INFLUENCE OF HEAT STRESS ON FEED INTAKE AND MILK PRODUCTION IN DAIRY COWS; A REVIEW

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Abstract
The effects of high ambient temperatures on production animals, once thought to be limited to tropical areas, has extended into northern latitudes in response to the increasing global temperature. Heat stress has been identified as one of the major challenges for livestock production. Global temperatures are steadily increasing, with Nigerian temperatures increasing at nearly twice the global rate. Of the livestock used for food production, dairy cows are the most sensitive to thermal changes, which have detrimental effects on their health, welfare, and overall productivity. Heat stress exerts a substantial effect on dairy production. The temperature and humidity index (THI) is widely used to assess heat stress in dairy operations. Herein, the review of effects of high temperature and humidity on feed intake and milk production in dairy cows. Heat stress on dairy cows tends to have effect on feed intake and milk yield by reducing voluntary feed intake as well as well reducing milk yield and quality.

Keywords: Heat stress, dairy cows, feed intake, milk production

Description of Problem

Dairy cows are homeotherms that strive to maintain their body temperature by regulating their thermal energy balance, and this can be threatened during periods of high temperatures (1). Heat stress is a physiologically driven response that occurs when an animal produces more heat than it can dissipate (2). Of the livestock species used for food production, dairy cows are the most sensitive to thermal changes (3). Exposure to long-term high ambient temperatures will thus have detrimental consequences for the health and production of dairy cows (4). The consequences of climate change are multifactorial, with heat stress highlighted as one of the major burdens on livestock production (5). Regions known for more temperate climates, such as Ireland and Scotland, are experiencing periods of heat stress (6).

Considerable metabolic heat is produced by the fermentation of the consumed roughage in the rumen, which also results in an additional heat load within the cow body system (7). In addition, with the steadily warming global climate and the intensification of hot periods, dairy cows have been subjected to even more severe heat stress (8,9), which threatens to severely reduce production performance, especially milk yield (10,11). Therefore, dairy cows are normally raised in cool areas to reduce heat stress. To help mitigate the negative effects of ambient temperature and humidity on body temperature and milk production, studies have focused on the development of scientific techniques to manage heat stress and increase cooling (8). These techniques can reduce the negative impact of hot and humid environments on dairy cows, and promote increases in the quality and efficiency of milk production in the dairy industry (9).

Heat stress is usually related to environmental conditions, for example, in animals reared in environment characterized by high temperature, high relative humidity or exposed to strong solar radiation (12). In few cases, heat stress can be attributed to extreme in the animal (13). The thermo-neutral zone of dairy cows (i.e., the air temperature range within which the heat production by the animal is at the minimum and the amount of energy available for milk production is at the maximum) is in the range of 5–25 °C (14). Outside of this range, the animal may not be able to dissipate metabolically produced or absorbed heat and thermal balance cannot be maintained, resulting in to poor performance and low production (15). All this entails animal responses induced by heat stress, which can be classified in physiological responses, morphological responses, behavioral responses, metabolic responses, productive responses, and immune status responses (16).

Effects of heat stress on production in dairy cows

Under normal conditions, fluctuation in the body temperature of cow is low. The normal body temperature ranges from 38.5°C to 39.5°C in calves, from 38.0°C to 39.5°C in heifers, and from 38.0°C to 39.0°C in adult cows (17). While an ambient temperature between 0°C and 25°C has been showed to be beneficial to production performance (18), ambient temperatures in excess of 25°C have been shown to cause an increase in the body temperature of dairy cows, thereby increasing heat stress (18,19). A study by Robinson *et al* (20) showed that heat production was 124.5 kcal/kg of $BW^{0.75}$ when beef cattle were exposed to an ambient temperature of 20°C, but was 141.8 kcal/kg of $BW^{0.75}$ when they were exposed to hotter conditions (35°C). This indicates that heat production increases with an increase in ambient temperature, resulting in a concomitant increase in the body temperature of the cow. However, body temperatures that exceed normal values are not ideal, and cows have been shown to decrease their feed intake and heat exchange capacity accordingly (21). As a result, this leads to lower milk production and reproductive indices (22), as well as increased costs for the dairy industry in the summer months (23).

Effects of heat stress on feed intake

Large amount of metabolic heat is produced during roughage digestion which increases the body temperature of cows. As ambient temperature increases in the summer months, and as body temperature concomitantly increases, cows decrease their feed intake to mitigate heat stress (24), thereby leading to a gradual decline in milk production and a change in milk composition. It has been reported that the feed intake of dairy cows begins to decrease when the ambient temperature reaches 25°C, and sharply decreases when the ambient temperature exceeds 40°C, after which feed intake is approximately 20% to 40% lower than the normal intake (25,26). Thus, an observed decrease in feed intake is an important index of heat stress in dairy cows, where the combination of decreased feed intake and increased ambient temperature gradually result in lower milk yield (23). If environmental factors can be actively monitored and management practices altered accordingly to alleviate heat stress in dairy cows, milk yield and quality can be improved by boosting feed intake (8).

Effects of heat stress on milk yield

Heat stress leads to a decrease in feed intake of dairy cows (22), thereby leading to a reduction in milk production (27). Heat stress not only decreases milk yield, but also affects milk content and somatic cell count (28). Lactating dairy cows have an increased sensitivity to heat stress compared with non lactating (dry) cows, due to milk production elevating metabolism (29). Moreover, because of the positive relationship between milk yield and heat production, higher yielding cows are more challenged by heat stress than lower yielding animals (30).

When a cow becomes heat stressed, an immediate coping mechanism is to reduce dry matter intake (DMI) causing a decrease in the availability of nutrients used for milk synthesis (31). Simultaneously, there is an increase in basal metabolism caused by activation of the thermoregulatory system. Mild to severe heat stress can increase metabolic maintenance requirements by 7 to 25% (32), further exacerbating both the existing metabolic stress and the decrease in milk production. Decreased milk production has been used in some studies as an indicator for reduced welfare for animals that are already challenged by various diseases such as mastitis (33). Rushen *et al*. (34) demonstrated that milk yield declines instantly when cows are exposed to stressful or unfamiliar environments. As a result, it is often assumed that milk production can be interpreted to be a direct welfare indicator in that it offers producers the ability to monitor the animal's individual response to a challenging event (e.g., increasing ambient temperature or changes in nutrition). However, others have challenged the use of milk production as an acceptable welfare indicator (35), particularly for heat-stressed cows, due to the confounding effects of decreased DMI and the delayed decline in milk production following elevated ambient temperatures.

Conclusion and Application

Heat stress has become a major concern for dairy producers because of the associated decreases in milk production and large economic losses. However, to ensure high standards of welfare for dairy cattle, a broader approach is needed that includes the importance of considering how heat stress may also cause negative affective states and that heat mitigation strategies should, where possible, consider the natural adaptions of cows to aversive conditions. Future research must examine the possibility of adapting cattle breeds that are better equipped for hot environments, thus minimizing the duration of compromised welfare and productivity. This literature review was written to provide readers with a clear sense of contemporary heat stress issues from the perspective of animal feed intake and milk production and the need for clear scientific assessment and intervention. The body temperature and feed intake of dairy cows are affected by rising ambient temperature and humidity, which in turn affect milk production.

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