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A review of the effects and management of heat stress on dairy cows

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Abstract

The dairy sector, more than any other livestock system in tropical regions, is facing enormous challenges in maintaining productivity in the face of rapidly changing climatic conditions. There is currently a lack of understanding about the combined effects of climate, season, and farm location on trait responses in various cattle breeds. Heat stress (HS) is caused by an imbalance between metabolic heat production within the animal body and its dissipation to the environment in hot and humid climates. Heat stress has a number of serious and economically damaging effects on cattle. The most significant effects of heat stress in dairy cows are increased body temperature and decreased milk production.

Keywords: Heat stress, dairy cows, facing enormous challenges

Introduction

Globally, the livestock sector plays a significant role by economically supporting poor and marginal farmers (Herrero *et al.* 2013) [7]. At the same time, because of the exponentially rising human population there is an increasing demand for livestock products due to increasing incomes and urbanization, which has changed the dietary habits of humans towards a preference for animal protein sources (Thornton, P.K). Currently, the dairy sector supports nearly 150 million households across the world (Faye and Konuspayeva 2012) [3]. An evident rise in world milk production during the past three decades, from 522 million tons (MT) in 1987 to 843 MT in 2018, highlights the increasing demand for milk and milk products (Faye and Konuspayeva 2012) [3].

Climate change, in particular global warming, will affect the health and welfare of farm animals, both directly and indirectly (IPCC, 2007) [8]. Environmental factors, such as temperature and light, exert significant effects on the production, health and immunity of animals. Heat stress in tropical countries is a problem of great concern among farmers and livestock producers as it causes great economic loss in terms of both production and reproduction traits of animals. Crossbred cattle are more susceptible to physical distress when exposed to heat stress as compared to other farm animals. Heat stress in dairy cows is caused by a combination of environmental factors (temperature, relative humidity, solar radiation and air movement) (Ghosh *et al.*, 2017) [5]. Heat stress occurs in animals when there is an imbalance between heat production within the body and its dissipation. Heat stress is the sum of external forces to a homoeothermic animal that acts to shift body temperature from the resting state. Heat stress reduces feed intake, milk yield, growth rate and reproductive performance (Patel *et al.*, 2017) [15] which lead to major economic losses to the dairy farmers especially in tropical countries. The upper critical temperature for lactating cows is in the range of 24 to 27 °C. The temperature humidity index (THI) commonly is used to indicate the degree of stress. When the THI exceeds 72, high producing dairy cows are affected adversely. The temperature-humidity index (THI) can be used as an indicator of thermal climatic conditions. Temperature-humidity index values of 70 or less are considered comfortable, 75-78 stressful and values greater than 78 cause extreme distress with lactating cows being unable to maintain thermoregulatory mechanisms or normal body temperatures (Mc Dowell *et al.*, 1976) [14].

Effects of thermal stress vary among individuals according to breeds, production level, prior experience etc. (Kadzere *et al.*, 2002) [10]. *Bos indicus* (Zebu) cattle are more thermo tolerant than *Bos taurus* cattle due to possession of thermo tolerant gene (Hansen, 2004) [6].

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Impact of heat stress on dairy cows

Body Temperature

Change in rectal temperature has been considered as an important measure of physiological status as well as ideal indicator for assessment of stress in animals (Johnson, 1980; West, 2003). McDowell *et al.* (1996)^[9, 14] reported that even a rise of less than 1 °C in rectal temperature was enough to reduce performance in most dairy animals. RT is generally considered to be a useful measure of body temperature and changes in RT indicates changes of a similar magnitude in deep body temperature. RT is considered as a good index of body temperature even though there is a considerable variation in different parts of the body core at different times of the day. Bernabucci *et al.* (2002)^[2] assessed the effect of hot season (39.5 ± 0.2 °C) in transition dairy cows and found that temperature differed ($P < 0.01$) significantly (39.5 vs. 39.1 °C). Koubkova *et al.* (2002)^[11] reported significant increase in RT from 37.3 to 39.3 °C when high yielding HF cows were exposed to high temperature conditions.

Feed intake

The NRC predicts that the DMI for a 600 kg cow producing 40 kg milk will decline from 18.7 kg at 20 °C to 16.7 kg at 35 °C (9%). However, the energy that is consumed during hot weather is used less efficiently for milk production because of greater maintenance costs, which are estimated to be 20% greater when environmental temperature are 35 °C than they were 20 °C. Ronchi *et al.* (2001)^[2] reported that dry matter intake decreased by 23% in heifers managed at 32 °C and 70% relative humidity. Holter *et al.* (1997) established a significant negative correlation between THI and DMI for cows and suggested that the effect of THI is probably mediated through the effects of increasing body temperature of cow.

Milk Production

Reduced milk production is the first perceived consequence of heat stress. Heat stress affects the productive performance of dairy animals by reducing their dry matter intake (DMI), feed efficiency and milk yield (Gantner *et al.*, 2011)^[4]. Reduced feed intake during heat stress is the major reason for reduced milk production in dairy cows (Baumgard *et al.*, 2012)^[1]. The optimum environmental temperature for lactation depends on species, breed and degree of tolerance to heat or cold. The milk yield of Holstein cattle declines at temperature above 21 °C, in case of Brown Swiss and Jersey cattle it declines at about 24 to 27 °C whereas milk yield of Zebu cattle declines only above 34 °C (Hafez, 1968). The most significant factors affecting milk yield during hot weather in South Carolina were the total numbers of hours when THI exceeded 74 during the preceding four days, and the number of hours exceeding THI 80 on the preceding day (Ghosh *et al.*, 2017)^[5].

Reproduction

The patterns of reproductive behavior of farm animals vary with the variation in climatic conditions. Pronounced variations observed in the signs of estrus, rates of conception and frequency of calving are generally attributed to climatic factors. Heat stress resulted in decreased growth rate, average daily gain and feed intake, estrus frequency, estrus duration, calving rate and increased in inseminations per conception (Patel *et al.*, 2017)^[15]. Rabiee *et al.* (2010)^[16] reported that secretion of gonadotropin-releasing hormone from the

hypothalamus and the gonadotropins, luteinizing hormone (LH) and follicle stimulating hormone (FSH) from the anterior pituitary gland affected by heat stress.

Management of heat stress

Increase water availability to cows

Normal water supply recommendations are inadequate in the summer. Water intake increases by up to 50% as the THI approaches 80. Watered space available and water intake per animal becomes very important. During heat episodes, Mader *et al.* (1997a)^[13] found that as much as three times the normal watered space (7.5 vs. 2.5 cm of linear space per animal) may be needed to allow for sufficient room for all animals to access and benefit from available water.

Change the feeding time

The two most important changes are mix and feed more often and feed a greater proportion of feed at night, 60 to 70% of feed. Watch for feed heating in the bunk – clean bunks out more often Increase airflow / ventilation. Open up the sides of the barn to maximize the natural ventilation. Install fans in the barn. The most important areas to increase ventilation are the holding area, along the inside of the feed bunk and over the stalls. (Kundu *et al.*, 2013)^[12].

Shed Cooling

Use a fan, foggers and fine mist in the barn to cool the air. This will help reduce the heat load on the cows. Breathing cooler air will help cows cool faster. Make sure misters are effective and that they don't inadvertently simply increase the humidity.

Changes in ration composition

Some the key changes for lactating cows: increase the ration concentration but do not compromise fibre levels, add fat to the ration, increase potassium to 1.4-1.6% (West, 2002), increase sodium to 0.45-0.5%, increase magnesium to 0.3-0.4%. This requires a careful selection of mineral sources to ensure that chloride levels are kept low. Consider a modest increase in protein but don't over feed a fraction.

Feed additives during summer

Purwar *et al.*, 2017 also found reduction in heat stress in KF heifer by supplementation of protected fat (2.5% of DMI), yeast (10 g/animal/day), niacin (6 g/animal/day), zinc (40 mg/kg DMI), and chromium (1.5 mg/kg DMI). Similarly Patel *et al.*, 2017^[15] also found reduce heat stress by supplementation of 80 and 120 ppm zinc to KF cows.

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