

Betaine helps combat heat stress in broilers



Including betaine in poultry diets can offer significant benefits to producers who are striving to maintain bird performance under high ambient temperatures when heat stress is a cause for concern, writes GENE L.Z.JIN*.

Heat stress can be a serious concern for Asian poultry producers as it can lead to financial losses by impairing poultry performance or at worst, result in increased mortality.

As well as adjusting basic management practices, such as altering the housing environment to reduce house temperature and humidity, revising the bird's nutrition is also important to minimise the impact of heat stress. Including dietary electrolyte supplements such as sodium bicarbonate and potassium chloride can go some way to correct the reduced levels of blood plasma carbon dioxide, bicarbonate and potassium in birds suffering heat stress.

However, more recently, betaine addition to the feed or drinking water has also been shown to be beneficial in heat stressed broilers by helping birds stave off dehydration.

What is heat stress?

Birds become heat stressed when they have difficulty in achieving the balance between body heat loss and body heat

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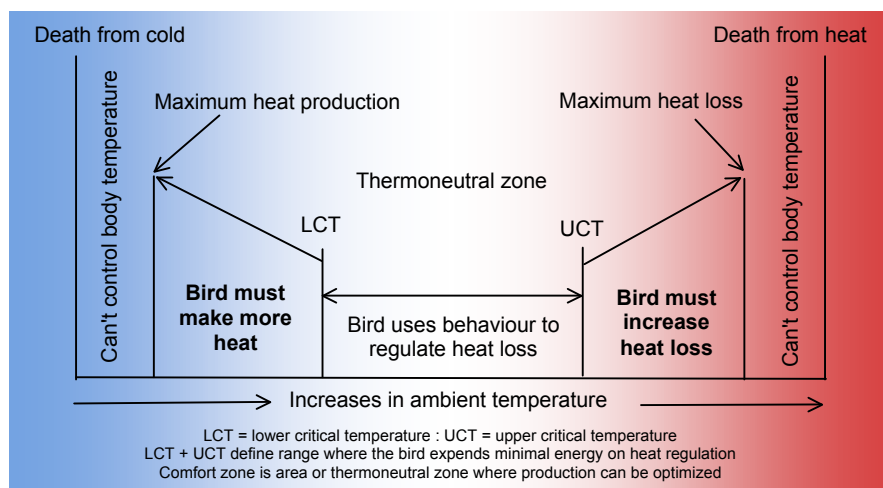


Figure 1: Broiler response to changes in ambient temperature.

production.

At high environmental temperatures they rely on a range of mechanisms to regulate their body temperature within a comfort zone described as the 'thermoneutral zone' (Figure 1). The normal body temperature of a broiler is 41°C. When the environmental temperature exceeds 35°C, the broiler experiences heat stress. In an effort to maintain body temperature, birds first rely on losing heat from blood vessels near the surface of the skin in a process called "non-evaporative cooling".

However, this mechanism is only effective when the ambient temperature is lower than the bird's body temperature.

As the ambient temperature increases beyond the bird's thermoneutral zone, the 'upper critical temperature' of the bird is reached (UCT, Figure 1), and non-evaporative cooling becomes ineffective.

At these higher temperatures, the bird becomes reliant on panting ('evaporative cooling') as the mechanism for controlling body temperature. Panting is an effective but energy-expensive way for the bird to control body temperature

Figure 2: Betaine improves performance of birds exposed to high ambient temperatures (30-39°C).

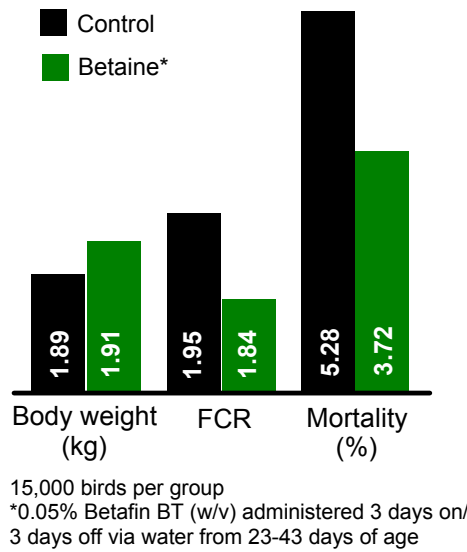
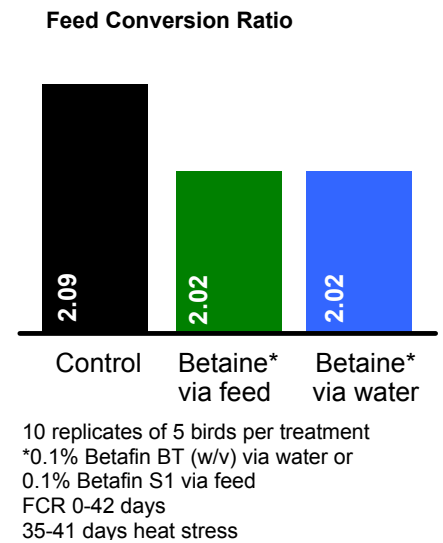


Figure 3: Betaine improves feed efficiency of birds exposed to high ambient temperatures (up to 35°C).



and typically results in lower feed intake and growth as well as reduced feed efficiency.

The bird will increase water intake to try and offset water loss, but the situation is complicated by the fact that the body's ability to retain the water is reduced as the evaporative cooling process escalates.

When environmental temperatures are higher than the thermoneutral zone, birds increase panting up to 10 times, from a normal rate of 25 breaths/minute to 250 breaths/minute (Nilipour, 2000).

This usually leads to an excessive loss of carbon dioxide, resulting in raised blood plasma bicarbonate levels and increased blood pH. The bird attempts to correct blood pH by excreting bicarbonates via the urine. Bicarbonates are negatively charged "ions" that must be coupled with positively charged ions such as potassium to be excreted in urine.

However as potassium is important in maintaining intracellular water balance, a loss of potassium ions via the urine reduces the bird's ability to maintain this water balance. Consequently, while birds do compensate for water losses associated with panting by consuming more water, its retention in the body cells is limited by the simultaneous loss of electrolytes such as potassium in the urine (Belay *et al.*, 1992).

A number of safeguards against heat stress can be incorporated into poultry housing as well as the bird's water and feed management. For instance many poultry houses in hot climates are now fitted with innovative ventilation and cooling systems to improve temperature control.

Unfortunately, the wind-chill benefit of tunnel ventilation systems begins to decline as air temperature reaches 35-40°C (Donald, 2000). Similarly, the effectiveness of evaporative cooling systems is progressively reduced as relative humidity increases above 70%.

Birds lose heat by evaporation of moisture during panting and therefore require greater amounts of drinking water, which may also be cooled to help reduce heat stress. Withdrawing feed until the

cooler evening hours can also help birds disperse the body heat generated by the digestion process.

Other nutritional practices used by the industry include increasing the dietary supplementation of nutrients such as vitamins (Bollengier-Lee *et al.*, 1999) and electrolytes, and also reducing dietary crude protein to cut the heat production associated with protein metabolism.

How betaine can help?

Betaine is a naturally occurring substance found in a wide variety of plant and animal species. It functions in the bird's metabolism as a methyl group donor for the synthesis of many important compounds such as protein, DNA/RNA, nucleic acids and choline.

Betaine also acts as an osmolyte, helping maintain the bird's cellular water balance to protect cells and tissues from dehydration and osmotic inactivation.

Betaine is an osmolyte. Water cannot be directly bound or held by the cell. It will move according to the prevailing concentration gradient of salts and solutes between the inside and outside of the cell. Therefore when the

Table 1: Betaine improves performance of broilers subjected to heat stress from 19 to 48 days of age.

Parameter	Control	Betaine ¹ via water	
		0.05%	0.10%
Body weight (g)	2240	2292	2326
FCR	2.14	2.11	2.05
Survival (%)	84.9	93.8	98.0 ^x

¹ Betafin BT; ^x P<0.06

Table 2. The effect of betaine on broilers exposed to high environmental temperatures and fed diets reduced in methionine and choline chloride.

Parameter	Control	Reduced methionine and choline chloride + betaine ¹
Body Weight, g	1925a	1992b
Feed intake, g	3540	3491
FCR	1.84a	1.75b
Corrected FCR ²	1.84a	1.73b

a, b means without a common letter differ at P<0.05

¹Betafin S1 at 750 g/tonne in diets reduced in total methionine by ~15%

²Corrected 3 points/100g bodyweight

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concentration is greater outside the cell, water will be pulled out of the cell in an effort to balance the concentration gradient. The cell shrinks in volume and the concentration of ions and solutes increase inside the cell. If left uncorrected the cell will eventually die.

Maintaining the balance of water and ions within the cell is essential for cell longevity and therefore the health of the bird.

The cell must accumulate ions and osmolytes to counteract prevailing extracellular concentration gradients. These intracellular ions and osmolytes are, in essence, used to 'hold' water within the cell.

The bird employs 'ion pumps' as a compensatory mechanism to control movement of water into and out of the cell, but their use has a high energy cost, with more energy diverted from growth and production to be used for maintenance purposes.

Importantly, the osmolyte function of betaine reduces the body cell's reliance on energy-costly ion pumps for maintaining their water balance. The bird's maintenance energy requirement is then reduced, despite osmotic stress, and more energy is available for growth and production.

The positive impact of Betafin, a highly purified form of betaine (97% betaine) produced by Finnfeeds, on bird performance has been demonstrated in a trial at Oklahoma State University, USA.

Broilers were subjected to high cycling environmental temperatures (12 hours at 24°C, 3 hours cycling from 24-37°C, 6 hours at 37°C, 3 hours cycling from 37-24°C). Betaine (Betafin BT via drinking water) improved survival, body weight and feed:gain at 48 days of age (Table 1).

The positive impact of Betafin on bird performance has also been demonstrated in a commercial

broiler unit in Thailand. The trial was conducted during the hot season (March-April), where daytime temperatures ranged from 30-39°C. The performance of two groups of 15,000 birds was monitored from 23-43 days of age.

One group was given a typical vitamin supplement in drinking water in a three days on/three days off regime, while the second group received Betafin added at 0.05% in the drinking water during the same time period. The results in figure 2 show that the feed conversion ratio (FCR) of the Betafin-treated group improved from 1.95 to 1.84 and mortality dropped from 5.28 to 3.72% at 43 days of age.

Similarly, a trial conducted at the University of Putra, Malaysia (UPM) showed that Betafin applied in feed or drinking water improved feed efficiency by 3.5% in birds exposed to temperatures up to 35°C (figure 3). Mortality rates were also reduced by as much as 39% at 42 days of age.

Betaine as a methyl donor

As a methyl group donor, betaine can replace up to 15-20% of dietary methionine (10% of total sulphur amino acids) and up to 100% of choline in typical commercial broiler diets, resulting in feed cost savings.

In a broiler study conducted at the Agricultural University of Athens, Greece, all choline chloride and approximately 15% of total

dietary methionine were replaced by betaine (Betafin, 750gt). Birds were exposed to summer ambient temperatures of up to 40°C. Despite the reduced dietary methionine/choline level, Betafin significantly improved growth (3.5%) and feed efficiency (4.9%).

Conclusions

Including betaine in poultry diets can offer significant benefits to producers who are striving to maintain bird performance, under high ambient temperatures when heat stress is a cause for concern. As an osmolyte, betaine has a specific role in maintaining cellular water and ion balance in poultry, and improves the bird's capacity to tolerate high environmental temperatures.

It also acts as a methyl donor, allowing feed cost savings by replacing some of the added dietary methionine and choline.

Studies under controlled high temperature conditions as well as practical trials conducted under high ambient temperatures have demonstrated the positive impact of Betafin to broilers.

The improvements in growth rate, feed efficiency and livability suggest that betaine supplementation should be considered as part of an overall strategy, which includes implementing proven housing and management practices to minimize heat stress.

Similar production and livability benefits may be expected in other species of poultry.

Full references for this article are available on request from the author.

Key words: Betafin (poultry), Betafin, betaine, broiler, heat stress, osmolyte