Improving gut health in chickens by means of diformates

by Christian Lückstädt, technical director, Addcon, Asia.

Both the feed industry and the food production sector still suffer from losses due to the contamination of feed with pathogenic bacteria and their resultant impacts in the animal, such as lower weight gains and increased mortality.

Banning the use of in-feed antibiotics (AGPs) in livestock, as happened in the EU as well as in parts of Asia, led by South Korea, puts more pressure on animal producers and feed millers. It also poses an important challenge to innovative animal nutritionists. Now, alternative feed ingredients are being adopted in order to fill the gap left by removing AGPs from the food chain.

Multi-drug resistance

Alarming news in this respect recently emerged in a report from the Federal Institute for Risk Assessment in the European Union. Taking all strains of salmonella into account, it found that 40% of them are already multi-drug resistant (Table 1).

A more recent report stated: The proportion of salmonella and E. coli isolates resistant to ampicillin, sulphonamides and tetracycline varied between 5% and 68% in poultry, pigs and cattle.

Some Member States reported a high occurrence of fluoroquinolone resistance in salmonella isolates from poultry (5-38%).

Ironically, the EU is one of the regions in the world with exceptionally stringent salmonella surveillance and control systems.

This implies that antibiotic resistance in salmonella and the other pathogenic bacteria can happen everywhere! It is now clear that we have been arming our pathogenic enemies for decades.

Multiple antibiotic resistances in pathogenic bacteria are becoming a serious health issue. If antibiotic resistance is transmitted to more common foodborne pathogens like salmonella and campylobacter, resistance could become a major problem, especially in vulnerable groups of people.

The two most commonly seen serovars in human salmonellosis epidemics are Salmonella enteritidis and S. typhimurium.

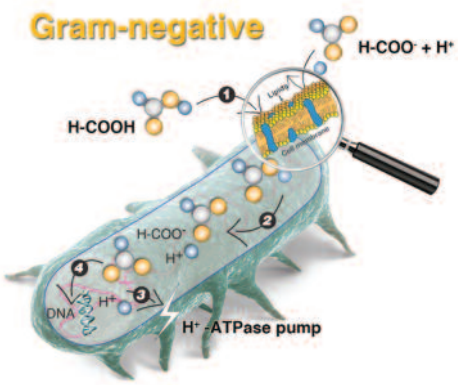

Fig. 1. Mode of action of organic acids against Gram negative bacteria.

Table 1. Resistance of salmonella isolates in Germany.

Number of salmonella isolates	Number of anti-microbial agents	Level of resistance (%)	Level of multi-resistance (%)
11,911	17	63	40

These two strains have emerged over the past 30 years in parallel with intensive animal husbandry.

Salmonella ranks among the world's biggest threats to health. In the United States alone, it is thought to be responsible for around 378 deaths and an estimated 19,336 hospitalisations each year.

Furthermore, the Center for Disease Control recently estimated a total annual cost of US$3 billion associated with salmonella in the US.

Similar calculations from Denmark in 2001 took this further, suggesting that spending the equivalent of US$14.1 million implementing a salmonella control programme actually resulted in a net saving of US$25.5 million to the national economy.

It is therefore of great interest to investigate management and dietary strategies to counteract salmonella in poultry production, without the use of in-feed antibiotics.

Organic acids have long been used to counteract Gram-negative pathogenic bacteria in animal feed, mainly in pig production. This approach is currently being further investigated for poultry nutrition – especially to combat salmonella, in order to establish a healthy gut.

The potential of single organic acids in feed preservation lies in their ability to protect feed from microbial and fungal destruction. Their effects on stomach pH and gut flora have also been known for decades and proven in many laboratory and field trials.

Acidifiers act as performance promoters by lowering the pH in the gut (mainly upper intestinal tract), inhibiting the proliferation of unfavourable micro-organisms.

	Control	Formi NDF 0.6%
Enterobacteria	10^7	10^5
Lactobacilli	10^7	10^8
Bifidobacteria	10^5	10^6

Table 2. Results of microbiological investigation of the intestine (CFU/g) in broilers fed with or without sodium diformate (Formi NDF) for 39 days.

Gut acidification stimulates enzyme activity and thus optimises digestion and the absorption of nutrients and minerals. Undissociated forms of organic acids penetrate the lipid membrane of bacterial cells and dissociate into anions and protons.

After entering the neutral pH of the cell's cytoplasm, organic acids inhibit bacterial growth by interrupting oxidative phosphorylation and inhibiting adenosine triphosphate-inorganic phosphate interactions (Fig. 1).

Improving broiler performance or hygienic conditions with the aid of organic acids has been reported by many sources, and was

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for instance reviewed by Desai et al. (2007). Since the 1980s, reports have shown organic acids, and formic acid in particular, to be especially effective against salmonella, when used in poultry diets. The use of pure formic acid in breeder diets reduced the contamination of tray liners and hatchery waste with S. enteritidis drastically.

By 1990, researchers in the US found significantly reduced levels of Salmonella spp. in carcase and caecal samples, after including calcium formate in broiler diets.

Further research reported that formic acid at 0.5% in the diet can be successfully used at farms to reduce salmonella contamination in feed, excretion of Salmonella spp. and re-infection of chicken populations. The scientific literature is full of such reports, but in practice, a number of more practical issues will sort out the effective acidifiers from the rest. Pure formic acid, however effective in feed, is also corrosive, hazardous, as well as volatile – it is literally too difficult to handle in a feed mill.

Furthermore, while producing pelleted poultry feed, you can expect losses of up to 20% of the formic acid being used. Furthermore, these volatile, liquid-based acids only offer antibacterial protection in the feed and the foregut of the birds.

Recent research has focused on overcoming these limitations.

Chemical compounds which are heat-stable, non-corrosive and yet still effective are the way forward. Diformates, like sodium diformate (Formi NDF, Addcon) satisfy these industry requirements.

Sodium diformate provides the anti-bacterial protection of formic acid while its crystalline, non-volatile nature allows it to be used safely in the feed mills. When used in animal feed, this enables the diformate to provide effective, efficient, yet safe protection against salmonella and other antibiotic-resistant pathogens.

	Crop	Caecum	
Hours after challenge	1	9	24
0.6% Formi NDF	-5 log CFU	-1 log CFU	-4 log CFU

Table 3. Anti-salmonella effect of sodium diformate (Formi NDF) in different matrices from the gastro-intestinal tract of poultry (in log-units).

Trial results

A trial with diformate showed how a healthy gut – with lower amount of enterobacter as well as salmonella and campylobacter, was achieved in broiler fed 0.6% of sodium diformate (Table 2).

These results clearly show the beneficial effects of Formi NDF against pathogenic bacteria in broilers, while leading to a state of eubiosis in treated chickens.

Notably lower enterobacter numbers and distinctly higher lactobacilli and bifidobacteria numbers show the beneficial impact of Formi NDF on the intestinal microbiota.

A recently published study by DEFRA (Department for Environment, Food and Rural Affairs, UK, 2011) analysed the effect of Formi NDF against pathogens in poultry.

The product was especially assessed for anti-salmonella activity in the presence of different matrices, like crop contents and caecal contents. This involved addition of the diformate at 0.6% followed by the addition of a defined number of colony forming units of the challenge strains (Salmonella enteritidis and S. typhimurium).

After a certain period of incubation a semi-quantitative sensitive isolation technique was applied to determine any change in cell count. In crop contents there was a log 5 reduction in only one hour with no re-growth detected at four and nine hours. In caecal contents there was a log 1 reduction at nine hours and a log 4 reduction at 24 hours (Table 3).

The published results prove irrefutably how a healthy gut with inhibited growth of pathogens and food safety can be achieved by dietary means, without resorting to supplementation with an AGP. ■