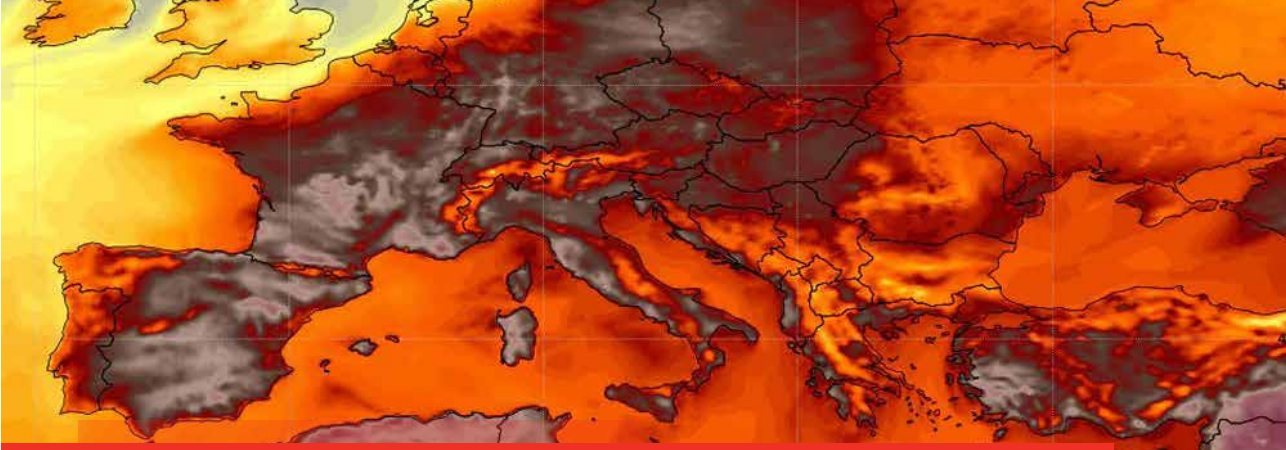

Alleviating heat stress with betaine

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High environmental temperatures negatively influence productive performances in poultry, such as broilers, layers and breeders. The optimum temperature for performance of poultry is likely to be 18 to 24°C, depending on the age and breed of the birds. If the ambient temperature is higher, birds can experience difficulties in keeping their body temperature at normal physiological levels – this is defined as heat stress.

During heat stress, the body temperature, respiration rate and heart rate of the animals increase. Imbalances occur in the acid/base metabolism, the distribution of ions throughout the body and water retention. Moreover, reduced immune functions and increased oxidative stress levels are observed. Eventually, severe heat stress will result in the death of the animals.

The level of heat stress in birds varies depending on the temperature, relative humidity, the duration of exposure, diurnal variation, housing conditions and acute versus chronic prevalence of high temperatures.

From the moment the heat energy produced is higher than the energy that can be excreted by the birds to the surroundings, symptoms of heat stress arise. One of the most obvious symptoms is decreased feed intake. Not only will the feed intake be lower in hot weather, but nutrient digestibility and conversion of the feed into meat/eggs will also be lower. This can be concluded from studies where animals in normal temperature environments are pair-fed the same amount of feed, but outperform their heat stressed counterparts. Impaired gut function and -integrity, inflammatory immune responses and oxidative stress explain this reduced performance. In addition to a decline in feed efficiency, the quality of end products (carcass quality and egg quality) differ significantly between heat stressed and control animals.

For the industry, the detrimental effects of high environmental temperature on poultry lead to considerable economic losses. As

the frequency of high-temperature days is expected to increase with climate change and global warming, mitigating the negative impact of heat stress on poultry production will be an important mission.

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The functions of betaine

Betaine plays an important role in alleviating heat stress in poultry and has multiple functions which are beneficial to animals experiencing heat stress.

First of all, betaine functions as a methyl donor in the liver. Endogenously synthesized from choline, betaine donates its methyl group to regenerate methionine, the central methyl donor in the transmethylation cycle, as shown in Figure 1.

When in addition to the endogenously produced betaine, additional betaine is supplemented to the feed, it can spare the other methyl donors in the transmethylation cycle (choline and methionine) and positively influence the methylation process, improving synthesis of compounds like carnitine and creatine. Thus, betaine plays a role in protein and lipid metabolism in the liver. Good functioning of this protein and lipid metabolism is highly important, especially when animals experience (heat) stress and feed intake is impaired.

In addition to its role as a methyl donor, betaine is considered an extremely effective osmoprotectant for cells. When heat stress causes water and ionic imbalances, betaine helps cells throughout the body to minimize water loss, to maintain cellular volume and to preserve cellular metabolism.

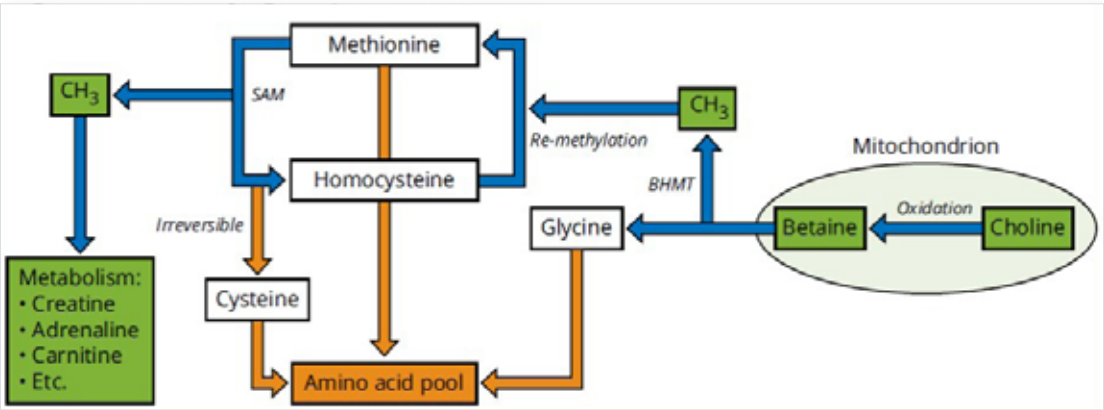

Figure 1: The transmethylation cycle

Functioning as an excellent osmolyte, betaine can be surrounded by a hydration shell of multiple water molecules. In situations of cellular dehydration, cells are exposed to osmotic and ionic stress. As a solution, betaine can be accumulated in the cells to maintain the water absorption and cell turgor. Intracellular betaine preserves the osmotic equilibrium and contributes to sustained metabolic processes inside the cell.

Betaine as an osmolyte not only helps the cell in minimizing water loss, it provides stabilizing effects on cellular structures (e.g. protein- and DNA-structure). Betaine is universally known for its unusually strong stabilizing effects on the three-dimensional folding structure of proteins, and protects proteins from denaturation and deactivation. The protection of these macromolecules against denaturation, for example caused by high temperatures, allows the cell to maintain its metabolic activities and to continue proliferation. Therefore, to preserve optimal function of several tissues and organs during heat stress, a sufficient availability of betaine is crucial.

Reducing heat stress

High environmental temperatures causing heat stress in poultry lead to stressful behavioural responses. Providing birds with enough betaine by supplementing the feed with betaine hydrochloride or betaine anhydrous, can reduce symptoms like panting and even prevent the increase of body temperature.

In the study of Singh *et al*. (2015), broilers were kept at temperatures varying between 28 and 35°C. Betaine hydrochloride significantly decreased rectal temperature and respiration rate on days 21 and 28, both at a dosage of 1.3 kg/ton and at 2 kg/ton (see Figure 2).

The improved capacity of the birds to control their body temperature can be explained by the increased water retention when betaine is supplied, which might increase peripheral blood flow and evaporation, reducing heat stress. Alleviating heat stress symptoms is not only beneficial for animal welfare, it leads to better performance and decreased mortality.

Improving digestion, absorption and nutrient utilization

One of the tissues where betaine establishes its beneficial effects during heat stress is the gut tissue. Dietary betaine increases the betaine concentration in the intestinal

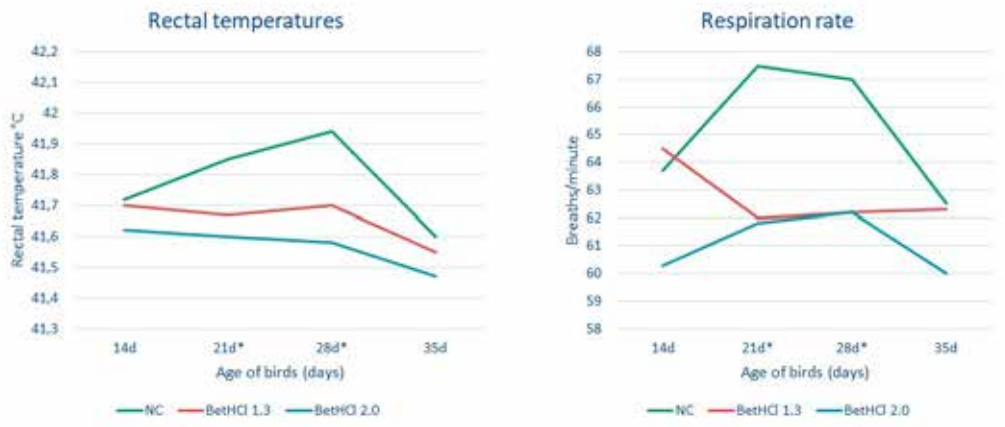

Figure 2: Rectal temperatures and respiration rate of experimental broilers fed diets containing different levels of betaine hydrochloride and exposed to thermal stress

(Figure adapted from Singh et al., 2015)

epithelium, stimulating the protection of the intestinal cells against osmotic disturbances. The osmoprotective effects of intracellular betaine preserve the important functions of the intestinal cells, such as enzyme production and nutrient absorption. Because betaine also stimulates intestinal cells to continue proliferation, a better conservation of the mucosal structure of the gut (crypts and villi) can be observed.

It is well known that the process of nutrient digestion and absorption depends on an intact gut epithelium and that this gut integrity is impaired during heat stress. The supplementation of betaine reduces the negative effects of heat stress on the gut and improves the digestibility of nutrients. When feed intake is reduced, an optimal utilization of the nutrients that are consumed is extremely important to keep up performance.

Results on production

Plenty of studies describe the positive results of betaine supplementation on the performance of poultry (broilers, laying hens, quails and turkeys). Many of these studies were done in environments with high temperatures, indicating the assistance of betaine in alleviating heat stress.

In broilers, increased weight gain, enhanced feed intake, improved feed conversion, a higher breast muscle yield and reduced abdominal fat weight are observed. In layers and breeders, betaine counteracts performance losses induced by heat stress. Egg production increases up to 23.6% and there's also an improvement of egg quality.

Moreover, a reduction of fatty liver problems and for breeders beneficial effects on reproduction, e.g. increased viability and motility of spermatozoa and improved hatchability, are resulting benefits.

Conclusion

The multiple functions of betaine can improve poultry tolerance to heat stress. Dietary application of betaine hydrochloride or betaine anhydrous, in dosages from 0.5 to 2 kg/ton, is an efficient tool as part of a strategy to counter the negative effects of heat stress in poultry production.