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# Strategies to Improve Dairy Cows' Feed Intake during Heat Stress

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en Español: Estrategias para mejorar la ingestión durante periodos de estrés por calor.

Thermostasis is the process by which cows attempt to keep their body temperature constant in spite of changes in environmental temperatures. Heat stress occurs when the cow is incapable of dissipating enough heat to maintain its core body temperature below 101.3°F. This increase in body temperature results from the combination of heat from the environment and that produced internally during rumen fermentation and nutrient metabolism. In addition, heat stress leads to an increase in respiratory frequency (panting) in an attempt to increase heat dissipation. This increase in physical activity is the reason why cows in hot environments produce more heat than in cold environments. Internal heat production increases at higher feed intakes and milk production, which is why high-producing cows are more sensitive to heat stress than lower-producing cows. One mechanism the organism has to reduce heat production is to reduce intake and thus less heat needs to be dissipated. Knapp and Grummer (1991) reported that when a cow's body temperature increased from 101.3° to 104°F, dry matter intakes decreased from 45 to 31 pounds. Berman (2005) showed cows started to suffer from heat stress at temperatures 9°F cooler when production increased from 77 to 99 pounds per day. They also reported that air velocity increased the maximum threshold, suggesting that cows housed in facilities with forced air can tolerate higher ambient temperatures.

**Please check this link first if you are interested in organic or specialty dairy production**.

## Temperature and Humidity

Cows during lactation start to drop feed intake when ambient temperatures exceed 77° to 79°F, with marked reductions above 86°F (NRC, 1989). Aside from the temperature, however, there are other environmental factors that need to be factored in. Cornell researchers have developed an equation to correct dry matter intake depending on ambient temperature, relative humidity (RH), wind speed, and direct exposure to solar radiation (Table 1). At 68°F and 50% RH, there is no effect on intake; however, when ambient temperatures exceed 75°F, intake drops considerably even at 50% RH. This is explained because when RH is high, the capacity to dissipate heat through the lungs is reduced during respiration and panting, which causes an increase in body temperature and a reduction in intake. In an experiment by Knapp and Grummer (1991), cows subjected to heat stress increased their body temperature, and both their intake and milk production decreased by 14 pounds per day. These results agree with a University of Arizona experiment in high-producing cows (more than 77 pounds per day) which showed production started to drop when rectal temperature exceeded 101.3°F. Collier et al. (2012) reported that when environmental temperatures were at 71.6°F, this increase in body temperature occurred at 45% RH or higher.

**Table 1.** Dry matter intake reduction as affected by ambient temperature and relative humidity.

| Dry matter intake reduction, % | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | **Relative humidity, %** | | | | | | | | | | |
| **°F** | **0** | **10** | **20** | **30** | **40** | **50** | **60** | **70** | **80** | **90** | **100** |
| 68.0 | 3 | 2 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 2 | 2 |
| 71.6 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 4 | 5 | 6 |
| 75.2 | 3 | 3 | 3 | 3 | 4 | 4 | 5 | 6 | 7 | 9 | 10 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 78.8 | 3 | 3 | 4 | 5 | 5 | 6 | 8 | 9 | 11 | 12 | 14 |
| 82.4 | 3 | 4 | 5 | 6 | 7 | 9 | 10 | 12 | 14 | 16 | 18 |
| 86.0 | 4 | 5 | 6 | 7 | 9 | 11 | 13 | 15 | 17 | 20 | 22 |
| 89.6 | 4 | 5 | 7 | 9 | 11 | 13 | 16 | 18 | 21 | 24 | 27 |
| 93.2 | 4 | 6 | 8 | 11 | 13 | 16 | 18 | 21 | 24 | 28 | 31 |
| 96.8 | 5 | 7 | 10 | 12 | 15 | 18 | 21 | 25 | 28 | 32 | 35 |
| 100.4 | 6 | 8 | 11 | 14 | 17 | 21 | 24 | 28 | 32 | 36 | 40 |
| 104.0 | 6 | 9 | 13 | 16 | 20 | 23 | 27 | 31 | 36 | 40 | 45 |
| 107.6 | 7 | 11 | 4 | 18 | 22 | 26 | 30 | 35 | 39 | 44 | 49 |
| 111.2 | 8 | 12 | 4 | 20 | 24 | 29 | 34 | 38 | 43 | 49 | 54 |

*Source: Fox and Tyluki (1998). Data obtained from cows housed in the shade with no forced air; wind speed and sun exposure were thus 0. The formula used was that for ambient temperature above 68°F without night cooling.*

Cows can tolerate greater temperatures during the day when ambient temperature during the night drops below 70°F. This suggests that whenever necessary (e.g., successive hot days), strategies are needed to reduce temperature during the night. In addition, it has also been reported that intake and milk production drops on a given day are more related to the climate of the two previous days (West, 2003).

Intake reduction is less accentuated in cows with lower feed intake and/or lower productivity. Cows around mid-lactation (100-180 days in milk, DIM) are those affected the most, followed by those at the end of the lactation (180-260 DIM), and finally cows in early lactation (less than 100 DIM). Cows in early lactation had the lowest DMI; however, they were the ones that produced the most milk. This suggests that cows at the beginning of the lactation use body reserves to compensate for the effects of environmental heat. In addition, the effects of heat stress also depend on the number of lactations. Pregnant multiparous cows in mid-lactation subjected to heat stress had greater intake reductions (22%) than first-lactation cows (9%) of similar lactation and gestation stage.

As discussed before, heat stress reduces intake and in turn milk production. However, experiments at the University of Arizona have demonstrated that the intake reduction caused by heat alone is responsible for only 40% to 50% of the drop in milk production. Other biological changes, such as those in the endocrine system and the increase in maintenance requirements, also contribute also to the reduction in energy available for milk production. In addition to the intake reduction, cows under heat stress look for shade and circulating air, increase water intake, reduce physical activity, increase respiratory cycles (panting), and increase sweating.

## Improving the Facilities

Providing clean, fresh water, enough shade, and adequate air circulation is critical to maintain production. When cows are subjected to heat stress, a significant portion of their body heat is eliminated through the skin. However, as ambient temperatures increase, heat losses through the lungs increase, and those through the skin are reduced. Cows increase their respiration cycles (panting) to augment heat elimination through evaporation. Heat losses through the skin increase when both skin and coat are soaked. The body temperature leads to water evaporation from the surface, dissipating heat. One of the most effective strategies to improve intake and milk production is to install water sprinklers along the feed bunk. These sprinklers eject big drops that are distributed along the cow's back while she is eating in the bunk. Water drops must be large enough to soak the coat and skin of the animal and have to be applied intermittently to allow time for them to evaporate before the next wetting cycle begins.

Table 2 summarizes the benefits observed with cooling systems made of sprinklers and fans in several experiments conducted in the United States. Researchers from the University of Missouri-Columbia (Igono et al., 1985) placed two lines of sprinklers in the freestall, one on top of the feed bunk, the other in the alley between the cubicles and the side wall. Sprinklers were set in cycles of 30 min. (20 min. on; 10 min off). Although they were able to reduce rectal temperatures, they only improved milk production by 1.6 pounds (52.7 pounds produced in the treatment group). A year later they repeated the experiment, this time with the addition of forced air on the top of feed bunk and cubicles; in this instance, milk production increased by 4.4 pounds per day (Igono et al., 1987). This demonstrated that increasing the air movement through the animals that have been soaked increases heat dissipation through the skin.

Intake and milk yield improved by 2 pounds per day when sprinklers were installed on top of the feed bunks in another experiment conducted in Alabama. In this experiment, the sprinklers were working in cycles of 15 min. (3 min. on; 12 min. off). Each treatment had fans both at the feed bunk and cubicles. It was determined that the fans alone did not improve cow comfort. The Missouri and Alabama experiments suggest that during severe heat stress, treating cows with sprinklers or fans exclusively is not enough and that both strategies need to be combined to reduce body temperature below 102.4°F.

**Table 2:** Effect of different cooling systems on milk yield.

| | **Treatment** | **Forced air feed bunk** | **Forced air cubicles** | **Sprinklers feed bunk** | **DMI (lb/day)** | **Milk yield (lb/day)** |
|---|---|---|---|---|---|---|
| Igono et al. (1985) | Control | No | No | No | N.D. | 51.1$^{a}$ |
| | Treatment | No | No | Yes | N.D. | 52.7$^{b}$ |
| Igono et al. (1987) | Control | No | No | No | N.D. | 51.4$^{a}$ |
| | Treatment | Yes | Yes | Yes | N.D. | 55.8$^{b}$ |
| Linn et al. (1998) | Control | Yes | Yes | No | 49.6$^{a}$ | 46.8$^{a}$ |
| | Treatment | Yes | Yes | Yes | 51.8$^{b}$ | 48.7$^{b}$ |
| Brouk et al. (1999a) | 2 S | No | Yes (double) | Yes | 55.6 | 93.9$^{a}$ |
| | F + S | Yes | Yes | Yes | 56.2 | 98.8$^{b}$ |
| | F +2S | Yes | Yes (double) | Yes | 56.3 | 96.5$^{ab}$ |
| Brouk et al. (2001) | F | Yes | No | Yes | 52.7 | 79.8$^{a}$ |
| | F + S | Yes | Yes | Yes | 54.0 | 85.6$^{b}$ |
| Brouk et al. (1999b) | F + S | Yes | Yes | Yes | 49.9 | 80.7 |
| | S | No | Yes | Yes | 49.7 | 80.3 |
| $^{a,b}$ = Significant P<0.05; N.D. = No data. | | | | | | |

A series of studies conducted at Kansas State University evaluated the efficacy of different cooling systems to alleviate heat stress. In the first experiment conducted during the summer, three different combinations of sprinklers and fans were evaluated in barns with four rows of cubicles. All the systems had sprinklers on top of the feed bunk programmed in cycles of 15 min. (3 min. on; 12 min. off). One treatment (2S) had two rows of fans on top of the cubicles, another treatment (F+S) had one row of fans on top of the cubicles and another on top of the feed bunk, and the last treatment (F+2S) had two rows of fans on top of the cubicles and one row on top of the feed bunk. Although there were no differences in intake between treatments, differences in milk yield were observed. The cows that were cooled with fans on top of the cubicles and the feed bunk produced more milk than those cooled with fans only on top of the feed bunk (93.9 vs. 98.8 pounds per day). There was no production response when the number of fans on top of the cubicles was doubled (F+2S). In a subsequent experiment (Brouk et al., 2001; Table 2), two cooling systems were evaluated, both with sprinklers and fans on top of the feed bunk but only one of them had a line of fans on the cubicles (F+S). It was confirmed that when the fans on top of the feed bunk were complemented with those on top of the cubicles, milk yield increased by 5.8 pounds per day. Based on the results of these two experiments, the authors concluded that the most effective cooling system for barns with four rows of cubicles was having sprinklers on top of the feed bunk and two rows of fans, one on top of the cubicles and another on top of the feed bunk. However, the results differed for barns with two rows of cubicles and sprinklers on top of the feed bunk (Brouk et al., 2001; Table 2). For these facilities, the best cooling system was a row of sprinklers on top of the feed bunk and one row of fans on top of the cubicles (S). An additional row of fans on top of the feed bunk did not improve milk yield. Barns with two rows of cubicles are narrower than those with four, which allows for better natural air circulation.

Sprinkling frequency and air flow also influence the efficiency of the cooling system. To increase the efficiency, cows must be dry before the next soaking cycle. The capacity to reduce the body temperature of cows during lactation was compared for different soaking frequencies (cycles every 5, 10, and 15 min.; Brouk et al., 2003). Each cycle supplied similar amounts of water in every treatment (0.35 gallon/headlock) during the same amount of time (1 min.). Air flow from the fans was continuous and supplied 700 cubic feet per minute (CFM). The drop in body temperature increased soaking frequency. These results suggested that the most effective system to alleviate heat stress is continuous forced air and soaking frequencies every 5 min. (1 min. on; 4 min. off). Subsequently, to corroborate whether the airflow influenced the cooling efficacy, three different airflows were evaluated (500, 750, or 900 CFM) with soaking frequencies every 5 min. (Brouk et al., 2004b). The system with the lowest airflow was the least effective, and there were no differences between the other two. This experiment demonstrated that there are no advantages to increasing the airflow above 750 CFM with a 5 min. soaking frequency.

Some facilities have chosen to install high-pressure misting systems to reduce the quantity of water used in a sprinkling system which, contrary to the sprinklers, eject very small droplets. If these drops are incapable of completely soaking the coat and skin of the cow, they can create an air space in between the skin and the water film. This air space insulates and can impede heat elimination through the skin and worsen the heat load of the animal.

According to Brouk et al., 2004b, a water-spraying system over the feed bunk together with forced air can have similar efficiency to the sprinklers (with 5 min. cycles) only when it soaks the skin of the cow completely. To achieve this efficiency, the system must be working continuously with a minimum water flow of 3.4 gallons per hour. When cattle are soaked with high-pressure misting, there is a combined effect of cooling the surrounding air and the animal through the water evaporated from the skin. Misters with water flow of 1.7 gallons/h were able to decrease body temperature in cows but were not as efficient as those with 3.4 gallons/h or sprinklers with 5 min. cycles. In addition, continuous high-pressure misting systems (3.4 gallons/h) use 18% less water than sprinklers in 5 min. cycles (1 min. on; 4 min. off; 4.2 gallons/h). There is a need for more production studies to corroborate whether this reduction in water use compensates for the greater increase in RH, particularly in high RH environments. There have been reports of higher incidence of respiratory problems in farms that use these systems, particularly when ventilation is inadequate and RH is high.

A cooling program could increase soaking frequency at the feed bunk as ambient temperature increases. One such example of cooling is as follows:

| Ambient temperature | Soaking cycle frequency |
|---|---|
| between 77° and 86°F | 12 min. (1 min. on; 11 min. off) |
| above 86°F | 8 min. (1 min. on; 7 min. off) |

The fans should work continuously when ambient temperature exceeds 68°F. These recommendations are just an example, and each farm has to devise its own specific cooling program taking into consideration environmental factors, barn design, production level, and overall condition of the cows. Close-up (3 weeks) and early lactation cows are the most sensitive to heat stress and need more stringent cooling strategies.

## Forage Inclusion on Diets

Due to the intake depression caused by heat stress, nutritionists in general increase the energy density of the diet by increasing the amount of concentrates and reducing the amount of forages in the ration. This is a sound practice if adequate levels of effective fiber are maintained which are necessary to stimulate rumination and maintain adequate rumen pH. Heat-stressed cows reduce rumination and tend to select finer feed particles. This combination of more concentrated rations together with reduced capacity to buffer rumen pH increases the risk of acidosis during hot weather. These changes can be observed in farms by a reduction in milk fat and higher incidence of lameness.

Research has confirmed the importance of forage inclusion in diets of cows under heat stress. In a University of Georgia experiment (West et al., 1999), heat-stressed cows were fed four experimental diets (forage NDF level = 17%, 19.2%, 23.5%, and 24.7%) having a 40-to-60 forage-to-concentrate ratio. Dietary fiber concentration was achieved by partial substitution of corn silage with bermudagrass hay. Forage NDF increased gradually from 17% (without hay) up to 24.7% (22.8% hay) in the ration. Milk yield was highest, 58.1 and 56.8 pounds per day, for cows fed diets with an intermediate concentration of forage NDF (23.5% and 19.2%, respectively), while milk fat percentages increased linearly with forage NDF inclusion rate. It was necessary to include a minimum of 23.5% forage NDF in the diet to maintain milkfat at 3.5% or greater.

## Water Supply

Water is among the critical nutrients during periods of heat stress as losses through evaporation increase at higher ambient temperatures (Table 3). Cows prefer to drink water with a temperature between 63° and 82°F. If the water is not cool enough, it further adds to the heat load. Clean, fresh water is also important during the summer because the high loss of body fluids and electrolytes during sweating and panting can increase the risk of cardiovascular problems. It is very important to have water troughs in the shade and to clean them frequently.

**Table 3.** Ambient temperature, milk yield, water intake (L/day).

| **Milk yield** | **Ambient temperature** | | |
|---|---|---|---|
| (LB/d) | 40°F | 60°F | 80°F |
| 40 | 70 | 83 | 96 |
| 60 | 82 | 96 | 109 |
| 80 | 95 | 108 | 122 |
| 100 | 108 | 121 | 135 |

**Source**: Waldner and Looper, Oklahoma State University (ANSI-4275).

## Summary

Extended periods of high ambient temperature coupled with high relative humidity compromise the ability of cows in lactation to dissipate excess body heat. Cows with elevated body temperatures exhibit lower intakes and milk yields. Supplemental fan cooling in combination with low pressure feed bunk sprinklers can reduce the effects of heat stress on milk production and feed intake. Several key areas of nutritional management should also be considered for complementing environmental cooling during hot weather.

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## References

Baumgard, L.H., J.B. Wheelock, S.R. Sanders, C.E. Moore, H.B. Green, M.R. Waldron, and R.P. Rhoads. 2011. Postabsorptive carbohydrate adaptations to heat stress and monensin supplementation in lactating Holstein cows. J. Dairy Sci. 94:5620-5633.

Berman, A. 2005. Estimates of heat stress relief needs for Holstein dairy cows. J. Animal Sci. 83:1377-1384.

Brouk, M.J., J.P. Harner, J.F. Smith, W.F. Miller, and B. Cvetkovic. 2004a. Responses of lactating Holstein cows to differing levels and direction of supplemental airflow. Proceedings of the Dairy Day. Kansas State University Agricultural Experiment Station and Cooperative Extension Service.

Brouk, M.J., J.P. Harner, J.F. Smith, W.F. Miller, and B. Cvetkovic. 2004b. Response of lactating Holstein cows to low pressure soaking or high pressure misting during heat stress. Proceedings of the Dairy Day. Kansas State University Agricultural Experiment Station and Cooperative Extension Service.

Brouk, M.J., J.F. Smith, and J.P. Harner. 2003. Effect of sprinkling frequency and airflow on respiration rate, body surface temperature, and body temperature of heat-stressed dairy cattle. Fifth International Dairy Housing Proceedings of the 29-31 January Conference. 263-268.

Brouk, M.J., J.F. Smith, J.P. Harner, and S.E. Defrain. 2001. Effect of fan placement on milk production and dry matter intake of lactating dairy cows housed in a four-row freestall barn. Proceedings of the Dairy Day. Kansas State University Agricultural Experiment Station and Cooperative Extension Service.

Brouk, M.J., J.F. Smith, J.P. Harner, B.J. Pulkrabek, D.T. McCarty, and J.E Shirley. 1999a. Performance of lactating dairy cattle housed in a four-row freestall barn equipped with three different cooling systems. Proceedings of the Dairy Day. Kansas State University Agricultural Experiment Station and Cooperative Extension Service.

Brouk, M.J., J.F. Smith, J.P. Harner, B.J. Pulkrabek, D.T. McCarty, and J.E Shirley. 1999b. Performance of lactating dairy cattle housed in two-row freestall barns equipped with three different cooling systems. Proceedings of the Dairy Day. Kansas State University Agricultural Experiment Station and Cooperative Extension Service.

Collier, R.J., L.W. Hall, S. Rungruang, and R.B. Zimbleman. 2012. Quantifying heat stress and its impact on metabolism and performance. 23rd Florida Ruminant Nutrition Symposium Proceedings.

Fox, D.G. and T.P. Tylutki. 1998. Accounting for the effects of environment on the nutrient requirements of dairy cattle. J. Dairy Sci. 81:3085-3095.

Holter, J.B., J.W. West, and M.L. McGilliard. 1997. Predicting *ad libitum* dry matter intake and yield of Holstein cows. J. Dairy Sci. 80:2188-2199.

Igono, M.O., H.D. Johnson, B.J. Steevens, G.F. Krause, and M.D. Shanklin. 1987. Physiological, productive, and economic benefits of shade, spray, and fan system versus shade for Holstein cows during summer heat. J. Dairy Sci. 70:1069-1079.

Igono, M.O., B.J. Steevens, M.D. Shanklin, and H.D. Johnson. 1985. Spray cooling effects on milk production, milk, and rectal temperatures of cows during a moderate temperate summer season. J. Dairy Sci. 68:979-985.

Knapp, D.M. and R.R. Grumyea. 1991. Response of lactating dairy cows to fat supplementation during heat stress. J. Dairy Sci. 74:2573-2579.

Lin, J.C., B.R. Moss, J.L. Koon, C.A. Flood, S. Rowe, J.R. Martin, B. Brady, F. Degraves, and R.C. Smith. 1998. Effect of sprinkling over the feed area and misting free stalls on milk production. The Professional Animal Scientist 14:102-107.

Maust, L.E., R.E. Mcdowell, and N.W. Hooven. 1972. Effect of summer weather on performance of Holstein cows in three stages of lactation. J. Dairy Sci. 55:1133-1139.

National Research Council. 1989. *Nutrient Requirements of Dairy Cattle, 6th Ed*. National Academic Press, Washington, D.C.

Rhoads, M.L., J.W. Kim, R.J. Collier, B.A. Crooker, Y.R. Boisclair, L.H. Baumgard, and R.P. Rhoads. 2010. Effects of heat stress and nutrition on lactating Holstein cows: II. Aspects of hepatic growth hormone responsiveness. J. Dairy Sci. 93:170-179.

Rhoads, M.L., R.P. Rhoads, M.J. VanBaale, R.J. Collier, S.R. Sanders, W.J. Weber, B.A. Crooker, and L.H. Baumgard. 2009. Effects of heat stress and plane of nutrition on lactating Holstein cows: I. Production, metabolism, and aspects of circulating somatotropin. J. Dairy Sci. 92:1986-1997.

Waldner, D.N. and M.L. Looper. *Water for Dairy Cattle.* Division of Agricultural Sciences and Natural Resources. Oklahoma Cooperative Extension Service. ANSI-4275.

Wheelock, J.B., R.P. Rhoads, M.J. VanBaale, S.R. Sanders, and L.H. Baumgard. 2010. Effects of heat stress on energetic metabolism in lactating Holstein cows. J. Dairy Sci. 93:644-655.

West, J.W. 2003. Effect of heat stress on production in dairy cattle. J. Dairy Sci. 86:2131-2144.

West, J.W., G.M. Hill, J.M. Fernandez, P. Mandebvu, and B.G. Mullinix. 1999. Effects of dietary fiber on intake, milk yield, and digestion by lactating dairy cows during cool or hot, humid weather. J. Dairy Sci. 82:2455-2465.