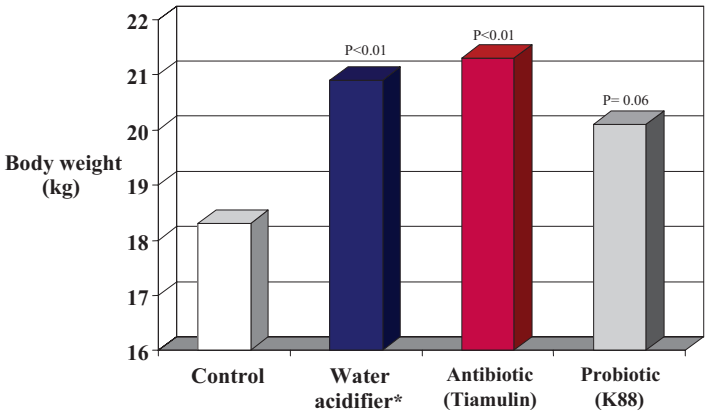
12.6%, eight hours after (Figure 1). A subsequent follow up study showed that by treating the water with lactic acid there was a significant reduction in *Salmonella* in the crop and pre-chill carcass wash versus control water.

By lowering water pH we not only gain by reducing gastric pH and potentially creating a more hostile environment for pathogenic organisms inside the pig but also restrict the growth of bacteria in waterlines. A recent weaned pig study showed the benefit of an aggressive water acidification program in pigs challenged with enterotoxigenic *E. coli.* The trial consisted of 6 dietary treatments including control, in-feed medication, *E. coli* probiotic, water acidifier, feed acidifier and a plant extract product. The pigs on the water acidification and in-feed medication program had improved body weight gain (Figure 2) and the pigs on the reduced water pH also had a reduction in *E.coli* shedding and diarrhea score.

Improved utilization of oral antibiotic

In addition to the benefits of pH reduction it has been demonstrated that adding potentiating agents can increase blood levels of chlortetracycline and oxytetracycline. The use of citric or terephthalic acid, added to water has been shown to increase the absorption of oral antibiotic (chlortetracycline) in growing swine. Research has also shown that blood chlortetracycline levels in both turkeys (Figure 3) and chickens can be increased with the addition of citric acid in the drinking water.

Figure 2: Effect of a water acidifier, Tiamulin, probiotic product on early weaned pigs challenged with enterotoxigenic E. coli F4 (K88)



** Ortho-Phos, lactic & formic acid*
Maple Leaf Agresearch, American Journal of Animal Science, 2005

Prevention of lime scale in waterlines

A concern for many swine producers is leaking water nipples. One of the causes of this problem in barns is the buildup of scale in water lines. Water in Canada tends to be high in pH with

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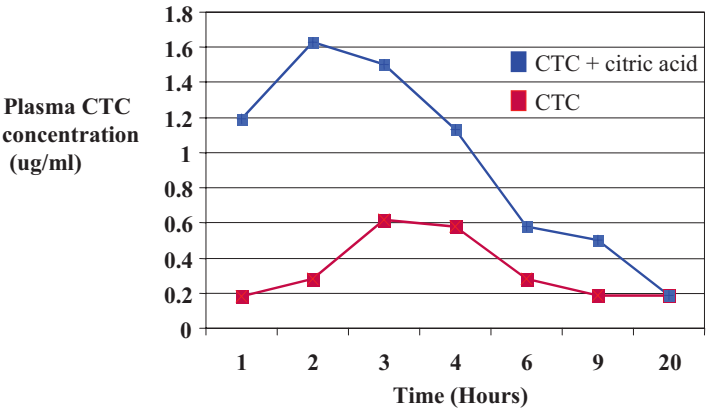
Figure 3: Average plasma concentration of CTC in turkeys (17 weeks old) following oral water administration of 15mg/kg CTC alone & with 150mg/kg citric acid



From: Pollet, RA Poultry Sci. 63:1110

corresponding high levels of hardness. Water hardness is a measure of the amount of dissolved calcium and magnesium in water systems. This hard water contributes greatly to scaling in pipelines.

In the water softeners used in residential homes, salt (sodium ions) is used to exchange soluble sodium with dissolved calcium and magnesium and then these minerals are trapped in a filter. This procedure reduces the incidence of scaling in water systems but will also dramatically increase the level of sodium in the water. By acidifying water we are doing something similar to water softening but instead of the addition of sodium ions, with acid we add hydrogen ions. With the reduction in water pH the solubility of the calcium and magnesium is much improved. With the addition of acid to water there is a change in the chemistry of the dissolved minerals and scaling of waterlines is much reduced.

Improved chlorine availability

Chlorination remains as one of the most effective water treatments, ensuring pigs receive clean water. Swine producers who are chlorinating their water lines should be aware of their water pH because chlorine effectiveness is pH dependent. When chlorine is added to water it will dissociate into two main forms, hypochlorous acid (HOCL) and hypochlorite ion (OCL). HOCL is approximately 100 times more effective as a disinfectant than is OCL. Availability of HOCL is dramatically reduced when water pH is above 7.0 (Table 2). Maintaining pH levels between pH 5.0 and 7.0 will maximize the available chlorine present as HOCL and help to ensure pigs receive clean water.

Table 2: The effect of water pH on the percentage of chlorine present as HOCL

Water pH	Available chlorine present as HOCL %
4.0	99
5.0	100
6.0	96
7.0	74
8.0	20

From: Cole, L. "Chlorine & Chloramines" Water Technology, 10(5): 36-39, 1987

The majority of the acid products for swine water systems are added via inline water medicators. This involves the mixing of a stock solution with a certain quantity of acid. There is growing interest however in direct injector pumps that work together with a contact flow meter. This system is very accurate, allows for convenient adjustment in water pH levels and eliminates having to mix stock solutions. A pH meter should be used to test initial water pH and to assist in calibrating down to your desired pH.

With the increasing interest in water quality along with the associated effects on feed intake and performance, consideration should be given to the addition of acids to water. When used as a management tool water acidification has the potential to improve health and performance, while improving water quality for swine water systems.

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