HEAT STRESS

UNDERSTANDING THE METABOLIC IMBALANCES DUE TO HEAT STRESS: WHY IT'S IMPORTANT

We see physical manifestations of heat stress (panting, reduced intake, milk production loss, etc.). What we don't see is the cascade of metabolic imbalances occuring as the animal's internal machinery tries to offset the negative effects of heat stress.

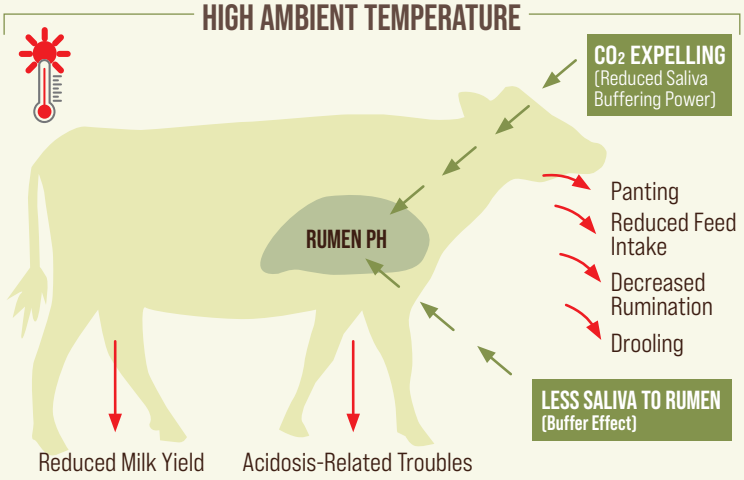
HACK FACT 1

Metabolic Imbalance: Acid-base Imbalance

PANTING is an important mechanism cows use to try to cool themselves resulting in:

- *Respiratory Alkalosis.* As respiration rates increase, the expiration of CO2 via the lungs increases and the blood carbonic acid concentration decreases, raising the blood pH. To compensate for this pH imbalance, the kidneys produce more bicarbonate in an attempt to balance the carbonic acid to bicarbonate ratio in the blood. However, much of the bicarbonate is excreted via the urine, causing alkalosis.
- *Subclinical and Acute Rumen Acidosis.* Since the bicarbonate is lost in the urine the buffering capacity of the saliva is reduced. This metabolic imbalance together with reduced rumination and increased drooling creates a more acidic rumen environment.

Panting is an important way cows cool themselves.



Cooling cows and increasing the buffer levels in the diet helps offset this imbalance.

HACK FACT 2

Metabolic Imbalance: Electrolyte Imbalance

Sweating is another way cows cool themselves.

- Sweating increases water loss from the skin under heat stress environments by as much as 59%. *The primary electrolyte lost during sweating is K (K2CO3 and KHCO3) rather than Na. With increased sweating comes an exponential loss of K. Additional K from potassium carbonate and/or potassium bicarbonate is preferable to potassium chloride, since the additional Cl reduces the cation anion difference and is shown to depress intake and milk production* (Sanchez et al.,1994).
- The decline in feed intake and the increased loss of K due to sweating significantly impacts the cow's K-Na balance, impairing the critical functions of the cellular Na+-K+ pump, which is important for moving glucose into the cells and further impacting the energy status of the cow.

Besides cooling cows, ensure they have access to plenty of water and adjust DCAD levels in the diet.

Metabolic Imbalance: Energy Redistribution

Heat-stressed cows enter a negative energy balance.

- Heat-stressed animals use energy in redistributing blood from the GIT to the periphery in an attempt to maximize radiant heat dissipation. To maintain blood pressure, the gastrointestinal tract vasculature vasoconstricts, and blood flow to the gut tissues can decrease up to 50%. As a result, the enterocytes become starved of oxygen and nutrients, which causes an increase in reactive oxygen species (ROS), down regulation of the tight junctions and compromises the integrity of the GIT resulting in leaky gut syndrome.
- Leaky gut increases the transport of Lipopolysaccharides (LPS) from the lumen into circulation. The circulating LPS causes a pro-inflammatory response, fever, organ damage and hormone disruption, which increases the demand for energy to help mitigate energy not going to milk production.
- Panting increases the energy requirement by between 7 and 25% (NRC 1981). Therefore, DMI would need to increase in order to meet the increased energy requirement, but intake declines for cows under heat stress, thus dealing a double blow to the cow's energy status and partly explaining the loss in milk production.
- High-producing dairy cows require more energy for heat dissipation from metabolic processes than low-producing cows. For example, cows yielding 41 vs. 70 lb./d of milk produce 27.3 and 48.5% more heat, respectively, than dry cows (Purwanto et al., 1990).

Besides cooling cows, increase the energy density of the diet.

Metabolic Imbalance: Oxidative Stress

Heat stress increases the reactive oxygen species due to metabolic stress at the cellular level.

- ROS levels in the GIT increase due to nutrient and oxygen deprivation resulting from the redistribution of blood to the animal's extremities.
- Oxidative stress also occurs in the different cells and tissues of the animal as the cells attempt to offset the negative impacts of heat stress on normal physiological and metabolic function, thereby creating a demand for increased production of cellular antioxidants like superoxide dismutase, glutathione peroxidase and catalase.

Besides cooling the cows, increase the nutritional precursors to the endogenous antioxidants and increase the dietary antioxidants.

Metabolic Imbalance: Immune Defense Mechanisms

Innate and adaptive immune systems are impacted by heat stress.

- Heat stress affects the adaptive immune response by disrupting the balance between T-Helper 1 and T-Helper 2 responses, and causing a response shift toward T-Helper 2 (Cartwright et al., 2023).
- Also impaired is the cell-mediated immune response, which is the response primarily responsible for the defense against intracellular pathogens. This makes heat-stressed cows more susceptible to metritis, mastitis and laminitis.

Besides cooling the cows, provide non-nutritional components like beta-glucans that help modulate the immune system.