Promoting chicken health and performance in south east Asia

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Contamination of poultry meat with foodborne pathogens is very common, both in developing and developed countries. This poses a serious threat to the human population. The major contaminants are pathogens like E. coli, salmonella and campylobacter.

For years, poultry farmers have been using antibiotics to control these pathogenic bacteria; however this has only aggravated the problem in the long term by creating strains of bacteria that are resistant (sometimes multi-resistant) to most of the commonly used antibiotics. Further, the human population is also exposed to these antibiotics.

In order to avoid this, some countries have already banned the routine use of antibiotics (AGP) in animal feed and have imposed strict withdrawal period guidelines.

Sustainable solution

Now, the time has come that we should look for a better, sustainable solution for the control of pathogens in poultry. Many scientists the world over are working on better alternatives for antibiotics.

The use of organic acids for food preservation has long been practiced. For decades we have been using organic acids in feed preservation, protecting feed from microbial and fungal destruction. Enough data has already been generated of their use in feed for pigs and poultry. In poultry production organic acids have mainly been used to sanitise the feed, against problems with salmonella infections.

Pathogenic bacteria such as salmonella enter the GI-tract via the crop. The environment of the crop with respect to microbial composition and pH seems to be very important in relation to the resistance to pathogens. High amounts of lactobacilli and low pH in the crop have shown to decrease the occurrence of salmonella.

Organic acids have strong bacteriostatic and bactericidal properties. Cherrington et al. (1991) and Russell (1992) both nicely elaborated the mechanism of action of organic acids. Bacteriostatic activity of organic acids is related to the reduction of pH, by virtue of its dissociation, making conditions unfavourable for the multiplication of pathogenic bacteria. Bactericidal activity is specific to the Gram-negative bacteria and is attributed to the lipophilic nature of the un-dissociated acid molecule.

When an un-dissociated acid molecule comes into the vicinity of bacteria, it gets attracted to the lipopolysaccharide layer of the cell membrane and eventually diffuses into the bacterial cell.

Once inside, the acid releases its proton in the more neutral environment resulting in a drop of the intracellular pH-value. This interferes with microbial metabolism, inhibiting the action of important microbial enzymes and the bacterial defence mechanism is put into action.

The H+-ATPase pump tries to pump out this proton leading, to a loss of energy which results in the death of the bacterial cell.

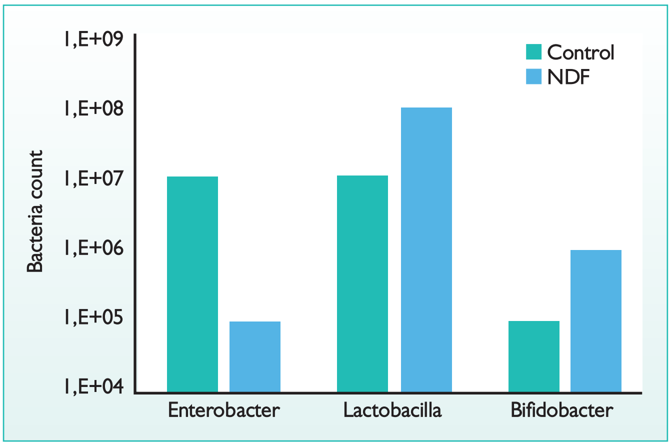

Fig. 1. Effect of 0.3% dietary NDF on the gut microflora of broilers – after Lückstädt and Theobald (2009).

Lactic acid bacteria

Unlike antibiotics, organic acids do not have a negative effect on beneficial, lactic acid producing bacteria. Lactic acid bacteria are able to grow at relatively low pH, as opposed to Gram-negative bacterial species, for example E. coli; salmonella etc. An explanation for this may be that Gram-positive bacteria have a high intracellular potassium concentration, which counteracts the acid anions.

Furthermore, those types of bacteria have a thick peptidoglycan layer (lipophobic), which is superficial to the cell membrane.

In addition to pathogen control, dietary acidification has also been shown to improve protein and amino acid digestibility. This may be due to a reduction in the buffering capacity of the feed and optimisation of the pH in the proventriculus, leading to better secretion of pepsin.

The acid anion also has a tendency to form complexes with minerals including Ca, P, Mg and Zn, which results in an improved digestibility of

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Table 1. Effect of 0.3% dietary sodium diformate (NDF) against salmonella and campylobacter in naturally contaminated broiler (percentage of positive samples) – adapted from Lückstädt and Theobald (2009).

	Salmonella		Campylobacter	
	Control	NDF	Control	NDF
Crop	20	0	60	0
Intestine	20	0	80	20
Faeces	25	0	n.d.*	n.d.
Meat	0	0	80	0

*n.d. – not determined

Table 2. Effect of 0.3% NDF on gut-pH, protein and fat digestibility as well as carcase quality in broilers at 35-days of age in Taiwan (Prof. Hsieh, 2012).

	Control	0.3% NDF	Difference (%)
pH in crop	4.24	3.96	-0.28 units
pH in stomach	2.94	2.58	-0.36 units
Protein digestibility (%)	61.6	63.3	+2.7
Fat digestibility (%)	90.5	91.1	+0.7
Wings (carcase) (%)	7.5[b]	7.9[a]	+5.6

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these minerals. This can help in improving egg quality. Furthermore, organic acids serve as substrates in intermediary metabolism.

Formic acid and propionic acid are used extensively in poultry production. Several other organic acids, including citric, fumaric, butyric and lactic acid are also in use and show some positive influence on growth performance.

The antimicrobial effect of organic acids increases with increasing concentrations and is also influenced by the molecular structure of the acid.

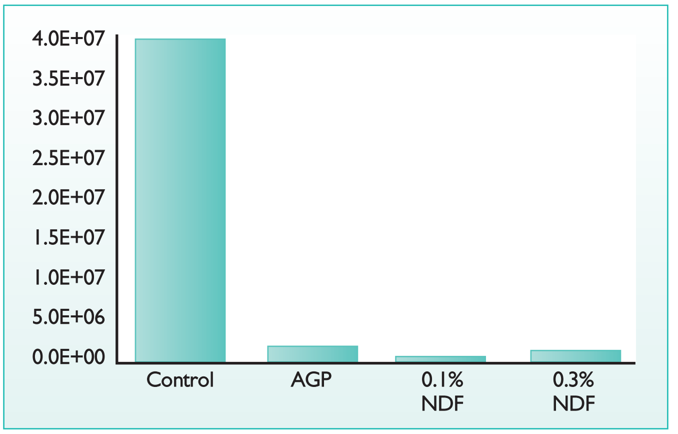

Fig. 2. Effect of 0.1% dietary sodium diformate (NDF) on E. coli numbers (MPN/g) in faeces of broiler – after Lückstädt et al. (2012).

Evaluating proper dosage

The MIC (Minimal Inhibitory Concentration) study done by Strauss and Hayler in 2001 is a good tool to evaluate the proper dosage for various organic acids to be used in the feed.

This study shows that formic acid is the most potent organic acid in the control of pathogenic bacteria, with the lowest MIC levels compared to other acids like propionic and lactic acid.

Studies done by Maribo et al. (2000) and Kirsch (2010) however showed that despite using formic acid in higher dosages in feed, the amount of acid that reaches the small intestine is barely 4-5%.

This corroborates with a study done by Thompson and Hinton (1997) which showed that even with an addition of a combination of formic and propionic acid in high concentrations to the feed, these acids could only be recovered from the crop and gizzard.

Another study on the metabolism of dietary propionic acid revealed that only little if any dietary propionic acid reaches the lower digestive tract and the caeca. This clearly indicates that control of pathogenic bacteria in the lower intestine is practically not possible by using the regular organic acid.

In 2006, Addcon GmbH, Germany launched sodium diformate (NDF) – a double salt of formic acid. This is a completely new molecule with a much higher percentage of formic acid as compared to the commonly available formic acid salt.

The major advantage of this molecule is its double bond structure, which ensures that around 85% of the formic acid equivalents reaches the small intestine and can deliver formic acid and its salts uniformly throughout the length of the GI-tract. Hence diformate comes with a double advantage – strongest antibacterial acid in the strongest form.

NDF has minimal evaporative losses during pelletising compared to organic acids and in fact it improves the pellet quality. Unlike liquid acids and blends which act only in the upper intestine, and the coated acids, which act only in the lower intestine, diformates show activity throughout the length of GI-tract.

Sodium diformate effectively controls salmonella and campylobacter infection at doses of 0.3% – see Table 1.

In a similar trial, it has been established that NDF significantly lowers the enterobacter count by almost 99% and supports the growth of the beneficial micro-flora, such as lactobacilli and bifidobacter, thus leading towards eubiosis – see Fig. 1.

Various studies done with NDF by different scientists have shown its efficacy in reducing the pH in the crop, improvement in the protein and fat digestibility (Table 2).

Furthermore, improved breast ratio, survival rate, FCR and EBI in broiler reared in Vietnam was reported by Lückstädt and Mellor (2012) – see Table 3.

Improved performance

Overall performance in the groups with NDF was increased, even when compared to the AGP group. The addition of 0.1% NDF under the circumstances of the trial resulted in an increase of 2.6% in weight gain, while the feed conversion rate was improved by 8.2%, compared to the negative control. The breast meat ratio increased by more than 5% if compared to the negative control, while the improvement compared the AGP-group was still nearly 3%. One could speculate that this was caused by the improved protein digestibility, which is often reported in conjunction with the use of dietary acidifier.

It could further be stated that the litter quality, as reported by Lückstädt et al. (2012) – based on the moisture content, was significantly ($P<0.05$) improved in birds fed NDF at both dosages (tested against the negative control).

Moisture content in the faecal matter was reduced by 7% (in the 0.1% NDF-dosage); while the AGP-group had only a reduction of 4% in the moisture content of faecal matter (moisture content of control litter was 57.2%).

In conjunction with the improved quality of the litter is also the significantly reduced ($P<0.05$) level of E. coli in the faeces (Fig. 2), which is measured as MPN (Most Probable Number).

If looked at the reduction rate, one could say that the use of dietary sodium diformate reduces the E. coli load in faeces by 96-97%!

Finally, in a recent large scale commercial investigation in India it was found that sodium diformate effectively reduce mortality, improves FCR and therefore, most importantly, decreases per kg cost of production in broilers (after Deshpande, 2012) – Table 4.

Numerous reports have demonstrated how including NDF in poultry diets has beneficial effects on performance by lowering bacterial pathogen load and improving nutrient digestibility, thus increasing performance.

These benefits are turned into economic returns. It is therefore recommended to use sodium diformate as a sustainable option in modern poultry production. ■

Table 3. Performance, dressing and economic parameters in broilers fed with or without sodium diformate (NDF) for 42 days – after Lückstädt and Mellor (2012).

	Negative control	0.1% NDF	0.3% NDF	AGP (300g/t)
Number of birds	96	96	96	96
Final weight (kg)	2.264	2.324	2.365	2.345
Daily weight gain (g/d)	52.8	54.2	55.2	54.7
Daily feed intake (g/d)	109.4	103.1	107.8	110.6
FCR	2.07	1.90	1.95	2.02
Survival (%)	95.8	97.9	97.8	99.0
Breast ratio (%)	22.7	23.9	24.0	23.3
EBI	244	279	277	268
Cost of feed/1kg gain*	0.72	0.66	0.69	0.71

*calculated in US-dollars

Table 4. Effect of 0.1% sodium diformate (NDF) on mortality, FCR and COP in broilers under Indian conditions – from Deshpande (2012).

	Control	NDF
Number of birds	3500	3000
Cost of chicks (25/pc)	87500	75000
Birds sold	3248	2898
Mortality	7.20	3.40
Average body weight	2.16	2.29
Total weight at market	7016	6636
FCR	1.79	1.71
Total feed	12558	11348
Cost of feed (18/kg)	226045	204269
Other cost (7/bird)	22736	20286
NDF cost	0	2270
Total cost	336281.2	301825
Cost per kg	47.9328	45.48
Cost saving per kg		2.45

Information on costs are in Indian Rupee