ASSESSMENT OF HEAT STRESS RISKS IN DAIRY AND BEEF CATTLE AND LIVE YEAST BENEFITS

Content

A- Practical indicators confirm that rumen efficiency in dairy cows is affected by heat stress

Heat stress is a common and growing concern in dairy production, and we are now fully aware that it is not limited to operations in hot climates. A 2016 study from Penn State University about smart farming technologies to monitor heat stress indicators (rumination, rumen temperature, rumen pH, etc.) revealed a clear correlation between environmental heat stress levels, rumination time and milk production. With each 10-point increase in the Temperature Humidity Index (THI) — for instance, an increase from 22 to 30°C with 50% relative humidity — daily rumination could be reduced by 1 hour and dairy production by 2.7 Kg/day (6 lbs.) *(Haan, 2016)*.

1. Relevant criteria to assess rumen efficiency

Thanks to such technologies, producers can anticipate production issues and take the right farm management decisions. This is a path towards precision farming that, at Lallemand Animal Nutrition, we have been taking for many years by developing a rumen efficiency audit program based on animal and environmental indicators. This program is known as the **Rumen Efficiency Investigation (REI)** software. Its goal is to help producers and nutritionists assess feed efficiency in real-life working farm conditions.

Today, this tool has been widely used (in more than 25 countries) in different production systems and farms. The data collected gives us an overview of the global rumen efficiency situation. Such data indicate that, in line with previous industry and university studies, overall, around 50% of farms are exposed to rumen efficiency issues. Reviewing data obtained under heat stress conditions, we find this ratio is significantly increased — indicating the real toll of heat stress on rumen efficiency.

The **REI** is a holistic approach based on the assessment of a set of measurable indicators at the farm level. There are **nine indicators** in total, selected by integrating bibliography reviews, practical dairy farm surveys and international expert views, and validated in the field (Fig. 1). These indicators are linked to:

- Animal performance: milk production, components, somatic cell counts, etc.
- Animal observation: ruminating activity, locomotion, rumen fill, body condition score, cleanliness.
- Manure observation: manure consistency and screening.
- Environmental conditions: temperature and humidity (the THI index).

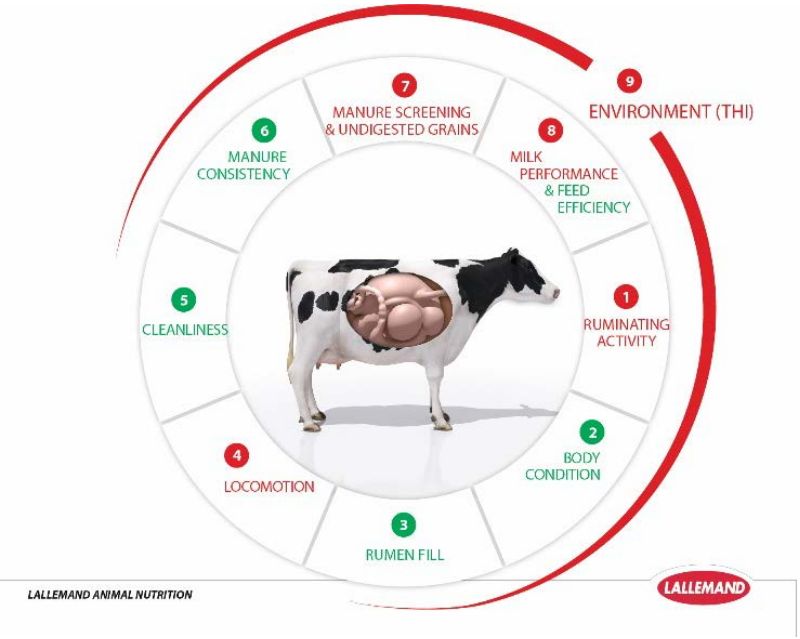

Figure 1: The 9 animal indicators that help define Rumen Efficiency Index (REI). In red, the indicators further detailed in this article.

2. Global survey: heat stress impacts some key rumen indicators

Through the REI, data was collected in farms under various conditions. All data obtained during the hot seasons were combined and Figure 2 gives an overview of the risk levels for five indicators within the heat stress risk period [for more information about the global REI survey download the White Paper: About half of dairy farms show suboptimal rumen efficiency]:

1. **Rumination activity** is linked to rumen function and health. According to the literature, a good target is to have 50-60% of cows lying in their stalls ruminating. **The overall REI data indicates that rumination is suboptimal in 69% farms.** Under heat stress conditions, this figures increases to include **86% of farms.** This is in line with a study showing that rumination activity is correlated to heat stress *(Haan, 2016)*.
2. The link between **locomotion** and rumen health is well established in the literature. Lame animals can have high levels of histamine production and bacteria endotoxin release in the rumen, which is often linked to SARA *(Nocek, 1997)*. Independent of the THI, the REI survey showed that in **72%** of the farms audited, locomotion represents a challenge. Similar results were observed under heat stress conditions.
3. **Manure screening** is recommended to measure the presence of undigested particles or grains and assess fiber size. The presence of undigested processed grains in the feces is linked to poor rumen efficiency. It also results from increased passage rate due to an imbalanced or low diet digestibility. Under heat stress conditions, **61%** of farms have a risk of insufficient grain digestion. In the overall survey, 51% of farms showed insufficient grain digestion.
4. Finally, milk component yield is a consequence of rumen efficiency. The REI survey shows that, under high temperature-humidity conditions, **milk fat/protein ration** is insufficient in **87% of farms**. Moreover, **somatic cell count** is at risk in **46% of farms**. When looking at average values for hot vs. colder seasons, there is a statistical difference in the milk component ratio and somatic cell count (Fig. 3). This confirms the effect of heat stress **not only on milk quantity yield, but also on the quality of the milk produced**, with potential implications on milk cost. In addition to financial implications, a high somatic cells count is a sign of poor health status.

Figure 2: How dairy farms perform under heat stress conditions according to 5 key rumen efficiency indicators (Lallemand internal data, 2017)

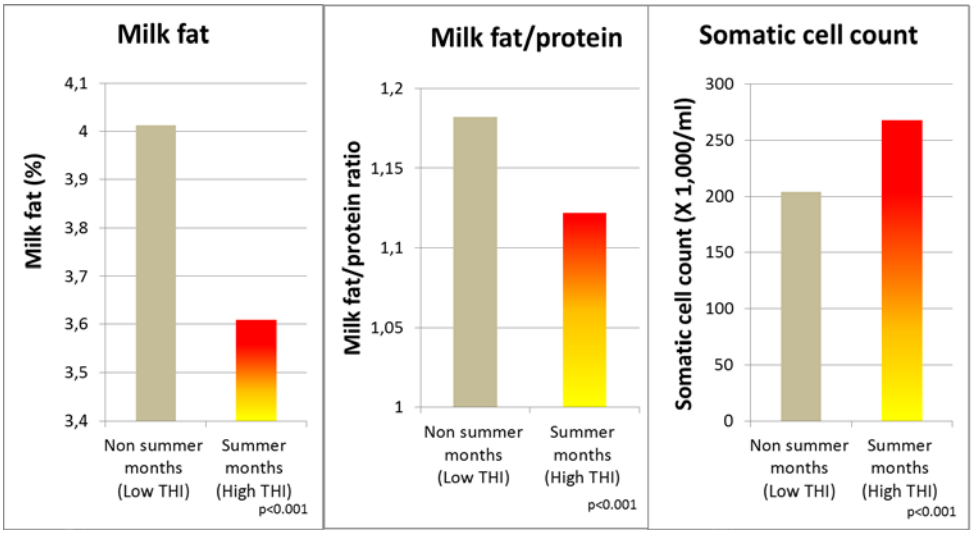

Figure 3: Average milk fat, milk fat/protein ratio and somatic cell count in milk between summer months and the rest of the year (Lallemand internal data, 2018).

This survey indicates that, under heat stress conditions, while feed intake is reduced, rumen efficiency appears sub-optimal, as demonstrated by early signs such as rumination, grain digestion, locomotion and milk composition.

3. Live yeast benefits

Heat stress is not limited to two summer months or tropical regions and could be an issue for long periods. By monitoring THI within the animals' environment (in the barn) — but also assessing visible indicators such as rumination, locomotion or undigested grains in manure — producers can better anticipate heat stress issues and make the necessary adjustments before dairy production starts falling.

Among the nutritional measures shown to alleviate heat stress, the use of the rumen-specific live yeast *Saccharomyces cerevisiae* CNCM I-1077 (LEVUCELL SC) shows positive effects on the rumen environment and, consequently, dairy production. The rumen-specific live yeast acts as a rumen modifier. It works by improving

the overall rumen environment and function through the control of rumen pH. *S. cerevisiae* CNCM I-1077 also helps improves animal performance through enhanced fiber degradation.

Several studies, conducted in partnership with universities, have demonstrated that S. cerevisiae CNCM I-1077 increases animal performance (feed efficiency and milk yield), rumen pH and improves early signs of rumen efficiency (e.g., fiber in the feces, rumination, manure consistency, etc.). In standard conditions (non-stressful), a meta-analysis of LEVUCELL SC data (14 trials, 1,600 dairy cows) has shown a consistent and significant improvement of feed efficiency by +3% in FCM/DMI *(De Ondarza, 2010)*. This improvement can increase by 6 to 9% **under heat stress conditions** (Table 1).

Trial reference	Animals	Environment	Effect of *S. c.* I-1077on feed efficiency	Effect of *S. c.* I-1077 on rumen pH	Other indicator
University of Florida *(Marsola et al., 2010)*	60 dairy cows	Severe heat stress	+ 7%	Lower % of cows with rumen pH <5.8	
New York State *(2004)*	300 dairy cows		+9%		
Bologna University *(Fustini et al.,2013)*	40 dairy cows	Mild to-moderate heat stress	+6.5%	Improved	Improved fiber degradation and rumination
University of Teheran *(2013)*	36 dairy cows	Sever heat stress	+8.5%	Increased	Improved manure consistency

Table 1: Summary of University trials with live yeast Saccharomyces cerevisiae CNCM I-1077 under heat stress conditions

This scientific evidence is supported by field experiences. For example, a farm trial was conducted in Japan under heat stress conditions (April- August 2017; THI 69-78) in order to assess the effect of LEVUCELL SC during summer in non-acidotic conditions on milk performance and rumen efficiency indicators, using the REI software. The audits were performed before the supplementation, with THI=59, and then after 1.5-, 2.5- and 4-months supplementation, with a THI between 69 and 78.

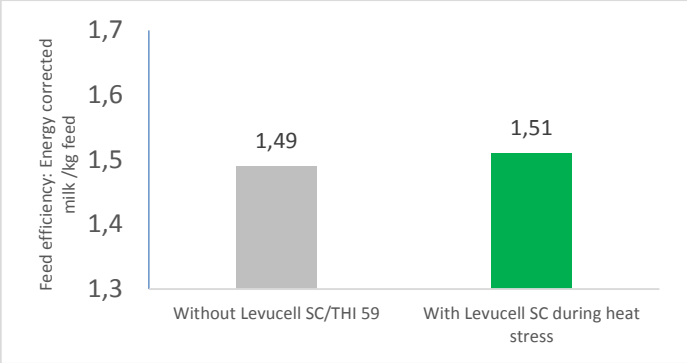

Figure 4: Average feed efficiency before and after Levucell SC supplementation under heat stress. (Japan, 2017).

This farm trial confirms beneficial effects on rumen efficiency indicators: while **rumination** was sub-optimal before, this was improved despite heat stress: 50% of cows were ruminating before supplementation (THI 59) and this figure increased to 63% of cows with LEVUCELL SC — despite a high THI. Other indicators such as rumen fill and cow cleanliness were also improved during supplementation. Moreover, the milk fat/protein ratio was maintained above 1.2 (a low risk level) despite heat stress. Finally, the live yeast not only alleviated the impact of heat stress on dairy cows, but it also improved the **performance** when compared to a non-stressful period: overall feed efficiency and income-over-feed costs are improved during the hot season as compared to low THI period (Fig. 4).

In conclusion, to quote M. Haan from PennState in his article: *"Producers, nutritionists, veterinarians, and other consultants within the dairy industry could make better use of the data already being generated on farms by existing technologies and should be prepared to take advantage of new technologies as they become available."* The REI software and data that can be obtained can give practical indications about a herd's status and can help better manage feeding and animals. As shown by the global survey, heat stress has a strong impact on rumen indicators and more than half the farms audited show sub-optimal rumen efficiency. Among the nutritional tools available to support rumen efficiency under stressful conditions, rumen-specific live yeast *S. cerevisiae* CNCM I-1077 is well documented and backed by several controlled trials. Such benefits can be seen at the farm level thanks to REI audits.

B- Preserving beef cattle production potential during the summer

1. A still underestimated issue in bovine

If in dairy cows, the impact of heat stress can be easily measured, seeing lower milk production, less feed intake and many more variations from their typical behaviors, in beef cattle the signs of heat stress are much less visible. Although there is less visibility, fattening cattle suffer just as much as dairy cows in warm temperatures. From **25°C onwards**, the animal immediately decreases its feed intake, which then takes several days to stabilize again, even at lower temperatures. The animals increase their respiratory rate and use up energy to dissipate excess heat, which contributes to a significant increase in maintenance needs: this is heat stress.

Susceptibility to heat stress also depends on genetic traits: for example, dark coat breeds suffer more than the light coat ones. Fat layer also plays the role of thermal shield, slowing down the dissipation of heat. Finishing cattle are also more impacted due to their smaller body surface area in proportion to their body weight.

2. How to assess heat stress in practice?

The temperature–humidity index, or THI, is a common indicator of heat stress risk level (Figure 5). This means that not only temperature is important but also the air relative humidity level, which exacerbates the effect of heat. For beef cattle, the **heat stress threshold is estimated at 72** (orange zone in the THI table). This means that for example, at 50% humidity, cattle suffer from heat stress from 25°C. By placing thermo-hygrometer or new generation of sensors that continuously monitor THI in the barn, producers can monitor and anticipate heat stress risks.

Temperature		% Relative Humidity													
°F	°C	0	5	10	15	20	25	30	35	40	45	50	55	60	65
72	22.0	64	65	65	65	66	66	67	67	67	68	68	69	69	69
73	23.0	65	65	66	66	66	67	67	68	68	68	69	69	70	70
74	23.5	65	66	66	67	67	67	68	68	69	69	70	70	70	71
75	24.0	66	66	67	67	68	68	68	69	69	70	70	71	71	72
76	24.5	66	67	67	68	68	69	69	70	70	71	71	72	72	73
77	25.0	67	67	68	68	69	69	70	70	71	71	72	72	73	73
78	25.5	67	68	68	69	69	70	70	71	71	72	73	73	74	74
79	26.0	67	68	69	69	70	70	71	71	72	73	73	74	74	75
80	26.5	68	69	69	70	70	71	72	72	73	73	74	75	75	76
81	27.0	68	69	70	70	71	72	72	73	73	74	75	75	76	77
82	28.0	69	69	70	71	71	72	73	73	74	75	75	76	77	77
83	28.5	69	70	71	71	72	73	73	74	75	75	76	77	78	78
84	29.0	70	70	71	72	73	73	74	75	75	76	77	78	78	79
85	29.5	70	71	72	72	73	74	75	75	76	77	78	78	79	80
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91	33.0	73	74	75	76	76	77	78	79	80	81	82	83	84	85
92	33.5	73	74	75	76	77	78	79	80	81	82	83	84	85	85
93	34.0	74	75	76	77	78	79	80	80	81	82	83	85	86	87
94	34.5	74	75	76	77	78	79	80	81	82	83	84	86	86	87
95	35.0	75	76	77	78	79	80	81	82	83	84	85	86	87	88

Figure 5: THI index and heat stress risk level for beef cattle (from Burgos & Collier, 2011)

Animal observation is key to assess heat stress situation, and common indicators of moderate heat stress include:

- Shallow breathing
- Profuse sweating
- Lethargic behavior

Then, open mouths and breathing with panting and tongue hanging out indicate more severe heat stress.

If the effects of heat stress in dairy cow are much more monitored, with well-known incidence on dairy production, other methods are necessary to measure its impact in meat cattle. This is possible for example thanks to new smart farming methods which allow real-time individual feed intake monitoring. For example, at Texas A & M AgriLife Research Center, Lallemand Ruminant Center of Excellence, the implementation of GrowSafe Feed Intake bunks (Figure 6) has allowed to show that under heat stress conditions, individual feed intake becomes very unstable. This drop in feed intake is sometimes more difficult to assess at the herd level, as it is very irregular in time from one animal to another.

Figure 6: GrowSafe feed intake bunks at Texas A&M AgriLife.

This leads to decreases in growth, which can even lead to negative growth (muscle loss due to low ingestion). Beef cattle weight loss could reach up to 10 Kg.

In extreme situations, the quality of the meat may also deteriorate (higher pH at the slaughterhouse, which can impair meat ripening). Ultimately, if the animal fails to cool down, this may lead to sudden death (e. g. enterotoxemia and heart failure).

Another, indirectly visible sign of heat stress is acidosis. Several trials performed by Lallemand Animal Nutrition using pH boluses in beef or dairy cows have shown a link between heat stress levels and low rumen pH.

In addition to performance and health, studies have also demonstrated that heat stressed animals experience increased oxidative stress combined with a lower antioxidant status. This could also have a negative impact on animal health, immune defenses, as well as meat quality.

3. Stabilizing the rumen with live yeast


Cattle at Texas A&M AgriLife.

A trial conducted at Texas A & M AgriLife Research Center (Lallemand Ruminant Center of Excellence) demonstrated that, in a situation of heat stress, the addition of rumen specific live yeast *Saccharomyces cerevisiae* CNCM I-1077 (LEVUCELL SC) to the diet allows the rumen pH to stabilize, with less daily individual changes, and the cattle to improve their intake. Feeding behavior was also improved, with more regular intake during the day, while animals not receiving LEVUCELL SC consumed more erratically during cooler periods.

As a result, the average daily gain (ADG) was improved by 50 g /day, and the carcass weight by 5 kg over the fattening period (70 days) with a poorly acidogenic diet.

Another study conducted in Italy on a commercial farm (Consortio Agrario del Nordeste) on Charolais breed cattle showed similar results: + 5% ADG with an average thermal index THI around 70, and allowed a further understanding of the mechanisms involved (Fig. 7). By supplementing the animals with a pH bolus system, which allows measurement of the ruminal pH in real time (SMAXTEC), this trial indicate that:

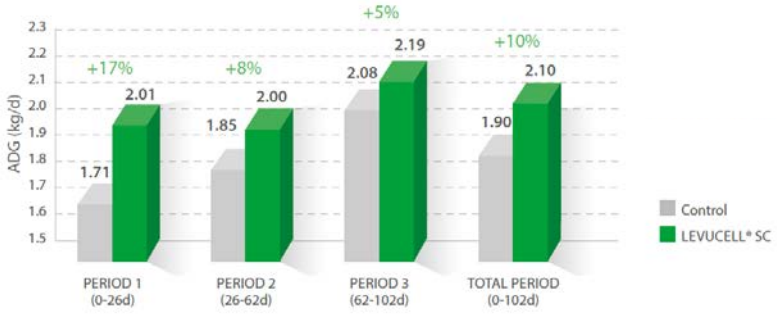

Figure 7: Effect of Levucell SC on Charolais daily weight gain (Period 3 correspond to heat stress) (Consortio Agrario del Nordeste, Italy, 2015)

- Rumen pH decreases in conditions of heat stress, linked in particular to the strong variations of feed intake and loss of saliva buffering capacity (panting).

- The live yeast stabilizes the rumen pH, especially as the animal is in a heat stress condition (Fig. 8).

Thus, ruminal pH is indirectly affected by climate conditions and the use of a ruminant specific live yeast, known for its stabilizing effects on ruminal pH (rumen modifier), allows the consequences of heat stress on feed intake and growth performance to be minimized.

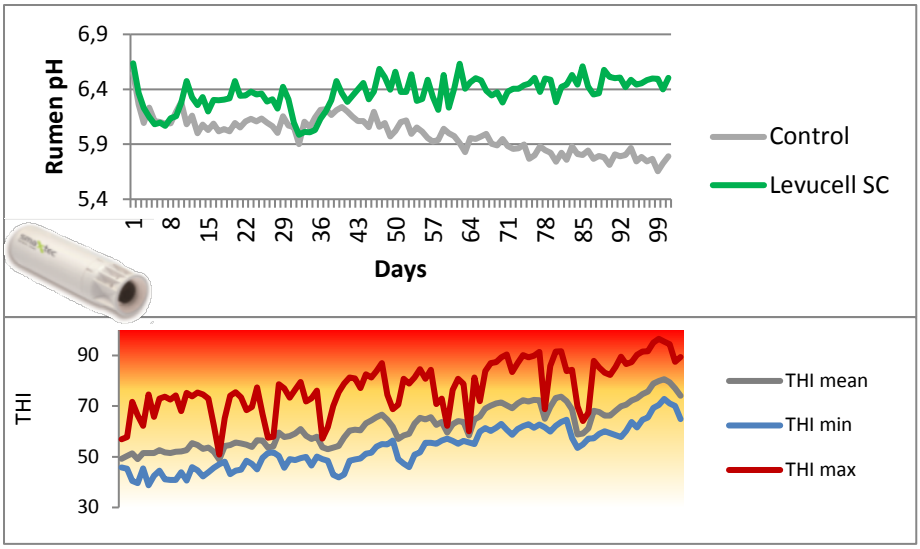

Figure 8 Top : effect of LEVUCELL SC on rumen pH variations. Bottom: Variations of the temperature humidity index (THI) for the same period (Consortio Agrario del Nordeste, Italy, 2015).

4. How to face heat stress in practice ?

Some simple adaptation measures can be put in place for the herd when the hot months are in sight:

- Check the flow of water tanks, as water supply can be limiting. As temperatures increase, water consumption also rises.

- Check sodium intake. Generally it is advisable to increase this contribution beyond the strict requirements, this in order to stimulate water intake. In Europe, an intake of 30 to 50 g / day is recommended. Also check potassium intake especially for high-grain rations (optimum intake 14 g / kg dry matter, minimum intake 8 g / kg DM).

- Ventilate the building at best as possible by creating a draft. Low openings for refreshing animals are very useful. Provide some shade.

- Concentrate the ration to limit the effects of feed intake reduction:
  - At 27°C - decrease in feed intake of 4% = potential growth loss 100 g approximately.
  - At 30°C - decrease in feed intake of 10% = potential growth loss 300 g approximately.
  - At 35°C - decrease in feed intake of 28% = potential growth loss 800 g approximately.

- Implement an early insect repellant strategy. Flies cause a decrease in rumination.

- Feed live yeast LEVUCELL SC in "reinforced" dose as soon as the ambient temperature increases. By stabilizing the rumen pH and feed intake, LEVUCELL SC will maintain the growth potential.

- Insuring an adequate level of antioxidant solutions (vitamin A and E) is important. Providing a combination of primary antioxidants such as Selenium yeast proven for its superior bioavailability (ALKOSEL, Lallemand Animal Nutrition) and a source of vegetal Superoxide Dismutase (Melofeed, Lallemand Animal Nutrition) is shown to increase antioxidant status of animals with positive consequences on meat quality.

- Carefully monitor the heating of the ration at the trough. A trial on farmed heifers revealed an 11% decrease in intake with a ration that was heating (Dr. Kung- University of Delaware). If the ration heats, try to spread and push it more frequently. However, the most effective method is to treat the silage at

harvest with a silage inoculant containing *Lactobacillus Buchneri* 40788 at a rate of at least 300,000 CFU/g.

- Distributing the ration at the coolest hours of the day also promotes consumption.

- Finally, considering longer-term planning, keep in mind that the increase in ambient temperature and the increasing variability are detrimental to fattening cattle. It is advisable to plan buildings design accordingly. Easy access to water with a drinking trough for up to 10 animals is recommended. If fans and foggers may appear today as an unnecessary luxury for beef cattle, they however, may appear to be vital in the near future.

In conclusion, heat stress could be underestimated in beef cattle. However, it does represents a challenging period for the animals, affecting feed intake and consequently rumen conditions and efficiency. Growth performance and health can be impacted, as well as meat quality. Risk monitoring (e.g. use of temperature-humidity sensors to record THI in the barn), planning ahead (use of adapted feeding strategy, supplementations and good silage management practices) and adapted barn and herd management practices are essential to optimize production and help overcome heat stress challenges in beef.

For further information and scientific resources about the rumen and potential challenges that can be found on farm, please visit: RuminantDigestiveSystem.com.

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