The differences between natural betaine and betaine hydrochloride

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In the 1860s, a German chemist, Scheibler, isolated a new organic base from sugar beet and called it betaine. Sugar beet and its derivatives (for example molasses and vinasses) are still the main raw materials from which natural betaine is extracted to be used in animal feed. However, it is increasingly the case that other sources of betaine, produced by chemical processes have become commercially available, for example betaine hydrochloride (HCl).

There is limited data in scientific literature comparing betaine HCl and natural betaine. In 2013, Danisco Animal Nutrition commissioned several studies to compare the products in terms of their physical properties and their consequent relative bio-efficacies.

Literature is abundant with research on the beneficial effects of natural betaine – the tri-methyl derivative of the amino acid glycine – on animal performance. These benefits apply particularly during times of heat and disease stress, and have been attributed to betaine's unique molecular structure. The betaine molecule contains three methyl groups that are labile, allowing it to function as a methyl donor in metabolism. The other important key point in the molecular structure of betaine is that it has both a positive and negative charge on the molecule. This lends it the characteristics of an osmolyte, aiding water balance in the body with resulting benefits on reducing maintenance energy requirements. This article will not focus on the beneficial effects of natural betaine or its mode of action, which is well documented in the literature, but rather will focus on comparing natural betaine and betaine HCl in recently conducted trials both in vitro and in vivo.

	Control no heat stress	Control heat stress (HS)	Natural betaine (HS)	Betaine HCl (HS)	SEM[2]
Bodyweight (BW) gain (g)	2982[a]	2724[b]	2963[a]	2896[a]b	85
Feed intake (g)	4359[a]	3851[b]	4007[ab]	4087[ab]	170
FCR	1.59[ab]	1.58[a]	1.55[b]	1.58[ab]	0.02
BW corrected FCR*	1.59[ab]	1.66[a]	1.55[b]	1.61[ab]	0.04
Breast meat (% of carcase weight)	27.9[ab]	26.8[b]	29.0[a]	27.8[ab]	0.004
Abdominal fat pad (% of BW)	1.39[b]	1.78[a]	1.29[b]	1.43[b]	0.11

[abc]means within a row without a common superscript are significantly different (P<0.05)
*3 points correction per 100g bodyweight difference versus the positive control.
[1]Each value represents the mean of eight replicates (10 birds per replicate). [2]Pooled standard error of mean.

Table 1. Performance and carcase measurements of 42 day old broiler chickens as influenced by heat stress and betaine source supplementation[1]. Betaine products added to supply 1.2kg betaine per tonne of feed.

In vitro trials

Betaine HCl is a chemically synthesised product which contains trimethylamine (TMA) as a by-product in varying concentrations.

Trimethylamine is a volatile amine associated with increased egg taint in poultry. However, there is a general lack of information comparing the levels of TMA in betaine HCl and natural betaine. Consequently, the first study examined the levels of TMA in some betaine products available in the market. Based on the analysis of samples of three betaine HCl products, the results (Fig. 1) showed that there is a big variation (0.2-6.0g/kg, as fed) in TMA content, even within batches of the same product.

This variation between both products and batches can result in unpredictably high levels of TMA in the finished feeds. It is interesting in this context to note that according to the European Food Safety Authority (EFSA Journal 2012;10(5):2679) 'For

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Fig. 1. Betaine HCl contains higher trimethylamine levels than natural betaine.

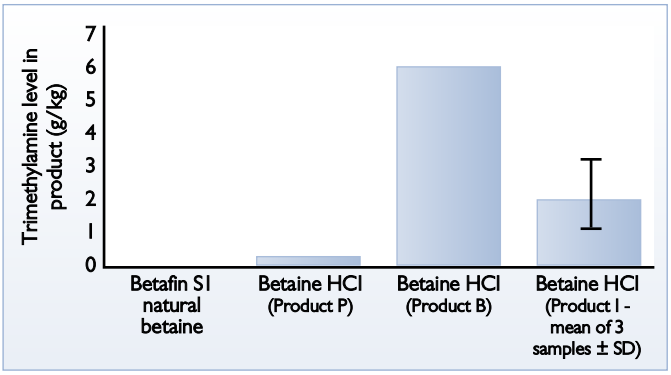
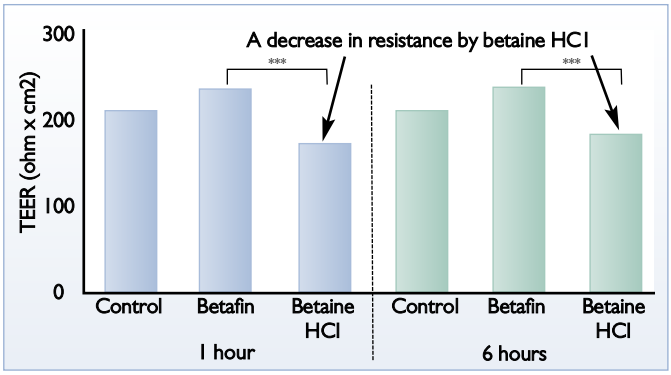


Fig. 2. Betaine HCl reduces the transepithelial electrical resistance (TEER) of the intestinal epithelial cells (see arrows).



*** Significantly different (P<0.001)

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trimethylamine and its salt the proposed high use level of 5mg/kg complete feeding stuff is safe for all animal species with a margin of safety ranging between 3 and 15'.

For this reason, it is important for nutritionists considering the use of betaine HCl to be well aware of the levels of TMA in the product, and its typical variation from batch to batch. Natural betaine was found to contain no detectable TMA (Fig. 1).

For betaine to function as an efficient osmolyte in vivo, the molecule must first be fully and rapidly solubilised in water. To test the difference in betaine solubility between natural betaine and betaine HCl, a further study was conducted at DuPont Nutrition and Health, Kantvik Active Nutrition, Finland.

This showed that Betafin natural betaine was approximately three times more soluble, and dissolved in water more than twice as rapidly as betaine HCl.

In a different type of study, using an in vitro intestinal cell model, betaine HCl was found to negatively influence the gut barrier compared to natural betaine (Fig. 2). If replicated in vivo this would have important implications for the animal's digestive physiology.

Weak cellular tight junctions between gut epithelial cells (indicated by a reduced TEER value, see Fig. 2) can lead to movement of antigens across the gut barrier to provoke a damaging and energetically costly inflammatory response.

This effect was supported by significantly higher in vitro cytokine IL-8 production with betaine HCl compared to both control and natural betaine.

Animal trials

Both coccidia and high ambient temperature can cause damage to gut tissues, increase gut permeability, reduce nutrient digestion and absorption, and consequently reduce animal performance.

Betaine is known to be a highly effective organic osmoprotectant and several studies have shown its positive effects on the performance of broilers exposed to production stresses such as coccidial challenge and heat stress.

However, most of the early published studies on betaine were conducted using natural betaine and there is lack of data comparing the natural source of betaine and betaine HCl on performance of broilers in challenge situations. This has been addressed in two recent studies carried out at Massey University, New Zealand.

In the first study broilers under heat stress showed a significant improvement in carcase breast meat yield, bodyweight gain and feed conversion ratio with Betafin natural betaine supplementation compared with the heat stress control group. In contrast, the betaine HCl product only showed numerical improvement compared with the heat stress control.

In a second study, using a coccidial challenge model, both betaine sources were able to improve nutrient digestibility compared to the challenged control, but only the birds fed the natural betaine were able to fully recover the reduction in nutrient digestibility caused by the coccidial challenge. This trial showed Betafin natural betaine delivered >€11 per tonne of feed more value than betaine HCl based on relative energy and amino acid digestibility in coccidia challenged birds.

These two studies clearly illustrated that Betafin natural betaine can offer greater net value in use than betaine HCl, particularly for birds under production stress.

	Un-challenged control	Challenged control	Challenged control – reduced methionine (CC)	Natural betaine (CC)	Betaine HCl (CC)	SEM[2]
IDE (MJ/kg DM)	13.38[a]	8.80[c]	8.91[c]	12.41[ab]	11.89[b]	0.52
Lysine	88[a]	70[c]	74[c]	85[ab]	81[b]	2.2
Methionine	90[a]	72[c]	66[d]	79[b]	76b[c]	1.6
Average AA	81[a]	58[c]	62[c]	76[ab]	73[b]	1.9

[abc]means within a row without a common superscript are significantly different (P<0.05)
[1]Each value represents the mean of eight replicates (eight birds per replicate). [2]Pooled standard error of mean.

Table 2. Ileal digestible energy (IDE), ileal lysine and methionine digestibility (%) and average amino acid (AA) digestibility (%) of 21 day old broilers as influenced by coccidia challenge and betaine source supplementation[1]. Betaine products added to supply 960g betaine per tonne of feed.

Conclusion

These recent comparative studies between natural betaine and betaine HCl clearly illustrate that some of the differences seen in vitro, for example relative solubility in water, speed of dissolution and relative effects in in vitro intestinal cell models are reflected in the in vivo bio-efficacy comparisons. The differences in residual levels of TMA in betaine HCl products should also be considered as part of a routine QC process.

In animal studies the true relative value of the two products can only be critically assessed in 'challenge' situations (for example heat stress, coccidial challenge) and, under these circumstances and on the basis of these recent trials, natural betaine showed clear added-value benefits.

The factors mentioned in this article should be seriously considered before making a purchasing decision based purely on cost per tonne treated to provide equivalent betaine levels. ■

References are available on request from monica.hart@dupont.com