

Department of Animal Science

Sprinkler Cooling (Direct Surface Wetting): What the Poultry Industry Can Learn from Cattle Folk

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Tom Tabler, *Professor and Extension Poultry Specialist, Department of Animal Science, University of Tennessee Institute of Agriculture*

Yi Liang, *Associate Professor, Department of Biological and Agricultural Engineering/Center of Excellence for Poultry Science, University of Arkansas*

Jonathan Moon, *Extension Instructor, Department of Poultry Science, Mississippi State University*

Tannah Christensen, *Extension Instructor, Department of Poultry Science, Mississippi State University*

Tanner Thornton, *Graduate Research Assistant, Department of Animal Science, University of Tennessee Institute of Agriculture*

Logan Lewis, *Extension Agent, University of Tennessee Extension, Montgomery County*

A major advantage of the modern tunnel-ventilated broiler house in hot weather is its ability to use the tunnel fans to move large quantities of air uniformly across the birds to assist in summer cooling. However, providing substantial **air movement over the birds is not always adequate** for heat stress relief. Additional mitigation can take place by evaporating water—evaporative cooling. Evaporative cooling is using heat to convert water from a liquid phase to a gas phase. The heat consumed during this change in state results in a temperature reduction. Evaporative cooling can be employed to cool broiler chickens in two distinctly different ways. With one method, the ambient air that surrounds the bird is cooled and fans are used to move this cool air over the birds. Alternatively, the bird's outer body surface can be cooled directly by evaporative cooling. Sprinkler systems used in conjunction with fans are an example of direct cooling. Pure convective cooling in a cool cell house involves using air flow alone to transfer heat from the chickens' warmer bodies to the cooler surrounding air. This method becomes less effective as the air temperature approaches the birds' body temperature. Sprinkling bypasses this limitation and provides an independent cooling process (evaporation) that is then increased by the fans and air flow (wind chill) over the birds. By focusing on direct cooling of individual birds, this system avoids cooling and over-humidifying the entire house, which is counterproductive to the chicken's natural ability to cool itself through panting and evaporative respiration.

Heat Balance in Livestock

Evaporative cooling is the mechanism used by livestock to release body heat and decrease their thermal heat load. Water works well for evaporative cooling because it has higher values of latent heat of evaporation and thermal conductivity than any other liquid (McDonald, 2011). High thermal conductivity means that heat can be removed and dissipated from locations deep within the body. Also, this form of cooling is very efficient because water removes a

considerable amount of heat from the skin upon evaporation because it has a higher latent heat of evaporation than any other liquid or solid (McDonald, 2011). Latent heat is the amount of heat absorbed or released by the animal as water changes from a liquid to gaseous state without a change in temperature. When environmental temperature is higher than the animal’s temperature, **evaporative cooling becomes the only effective method for dissipating heat**. This makes it difficult for chickens to manage body heat at extremely hot temperatures because chickens do not sweat. To make matters worse, high relative humidity further limits the ability of an animal to cool itself by evaporative cooling (Kibler and Brody, 1952).

A homeotherm is defined as an animal that maintains a relatively constant core body temperature when faced with varying environmental conditions (Bligh and Lampkin, 1965; Mount, 1979). Thermoregulation is the process that allows the animal to adjust to changing heat loads so that a stable core body temperature is maintained. Thermoregulation is a classic example of a dynamic process in a homeothermic animal and can be observed in the short term by changes in body temperature, which reflect temporary imbalances in heat production and dissipation (Hahn and Nienaber, 1993). In most situations, there is a continual net loss of sensible heat from the body surface by conduction, convection and radiation, and under all conditions there is a continual loss of insensible (evaporative) heat from the respiratory tract and skin surface (Curtis, 1983; Hahn, 1985, Young et al., 1997). The net rate of heat loss or gain by an animal depends upon the thermal demand of the surrounding environment and the resistance to heat flow of the tissue, skin and its cover (NRC, 1981). A model of heat balance was presented by Tait (2015) (Fig. 1).

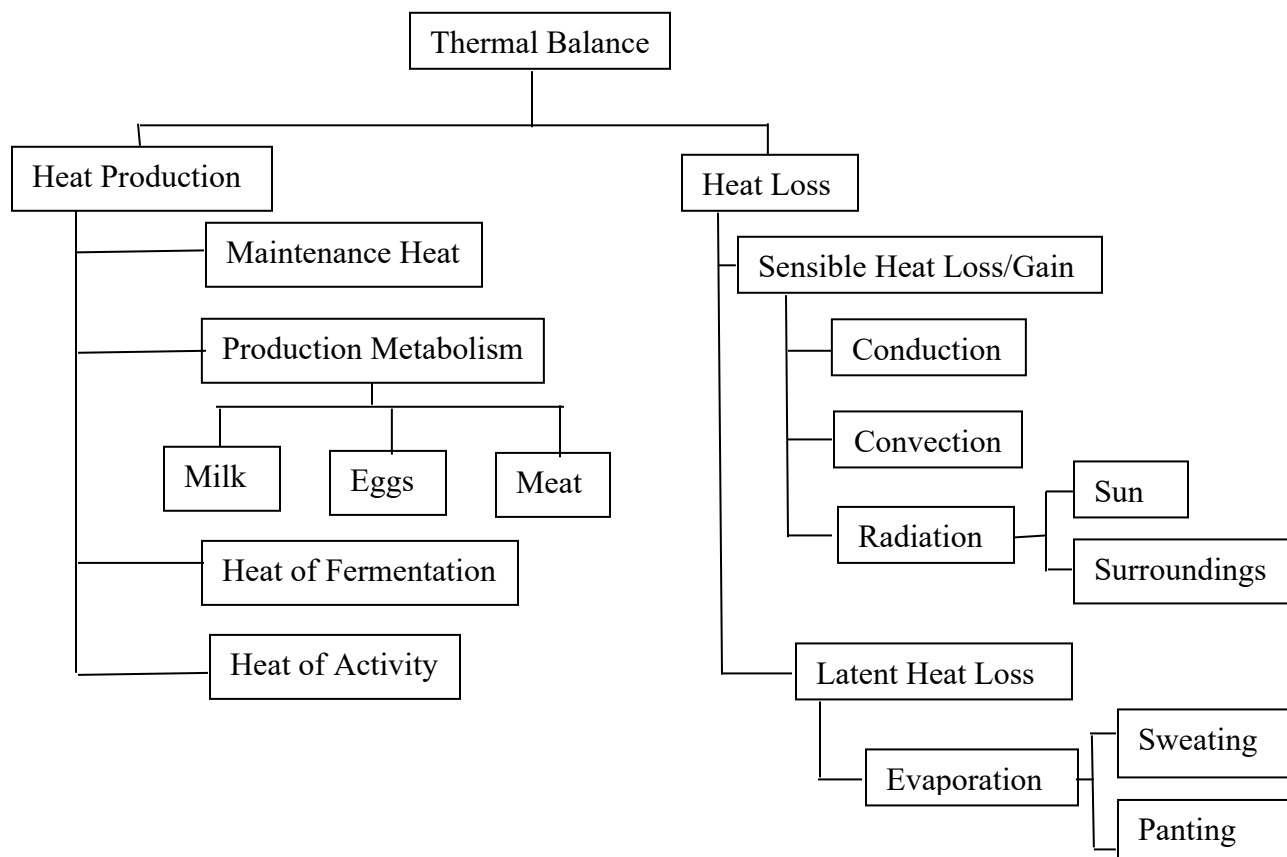


Figure 1. Heat balance model illustrating the thermal balance of cattle in terms of body temperature. Source: Tait (2015).

The basic thermoregulatory strategy of most mammals is to maintain a body core temperature above ambient temperature to **allow heat to flow from the core via four basic routes** of heat exchange (conduction, convection, radiation and evaporation) (Curtis, 1983; Hahn, 1985). Three of these routes (conduction, convection and radiation) are referred to as sensible routes or non-evaporative means of heat loss and require a thermal temperature gradient or difference between the animal's body and its immediate environment to operate. Yousef (1985) depicted graphically (Fig. 2) body temperature as a balance of heat loss and heat gain and demonstrated the role of the four mechanisms of heat loss in this process.

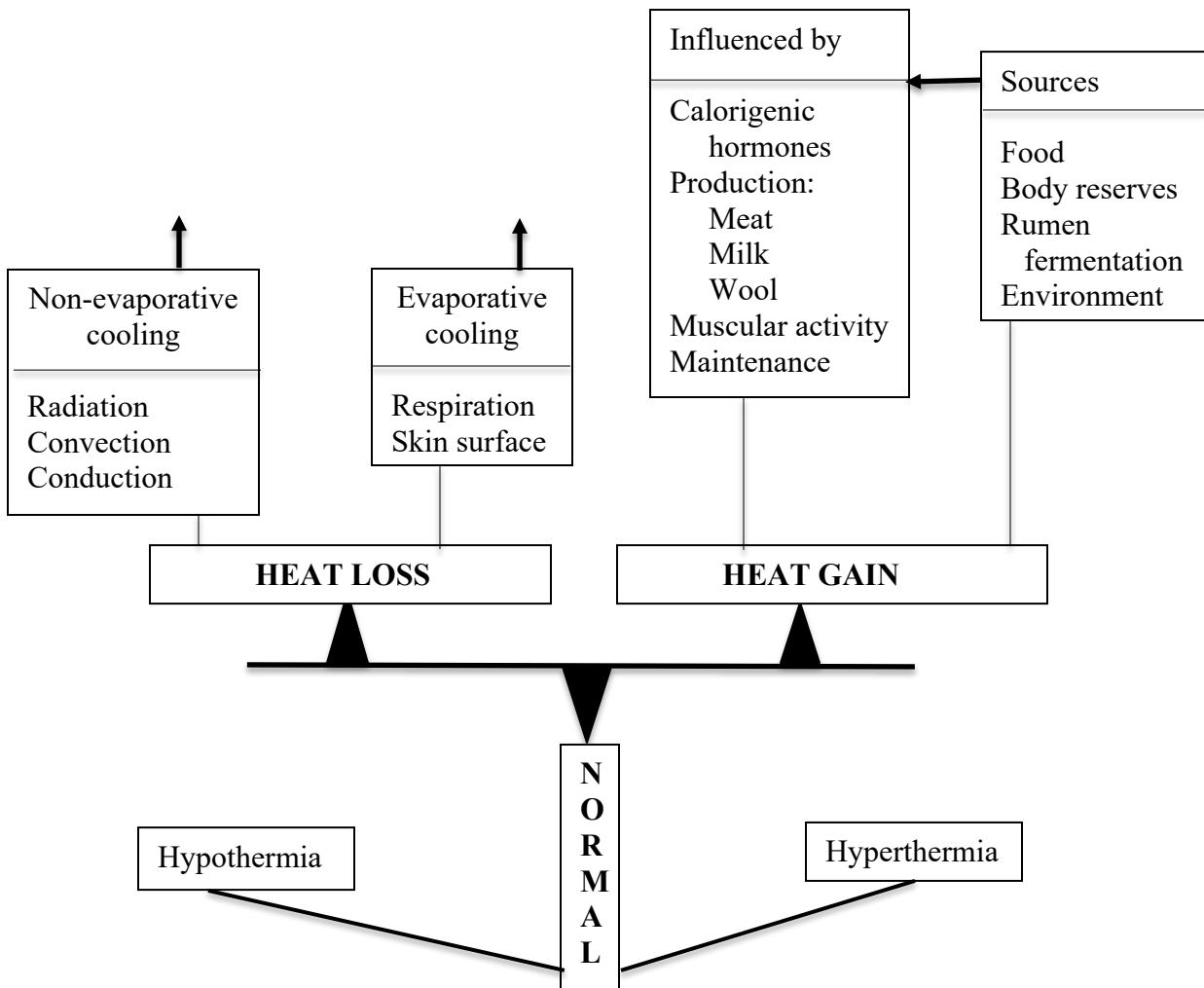


Figure 2. Body temperature as a balance of heat loss and heat gain. Source: Adapted from Yousef (1985).

Conductive heat exchange is the heat flow between two bodies in direct contact. The rate of exchange by conduction is dependent on the difference in temperature between the animal and the environment and the area of contact (McDowell, 1972; Curtis, 1983; Yousef, 1985). When cool air meets a warm body, the layer of air surrounding the surface of the body is heated and rises away from the body, carrying heat with it, and thereby cooling the body through the process of convection. If air temperature is greater than skin temperature, then air movement will

promote the movement of heat into the animal until air temperature equals skin temperature when the transfer of heat ceases (Silanikove, 2000). Radiant heat is the transfer of heat by the exchange of electromagnetic waves. In physiological studies it is customary to divide the wavelength spectrum into short and long waves. Short wave heat exchanges relate to the sun; whereas, the radiant heat interchanges between the animal and its surroundings occur in the long wave bands (Robertshaw 1985; Yousef, 1985). Evaporative heat loss occurs when **heat is lost from the saturated surface of a body to a less saturated surrounding environment** (Tucker, 1990). This highlights the importance of having low humidity in the broiler house to allow chicken body heat to move to a less saturated environment. When an acceptable thermal gradient exists, the animal's excess body heat is transferred readily from its warmer body to the cooler environment (Hahn, 1994).

Cattle Industry Recognized Sprinkler Benefits Years Ago

As ambient temperature approaches skin temperature, heat loss from the skin is minimal, unless the animal is wet (Shearer and Beede, 1990; Brouk et al., 2001). **Heat exchange is increased by wetting the skin but only if the water can evaporate.** The poultry industry can learn much from our friends in the cattle business who have been using sprinklers to cool cattle for many years. As early as 1946, preliminary studies conducted with dairy cattle in the Imperial Valley of Southern California found that at air temperatures of about 108 F and relative humidity of 18 percent, spraying cows reduced body temperatures 2.7 F and slowed respiratory rates by about 20 breaths per minute (Tait, 2015).

Like broiler chickens, cattle have difficulty dissipating heat by evaporative cooling under conditions of high humidity and low air movement. For cattle, rain and wind will enhance body cooling and reduce heat load in hot, dry environments. For chickens, the use of sprinklers and fans is an artificial method of creating a similar effect of cooling broilers when the in-house humidity is controlled (<70 percent). It is critical for the relative humidity to be low enough for the water to evaporate. **As direct sprinkling of water on the surface of the animal evaporates, the animal is cooled through the latent heat of vaporization** (Igono et al., 1985). However, the water can't evaporate if the house is too cool and too humid, as is often the case in a cool cell-cooled house, thus, direct surface wetting of the chickens will do little good if the house temperature is 82 F and the relative humidity is 90 percent.

Further highlighting previous cattle data, Curtis (1983) cited experimental work in California in which a sprinkler plus shade effectively cooled heat-stressed cattle. At temperatures of 90 F and above, cattle sprinkled for one minute every half hour and allowed access to shade had higher weight gains than cattle offered only shade. In addition, Davis et al. (2003) reported that sprinkling reduced overall body temperature, which suggests cattle comfort is enhanced by sprinkling. Enhanced performance as well as impressive cooling water savings have been reported for sprinkled broiler chickens as well (Tabler et al., 2008; Liang et al., 2010; Liang et al., 2012; Liang et al., 2014; Liang et al., 2020; Moon et al., 2023; Tabler et al., 2025). **Sprinkling broiler chickens is most effective when combined with air movement over the birds.** Bucklin et al. (1991) reported that for effective sprinkler and fan cooling systems for cattle, three basic principles were necessary: 1) use an intermittent spray (on/off interval), 2) use a large droplet size (not a fog or mist) and 3) supplement natural air movement mechanically with fans.

These same principles hold true for broiler chickens. Sprinkling cattle under shades during the summer for one minute every 30 minutes when the temperature was above 81 F resulted in significantly higher feed consumption and rate of gain compared with cattle under shade and not sprinkled and sprinkling was as effective as a refrigerated air-conditioned barn at 75 F (Morrison et al., 1973). Another closely related study compared the activation temperature of sprinklers and found that activating sprinklers at 72 F rather than 90 F increased dry matter intake by 5 percent and increased gains by 7 percent (Morrison et al., 1981). In dairy cattle, there is significant economic benefit to allowing access to sprinklers during hot temperatures (Wiersma et al., 1973). The economic benefits of providing sprinkler access to feedlot cattle may be less noticeable, possibly because beef cattle experience compensatory gain following periods of low average daily gain (Baccarri et al., 1983). However, sprinkling feedlot cattle does improve animal well-being and decreases body temperature during hot weather conditions (Davis et al., 2003), and for that reason alone, the use of sprinklers should be considered.

Again, the same is true for broiler chickens. While it's well known that cattle have hides and broiler chickens have feathers, the **dynamics of cooling and relieving heat stress are the same**. Wetting the surface intermittently and evaporating the water using air flow to create a wind chill effect cools the animal, regardless of whether that animal is a beef steer in a feedlot in the Oklahoma Panhandle or a broiler chicken in a commercial poultry house in Tennessee, Mississippi or Arkansas. However, especially where broiler chickens are concerned, it is critical to maintain an in-house humidity of <70 percent. If the humidity is too high, water can't evaporate, and the cooling effect will be less. In many cases, cooling systems that coupled wetting animals with water evaporation off the animals' skin (wind chill) were shown to be superior to those that sought to merely lower the air temperature (Bucklin et al., 1991; Lin et al., 1998). Also, **sprinklers are effective at cooling animals only when used in on/off intervals**. You cannot run them constantly and have success. Sprinklers need to partially wet the animals and then allow them time to dry using evaporation of body heat to properly cool the animal.

Slow to the Table

The poultry industry has been a bit slow coming to the table where sprinklers are concerned compared with our friends in the beef cattle, dairy cattle and swine industries. These other livestock sectors recognized years ago the benefits of sprinkling livestock during periods of heat stress and the importance of maintaining a low humidity while doing so. The poultry industry has been somewhat reluctant to buy into sprinkling broilers for fear it would result in wet litter, leading to animal welfare issues and increased cases of footpad dermatitis. However, an increasing body of **research related to sprinkling broiler chickens from multiple researchers has proven these fears unfounded** when sprinkling is managed correctly (Berry et al., 1990; Tabler et al., 2008; Liang et al., 2010; Liang et al., 2012; Liang et al., 2014; Dunlop, 2018; Liang and Tabler, 2018; Liang et al., 2020; Dunlop and McAuley, 2021; Moon et al., 2023; Tabler et al., 2025). As our friends in the cattle business learned long ago, the key is to correctly manage the sprinkler on/off interval and control the humidity. When managed correctly, we in the chicken business can maintain an in-house humidity level that is as much as 20 percent or more lower than what is common in a conventional cool cell house (<70 percent humidity instead of the 90 percent or higher humidity in a cool cell situation). This lower humidity plays a huge role in maintaining dry litter and keeping our chickens alive during periods of heat stress.

It is not high temperature alone that kills big chickens in hot weather. It is the combination of high temperature and high humidity that kills chickens. If we can maintain the relative humidity at or below 70 percent in the broiler house, the chickens can tolerate some fairly high in-house temperatures, allowing them to use their own evaporative respiration and the evaporation of sprinkler water off their body surface to remove body heat and cool themselves. Humid air can evaporate very little water; it takes dry air to evaporate water. However, dry air is often hotter air, and hot air in a house full of big chickens scares most growers. But there is no need to be concerned if you see the temperature approach 88 F or 90 F in a sprinkler-cooled house. What this tells you is if the temperature is that high, the humidity is going to be reasonably low. Cool air is moist, humid air. Hot air is dry air, and **dry air is beneficial** from the standpoint of lower in-house humidity, drier litter conditions, improved welfare and footpad scores, greater evaporative respiration potential from the birds and a more comfortable in-house environment.

As a grower, you do not want to operate a sprinkler-cooled broiler house at 82 F to 84 F like you would a cool cell house. A sprinkler-cooled house needs to operate at 88 F to 90 F to be effective. Raise the cool cell set point to operate at 88 F or 90 F to prevent the house from becoming too warm; and operate the cool cells (if necessary) only for short time intervals (10 to 15 seconds) to prevent house temperatures >90 F, you don't want to raise the humidity level in the house. Warmer temperatures do take some getting used to, but anything less than 88 F and the sprinkler house will be too cool and too humid for the sprinkler water to evaporate, and you will have issues. Don't worry about the higher house temperature. It's at this higher temperature and lower humidity when the sprinkler system is most efficient, and bird performance will not suffer. With the tunnel fans providing adequate air flow down the house (wind chill), the birds may actually be more comfortable at 90 F and 70 percent humidity in a sprinkler-cooled house than at 82 F and 90 percent humidity in a cool cell house, resulting in improved performance.

Summary

Cattle folks learned long ago the value of sprinkling livestock with water to relieve heat stress during hot weather. The poultry industry has been slower to catch on, but a growing body of research continues to highlight the value of direct surface wetting and sprinkling broiler chickens to improve animal well-being and decrease body temperature during hot weather. Cooling broilers by sprinkling does require different thinking when it comes to house temperature and humidity. You must allow the house temperature to run several degrees hotter (88 F to 90 F) than you may be used to (and are comfortable with) to successfully manage sprinkler cooling. However, this hotter temperature will result in lower in-house humidity (20 percent or more lower than in a cool cell house) which will more than compensate for the higher temperature and allow the birds to make better use of their own natural evaporative respiration. Evaporation of sprinkled water off the bird's surface will further help to cool the chickens. You must allow enough time interval between ON cycles for the sprinkled water to evaporate off the bird's surface, and you must have adequate air flow (wind chill) over the birds. The poultry industry can **learn much from our friends in the cattle business** when it comes to relieving heat stress with sprinkler cooling and direct surface wetting of livestock. What works for cattle will also work well for chickens if we take advantage of the opportunity. Cooling water savings of more than 50 percent and greater poultry industry sustainability are just icing on the cake.

References

- Baccari, F. Jr., H. D. Johnson, and G. L. Hahn. 1983. Environmental heat effects on growth, plasma T3, and postheat compensatory effects on Holstein calves. *Proceedings of the Society for Experimental Biology and Medicine* 173(3):312-318.
- Berry, I. L., T. A. Costello, and R. C. Benz. 1990. Cooling broiler chickens by surface wetting. ASAE paper, St. Joseph, MI. American Society of Agricultural Engineers.
- Bligh, J., and G. H. Lampkin. 1965. A comparison of the deep-body temperature of Hereford and Zebu cows recorded continuously by radio-telemetry under similar field conditions. *Journal of Agricultural Sci*, 64:221-227.
- Brouk, M. J., J. F. Smith, and J. P. Harper. 2001. Efficiency of modified evaporative cooling in Midwest dairy freestall barns. In *Livestock Environment VI. Proceedings of the 4th International Livestock Environment Symposium*. Louisville, KY, pp 412-418.
- Bucklin, R. A., L. W. Turner, D. K. Beede, D. R. Bray, and R. W. Hemken. 1991. Methods to relieve heat stress for dairy cows in hot, humid climates. *Applied Engineering in Agriculture* 7(2):241-247.
- Curtis, S. E. 1983. *Environmental Management in Animal Agriculture*. Iowa State University Press. Ames, IA. ISBN:0-8138-0556-2. 405 pages.
- Davis, M. S., T. L. Mader, S. M. Holt, and A. M. Parkhurst. 2003. Strategies to reduce feedlot cattle heat stress: Effect on tympanic temperature. *Journal of Animal Science* 81:649-661.
- Dunlop, M. 2018. Effect of an in-shed sprinkler cooling system on temperature, relative humidity, water usage, litter conditions, live weight and mortality. *AgriFutures Australia Publ. No. 18/044*. Available at: <https://era.dpi.qld.gov.au/id/eprint/6511/1/18-044%20%281%29.pdf>. Accessed: September 11, 2025.
- Dunlop, M. W., and J. McAuley. 2021. Direct surface wetting sprinkler system to reduce the use of evaporative cooling pads in meat chicken production: Indoor thermal environment, water usage, litter moisture content, live market weights, and mortalities. *Poultry Science* 100:101078.
- Hahn, G. L. 1985. Management and housing of farm animals in hot environments. In M. K. Yousef (Ed.) *Stress Physiology in Livestock, Volume II*. CRC Press, Boca Raton, Florida, pp. 151-174.
- Hahn, G. L. 1994. Environmental requirements of farm animals. In J. E. Griffiths (Ed) *Handbook of Agriculture Meteorology*. Oxford University Press, New York, p. 220.
- Hahn, G. L., and J. A. Nienaber. 1993. Characterizing stress in feeder cattle. *Beef Research Project Report*. US MARC, ARS, U.S. Department of Agriculture.
- Igono, M. O., B. J. Stevens, M. D. Shanklin, and H. D. Johnson. 1985. Spray cooling effects on milk production, and rectal temperatures of cows during a moderate temperate summer season. *Journal of Dairy Science* 68:979-985.
- Kibler, H. H., and S. Brody. 1952. Relative efficiency of surface evaporative, respiratory evaporative, non-evaporative cooling in relation to heat production in jersey, Holstein, Brown Swiss and Brahman cattle, 5° to 105° F. *Missouri Agric. Exp. Sta. Res. Bull.* 497.
- Liang, Y., G. T. Tabler, I. Berry, and S. Watkins. 2010. Field evaluation of controlled surface wetting system to cool broiler chickens. ASABE Paper presented at the 2010 ASABE meeting. Pittsburgh, PA. June 20-23. Paper No. 1008478. ASABE, St. Joseph, MI.
- Liang, Y., S. E. Watkins, G. T. Tabler, and D. McCreery. 2012. Sprinklers cool birds and conserve water. *University of Arkansas Division of Agriculture Publ. No. FSA1073*. November.

- Liang, Y., G. T. Tabler, T. A. Costello, I. L. Berry, S. E. Watkins, and Y. V. Thaxton. 2014. Cooling broiler chickens by surface wetting: Indoor thermal environment, water usage, and bird performance. *Applied Engineering in Agriculture* 30:249-258.
- Liang, Y., and T. Tabler. 2018. Water use patterns differ between pad and sprinkler cooling. University of Arkansas Division of Agriculture Publ. No. FSA1068. January.
- Liang, Y., G. T. Tabler, and S. Dridi. 2020. Sprinkler technology improves broiler production sustainability: From stress alleviation to water usage conservation: A mini review. *Frontiers in Veterinary Science* 7:544814.
- Lin, J. C., B. R. Moss, J. L. Koon, C. A. Flood, R. C. Smith, K. A. Cummins, and D. A. Coleman. 1998. Comparison of various fan, sprinkler, and mister systems for reducing heat stress in dairy cows. *Applied Engineering in Agriculture* 14(2):177-182.
- McDonald, C. J. 2011. Factors that impact water intake of feedlot steers throughout the feedlot period. M.S. Thesis. Iowa State University.
- McDowell, R. E. 1972. *Improvement of Livestock Production in Warm Climates*. W. H. Freeman and Co., San Francisco, CA.
- Moon, J., J. DuBien, R. Ramachandran, Y. Liang, S. Dridi, and T. Tabler. 2023. Effects of a sprinkler and cool cell combined system on cooling water use, litter moisture, and indoor environment of broiler houses. *Animals* 13:2939.
- Morrison, S. R., R. L. Givens, and G. P. Lofgreen. 1973. Sprinkling cattle for relief of heat stress. *Journal of Animal Science* 36(3):428-431.
- Morrison, S. R., M. Prokop, and G. P. Lofgreen. 1981. Sprinkling cattle for heat stress relief: activation temperature, duration of sprinkling and pen area sprinkled. *Transactions American Society Agricultural Engineers* 24:1299-1300.
- Mount, L. E. 1979. *Adaptation to Thermal Environment. Man and his productive Animals*. University Park Press, Baltimore, MD.
- NRC. 1981. *Effect of Environment on Nutrient Requirements of Domestic Animals*. National Research Council, Washington, DC.
- Robertshaw, D. 1985. Heat loss in cattle. In M. K. Yousef (Ed) *Stress Physiology in Livestock* Volume 1. CRC Press, Inc., Boca Raton, FL., pp55-66.
- Shearer, J. K., and D. K. Beede. 1990. Heat stress 1. Thermoregulation and physiological responses of dairy cattle in hot weather. *Agri-Practice* 11(4):5.
- Silanikove, N. 2000. Effects of heat stress on the welfare of extensively managed domestic ruminants, *Livestock Production Science* 67:1-18.
- Tabler, G.T., I. L. Berry, Y. Liang, T. A. Costello, and H. Xin. 2008. Cooling broiler chickens by direct sprinkling. *Avian Advice* 10(4):10-15. Winter.
- Tabler, T., Y. Liang, J. Moon, and T. Thornton. 2025. Sprinkler cooling of broilers highlights sustainability and water conservation potential. University of Tennessee Extension Publ. No. D235.
- Tait, L. A. 2015. Heat load alleviation in beef cattle: Water application during continuous high temperature exposure. Ph.D. Dissertation. The University of Queensland, Australia.
- Tucker, R. W. 1990. Thermoregulation of beef cattle and the effect of heat stress on the performance on Queensland feedlot cattle. M. S. Thesis, The University of Queensland, Australia.
- Wiersma, F., D. Ray, and C. Roubicek. 1973. Modified environment for beef in hot climates. *Transactions of the American Society of Agricultural Engineers* 16:348-353.
- Young, B. A., A. B. Hall, P. J. Goodwin, and J. B. Gaughan. 1997. Identifying excessive heat load. In *Livestock Environment V. Proceedings of the 5th International Livestock*

Environmental Symposium, American Society of Agricultural Engineering, St. Joseph, MI, p 572.

Yousef, M. K. 1985. Thermal environment. In: M. K. Yousef (Ed) Stress Physiology in Livestock Volume 1. CRC Press, Inc., Boca Raton, FL.



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