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Help dairy cows beat the heat: Diet matters

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The American dairy industry has the challenge to supply consumers with accessible, affordable, and nutritious milk. To meet the growing demand for dairy over the last century, the industry has made long strides to improve the efficiency of growth and milk production (i.e., increased body weight gain and milk produced per unit of feed consumed). Advancements in genetic selection, nutrition and management have elevated productive performance per animal, and reduced animal waste, water and land use, and carbon footprint per unit of milk. However, a daunting threat to dairy productivity moving forward is climate change. Science has demonstrated that our climate has changed over the past century. Therefore, it is reasonable to expect that our climate will continue to change in the future and the dairy industry will adapt.

Current scientific consensus is that our planet is warming with estimates ranging between two and 10°F over the course of the next century. In New York, average annual temperatures have continually increased each decade over the past 100 years and are projected to increase further by the 2050s. New York dairy farmers may expect the annual number of days over 90°F to increase three to four-fold by 2050. Other top dairy-producing states such as California, Wisconsin, and Pennsylvania are also likely to experience similar temperature trends, and dairy cattle in every state within the contiguous U.S. will be prone to heat stress.

Heat stress in dairy cattle is characterized by an increase in body temperature that causes a loss in milk production or growth (maternal or fetal). The heat-stressed cow or calf decreases feed intake and physical activity, and increases respiration rate, sweating, and panting to cope. Modern high-producing Holstein cows, given their higher metabolic heat output, are highly sensitive to heat stress. As milk yield continues to increase thanks to improvements in nutrition, management and genetics, the susceptibility of high-producing cows to heat stress will rise. Without heat abatement, heat stress-related milk yield losses (kg/cow/year) are estimated to be 139, 293, 729, and 1,803 in New York, California, Arizona, and Florida, respectively. Calves are at a slight advantage to manage increases in heat load as compared to mature cows because of their lower heat production per unit of surface area. However, high ambient temperatures still adversely impact growth performance (i.e., lower average daily gain and weaning body weight) and increased mortality rate. Heat abatement by providing shade, fans, sprinklers, and misters are approaches to enhance heat stress resilience in dairy cattle. These practices are common but only partially reduce the effects of heat stress. They may also demand water and perhaps natural fossil fuels to operate. Genetic selection for heat resilience (i.e., slick hair gene) from Senepol cattle enhances resilience, but milk production potential may be impacted.

Current research indicates that the heat-stressed animal experiences modifications in gastrointestinal health and post-absorptive metabolism. As means of improving body cooling, animals shunt blood supply from intestines towards the skin. This weakens the protective barrier of intestinal cells, and bacteria and endotoxin enter blood circulation. This syndrome called "leaky gut" causes systemic inflammation and induces immune system activation. This comes with an energetic cost to a lactating dairy cow, as it redirects glucose utilization away from milk synthesis to support immune cells energy to fight the infection. Additionally, body fat mass is retained and skeletal muscle breakdown accelerates. Thus, dietary approaches that enhance gut health, protect the intestinal barrier, and restore nutrient partitioning towards lean mass accretion and milk production should be considered to enhance heat stress resilience in dairy cattle.

WHAT TO FEED HEAT-STRESSED DAIRY CATTLE?

- Dietary fiber (i.e., NDF) has a greater heat increment of production associated with acetate formation in the rumen as opposed to propionate formation from concentrate diets. Feeding a higher quality (i.e., lower uNDF 240) and easily digestible forage is preferred because it lowers the heat increment and increases the energy value for the cow.
- Increasing the energy density of diets is important to consider because heat

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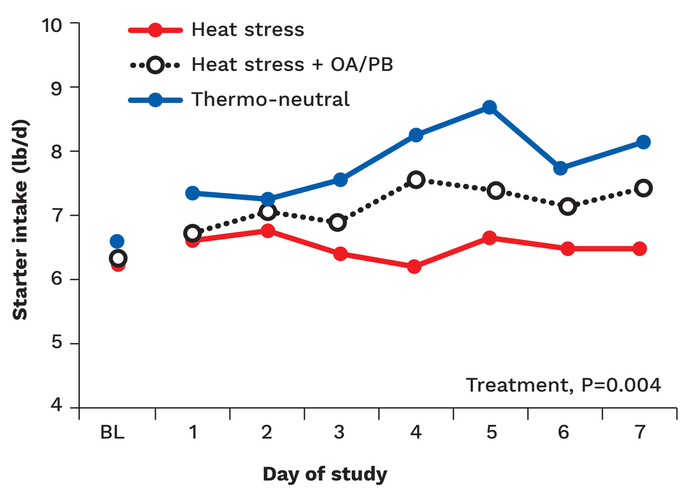
stress lowers feed intake. Added natural and commercial fats are excellent sources of energy with a high efficiency of utilization and low heat increment. However, feeding less than six percent fat on a dry matter basis and ensuring that commercial unsaturated fats are protected (e.g., calcium salts or mixed prills) is important to maximize feed intake and fatty acid digestibility, and to limit adverse effects on rumen biohydrogenation of unsaturated fats and milk fat synthesis. More research is needed to better understand the effects of individual fatty acids in heat-stressed cattle.

• In addition to supporting milk protein synthesis, diets high in metabolizable methionine (perhaps from rumen-protected methionine supplementation) is a potential approach to reduce inflammation and oxidative stress in lactating dairy cows. This is important to consider because these conditions occur in heat-stressed cattle.

FIGURE 1



Effects of heat stress and dietary organic acid and plant botanical (OA/PB) supplementation on starter intake of weaned Holstein calves. Bull and heifer calves were randomly assigned (n=12-13/group) during the first week of life; unsupplemented heat stress conditions, OA/PB supplemented heat stress conditions (75 mg/kg of body weight; AviPlus R®; Vetagro, Italy) unsupplemented thermo-neutral conditions. BL: baseline starter intake.

• Betaine is a methyl donor and osmolyte that may enhance fiber digestibility and gut barrier integrity. This may translate into improved rumen fermentation activity and gains in nutrient absorption. These outcomes are potential reasons why betaine feeding is shown to increase milk production in cows during extreme heat.

• Vitamin (i.e., A, C, E) and mineral (i.e., magnesium, potassium, selenium, sodium, zinc) nutrition is considered due to their anti-oxidative capacities, which can bolster immunity and health of heat-stressed animals. Protected B vitamins such as biotin (B8), cobalamin (B12), riboflavin (B2), and pantothenic acid (B5) support hepatic glucose production and endogenous nutrient utilization. Dietary rumen-protected niacin (vitamin B3) supplementation is also a promising approach to enhance thermotolerance in cows. The reason for increased milk production with niacin feeding is likely due to the ability of the nutrient to enhance skin vascularity and sweating rate.

• For calves, nutritional therapy must start in the uterus. Studies show that keeping cows cool during the dry period is key to enhance fetal growth, colostrum quality (i.e., IgG concentration), and passive immunity transfer. In the pre-weaning phase, a common practice is to increase milk or milk replacer feeding to compensate for reductions in starter intake caused by heat stress.

• Post-weaning, dietary organic acid and plant botanical (OA/PB) supplementation may be beneficial. At Cornell University, our research team investigated the effects of rumen-protected OA/PB (25 percent citric acid, 17 percent sorbic acid, 1.7 percent thymol, and 1 percent vanillin; AviPlus R®, Vetagro, Inc.; 75 mg/kg of body weight/d) in starter diets of heat-stressed Holstein bull and heifer calves. In pigs, dietary OA/PB feeding has intestinal healing properties and accelerates growth. In our study, post-weaned calves that developed heat stress experienced decreases in energy intake, average daily gain, and hot carcass weight. Feed intake (**Figure 1**), average daily gain, and hot carcass weight was partially restored when calves were fed OA/PB. We are currently determining whether OA/PB feeding enhanced rumen fermentation and maintained a healthy intestinal microbiome to support heat stress resilience.

Although our ability to accurately predict the degree of climate change will be tested, heat stress is an industry challenge. A combination of heat abatement and sound dairy nutrition can work in unison to help dairy cattle cope with extreme heat without compromising health or performance. ▮

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