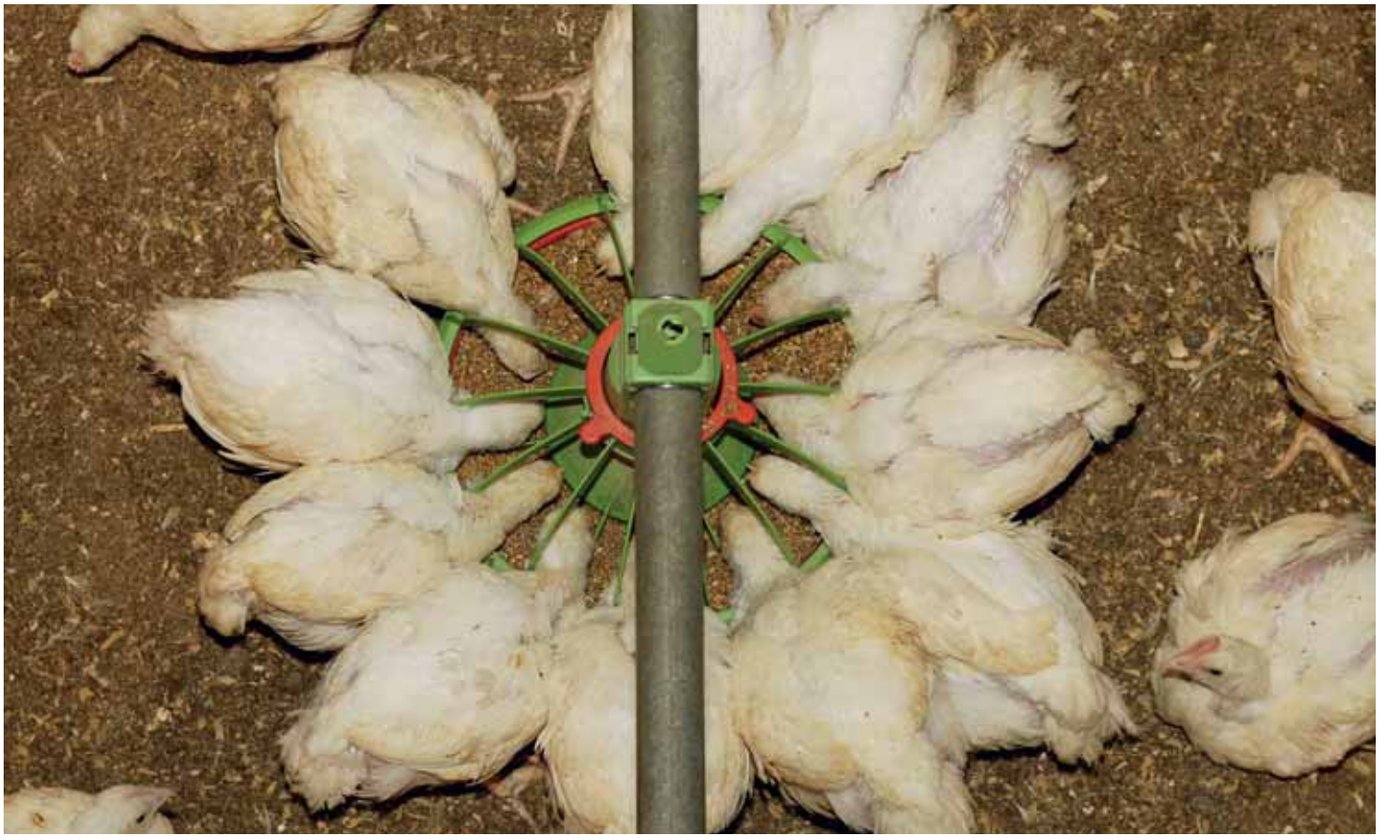
Synthetic betaine: Functional alternative in broiler nutrition



Betaine is an important ingredient in broiler nutrition. It improves production performance, replaces other methyl group donors such as choline and methionine, assists birds under heat stress conditions and improves slaughter characteristics. The major source so far has been betaine anhydrate extracted from sugar beet. However, a proper crystalline betaine hydrochloride has proven to also work well. This is available all year long and production capacity is independent to sugar beet production. Moreover, it is cost effective.

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Betaine is a known functional nutrient in broiler nutrition, which was in the past mainly used as betaine anhydrous extracted from sugar beets. Nowadays, betaine is also available as betaine hydrochloride from synthetic production. Latest research highlighted that the nutritional properties of these products were equal, unveiling a cheaper, non-hygroscopic as well as non-seasonal (available all year) source of betaine for the feed industry. However, special care should be taken that the free-flowing properties of betaine hydrochloride are always ensured, since hygroscopicity may limit application in feed factories. With a strong focus on the crystallisation process and correct application of a free flowing carrier, a non-hygroscopic betaine hydrochloride can be produced.

Absorption and metabolism

Betaine is absorbed via the duodenum. Human studies showed rapid absorption and distribution, with a peak increase in serum 1–2 hours post food intake. Betaine is absorbed in the gastrointestinal tract (GIT) whereas up to 3/4 of it can remain at GIT intracellular level. Intracel-

lular accumulation takes place via active (Na^+ or Cl^-) and passive (Na^+) transport systems.

Betaine is eliminated by metabolism, not excretion, and catabolised via a series of enzyme reactions (transmethylation) that occur in the mitochondria of liver and kidney cells. The principal physiological role of betaine is to act as an osmolyte and as methyl donor (transmethylation). As an osmolyte, betaine increases intracellular water retention and therefore protects intracellular enzymes against osmotic induced inactivation. As a methyl donor, betaine participates in the methionine cycle (mainly in the liver) and can be further used in transmethylation reactions for synthesis of essential substances like carnitine and creatine. Betaine has shown to also accumulate in other internal organs (gut, liver, kidney and heart) to protect them and enhance performance in human athletes.

Biological equivalence

Betaine is a zwitterion metabolite also known as trimethylglycine. It was first discovered in sugar beets and it is also present in other plants, animals and seafood. However, sugar beets contain exceptionally high levels of betaine which accumulate in condensed soluble (116,000 mg/kg). Nowadays, betaine is also available in several purified forms (anhydrous, monophosphate and hydrochloride betaine). Some questions were raised if osmoregulatory properties of betaine hydrochloride were similar to those of betaine anhydrous. To study this question, an *in vitro* trial was setup to mimic gastric passage. The University of Ghent evaluated the biological equivalence of different betaine sources (monohydrate and anhydrous produced by extraction vs. betaine hydrochloride and anhydrous, produced by chemical synthesis), using Mass Spectromety combined with HPLC analysis in a model that simulates gastric passage. Results showed that irrespective of the ionic form and production method (natural extraction vs. chemical synthesis) different sources of betaine gave the same analytical results. As after gastric passage both molecules proved to be identical, no differences in biological activity or osmoregulatory function between betaine hydrochloride and betaine anhydrous as an effective feed additive could reasonably be expected.

Betaine in poultry production

The dietary effects of feeding betaine in poultry was reviewed by both Eklund and Ratriyanto. Results of nutrient digestibility, animal performance, metabolism and improvement in carcass leanness indicated the benefits of betaine as a feed additive and of improving animal performance and slaughter characteristics. Studies included in these reviews were indeed conducted with a particular scientific thought and animal responses were the result of one of the betaine's modes of action (methyl donor or osmolyte) which are both influenced by the concentration of other methyl donors in the diet and the presence of either an osmotic or metabolic stress.

Dietary supplementation of betaine may reduce the requirement of other methyl donors such as methionine and choline. However this theoretical application must be subjected to considerable analysis before practical implementation. This sparing effect of methionine and choline has been thoroughly investigated. It seemed that the dietary addition of betaine and methionine can replace each other in broiler chicks. Moreover 30 and 80% of the supplemental methionine can be substituted by betaine without negative effects on performance. A more conservative replacement approach was evaluated by Lensing and Van der Klis and Cresswell. Both experiments studied the bio-equivalency between betaine and choline/methionine in broiler diets whereas choline was fully replaced and methionine decreased by 25-30% of daily requirements. Within this range of replacement no differences in broiler performance were observed.

Trial in India

In line with the results found by Cresswell, Excentials tested feeding strategies to get more insight into application strategies. This trial was performed in 2011 at IPME Pune in India and showed improved performance and carcass yield for all treatments. Moreover, this trial presents an insight into different

Figure 1 and 2 - Betaine hydrochloride alleviate the negative impact of heat stress on rectal temperature and panting.

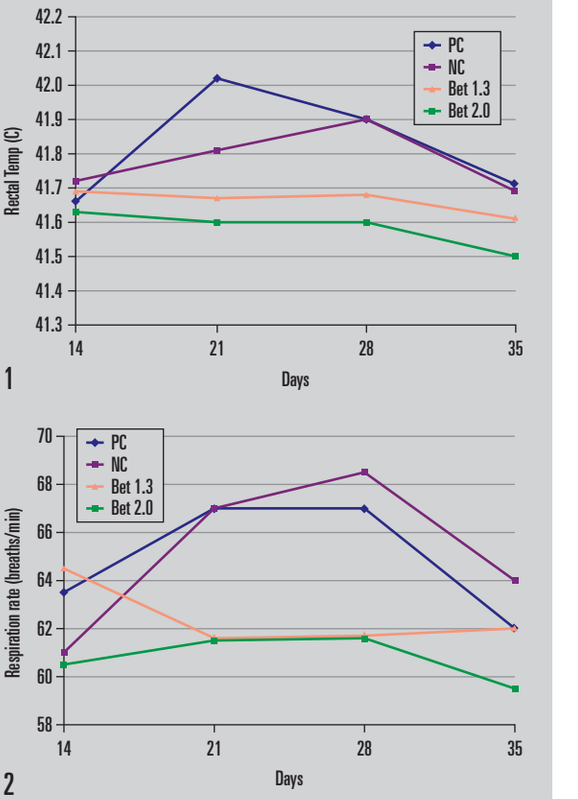

Table 1 - Trial results Excential Beta-key on production performance, slaughter yields and economical evaluation.

Excential Beta-Key Treatments	T1 (Control)	T2	T3	T4
Performance				
Final body weight (kg)	2.11	2.16	2.12	2.15
Feed conversion (kg feed/kg growth)	1.92	1.83	1.89	1.85
Economical Evaluation				
Average feed cost (USD/Kg)	0.368	0.370	0.367	0.368
Average feed consumption (Kg)	4.04	3.96	4.07	3.98
Total feeding cost (USD/bird)	1.487	1.466	1.492	1.464
Chick cost (USD) per bird	0.56	0.56	0.56	0.56
Medication/vaccination (per bird)	0.05	0.05	0.05	0.05
Administrative (per bird)	0.11	0.11	0.11	0.11
Total production cost (USD/bird)	2.207	2.186	2.212	2.184
Average live body weight(Kg)	2.11	2.16	2.13	2.15
Average dressing %	74.82	77.60	75.99	77.57
Average dressing weight(Kg)	1.577	1.679	1.616	1.671
Production cost per kg live weight (USD)	1.05	1.01	1.04	1.01
Cost of production per kg Dressed weight (USD)	**1.40**	**1.30**	**1.37**	**1.31**

T1: Control diet

T2: Diet containing Excential Beta-Key @ 500 gm per/MT

T3: Diet containing Excential Beta-Key @ 500 gm per/MT by replacing 750 gm choline chloride & 200 gm Methionine

T4: Diet containing Excential Beta-Key @ 1000 gm per/MT by replacing 1000 gm choline chloride & 300 gm Methionine

Purities: Excential Beta-Key: min. 71%; Choline Chloride 75%; DL-Methionine 98%

application strategies. Two thousand Cobb broiler birds were divided over four treatments. The control diets were typical corn-soy diets containing 2000 ppm, 1500 ppm and 1500 ppm added Choline Chloride (75%) and 0.61%, 0.58% and 0.45% total methionine for starter, grower and finisher diets respectively. Best economical results were achieved with on top addition of betaine (treatment 2): an investment of 0.002$/kg feed resulted in 7% savings in production costs of dressed weight. Replacement of certain levels of choline and methionine showed good economical results. Treatment 3 (strong replacement of choline and methionine) shows that with lower feeding costs, a small improvement in production can be achieved. Treatment 4 (careful replacement of choline and methionine) is a safe strategy with equal costs of the diet, but a good return on investment. Premix companies, compound feed manufacturers and integrated companies may have different commercial interests that each may desire their own strategy. Results of this trial are summarised in *Table 1*.

Overcome heat stress

Several scientific publications show the proof of principle that betaine anhydrate can be used to overcome heat stress. The impact of severe heat stress could partially be overcome by adding betaine to the diet in slow growing broilers. Adding 1 kg betaine to the diet improved weight gain and feed conversion compared to negative control treatment. More importantly, rectal temperature decreased (43.2°C versus 41.9°C) compared to negative control. Panting, a mechanism of heavily breathing to loose heat via evaporation, was also reduced significantly. Under milder heat stress conditions (31°C, ±85% relative humidity) in conventional broilers, the same effects can be expected (Haldar ea, Thailand 2011). More importantly, it is proven that betaine hydrochloride has similar osmoregulatory properties as an anhydrous source. Heat stress commenced on day 14. In this trial a positive control, and negative control were used whereby the negative control treatment was lowered in methionine (850 gr/Mt), added choline was removed and energy was reduced (-50 kcal ME). Betaine hydrochloride was added at 1.3 kg/Mt and 2.0 kg/mt whereby same replacement of methionine, choline and energy as in negative control was used. Body weight of broilers at 38 days increased from 1.80 kg (control) to 1.84 kg and 1.86 kg for birds fed 1.3 kg/mt and 2.0 kg/mt betaine hydrochloride respectively. Feed conversion improved from 1.67 in positive control to 1.63 (1.3 kg betaine HCL) and 1.62 (2.0 kg betaine HCL). *Figures 1 and 2* show the effect on rectal temperature and panting, clearly indicating that during heat stress betaine hydrochloride alleviates these negative effects.

** References are available upon request*