Betaine may minimize effects of heat stress in broilers

ABSTRACT

Strategies to minimize heat stress tend to concentrate on management practices such as providing adequate ventilation or introducing dietary electrolyte supplements. Betaine can be a useful tool as part of an overall strategy to minimize the damaging effects of heat stress by maintaining performance.

By JANET REMUS

Combating the negative effects of heat stress can be one of the primary concerns for U.S. broiler poultry producers as temperatures soar during the summer months.

Strategies to minimize heat stress tend to concentrate on management practices such as providing adequate ventilation or introducing dietary electrolyte supplements such as sodium bicarbonate and potassium chloride.

Betaine, a natural plant extract, is now also gaining ground as a heat stress beater in broiler production. Research in the U.S. has demonstrated that adding betaine in the feed or water can help reduce dehydration by facilitating water retention in the body and also help to maintain both the bird's energy balance and feed intake.

What is heat stress?

Heat stress occurs when birds have difficulty in balancing body heat loss and body heat production.

At high environmental temperatures, birds rely on a range of mechanisms to regulate their body temperature within a comfort zone described as the "thermoneutral zone." The normal body temperature of a broiler is 106ºF. When the environmental temperature exceeds 95ºF, the broiler is likely to experience heat stress.

TABLE

Effect of betaine on performance of broilers subjected to heat stress from 19 to 48 days of age

Parameter	Control	-Betaine via water- 0.05%	0.10%
Bodyweight (lb.)	4.93	5.04	5.12
Feed conversion ratio	2.14	2.11	2.05
Survival (%)	84.9[Y]	93.8[X]	98.0[X]

[X,Y]Means without a common letter differ ($P < 0.06$).

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."

This process also consists of behavioral mechanisms to adjust body temperature, such as resting in a cool, shady area on a hot day.

However, this non-evaporative cooling 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" (UCT) of the bird is reached, and non-evaporative cooling becomes ineffective at regulating body temperature. This is due to the reduced difference in temperature between the bird and its environment, which slows heat loss from the bird.

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

The bird will increase water intake to try to 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 per minute to 250 breaths per 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.

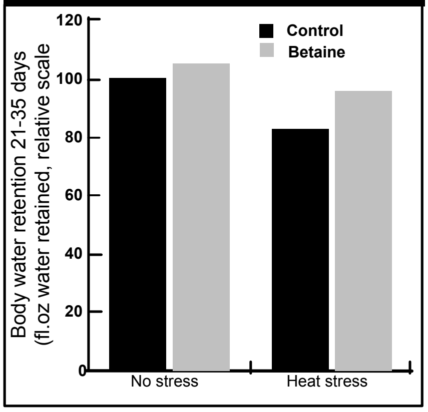
However, as potassium is important in maintaining intracellular water balance, a loss of potassium ions via the urine reduces the bird's ability to maintain this water balance.

Consequently, while birds do compensate for water losses associated with panting by consuming more water, its retention in 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 into 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.

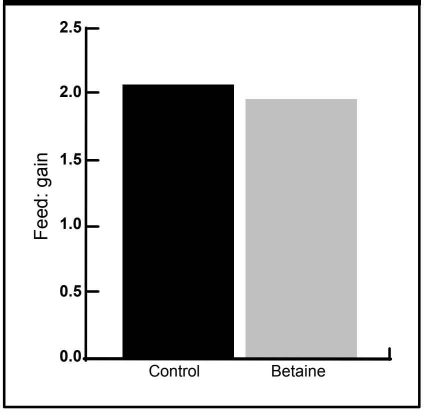
Unfortunately, the wind-chill benefit of tunnel ventilation systems begins to decline as air

FIGURE



1. Effect of heat stress and betaine supplementation via drinking water on whole body water retention in broilers.

FIGURE



2. Effect of betaine on feed conversion of broilers exposed to heat stress from 21 to 49 days of age.

temperature reaches 95-105ºF (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 may 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.

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

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 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 increases 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.

Studies at Oklahoma State University have demonstrated the positive impact on bird performance of supplementing the diet with a highly purified form of betaine.

In one trial, increased water retention was observed in broilers kept in environmental chambers and given betaine via drinking water (0.1 % w/v betaine; Figure 1).

The birds were either exposed to a constant temperature of 75ºF, i.e., thermoneutral temperature (no stress), or exposed to "heat stress," i.e., 12 hours at 75ºF, three hours cycling from 75 to 99ºF, six hours at 99ºF and three hours cycling down from 99 to 75ºF. In the same study, birds fed betaine were also shown to be more effective in controlling their body temperature.

In a second trial, broilers were subjected to high cycling environmental temperatures (12 hours at 75ºF, three hours cycling from 75 to 99ºF, six hours at 99ºF and three hours cycling from 99 to 75ºF). Betaine improved survival, bodyweight and feed:gain at 48 days of age (Table).

In a further study at the University of Tennessee, broilers were subjected to heat stress (10 hours at 77ºF, three hours cycling from 77 to 95ºF, eight hours at 95ºF and three hours cycling from 95 to 77ºF) and fed diets with or without betaine from 21 to 49 days of age. Betaine significantly improved feed conversion 6.3% at 49 days of age (Figure 2).

By increasing the bird's tolerance to high temperatures, betaine can be a useful tool as part of an overall strategy to minimize the damaging effects of heat stress by maintaining performance.

Importantly for producers, trials have shown that betaine can help maintain feed efficiency and survival of birds exposed to high temperatures. ¦

¦ Dr Janet Remus is Danisco Animal Nutrition's technical services manager for the Americas.

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