Live yeast could help reduce the impact of heat stress on dairy production

by Laurent Dussert, Aurélien Piron, Lallemand Animal Nutrition, France.

Heat stress could cost the dairy producer over €400/cow/year. Around 80% of these losses are associated with drop of productivity, and 20% with health issues: impaired reproduction and immunity, which translate into increased mortality and mastitis frequency.

In 2011, Prof. Burgos Zimbelman and Collier, from the University of Arizona, revised the heat stress scale and revealed that the severity of heat stress was largely underestimated, especially for high producing cows, and consequently lowered the heat stress threshold. Today, heat stress is more common than previously thought and can impact dairy production even under temperate climates.

This article looks at how to assess heat stress in practice before focusing on nutritional approaches to limit its impact on performance.

It is generally recognised that the cow's comfort zone is between 5-20°C. But external temperature is not the only parameter: relative humidity is also important to define the cow's comfort zone.

Moreover, a cow's thermo-neutral zone is dependent upon its physiological status and level of production: higher producing cows are more sensitive to thermal stress.

It is referred to as heat stress when environmental conditions exceed the cow's thermal zone of comfort.

There are two types of parameters to diagnose heat stress in dairy cows, either based on animal observations, or on environmental signs.

Fig. 1. University of Arizona revised heat stress scale (2011): to each temperature/humidity couple corresponds a level of thermal stress for the dairy cow. Yellow: stress threshold; Orange: mild-moderate stress; Red: moderate-severe stress; Purple: severe stress.

Temp		Relative humidity																		
°F	°C	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
72	22.0	64	65	65	65	66	66	67	67	67	68	68	69	69	69	70	70	70	71	71
73	23.0	65	65	66	66	66	67	67	68	68	68	69	69	70	70	71	71	71	72	72
74	23.5	65	66	66	67	67	67	68	68	69	69	70	70	70	71	71	72	72	73	73
75	24.0	66	66	67	67	68	68	68	69	69	70	70	71	71	72	72	73	73	74	74
76	24.5	66	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75
77	25.0	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76
78	25.5	67	68	68	69	69	70	70	71	71	72	73	73	74	74	75	75	76	76	77
79	26.0	67	68	69	69	70	70	71	71	72	73	73	74	74	75	76	76	77	77	78
80	26.5	68	69	69	70	70	71	72	72	73	73	74	75	75	76	76	77	78	78	79
81	27.0	68	69	70	70	71	72	72	73	73	74	75	75	76	77	77	78	78	79	80
82	28.0	69	69	70	71	71	72	73	73	74	75	75	76	77	77	78	79	79	80	81
83	28.5	69	70	71	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82
84	29.0	70	70	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	83
85	29.5	70	71	72	72	73	74	75	75	76	77	78	78	79	80	81	81	82	83	84
86	30.0	71	71	72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	84
87	30.5	71	72	73	73	74	75	76	77	77	78	79	80	81	81	82	83	84	85	85
88	31.0	72	72	73	74	75	76	76	77	78	79	80	81	81	82	83	84	85	85	86
89	31.5	72	73	74	75	75	76	77	78	79	80	80	82	82	83	84	85	86	86	87
90	32.0	72	73	74	75	76	77	78	79	79	80	81	83	83	84	85	86	86	87	88
91	33.0	73	74	75	76	76	77	78	79	80	81	82	84	84	85	86	86	87	88	89
92	33.5	73	74	75	76	77	78	79	80	81	82	83	85	85	85	86	87	88	89	90
93	34.0	74	75	76	77	78	79	80	80	81	82	83	85	85	86	87	88	89	90	91
94	34.5	74	75	76	77	78	79	80	81	82	83	84	86	86	57	88	89	90	91	92
95	35.0	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
96	35.5	75	76	77	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94
97	36.0	76	77	78	79	80	81	82	83	84	85	87	87	89	89	91	92	93	94	95
98	36.5	76	77	78	80	80	82	83	83	85	86	88	88	89	90	91	92	93	95	95
99	37.0	76	78	79	80	81	82	83	84	85	87	88	89	90	91	92	93	84	96	96
100	38.0	77	78	79	81	82	83	84	85	86	87	89	90	91	92	93	94	95	97	96
101	38.5	77	79	80	81	82	83	84	86	87	88	89	90	92	93	94	95	96	98	98
102	39.0	78	79	80	82	83	84	85	86	87	89	90	91	92	94	95	96	97	98	99
103	39.5	78	79	81	82	83	84	85	87	88	89	91	92	93	94	96	97	98	99	100
104	40.0	79	80	81	83	84	85	86	88	89	90	91	93	94	95	96	98	99	100	101
105	40.5	79	80	82	83	84	86	86	88	89	91	92	93	95	96	97	99	100	101	102
106	41.0	80	81	82	84	85	87	88	89	90	91	93	94	95	97	98	99	101	102	103
107	41.5	80	81	83	84	85	87	88	89	91	92	94	95	96	98	99	100	102	103	104

Animal observations

In practice, cows subject to moderate heat stress (around 25°C and 50% relative humidity) show visible signs such as:

- Reduced milk production (~10%).
- Decreased feed intake.
- Shallow breathing.
- Profuse sweating.
- Lethargic behaviour.
- Open mouth.
- Breathing with panting and tongue hanging out.

Under severe heat stress (for example at 34°C and high humidity), milk production drop can reach 35% and feed intake is severely reduced.

Environmental signs

The environmental indicator of heat stress risk is the Temperature Humidity Index (THI). It takes into account the combined effects of environmental temperature and relative humidity.

Each THI value has been linked to a level of stress, associated to potential damages to the cow's production and health status.

The THI scale has been revised in 2011, by Prof. Burgos Zimbelman and Collier from University of Arizona: they found out that the impact of heat stress was underestimated for today's high producing dairy cow.

Indeed, THI scale was established in the 1960s, when cows were less productive than today. Increased milk potential has contributed to increased cattle sensitivity to thermal stress and reduced the threshold THI at which milk losses occur.

According to the new THI scale, a THI of 68 is low enough to cause adverse affects (Fig. 1).

This corresponds for example to 22°C ambient temperature with 45% of humidity, a rather common condition in moderate climates, even in northern Europe for example.

Continued on page 9

Continued from page 7

In practice:

- A thermo-hygrometer can easily be used to quickly evaluate the level of risk of heat stress.
- Historical weather data, such as those recorded on the internet can also help evaluate heat stress risks and possible impact.

Impact on productivity

Cows respond to heat stress by increased sudation, panting, drooling etc. to help cool their body. These activities increase the animal maintenance energy, and part of milk production energy will be redirected to thermal regulation.

Furthermore, heat production in the dairy cow is essentially due to rumen fermentations. In order to reduce heat production, all activities are reduced and the feeding pattern is altered. As feed intake and rumination decrease, cows will tend to eat less during the day, but more often and in smaller quantities.

They will tend to consume more feed at night when it is cooler, slug feed, sort feed and tend to choose feeds that produce less heat during digestion, choosing grains and proteins over forages.

Moreover, heat stress generally increases the production of free radicals, leading to oxidative stress. In dairy cows, oxidative stress has a negative impact on immune and reproductive functions: increased mastitis frequency and higher somatic cells count in milk, decreased fertility, increased embryo mortality, post-partum retained placenta, and early calving, with consequences on the calves' live weight, mortality and health.

The first short-term impact of heat stress is the reduction of milk yield. Reduced milk yield results from a combination of reduced feed intake, alterations in endocrine profiles, energy metabolism and other unidentified factors. It is usually acknowledged that milk production can decrease between 10 to 35% during warm summer months.

Longer term consequences will be linked to the effects of heat stress on cow health, immune function (mastitis risks and increased somatic cell count in milk), reproduction, and even death. A 1999 study by Hansen and Aréchiga showed that conception rate dropped under severe heat stress in dairy herds. It is currently estimated that conception rate decreases by around 50% under heat stress.

These effects are linked to the impact of heat stress:

- On oxidative stress.
- On the decreased buffer capacity of the rumen, due to reduced cud chewing and losses due to drooling. Under heat stress, subclinical acidosis risks are increased, with further consequences such as lameness etc.

Heat stress level	Practical example of temperature/humidity couple	Duration (hours/day)	Milk loss under heat stress (kg/h; kg/cow/day)
Stress threshold THI (68-71)	22°C (72°F) 50%	4	-0.283kg/h 1.1kg/cow/day
Mild-moderate stress THI (72-79)	25°C (77°F) 50%	9	-0.303kg/h 2.7kg/cow/day
Moderate-severe stress THI (80-89)	30°C (86°F) 75%	12	-0.322kg/h 3.9kg/cow/day
Severe stress THI (90-99)	34°C (93°F)		Not measured

Fig. 2. The impact of the various heat stress levels on milk production with some practical examples.

In 2003, Saint Pierre et al. evaluated the overall financial consequences of heat stress for the US dairy industry.

This study analysed data for each of the 48 American states and showed huge discrepancies according to climate and heat stress level, with overall losses close to $700/cow/year for the most affected states (Texas, Florida).

Based on milk loss alone, they have calculated overall annual losses of $897 million, equivalent to almost $100 per dairy cow per year on average. To this must be added the costs linked to reproduction, early culling, health issues and mortality.

Nutritional management

Appropriate nutritional programs are important to help limit the impact of heat stress. One of the goals should be to improve feed efficiency to compensate for the reduced feed intake, while protecting the rumen environment from acidosis risks. Since cows will be consuming less as temperatures rise, increasing the energy density of the diet can be considered to compensate in part for the decreased DMI. High quality, highly digestible and palatable forages should be available to the animal if possible. More starch or added fat can be useful too.

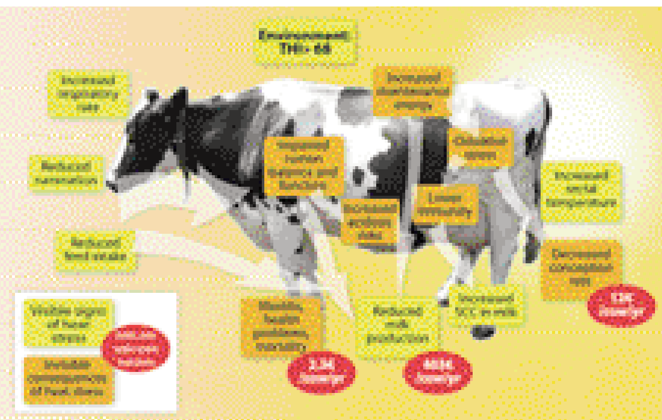
It must also be kept in mind that as rumen balance is stressed, cows are at a higher risk of acidosis, consequently extra care should be taken to manage the rumen. Feeding of a high quality fibre source in the diet that helps maintain a stable rumen, but still contributes energy rather than just gut fill, is therefore essential, especially for high producing herds receiving high starch diets.

Moreover, the use of rumen modifiers which improve and protect the rumen environment, such as rumen specific live yeast is also advisable. In the following chapter a recent trial conducted under severe heat stress condition is detailed, which confirms the benefits of live yeast Saccharomyces cerevisiae I-1077 to limit milk production loss.

Another important aspect is to properly balance the mineral electrolytes in the milk cow diet since excessive sudation (sweating), leads to losses of sodium and potassium.

Finally, since the increased respiration rate induced a higher production of reactive oxygen substances (ROS), it is recommended to increase antioxidant intake such as selenium and vitamin E. In the case of selenium, in particular, it has been shown that dairy cow supplementation with organic selenium (supplied through selenium enriched yeast) can help reduce somatic cells count in milk more efficiently than mineral selenite (Fig. 3).

The major factors involved in heat stress and associated costs of severe heat stress.



Effect of live yeast

Rumen specific live yeast Saccharomyces cerevisiae I-1077 has been selected and documented for its interaction with the rumen microflora and its positive effect on rumen environment and function (stabilisation of rumen pH, increased fibre degradation leading to better feed efficiency). It is recognised by dairy nutritionists as a natural, safe and effective rumen modifier, registered in many countries as a dairy feed additive.

A meta-analysis that encompassed 14 trials in various production systems (1,600 dairy cows in total), shows that, under non-stressful conditions, S. cerevisiae I-1077 significantly improved Feed Efficiency by +3% on average.

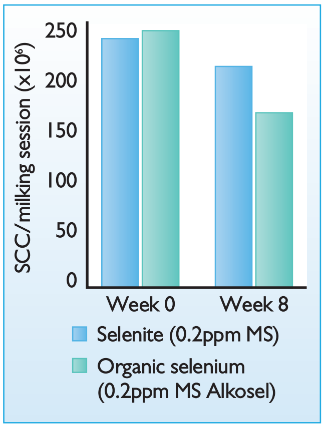


Fig. 3. Selenium yeast, which is more effective than inorganic selenium for raising blood selenium level, has the ability to reduce SCC in milk (Malbé et al, 1995).

Field trials indicate that this particular live yeast is very effective under conditions that exert stress on the rumen environment, such as feed transition or heat stress. From New York State to China, trials conducted under heat stress conditions have shown a positive effect on feed efficiency, resulting in increase of income over feed cost by up to 9% during summer period.

Based on these results and the abundant literature about the positive effects of S. cerevisiae I-1077 on rumen function, the Department of Animal Sciences of the University of Florida, Gainesville, USA, conducted a trial in 2009 under well controlled conditions.

The objective was to evaluate the

Continued on page 11

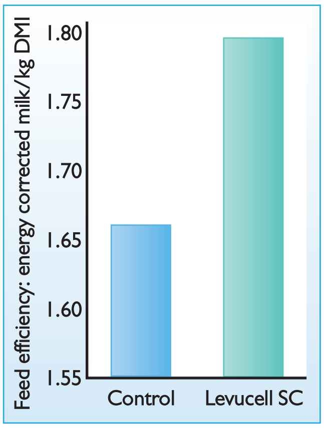
Continued from page 9
impact of live S. cerevisiae I-1077 on both feed efficiency and rumen environment (pH) of high producing dairy cows under severe heat stress.

The trial was conducted between May and September 2009, under extreme heat stress conditions (THI = 80 on average), on 60 dairy cows in total. The basal diet was: corn silage (41.1%), alfalfa hay (10.4%), brewer's grains wet (5.2%) and grain mixture (43.0%).

The three-month study showed that dairy cow diet supplementation with S. cerevisiae I-1077 (LevucellSC 20, Lallemand Animal Nutrition, France), at the stress-specific inclusion rate of 20 billion live yeast cell (CFU)/cow/day, led to:

- Significant increase of feed efficiency by 7%, equivalent to an extra 120g of milk per kg DMI, bringing the producer a return on investment evaluated at 6:1 (Fig. 4).
- Significant decrease of the number of cows at risk of acidosis: both rumen pH (Fig. 5), and rumen lactate level, one of the causes of rumen acidosis, were reduced. Some 45% of cow had a pH lower than 5.8 in the control group versus 10.5% of the cows treated with 1g/cow/day of Levucell SC 20.

Fig. 4. Effect of supplementation of dairy cows diets with Levucell SC on feed efficiency under severe heat stress (Marsola et al, 2010).



Two main modes of action

The live yeast strain Saccharomyces cerevisiae I-1077 has been selected and extensively studied by leading international research institutes and universities for its modes of action in the rumen and benefits on rumen health and function. Two main mechanisms can help explain its effects on dairy performance:

- Improved rumen pH: reduced acidosis risk.
- Improved fibre digestion and nitrogen utilisation: increased feed efficacy.

It is easy to see how these effects can help counteract the detrimental action of heat stress, but also, of any stressful event for the rumen balance (for example feed transition):

- Heat stress is a risk factor for rumen acidosis: S. cerevisiae I-1077 stabilises rumen pH. This effect has been demonstrated under various conditions and with different diets.
- Feed utilisation is decreased during heat stress: as shown by the Florida University trial, feed efficacy is improved with the addition of Levucell SC 1-1077 during heat stress.
- This live yeast is proven to increase fibre degradation in the rumen, an effect shown on a variety of forages. During heat stress, enhanced fibre degradation will lead to a better supply of energy to the animal, minimising the impact of decreased DMI and increased energy maintenance requirements.

Conclusion

Dairy production can be heavily impacted by heat stress and the recent re-evaluation of the heat stress threshold indicates that dairy are under greater risk than previously suspected.

The recent research on microbial natural solutions show that, when the best herd management practices are respected (housing and nutrition), the additional help of these natural nutritional solutions could benefit the dairy producer by further helping to manage and limit the impact of heat stress on cow health and productivity: live yeast S. cerevisiae I-1077 helps to restore and maintain rumen function, improving rumen pH and feed efficiency during stressful conditions. Organic selenium restores and protects the animal antioxidant status with positive impact on milk hygiene, cow fertility and immunity. ■

Fig. 5. Effect of supplementation of dairy cow diets with live yeast Levucell SC on rumen pH under severe heat stress (Marsola et al, 2010).