Biological Times

Volume No. 5 | Issue No. 9 | Pages 11-13

# Heat Stress in Dairy Cows: From Recognition to Effective Management

Muhammad Wassaf*[1], Naseer Ahmad[2], Hammad Ata[2] and Dawood Ali[3]

1. Faculty of Veterinary Sciences, University of Agriculture Faisalabad, Pakistan
2. University of Veterinary and Animals Sciences, Lahore, Pakistan
3. Faculty of Veterinary and Animal Science, PMAS-Arid Agriculture University, Rawalpindi, Pakistan

*Corresponding Author: **muhammadwassaf918@gmail.com**

## ABSTRACT

The rise in temperature is a great problem in dairy farming throughout the world and is very important for the stress of farm animals, decreasing food consumption and milk production. This extension article briefly summarises heat stress, factors that predispose to heat stress, clinical signs and biological effects of heat stress, and measures to mitigate the effects of heat stress to reduce farm productivity losses. This requires a multi-factorial approach to the problem, integrated. Immediate thermal load reduction is achieved by environmental cooling systems (shade, fans and misting) while nutritional management is achieved through providing energy-dense rations, dietary buffers and functional additives. Water management involves facilitating important evaporative cooling and hydration, while genetic selection involves enabling thermotolerant traits, including Bos indicus crossbreeding and SLICK haplotypes. In addition, strategic farm management reduces the number of times the farm needs to be fed, and positions feed troughs and barns to avoid thermal peaks. To conclude, combining these practical strategies is valuable to dairy farmers, as good management practices can make animals better, more productive, and more profitable dairy systems.

**Keywords:** Dairy cattle, Heat stress management, Thermotolerance, Temperature-Humidity Index, Nutritional management, Genetic selection

**To cite this article:** Wassaf M, N Ahmad, H Ata & D Ali. Heat Stress in Dairy Cows: From Recognition to Effective Management. Biological Times. 2026. September 5(9): 11-13.

**Introduction**

High summer temperatures pose a serious challenge to livestock production in many parts of the world. The Earth's global average temperature has increased by 1.2 °C due to industrialisation, leading to more severe heat waves [8]. In hot and humid nations, summer temperatures can rise 30-39 degrees or more, compromising animal comfort [5]. Heat stress is typically caused by elevated ambient temperatures, high surrounding humidity, intense solar radiation, and minimal wind speed [1]. These factors cause chronic heat stress, even in countries such as the European Union and the USA, where recent climate shifts impair natural cooling [5].

Animals experience heat stress when they are unable to dissipate heat generated by their own metabolic activities and absorbed from their surroundings, thereby disrupting thermoregulation [1]. Dairy cows' biological systems are impacted by heat stress [2]. Dairy cattle breeds in tropical regions, such as the Subcontinent, are highly diverse, including heat-adapted Bos indicus cattle and heat-susceptible Bos taurus breeds. Consequently, they differ significantly in their response to heat stress due to their genetic background. Genetic selection also plays a crucial role in mitigating heat stress by enabling the breeding of animals with higher thermotolerance[5].

Milk production is directly linked to feed intake [3]. In summer, cattle reduce their feed intake to lower internal heat generation[7]; it has been estimated that at 40 °C, feed intake drops by up to 50%, leading to a significant decrease in milk yield. As heat stress reduces dry matter intake, the animal's maintenance and production needs are compromised. Consequently, increasing the dietary concentration of energy and protein becomes essential to offset this lower feed intake [3].

Heat stress leads to substantial economic losses worldwide. For instance, annual financial losses in the USA range from $1.69 to $2.26 billion, while in India, heat stress caused an estimated reduction of 0.73 million litres of milk production in 2020 [18]. Therefore, in addition to genetic selection, proper housing for dairy cows must be considered, as it is highly effective against heat stress. Controlling the internal temperature of the housing facility is, therefore, essential [14].

Since heat stress has deleterious effects on dairy cow health and productivity, effective mitigation techniques are required [4,14]. This article reviews the causes, clinical signs, and impacts of heat stress, while outlining practical management strategies to help farmers reduce heat stress and sustain farm productivity.

**What is heat stress?**

Heat stress is a condition in which the body is unable to compensate for a gain in body heat, which results in a disruption of thermal balance. This imbalance leads to physiological changes, a decrease in feed intake, and, over time, a decrease in milk yield, in addition to affecting milk quality, that is, fat and protein content [7]. Physiologically, they create a thermal stress situation, which ultimately causes a decrease in production performance and weight gain, in an environmentally adverse way. This happens when the temperature of the surrounding air rises, and the relative humidity rises while the air movement reduces or stops. When environmental factors are greater than the upper critical temperature limit, this is the highest possible body temperature an animal can have without becoming stressed. This limit depends on the animal's age, breed, and health condition [8]. The impact of hot environments on animal health is manifold; for an animal to fully realise its genetic potential, all environmental factors that affect its performance need to be controlled. Lactating Holstein cows, for example, have a thermoneutral zone of 4 °C to 24 °C and milk production starts to drop off sharply when ambient temperatures rise above 29 °C [3].

**Causes of heat stress**

The causes of heat stress can be divided into two categories depending upon their source: internal and external stressors, which originate from the animal's body and from the environment, respectively. Some of the common factors include deprivation of water, feed, heat, overcrowding, confined housing, and handling [8,19]. While numerous factors contribute to heat stress, a primary cause is the accumulation of heat in the animal's body from direct solar radiation. Moreover, dark-coated animals absorb significantly more solar heat than lighter- or white-coated livestock. Diet also plays an important role in heat stress management. Forages produce a higher heat increment of digestion than grains; consequently, animals fed higher-concentrate or grain-based diets generate less internal heat [2]. This is because the microbial fermentation and digestion of fibrous roughage require greater metabolic effort, resulting in increased heat production that is harder for the animal to dissipate. Similarly, high-yielding cows are highly susceptible to heat stress because of high heat dissipation from their body due to meeting the production demands.

**Clinical signs & symptoms**

Heat stress in animals is usually very subtle. Here are a number of signs and symptoms of heat stress in dairy cattle. It includes decreased feed intake, decreased milk (>10 %) and butterfat percentage (0.2–0.3 %), increased breathing rate (>80 breaths/minute), and increased body temperature (>39.2 °C) and reduced overall performance [2,10,11]. Dry matter drops, so does milk production. When water availability is restricted, milk production drops sharply [17]. Under heat stress, the cow prioritises water for thermoregulation and evaporative cooling rather than milk synthesis, shifting physiological priorities to survival and body cooling. Modern studies show reduced rate of passage, decreased rumen pH, higher rumen ammonia and exchange in unstable fatty acids due to heat stress. A statistically significant effect of THI (temperature–humidity index) on RT (rumination time) was identified, with THI increasing as RT decreases [12].

**Effects of heat stress**

The lactation curve is significantly reduced in summer due to heat stress, and milk quality is also affected during the summer, especially as a result of the ongoing genetic selection for higher milk production in dairy cattle. High ambient temperatures are especially associated with milk composition, and high somatic cell count is a sign of poor milk quality in

hyperthermic conditions [6,7]. In addition, heat stress has been reported to have a specific effect on milk protein, lowering the total milk protein content [12]. There is a point in lactation when most of the glucose is used in milk production, and the cows' energy requirements are frequently higher than their daily dry matter intakes, leading to negative energy balance and reduced production efficiency [6]. This energy shortage is exacerbated by alterations in the rumen which occur as a result of heat stress, which affects the microbial population and the fermentation processes. High temperatures promote the growth of bacteria that produce lactate (e.g., *Streptococcus spp.*) and bacteria that use soluble carbohydrates (e.g*., Ruminobacter spp. and Treponema spp*.), and inhibit the growth of important cellulolytic bacteria, as well as bacteria that produce acetate (e.g., *Actinobacteria spp. and Acetobacter spp*.). These changes in rumen fermentation have direct effects on systemic metabolism, which leads to a decrease in circulating levels of key metabolites and amino acids, such as isoleucine, methionine, myo-inositol, tryptophan, tyrosine and valine. These microbial and metabolic disturbances can combine together to reduce feed intake, milk production, growth and reproductive ability [10]. At the cellular level, heat shock transcription factors (HSFs) are activated along with heat shock proteins (HSPs) to activate the heat shock response and maintain homeostasis. Of these, HSP70 is important for cellular defence, and HSF1 is crucial for thermotolerance. In heat-stressed bovine lymphocytes, the expression level of major histocompatibility complex class II (BoLA-DRB3) genes was decreased while the expression level of stress-protective genes such as HSP90B1 and HSP70-1A was increased. All of these physiological, metabolic and cellular changes highlight heat stress as an emergency condition with the need for specific mitigation measures [13].

**Heat stress management**

Proper heat-stress management will need a coordinated, multifactorial approach to ensure dairy cow health, maintain milk yield and promote reproductive performance.

Immediate measures to reduce thermal stress should be implemented in conjunction with longer-term measures to adapt to thermal stress, as thermal stress can have a significant effect on reducing dry matter intake and metabolic stability. A good mitigation strategy includes nutrition, watering, genetics, farm management, and environmental cooling [14,19]. Some of the strategies are these:

**Environmental management**

The systematic review and meta-analysis indicate that the combined environmental cooling system is the most effective system to achieve the most rapid recovery of physiological stability in terms of improving milk yield and reducing elevated rectal temperature and respiration rate. Mechanical cooling techniques (shade, forced ventilation fans and evaporative misting or sprinkler systems) resulted in a more acute effect on heat stress than nutritional interventions. Implementing targeted cooling in high temperature humidity index situations can target the microclimate of the cow so that she can 'cool down' before heat load causes metabolic hyperthermia, which may result in oxidative stress and inflammatory responses [4,15].

**Nutritional management**

One of the most important nutritional approaches is to ensure a well-balanced fibre-to-concentrate ratio, in addition to optimum energy and protein density, to help manage heat stress in dairy cows. Lysine, methionine and histidine supplementation have been found to improve metabolic function and decrease rectal temperature under extreme heat stress situations [16]. In the same way, a two-month period of dietary betaine supplementation increases nutrient digestibility and rumen fermentation dynamics and increases feed intake. The addition of PUFAs to diets provides additional protection from heat-induced physiological and immunological decline. Also, dietary buffers (NaHCO3, K2CO3 and KHCO3) and chromium (Cr) produced big gains in dry matter intake, total milk production and insulin sensitivity. Lastly, prebiotics, probiotics and essential oils create an ideal blood metabolite profile, maintain gut integrity and improve overall productive performance [9].

**Water management**

Water is an important element in reducing heat stress in cows, primarily through misting, sprinklers, and evaporative cooling pads. The basic action of these systems is to assist the cow's tendency to evaporate excess heat when ambient temperatures become too high for normal heat loss. So we know that when water is not available, milk production decreases [17].

This has been confirmed by research. During a Brazilian study, cows that were cooled using fans and misting nozzles had greater milk production in spring and summer, and their milk yield was more consistent than that of the naturally cooled cows throughout the year [7]. An evaporative cooling pad was superior to a misting nozzle in maintaining milk yield and keeping body temperature more stable throughout the year in a study conducted in Florida. However, water cooling has its limits; it works best in hot, dry air, as it is based on the difference between wet and dry-bulb temperatures. Sprinklers in the feeding alley are better than full misting in humid climates or in compost barns where excess moisture is detrimental to hygiene. Two flow rates of sprinklers were tested in a trial in California that resulted in the same milk cooling, and a 3.3–3.7 kg increase in daily milk output while frequency of visits to the feeding alley was slightly reduced [15].

**Genetic management**

To reduce heat stress effects in dairy cattle breeds raised in low-input production systems, especially in Sub-Saharan countries, farmers should rely on genetic selection for traits that are heat-resistant and have the ability to survive under humid, temperate conditions as well. The following strategies are considered : (1) choice of breed or cross for raising on the farm, as some genotypes are more resistant to heat while some are not; (2) introgression of genes that are associated with thermotolerance; and (3) using selection criteria to pick the best breed regarding their ability to tolerate heat. Zebu cattle (*Bos indicus*), for example, possess heat-tolerance genes compared to others like *Bos taurus*, as cattle derived from the latter are highly heat-stressed. Another strategy could be genome editing technology. Genomic selection allows young bulls to be selected which are thermotolerant while ignoring other species [5,13].

**Farm management**

Generally, there are three ways to deal with heat stress when managing cows of different breeds and ages: modify the physical environment; select for heat tolerance; and feed well. Other barn management practices that will help during hot weather are to monitor the distribution of solar radiation in the barn. Such an evaluation is useful to protect high-yield cows by placing them in the thermal optimum areas of the barn. The location, size and water temperature of water troughs are also important factors in encouraging cows to drink more water, as water that is cooler than a cow's internal temperature will be more effective [17]. Where these water points are located has a strong influence on drinking behaviour during heat stress. Shade, water sprinklers and ventilation have been found to have a cooling effect on air temperatures in holding pens and to increase milk production in housed systems in tropical climates [4,14].

**Conclusion**

Heat stress is a significant physiological stressor, with a great impact on dairy cow performance and sustainability. Thermal strain results in complex metabolic, microbial and cellular disruption and a one-solution approach is not sufficient. Successfully managing heat stress isn't a one-fix solution; it calls for tackling the problem from several angles at once. That is the short-term solution, where environmental cooling solutions are used in conjunction with changing the cow's diet, and the long-term solution is to breed herd bulls that are genetically more resilient to heat stress. Shade, evaporative water systems, high-energy-density feed and genetic thermotolerance are management techniques that dairy producers can use to help assure animal welfare, milk production stability and profitability in warmer climates.

**References**


[1] Giannone C, Bovo M, Ceccarelli M, Torreggiani D, Tassinari P. Review of the heat stress-induced responses in dairy cattle. Animals. 2023 Nov 9;13(22):3451.

[2] Bomko V, Kuzmenko O, Cherniavskyi O. Heat stress in dairy cows. ТЕХНОЛОГІЯ ВИРОБНИЦТВА І ПЕРЕРОБКИ ПРОДУКЦІЇ ТВАРИННИЦТВА. 2021:7.

[3] Divekar BS, Dhami AJ. Heat stress management in dairy bovines: An overview. Int J Vet Sci Anim Husb. 2016;1(3):19-23.

[4] Herbut P, Hoffmann G, Angrecka S, Godyń D, Vieira FMC, Adamczyk K, Kupczyński R. The effects of heat stress on the behaviour of dairy cows – a review. Ann Anim Sci. 2021;21(2):385-402. doi:10.2478/aoas-2020-0116

[5] Habimana V, Nguluma AS, Nziku ZC, Ekine-Dzivenu CC, Morota G, Mrode R, Chenyambuga SW. Heat stress effects on milk yield traits and metabolites and mitigation strategies for dairy cattle breeds reared in tropical and sub-tropical countries. Frontiers in Veterinary Science. 2023 Jul 7;10:1121499.

[6] Sammad A, Wang YJ, Umer S, Lirong H, Khan I, Khan A, Ahmad B, Wang Y. Nutritional physiology and biochemistry of dairy cattle under the influence of heat stress: Consequences and opportunities. Animals. 2020 May 3;10(5):793.

[7] Oliveira CP, Sousa FC, Silva AL, Schultz ÉB, Valderrama Londoño RI, Souza PA. Heat stress in dairy cows: impacts, identification, and mitigation strategies—a review. Animals. 2025 Jan 17;15(2):249.

[8] Frigeri KD, Kachinski KD, Ghisi ND, Deniz M, Damasceno FA, Barbari M, Herbut P, Vieira FM. Effects of heat stress in dairy cows raised in the confined system: A scientometric review. Animals. 2023 Jan 19;13(3):350.

[9] Kotsampasi B, Karatzia MA, Tsiokos D, Chadio S. Nutritional strategies to alleviate stress and improve welfare in dairy ruminants. Animals. 2024 Sep 4;14(17):2573.

[10] Utamy RF, Ako A, Hasbi H, Ramadan Z, Hakim AA, Sukri SA. Performance, physiological status, and heat tolerance of Holstein-Friesian dairy cows at different lactation phases. Adv. Anim. Vet. Sci. 2024;12(10):2034-42.

[11] Iqbal A, Qudoos A, Bayram I, Tytariova O, Bomko V, Kuzmenko O, Cherniavskyi O. Heat stress in dairy cows.

[12] Talukder S, Qiu D, Thomson PC, Cheng L, Cullen BR. Impact of heat stress on dairy cow rumination, milking frequency, milk yield and quality in a pasture-based automatic milking system. Animal Production Science. 2023 May 25;64(1):NULL-.

[13] Ma Q, Tharwat M, Alshanbari FA, Khan MZ. Heat Stress Effects on Milk Production and the Genomic Architecture of Thermotolerance in Dairy Cattle. Biology (2079-7737). 2026 May 15;15(10):813.

[14] Mubeen M. HEAT STRESS MANAGEMENT IN DAIRY CATTLE: A SYSTEMATIC LITERATURE REVIEW. Innovations in Agricultural and Environmental Science. 2025 Dec 31;2(02):109-19.

[15] Liu E, Liu L, Zhang Z, Qu M, Xue F. An automated sprinkler cooling system effectively alleviates heat stress in dairy cows. Animals. 2024 Sep 5;14(17):2586.
[16] Loor JJ, Lopreiato V, Palombo V, D'Andrea M. Physiological impact of amino acids during heat stress in ruminants. Animal frontiers. 2023 Oct 1;13(5):69-80.
[17] Golher DM, Patel BH, Bhoite SH, Syed MI, Panchbhai GJ, Thirumurugan P. Factors influencing water intake in dairy cows: a review. International Journal of Biometeorology. 2021 Apr;65(4):617-25.
[18] St-Pierre NR, Cobanov B, Schnitkey G. Economic losses from heat stress by US livestock industries. Journal of Dairy Science. 2003 Jun 1;86:E52-77.
[19] Polsky L, von Keyserlingk MA. Invited review: Effects of heat stress on dairy cattle welfare. Journal of Dairy Science. 2017 Nov 1;100(11):8645-57.