Measures to alleviate heat stress in dairy cows and reduce economic losses

Heat stress is a natural phenomenon that affects dairy cows and other domestic animals in tropical, sub-tropical and often in temperate regions of the world during the summer months.

by Dr ir Hassan Taweel, Global Business Development Manager Ruminants, Nutriad, Belgium.
nutriad.com

Heat and humidity during the summer months combine to make a very uncomfortable environment for dairy cows. The thermo-neutral zone of dairy cows ranges from 0 to 25°C, above this critical temperature (combined with humidity) cows begin to alter their basal metabolism and metabolic rate.

To be able to estimate occurrence and severity of heat stress and to evaluate environmental effects on lactating dairy cows, scientists developed an index that combines measures of both ambient temperature and relative humidity. This index is called Temperature Humidity Index (THI).

$$THI = (1.8 \times T + 32) - ((0.55 - 0.0055 \times RH) \times (1.8 \times T - 26))$$

Where T= Temperature in °C, and RH = Relative Humidity in %

When THI index ranges from 72-79, cows begin to suffer from mild to moderate heat stress. At THI of more than 80 cows become heat stressed. It is important to realise that in many temperate regions of the world where summers are mild and temperature rarely exceed 30°C, moderate to severe episodes of heat stress can occur due to high humidity. THI index of 75 or above can occur when temperature is 27°C, if humidity is above 80%.

Furthermore, new data analysis from on-farm studies concluded that milk production in high producing dairy cows began to decline at an average THI of 68.

Heat stress negatively impacts a variety of dairy parameters including milk yield and reproduction and therefore is a significant financial burden. The economic losses to the dairy industry in the USA alone due to heat stress were estimated to be in the range of $900-1,500 million a year. This figure represents a loss in the range of $110-190 per cow per year. Hence implementing measures to alleviate heat stress and restore cow's health and production efficiency will have a good return on investment.

Consequences on performance

In an attempt to dissipate body heat, dairy cows react to heat stress by reducing feed intake and rumination time, increasing respiration rate, standing time and water intake, excessive salivation, drooling and panting.

Moreover cows tend to sort their TMR for high energy components and leave the forage part. This leads to less favourable rumen environment and function, lower rumen pH and lower microbial protein production and nutrients digestibility. In addition, maintenance requirements increase as the cows attempts to lose body heat.

Heat stress can decrease feed intake by more than 30% and even on well-managed and well-cooled dairies heat stress can decrease feed intake by 10-15%. As a consequence, this leads to a significant reduction in milk yield. Heat stress typically decreases milk yield by 10-15%, even in well-cooled dairies.

The impact of temperature on lactose and mineral content of milk is much smaller than the impact of temperature on protein and fat yields. Generally, in temperate regions, the fat content may average 0.4% lower and the protein content 0.2% lower during hotter periods.

The reduced feed intake and rumen function and increased maintenance requirements caused by heat stress has traditionally been assumed to be primarily responsible for the decrease in milk yield.

However, recently it was demonstrated that reduced nutrient intake accounts for only about 40-50% of the heat stress-induced decrease in milk synthesis.

A large portion of the direct effects of heat stress may be a consequence of changes in endocrine function and nutrient partitioning. Few authors demonstrated, using the model of thermo-neutral pair fed cows, that heat stressed cows show increased insulin effectiveness and sensitivity.

Insulin is a potent anti-lipolytic signal (blocks fat break down) and the primary driver of cellular glucose entry. Heat-stressed cows become hypersensitive to insulin, and will reduce or block adipose mobilisation and increasing glucose 'burning' in an attempt to minimise metabolic heat production. This diverts glucose from mammary tissue to other body tissue (primarily skeletal muscle) and reduces glucose supply to the mammary gland for lactose production leading to reduced milk yield. This may be the primary mechanism which accounts for the additional reductions in milk yield that cannot be explained by decreased feed intake and rumen function.

It has also been shown recently that heat stress during the dry period impairs mammary gland development and alters metabolism in dry and transition cows, which, in turn, reduces milk yield in subsequent lactation even after cows have returned to more comfortable environmental conditions after calving.

In addition to its negative effect on intake, rumen function and health, digestibility and milk production and composition, heat stress also negatively affects fertility and reproduction in dairy cows.

Heat stressed cows show a reduced plasma estradiol and LH concentrations and reduced numbers of FSH and LH receptors on granulosa cells. Some data indicates that only 10-20% of inseminations in 'heat stressed' cows result in pregnancies.

Measures to alleviate heat stress

There are many managerial actions that can be taken at farm level to alleviate heat stress and reduce its impact on production and reproduction efficiency.

Breed and animal selection is one measure; Jersey cows and light colour

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coated cows can cope better with heat stress than Holstein and dark colour coated cows.

Shaving the cows can help increase evaporative heat loss. Some studies showed that evaporative heat loss is 6-8% higher in shaved cows compared to unshaved cows under the same environmental conditions.

Painting surfaces white, providing shade, improving air movement and ventilation in the farm, supplying cold water in abundance and using cooling mats can help the cow lose heat.

The most effective measure, by far, is cooling the cow using a combination of fans and sprinklers. Many studies showed the effectiveness of this combination compared to either fans or sprinkles separately.

Moreover, a five-minute cycle (one minute sprinkling followed by four minutes fanning) proved to be more effective than other longer or shorter cycles in reducing respiration rate and alleviating symptoms and consequences of heat stress.

Nutritional strategies

Timing and frequency of feeding, i.e. providing most of the ration (80%) during the cooler periods of the day (early morning from 4:00-6:00am, and late evening from 9:00-11:00pm); adding water to dry rations and thoroughly mixing the ration can help alleviate some of the negative consequences of heat stress on intake and rumen function.

Adding fat (saturated fatty acids), extra minerals (especially Na, k, and Mg to compensate for higher losses from the body due to increased sweating) and extra vitamins (especially A, D, E to compensate decline consumption due to decreasing intake during hot, humid weather) and buffers (especially KHCO3).

Reducing levels of NPN and increasing RUP in ration can help compensate the decline in microbial protein flow to the small intestine (Nutri-Meth, Nutriad's coated by-pass methionine is very effective in increasing the supply of metabolisable methionine to high producing dairy cows).

Adding preservatives and antioxidants (such as Nutriad's Bacti-Nil and Oxy-Nil) to the TMR prevents heating, increases freshness and bunk life during hot weather and can preserve TMR nutritional quality and improve feed intake.

Moreover, the use of sensory additives (palatability enhancers, such as Nutriad's Gusti-Plus) improves the palatability of the TMR during periods of hot weather, reduces sorting and influences eating behaviour (meal size and frequency) and resting time, thus stabilising the daily pattern of ruminal pH, and increasing DMI and milk production.

Cows drink up to 50% more water when the THI is above 80, hence supplying cold water, and adding (supplementing) energy/mineral/vitamins sources via water can be an effective strategy to maintain nutrients intake during hot periods and counteract heat stress.

Supplementing glucogenic energy via water (i.e propylene glycole, glycerol) can increase glucose supply to the cow during periods of heat stress and help maintain production level.

Other effective nutritional strategies to reduce the impact of heat stress on production and reproduction efficiency, include the use of smart feed additives. As heat stress affects rumen, endocrine and metabolic function, additives that act at both levels (rumen and metabolism) can be employed to alleviate heat stress.

Direct fed microbial (DFM) products based on different strains of fungal extracts and/or yeast cultures have shown to be effective in stabilising rumen function and improving microbial growth and fermentation capacity.

Those DFM are found to be very effective in improving growth rate of major bacterial and fungal species in the rumen especially fibre degrading and/or lactic acid utilising bacteria.

Addition of DFM (such as Nutriad's Nutri-Ferm Prime) to the ration improves rumen microbial fermentation and increases microbial protein synthesis and fibre digestion, leading to 4-8% improvement in milk yield.

Niacin is another additive that can be used to alleviate heat stress in dairy cows. Niacin is involved in most energy-yielding pathways within the animal and its cells, therefore it is important for energy metabolism and milk production.

Recent research demonstrated that niacin plays a role in the transfer of core body heat to skin via its effect on vasodilatation and possibly sweating rate.

In those studies heat stressed cows supplemented with niacin managed to maintain lower core body temperature (measured as vaginal and rectal temperature) compared to controls, by increasing evaporative heat loss by 23%.

Nutriad's Nutri-PP is a protected source of niacin based on our patented micro-encapsulation technology. It ensures that niacin will escape rumen fermentation and be absorbed from the small intestine into the bloodstream.

Conclusions

Heat stress affects dairy cows in many regions of the world and leads to substantial economic losses through its detrimental effect on cow's rumen health, metabolism, production and reproduction.

We are just starting to understand the physiological and metabolic consequences of heat stress. Seasonal heat stress is now also recognised as a problem in temperate areas. There are many measures one can take to alleviate heat stress or reduce its negative consequences on production and reproduction.

Some are housing and management related and can vary from breed selection to shaving the cows to cooling and ventilation.

Some are feeding and nutrition related and vary from frequency and timing of feeding to adding fats, minerals, vitamins, buffers, water supplements, to smart additives such as direct fed microbials, protected niacin and palatability enhancers (sensory additives). ■