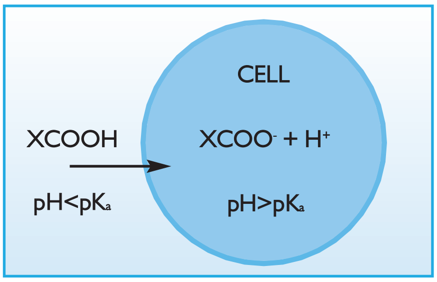
The way forward with organic acids in pig feed

by Mathieu Calmont and Justin Y. W. Tan, Borregaard LignoTech, PO Box 162, NO-1701 Sarpsborg, Norway.

Organic acids have gained worldwide acceptance as the choice replacement for antibiotic growth promoters (AGPs) in livestock feed. This is due to their ability to kill pathogenic micro-organisms that cause disease and deter the growth performance of livestock.

As antimicrobial agents, organic acids function in two distinct ways. The more commonly known mode of action of acidifiers is via pH depression by the release of protons to surrounding media, creating undesirable or unfavourable conditions for pathogens.



The other less known mode of action is its ability to change from a non-dissociated form to a dissociated form, depending on the pH of its surrounding environment.

When an acid is in a non-dissociated form, it can diffuse freely across the semi-permeable surface of micro-organisms, penetrating through the cell wall and into the cell cytoplasm.

Once within the cell, the acid undergoes a dissociation process, releasing protons that cause the internal pH of the cell to drop. As the normal pH of the cell is usually close to pH 7, this drop in pH will suppress cell enzymes and nutrient transport systems, causing metabolic disturbances within the cell, finally killing the pathogen. The latter mode of action is of far higher significance compared to the former in terms of antimicrobial efficacy.

It is also a myth and a misconception that organic acids have any benefits in the intestines of livestock. It has been proven that organic acids work primarily in the stomach of livestock animals, where the pH is lower than the pK_a of the acid, as the intestinal tract is much too alkaline for any reduction in pH to be significant or beneficial. To comprehend this completely, one must be able to fully understand the relationship between the pK_a of an acid and its surrounding pH.

The antimicrobial activity of organic acids enables such additives to be widely used in the preservation of livestock feed, silages, cereals and grains. Organic acids are known to be effective both in reducing bacterial contamination as well as preventing mould growth in livestock feedstuffs.

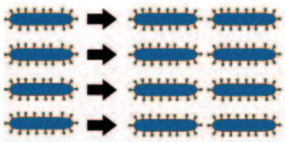
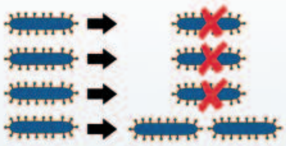
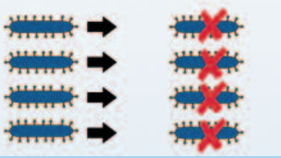
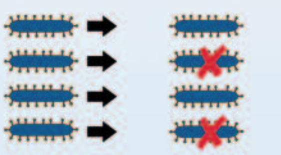
The predicament

However, despite its proven effects and benefits as an antimicrobial agent, the use of acidifiers in animal feed remains limited. This is mainly due to its detrimental properties, as pure organic acids are corrosive and volatile in nature, resulting in its likeliness to cause serious damage to equipment and work areas, and thorough cleaning needs to be undertaken after its use.

The use of acidifiers in the livestock industry leads to major usage problems, where workers involved in the handling of these chemicals are required to wear suitable protective equipment such as gloves and goggles to avoid harmful contact or exposure to

Continued on page 9

Table 1. Effect on bacteria.

Treatment	Colonisation/destruction	Effect on bacteria
None		**Colonisation:** There is rapid bacterial colonisation of the environment due to lack of inhibition
Formic acid (5kg/MT)		**Bacteriostatic effect:** Due to the low organic acid inclusion rate, not all bacteria are killed. As soon as the organic acid molecules are fully consumed, live resistant bacteria recolonise the environment
Formic acid (20kg/MT)		**Bactericidal effect:** At such high concentrations, all bacteria is destroyed
SoftAcid (5kg/MT)		**Bacteriostatic effect:** A large portion of bacteria are eliminated by organic acid molecule dissociation. Resistant bacteria are inhibited by lignosulphonic acid molecules and colonisation is stopped. Thus, the SoftAcid effect is similar to the pure acid effect

Continued from page 7
these substances. A large quantity is also often lost through evaporation, where 15-20% is known to be lost during the process of pelleting. In addition, organic acids tend to have a very strong odour, making working environments unpleasant for all involved in its handling. Once added to feedstuffs, organic acids often cause a decrease in animal feed consumption.

The drawbacks

This has led to the acceptance of what is known as buffered organic acids. These are organic acids that are combined with alkaline agents such as calcium or ammonia to form a salt complex such as calcium formate and ammonium propionate.

While this effectively reduces the corrosivity of pure organic acids, the corrosive nature of buffered acids is still inherent, even if it is reduced.

There is no doubt that the carrier, being part of the molecular weight of the substance, replaces a large portion of the acid and is thus much less efficacious compared to the pure form of the acid. The ammonia/sodium portion represents 20-35% of the molecular weight of the formula and yet is in itself of no benefit to the animal as an antimicrobial.

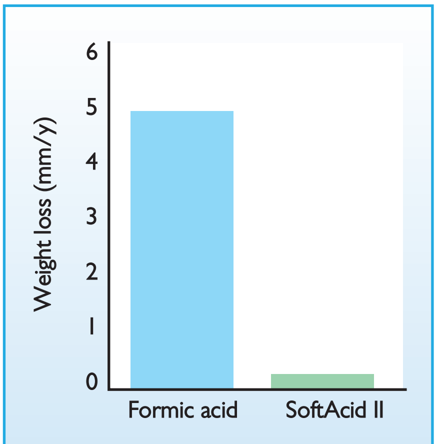
For example, when ammonia or sodium hydroxide (caustic soda) is used as an alkaline agent, the pH of an organic acid may increase from 0.5 to 4.0. This leads to a significant drop in the pH reducing efficacy of such buffered acids. Moreover, it can no longer be called formic acid, as it is now a totally different chemical with very different properties altogether.

In the case of ammonium formate, the heating process (or storage for a long period) generates formamide, which is classified as a toxic substance, a teratogen, and is possibly carcinogenic as well.

Some acidifier products also claim to have a fat coating, in order to reduce corrosivity, volatility and absorption in the intestines.

Fat coated organic acids have literally no

Fig. 1. Corrosion of black steel (SINTEF, Norway, 2003).



Product	Control	SoftAcid II 1.0%	SoftAcid II 1.5%	SoftAcid II 2.0%
No. of groups	16	16	16	16
No. of pigs	402	402	402	402
4-6 weeks				
Daily gain (g)	137	155	154	158
Daily intake feed (FUp)	0.24	0.25	0.25	0.25
FUp/kg gain	1.92	1.70	1.72	1.69
6-10 weeks				
Daily gain (g)	487	507	510	489
Daily intake feed (FUp)	0.89	0.93	0.92	0.91
FUp/kg gain	1.83	1.83	1.80	1.86
4-10 weeks				
Daily gain (g)	374	392	396	382
Daily intake feed (FUp)	0.68	0.71	0.70	0.70
FUp/kg gain	1.83	1.80	1.78	1.82

FUp- Feed Unit pig. One unit of FU = approximately 12.65MJ/kg metabolic energy.

Table 2. Results from the Danish feeding trial (Rullende afproving, Denmark).

pH reducing effects, have a rather low organic acid content, and are known to be very expensive. It has no beneficial effects in the stomach, as it still remains in its fat coated form. It also has no effects whatsoever in the intestines, where the pH is too high and the acids are useless. Last but not least, it is impossible to use in drinking water, if no emulsifying agent is added.

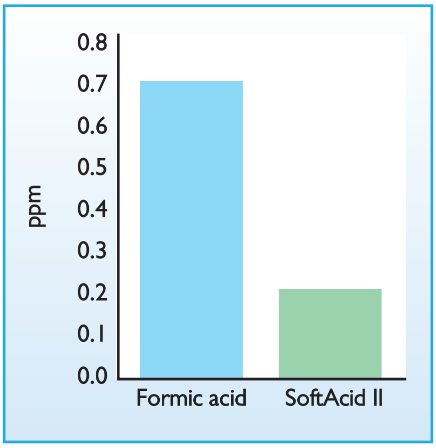
The solution

For organic acids to be used increasingly in livestock feedstuffs, there is a necessity for an improved form – one that is non-corrosive, safe, effective and easy to use. Users of organic acids should not have to compromise between the safety and efficacy of their chosen product.

For this purpose Borregaard LignoTech has specifically developed a new, unique and patented technology called SoftAcid.

SoftAcid is a product range that consists of organic acids and modified lignosulphonic acid. It is the presence of the latter which gives the product its name 'Soft,' due to its ability to moderate the aggressive nature of the organic acids. SoftAcid is consequently non-corrosive, safer to use and easier to handle compared to other pure organic acids.

Fig. 2. Evaporation of acid (results from Felleskjopet, Norway).



Meanwhile, SoftAcid has also been proven to be more effective compared to buffered or coated acids. Tests conducted at the Norwegian National Veterinary Institute and North Carolina State University clearly demonstrated that SoftAcid is highly effective at inhibiting the growth of salmonella and E. coli. SoftAcid technology can be incorporated into any existing organic acid or a blend of different organic acids to recreate this new innovative approach to the use of organic acids for livestock feed.

Bacterial inhibition

In the digestive tract, H+ ions (endogenous hydrochloric acid) release the organic acid molecules from the SoftAcid macromolecules. Lignosulphonic acid also has clear inhibiting properties on bacterial colonisation. Bacteria are known to communicate by sending out small molecules (lactones) into the environment to check for colonisation potential, which is further determined by bacterial population density.

Basically, most of these signaling molecules are attracted by lignosulphonic acid due to the Alwatech process, which interferes with the bacterial colonisation process.

The benefits

- Reduction in corrosivity.

SoftAcid has been found to be significantly less corrosive towards black steel as well as

Continued on page 11

Continued from page 9
other metals compared to formic acid (see Fig. 1).

This is because the aggressive nature of organic acids is reduced by the presence of lignosulphonic acid. With respect to corrosion, the dissociated lignosulphonic acid anions migrate towards the positively charged solid surfaces (such as concrete and steel) to form a protective layer.

Experiments at SINTEF Materials Technology showed that the corrosion rate of SoftAcid on carbon steel was reduced by 96.7% compared to pure formic acid.

A 75% reduction in corrosion rate was also recorded when concrete cubes were used instead of black steel.

Test parameter	0.6% Formic/ propionic acid mix	0.6% SoftAcid II
No. of pigs	236	236
Start weight (kg)	30.86	31.18
Finish weight (kg)	91.35	92.85
Days	77.7	77.7
Lean meat (%)	55.0	54.5
Weight gain (kg)	60.48	61.67
Daily feed consumption (kg)	2.16	2.19
Feed conversion ratio	2.77	2.75
Daily weight gain (g)	778	793

Table 3. Results from the German feeding trial.

● **Reduction in odour/evaporation.**
A significant quantity of organic acids that are used as antimicrobial agents in feed and also to preserve grains and cereals against mould growth are lost via evaporation. Due to its volatile nature, organic acids also emit malodours that pose great health risks to both humans as well as to animals.

Borregaard has also developed its own method in measuring the organic acid evaporation rate in feed plants and to compare it with SoftAcid.

The monitoring of acid levels present in the air during the production of feed pellets containing formic acids was carried out (see Fig. 2) on a commercial feed mill.

From the obtained data, it can be concluded that the amount of formic acid present in the work environment was greatly reduced when formic acid was replaced by SoftAcid. A corresponding reduction in odour was also observed.

Because SoftAcid was able to reduce the rate of evaporative loss of the organic acids, there was a higher concentration of acids remaining, thus increasing its effectiveness as an antimicrobial in livestock feed.

● **Improved animal performance.**
SoftAcid makes an excellent choice as a replacement for AGPs in livestock feed, due to its specific and unique ability to either kill or inhibit the growth of pathogenic microorganisms such as bacteria and fungi, thus promoting growth and improved performance of various species of livestock animals.

Farmers co-operative Felleskjøpet Agri BA is the largest feed producer in Norway. With 57 grain depots, it is also the largest grain collector in this Scandinavian country.

According to Vebjørn Nilsen, the technical and process manager who is responsible for 15 feed plants across Norway, SoftAcid technology has been instrumental in their anti-salmonella programme, and part of the mechanism which enables this giant co-operative to be the only feed producer in the world to guarantee salmonella-free feed for their customers.

Extensive trials have also been carried out at Danske Slagterier, or the Danish Bacon & Meat Council (see Table 2). SoftAcid has been found to have better palatability, with inclusion rates of up to 2% having no detrimental effect on feed intake.

Results show that SoftAcid is an effective product for the prevention of digestive problems, and results in better utilisation of the feed and improved animal performance.

It was also found to have a positive influence on the microbial population of the pig's digestive system, resulting in a reduction in the number of coliform bacteria present in the small intestines. It should be noted that the performance of SoftAcid was found to be similar to that observed with pure formic acid.

Trials conducted in Northern Germany (see Table 3) also show that replacement of a formic/propionic mixture on a 1:1 basis by SoftAcid produced an improved performance in terms of feed intake, weight gain and feed conversion ratio.

The trial was conducted in post-weaning piglets from the age of four weeks until they were approximately 10 weeks old. The dosage of both SoftAcid and the market leader acidifier at the time, was fixed at 0.6% each. Results show that there was an additional live weight gain of 15g per day due to the use of SoftAcid.

This gives an extra weight gain of 1.2kg. These results show the benefits of SoftAcid against a leading competitor acid with respect to weight gain of the animals.

Conclusion

Currently, with the availability of protected acids and SoftAcid technology, feed and livestock producers no longer have to compromise between efficacy and safety when choosing to use organic acids as an alternative feed additive.

SoftAcid completes the evolution of the use of acidifiers since its early days, enabling organic acids to safely and effectively replace AGPs in animal feed, while providing many other benefits for the animal as well as profits for the producer. ■