UNDERSTANDING HEAT STRESS IN DAIRY TO ALLEVIATE IT

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"Heat stress (HS) is caused by several weather factors: temperature, relative humidity, solar radiation, air movement, and precipitation. Due to climate change and the selection of high-producing animals, dairy cows are more confronted with high temperatures while getting more sensitive to HS, compromising their performance. Here is an insight on HS origin, its consequences, and mitigation strategies."

ORIGIN AND DETERMINATION OF HEAT STRESS

Parameters received by cows such as thermal radiation, wind speed, and precipitation are complex to be recorded, while temperature and relative humidity are simple measures. Thus, the most common indicator to estimate the magnitude of HS is based on these parameters and is called Temperature Humidity Index (THI). *Johnson* proposed the following equation in 1962 (in °F, then adapted to °C), and different thresholds have since been identified (cf. Figure 1):

$$THI = (1.8 \times T^{o}C_{db} + 32) - [(0.55 - 0.55 \times RH/100) \times (1.8 \times T^{o}C_{db} - 26)]$$

where;

$T^{o}C_{db}$ = dry bulb temperature (°C), and

RH = relative humidity

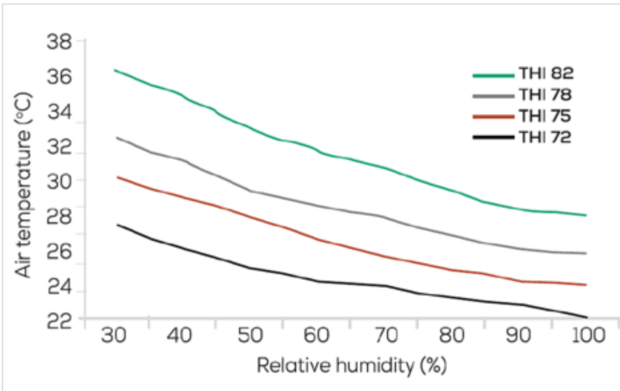

Figure 1. *Calculated THI from air temperature and relative humidity (based on Habeeb et al., 2018)*

- *THI < 68: no heat stress*
- *THI > 72: milk yield impaired, calf rate is affected*
- *THI > 78: milk production is strongly impaired, dry matter intake is reduced*
- *THI > 82: signs of severe heat stress*

Cattle maintain a relatively constant core body temperature (CBT) over a wide range of weather. The CBT is a result of heat production and losses. In normal conditions, there are several sources of heat production by cows: basal metabolism, physical activity, rumination and digestion, and production metabolism. HS is observed when cows cannot maintain their CBT, leading to the rising of CBT and the impairment of metabolic functions. High-producing cows are more sensitive to HS than low producers, as they require a higher metabolism, creating more heat. For example, cows producing 35L/day tolerate threshold temperatures for HS 5°C higher than cows producing 45L/day.

OBSERVING HEAT STRESS IN DAIRY

Recognizing the signs of HS is the first step to implementing practical mitigation strategies. When suffering from HS, cows change their behavior to reduce the amount of heat produced or increase heat dissipation. Mechanisms such as increased respiration rate and panting, open-mouth breathing, reduced feed intake (FI) and rumination time, reduced activity and lying time, and seeking shade and water… can then be detected. Regular observation of cows, coupled with records of FI and milk production in parallel to THI, help alleviate HS early on.

Indeed, the FI drop is responsible for the decreased performance witnessed during HS, but only partially, as demonstrated in studies using heat-stressed cows pair-fed to cows in normal conditions (i.e., restricted FI). It is estimated that FI reduction accounts for 50% of the milk drop, the rest being linked to the evolution of the cow's metabolism.

EFFECT OF HEAT STRESS ON DAIRY COWS

Ruminal acidosis is closely related to HS as the FI behavior of the cows is switched toward fewer but bigger meals, while rumination time decreases, and bicarbonate is redirected to the bloodstream, all leading to an acidification of the rumen. The rumen pH drop is observed both in the case of high fiber or high concentrate diets, together with an increase of the rumen temperature, leading to impaired rumen functions. Along with rumen acidosis, some metabolic-related diseases appear, such as gut lesions, lameness & laminitis due to massive endotoxins (LPS) production, oxidative stress (OS), inflammation, etc. Indeed, the higher CBT, responsible for lower blood flow in the small intestine, triggers the production of reactive species from oxygen and nitrogen, thus damaging the intestinal mucosa. This, in turn, facilitates the passage of LPS and pathogens through the gut wall via loose, tight junctions, further compromising the resilience of the cows: LPS induce a systemic immune reaction through the release of pro-inflammatory cytokines and acute-phase proteins such as haptoglobin. What's more, LPS challenges are always followed by increased SCC and mastitis. In parallel, the inflammatory state generates a higher energy demand while its supply is reduced because of decreased FI. Additionally, OS causes the production of heat shock proteins, which activate the immune system and further increase the energy demand for reaching the "back-to-normal" state. This is achieved by switching the energy metabolism and activating the endocrine and immune systems.

All these physiological adaptations and responses to HS-related challenges can have long-lasting effects on the cows and directly affect the economic performance of the dairy operation (cf. Figure 2).

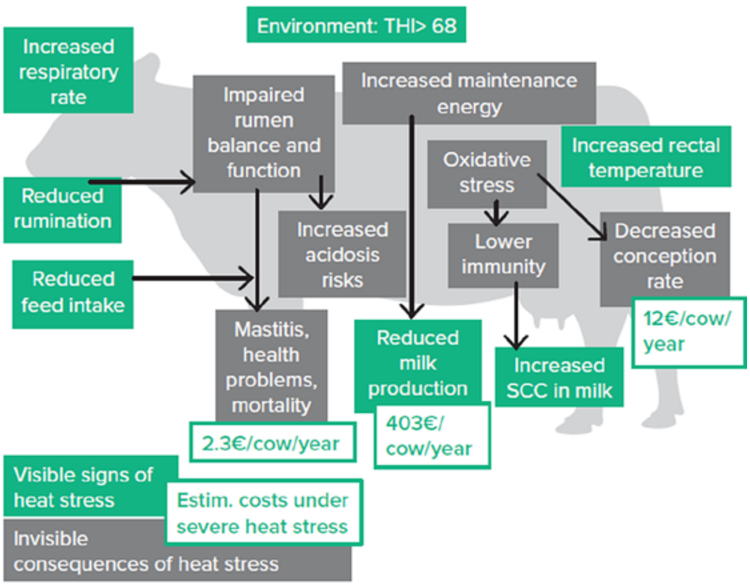

Figure 2. *Heat-stress impact on dairy cows' metabolism, performance, and health (adapted from St Pierre et al., 2003)*

Due to the decreased nutrient intake, the restricted energy is redirected toward maintenance instead of milk production. Indeed, the energy maintenance requirements increase with the need to cool the cow's BCT: +22% at 32°C compared to 16°C for a 36L-cow. Researchers have investigated the indirect effect of HS by comparing until the end of the 1st lactation, heifers born from cows kept in HS or normal conditions during the last stage of pregnancy. Heifers born from HSed cows were smaller at birth, were less resilient, and had a lower growth rate and a lower milk production during their 1st lactation.

PREVENTING HEAT STRESS

There are several ways to reduce the severity of HS. Adapting the barn (light-colored roof, use of fans for airflow and evaporation, use of misters near the through or in the waiting area to the milking parlor...), managing the animals (avoiding other stressful events, reducing waiting time, feeding at cooler times and more often to stimulate FI...) and adjusting the diet.

Amongst the adjustments, water can be included in the diet to reduce the dry matter content, and nutrient density can be increased. This can be achieved by reducing the fiber content (28% NDF), which is responsible for higher heat loss than concentrates, while ensuring that the particles size is adequate to reduce the acidosis risk. Increasing the energy density of the diet can also be achieved by including some rumen-protected fat, which could compensate for the reduced FI without impairing rumen fermentations. In the same line, the starch content should be around 25%, and by-pass starch preferred. In order to balance fermentable starch and degradable protein, care should also be given to increase the by-pass protein and maintain the RDP at 65% of the crude protein. Finally, increasing the supply of minerals like sodium and potassium is essential to support the increased cations demand of the kidneys, thus maintaining the rumen's buffer capacity and compensating for the loss in electrolytes because of excessive sweating.

In addition to these diet alterations, selected phytogenic feed additives (PFA) have shown a contribution to the support of milk performance in dairy cows submitted to HS in different trials, by FI stimulation and regulation. This was expressed through the limitation of the milk drop and a decrease in the milk urea nitrogen. Selected PFA can also contribute to reducing the severity of the OS and inflammation consequences, as observed through reduced blood haptoglobin (a marker of inflammation), higher blood TEAC (an indicator of antioxidant capacity), and a reduction of SCC in cows supplemented with PFA compared to control.

Literature and more information are available upon request.

About Delphine Lacombe

Delphine Lacombe joined Delacon in April 2018 as Customer Technical Manager for the ruminant team. She is an agronomist engineer, graduated from Agrocampus Ouest in France, and started working as a dairy nutritionist for a feed mill. Delphine has been working within the animal nutrition industry for the past ten years, mainly in the feed additive business. Currently, she is responsible for the technical support of the EE and Latam regions.