Betaine: A very valuable nutrient

Betaine is a naturally occurring compound found in different plants (e.g. sugar beets) and as a metabolite in animals. Betaine is also known as trimethylglycine, referring to its structure – three methyl groups (-CH_3) attached to the amino acid glycine.

The presence of these three groups explains the first nutritional function of betaine as a methyl donor in transmethylation reactions in the liver. In addition to this function, betaine also has an important biological role in protecting cells against osmotic stress. Accumulation of betaine as an osmolyte in cells under hyperosmotic conditions, protects the cellular structures and prevents a decrease in metabolic activity of these cells.

Betaine as a methyl donor

Several important biological compounds (e.g. carnitine, creatine, and hormones) require a methylation step during their synthesis. This methylation takes place in the liver, during a well-defined physiological process called the transmethylation cycle. In this cycle, labile methyl groups will be transferred from methyl donors (methionine, choline, and betaine) to the acceptors (*Figure 1*).

As a methyl donor, betaine can replace choline completely. Moreover, betaine will be a more efficient methyl donor. Conversion efficiency of choline to betaine, an essential step in the transmethylation cycle when choline acts as methyl donor, is reported to be only 55%. The reason for this loss in efficiency is the transport of choline to the mitochondria and the enzymatic transformation to form betaine, which takes place in two steps.

Methionine cannot be completely replaced by betaine because it plays an essential role in the transmethylation cycle. Although, thanks to the capacity of betaine to remethylate homocysteine to methionine, a sparing effect of betaine on methionine is seen in poultry, allowing methionine to be available as building block for protein synthesis.

Betaine as an osmoprotectant

To prevent cellular dehydration in a hyperosmotic environment, cells must accumulate osmolytes. Because betaine is a highly soluble zwitterionic molecule (dipolar molecule with a positive and negative charge), it serves as an important organic osmolyte for the control of osmotic pressure in cells. It is important for cells to keep their water content in balance to fulfil their cellular metabolism.

Thanks to betaine, cellular functions such as DNA replication and enzyme production are better preserved under stressed conditions. An example in plants for the osmoprotective working of betaine is the high betaine content in sugar beets. Sugar beets have a high level of sucrose and thus a high osmotic pressure. Accumulation of betaine in sugar beets can be considered nature's defence mechanism against osmotic pressure.

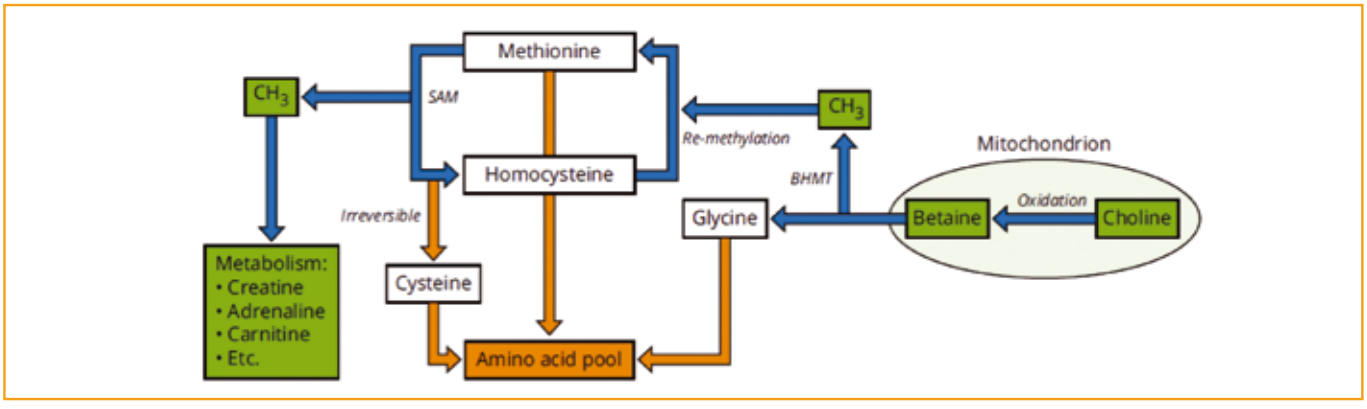
Applications in animal feed

As betaine is an efficient methyl donor, one of its well-known applications in animal feed is as a cost saving mechanism. Here, all added choline chloride and part of the added methionine can be replaced. Especially in broiler diets, it is proven in different sudies that this replacement maintains excellent performance levels at lower cost prices of the diets. Besides this application, higher dosages of betaine (e.g. 1kg/ton feed) can be dosed in animal diets for multiple indications.

First indication: Heat stress

In different animal species heat stress will reduce performance and decrease production results. Heat stress is a typical condition where it is important for animals to regulate their water balance. Through its ability to act as a protective osmolyte, betaine relieves heat stress, which leads to lower rectal temperatures and less panting behaviour in broilers, for example.

Figure 1: Methyl group metabolism.



Multiple trials in different animal species have indicated betaine's beneficial effects in keeping up performance during hot weather as well as high humidity.

Second indication: Coccidiosis

Coccidia infections are associated with diarrhoea and disturbances of the osmotic balance. Supplemental betaine increases the robustness of the intestinal epithelial cells and can reduce lesion scores in coccidian-infected chickens. Particularly in combination with ionophoric coccidiostats (e.g. salinomycin), betaine shows improved performance of infected chickens, as ionophoric coccidiostats appear to limit the natural enzymatic conversion of choline to betaine.

Third indication: Carcass quality

Another indication for using betaine in animal diets is its influence on carcass quality. Betaine plays a role in different processes influencing carcass characteristics. The sparing effect on methionine and the glycine provided by betaine after its three methyl groups are released, explain the influence on protein synthesis.

Both in poultry and pigs, higher breast meat yield and lean meat yield, respectively, are reported in several studies. Betaine plays a role in not only protein, but also in fat metabolism. Betaine is a lipotropic compound, which means it helps in the mobilisation of fat and results in lower fat percentages of carcasses. The osmotic function of betaine will also improve water binding capacity.

Fourth indication: Liver protection

The transmethylation cycle is an important process for liver health. Adequate synthesis of compounds such as carnitine and phosphatidylcholine are essential for a healthy functioning liver. Impaired liver function can be seen during high production when fat has to be mobilised and leads to disorders such as fatty liver disease in laying hens. Because betaine is such an efficient methyl donor, it supports the liver optimally. Administration of betaine as hepatoprotector is effective to attenuate liver injury and improve liver function.

Other indications

Along with the four mentioned indications and the use of betaine in the replacement of methionine and choline, betaine has also been used to alleviate salt stress, improve fertility, increase digestion, prevent leaky gut, and combat oxidative stress. All these different reported applications in different animal species show the value of betaine as nutrient, especially under stress conditions.

Supplementation in animal diets

Some feed materials, such as wheat, contain considerable amounts of betaine. Because plants will produce and accumulate betaine to protect themselves against drought, betaine concentrations are rather variable and dependent on growth conditions.

To provide animals with enough of this very valuable nutrient, additional betaine should be added to the diet. Natural (anhydrous) betaine, extracted from sugar beets, can be used as a feed additive, but synthetic betaine (anhydrous or hydrochloride) is also available and is a more cost-efficient source of betaine. Product characteristics such as hygroscopicity and free-flowing capacity are some factors to consider when adding additional betaine to the feed. ❖

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