Betaine: an underestimated functional nutrient

Betaine is a zwitterion metabolite (a neutral molecule with both positive and negative electrical charges) also known as trimethylglycine. The benefits of betaine in animal nutrition are now well recognised, especially in poultry and swine agro-industries.

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Due to its specific chemical structure, betaine has two main physiological functions: it provides methyl groups, required for the synthesis of various metabolically active compounds such as carnitine – an important molecule for muscle energy metabolism – or creatine, and is acting as an osmolyte. The dipolar zwitterion form gives its osmoprotective properties.

Osmoregulation is the ability of a cell to maintain its structure and functions by regulating the movements of water in and out of the cell. Betaine has the ability to especially accumulate in cells exposed to osmotic and ionic stress, such as intestinal epithelium, in order to improve intracellular water retention.

This water is then available for metabolic processes in the cell. By this process, betaine inhibits the accumulation of inorganic ions, and this protects enzymes and membranes from osmotic inactivation.

The osmoprotective properties of betaine are likely to improve nutrient digestibility by supporting intestinal cells, but also the growth and the survival of intestinal microbes. This explains the beneficial effect of betaine to help poultry counteract the negative effects of heat stress and to support the performance of poultry in case of coccidiosis. In fact, betaine not only improves intestinal structure but it also acts directly on coccidia by a partial inhibition of the invasion and the development of coccidia.

Time (hours)	0	8	24	32	48
Betaine hydrochloride					
Anhydrous betaine					
beTane					

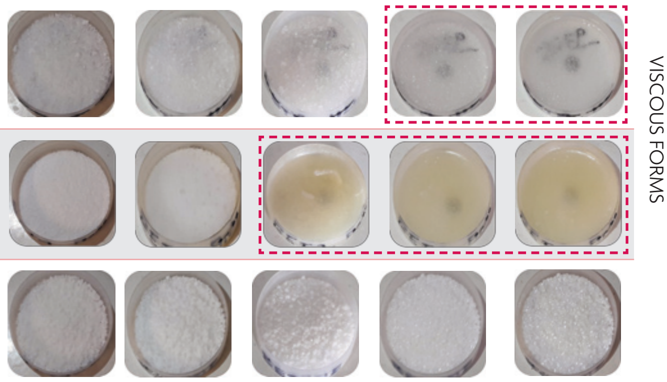

Table 1. Comparative behaviour of betaine hydrochloride, anhydrous betaine and beTane at 45°C and 50% humidity over time.

Is one source of betaine better?

In the past, betaine has been mainly used under its natural form, anhydrous betaine, usually extracted from vegetable sources like sugar beet and their by-products.

However, the limitation of the natural resource has led to the development of the use of chemical and synthetic forms, including betaine hydrochloride, which is available all year round in a quasi-unlimited quantity and is cost-effective.

As far as we know, there are very few independent studies comparing the two sources of betaine.

In a trial at the MiXscience Research Center (MRC) in 2014, we compared the effect of a supplementation of 500ppm of betaine coming from the synthetic anhydrous betaine and betaine hydrochloride in a diet containing 150ppm of choline, under hot temperature conditions between 20 and 35 days. We noticed no difference between the two groups and did not conclude the superiority of one form of betaine over another.

Table 2. Six treatments used to assess the zootechnical properties of betaine.

Group	Control	B250	B500	B1000	CB250	CB500
Betaine form	-	Free betaine			Coated betaine	
Net equivalent betaine supplementation in the diet from 0-34 days (g/T)	None	250	500	1000	250	500

The hygroscopic problem

Although the beneficial effects of both sources of betaine have been largely demonstrated for animal growth, feed utilisation, carcase quality, resistance to heat stress or coccidian infection, the major limitation for the use of these compounds remains their manipulation at the industrial level because of their high capacity to attract water.

Indeed, the highly hygroscopic nature of both sources of betaine sometimes limits their application in feed mills. Actually, in presence of wet atmosphere, betaine easily turns to a viscous or lumpy substance and becomes very difficult to process, especially in silos.

This could significantly impact the stability of the premixes or the feed. In order to improve the ease of use of this product, it is possible to protect the betaine with a hydrophobic material, as it

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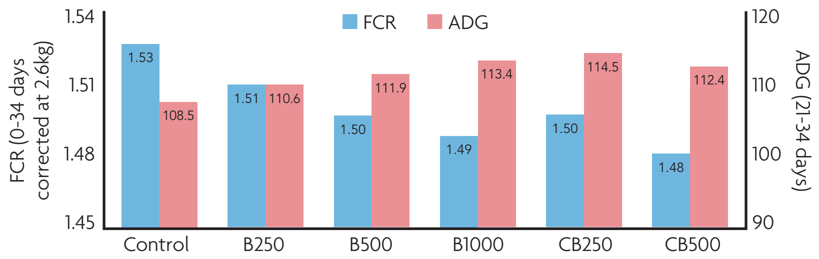

Fig. 1. In vivo validation of the interest of a protected form of betaine compared with free betaine based on performance results of chicks (FCR: Feed Conversion Ratio, ADG: Average Daily Gain).

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has been developed by MiXscience (France, AVRIL Group) with its beTane product. To illustrate the interest of this technology, in vitro experiments have been performed.

Table 1 shows the comparative behaviour of three forms of betaine: betaine hydrochloride, anhydrous betaine and beTane, a new encapsulated betaine hydrochloride. When challenged at 45˚C (this temperature is supposed to mimic extreme storage-temperature conditions, but it is also modelling an accelerated aging situation), beTane keeps its physical integrity over time, whereas anhydrous betaine or non-encapsulated betaine hydrochloride turns to a viscous gel and even a resin, potentially hard to eliminate at factory scale.

Zootechnical properties

To ensure that encapsulation does not affect zootechnical properties of betaine, the encapsulated form of betaine was compared with a non-protected form at different doses in poultry. The results were presented at the European Symposium on Poultry Nutrition by Klein et al. (2016).

160 male Ross PM3 chicks were allocated to 40 cages, with four birds per cage and 6-7 replicates per group. The trial duration was 34 days. Six treatments were applied (Table 2). Birds were challenged with high temperatures from day 21 to 34 of the experiment according to the following daily sequence:

- 24˚C from 6pm to 8am.
- 28˚C from 8am to 11am.
- 30˚C from 11am to 3pm.
- 28˚C from 3pm to 6 pm.

High temperature induced variability, but performances were improved for all betaine groups compared to the control group, especially during the heat stress phase (Fig. 1) validating the osmoprotective potential of betaine. No statistical differences were observed between treatments but, overall, the highest performance results were observed with the encapsulated betaine applied at 500g/t. Results were even better than free betaine applied at 1,000g/t indicating that no negative impact of the encapsulating technology was observed.

Conclusion

In vitro and in vivo trials confirm the fact that an encapsulated form of betaine is a real alternative to solve industrial constraints of using this product without affecting its zootechnical efficacy.

Preliminary results also indicate that an encapsulating technology is probably an efficient way to reduce net betaine incorporation in a diet formulation. ■