Review Article

Heat Stress and its Management in Dairy Cattle: Current Scenario in South Asia

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Abstract | Heat stress is failure of heat dissipation of body when too much heat is produced. Summer season is the most detrimental for production in animals especially reared in tropical and sub tropical area. Exotic dairy cows are more prone to environmental stress as they have more heat of metabolism. Moreover, they are high producer and high producer animals are more susceptible to heat stress. Heat Stress has harmful impact on production, reproduction, metabolism and immune status of animal. Semen quality of exotic cattle is also affect by heat stress. Similarly, fertility decreases during highly warm months due to heat stress. In managemental perspective, cooling systems (Fans and mist) along with shades and grazing at night are involved in environmental modification. Due to heat stress, intake of dry matter decreases but requirement of energy increases along with the bypass protein. So there is need of nutrition based management of animals in proper way.

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Introduction

Heat stress in animals is associated the imbalance in heat production and dissipation in the body of the animals; more heat is produced or absorbed but less heat is dissipated from body. Dairy animals are warm-blooded animals and have ability to maintain their temperature on a specific degree. When more heat is produced or absorbed by the body but less is dispersed, animals suffer from heat stress (Vasantha *et al*., 2016). This condition harmfully affects the performance of animals. Animals reduce their production and reproduction performance (West, 2003; Nardone *et al*., 2006, 2010).

The thermal comfort zone for Bos-Taurus and Bos-Indicus is 2-20°C and 10-27°C (Ahmad and Tariq, 2010). Animals experience heat stress when the body temperature is above the optimum range defined for normal activity because the total heat produced is greater than the heat dissipation capability (Bernabucci *et al*., 2010).

To measure heat stress in animal bioclimatic index, temperature humidity index (THI) is commonly used (Hahn *et al*., 2003). It has been proved by experiments that performance of animals decrease when temperature humidity index (THI) reaches 68-72 (Armstrong, 1994; Zimbelman *et al*., 2009).

An animal can respond to heat under adverse hot conditions by making physiological changes and

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adjustments within the body, so that it can live in that environment. Such improvements may help to ensure functionality of critical systems and processes within the body. Because cattle sweat very little, the main ways through which they cool themselves include breathing, radiating heat from their bodies, and reducing the intake of feed. However, if the heat produced by animal becomes excessive than the heat dissipated, then such a situation could be described as severe heat stress. As a result, secretions of prolactin, cortisol, progesterone and insulin are altered in heat induced cattle (Ronchi *et al*., 2001; Itoh *et al*., 1998). Prolactin is positively related to galactopoiesis, while the corticotropin-releasing hormone stimulates somatostatin; possibly a key mechanism by which GH and thyroid levels are reduced in heat-stressed animals (Riedel *et al*., 1998).

In warm environments heat stress reduces the milk production, fertility rate, conception rate and health and immunity of the animals. Warm environment has negative effect on overall performance of the animals (Jordan, 2003; Bernabucci *et al*., 2010). The thermal comfort zone for most animals is between 4° C and 25° C, wind velocity 5 to 18 km/hr and relative humidity 55 to 65%. Animals suffer from heat stress when temperature exceeds 25° C due to which animal cells are affected, body temperature rises, and production performance is reduced (Kamal and Habeeb, 1999).

Heat stressed cows are less expected to show standup estrus and mostly show the signs of estrus at night when cows are less possible to be observed, temperatures are cooler and duration of estrus is shorter (Hales *et al*., 1996).

A series of severe changes occur in the biological functions of animals due to heat stress. These changes lead to decrease in feed efficiency, utilization, feed intake, protein, energy, mineral imbalances, disturbances in water, enzymatic activities, blood metabolites, hormonal secretions and ending to damage the productive and reproductive performance as well as lowers natural immunity and animals becomes more susceptible to disease (Habeeb *et al*., 2008).

Current scenario in South Asia

Summer season is the most detrimental and most accentuated time for production in animals especially in animals reared in tropical and sub tropical area (Scholtz *et al*., 2010). South Asian countries are dropped in tropical and subtropical region. In South Asia, the summer temperature goes beyond 45°C which is 18°C above the upper critical temperature of dairy cattle. It is reported by Intergovernmental Panel on Climate Change that temperature of the earth is increasing by 0.2°C per decade and predicted that the global average surface temperature might increase to 1.4-5.8°C by 2100 (IPCC, 2006). It was also pointed out that mainly developing countries are more vulnerable to extreme climatic events as they largely depend on climate sensitive sectors like agriculture and forestry.

South Asia have large variety of domestic large ruminants and these breeds are well acclimated to the hot and humid environment of this area but no model has been purposed for commercializing the dairy industry in suitable for South Asian countries. On other hand native breed and production-system is not enough to meet the milk and meat requirements. Therefore, South Asian countries are bound to follow not only the production system purposed by the European countries but also their breeds to match the over-growing demand of milk and dairy products of the region.

Exotic breed have good reproductive and productive potential and have proved their worth in dairy industry. As these breeds are breed and rear for production for Mediterranean and temperate zone, these breed face serious problems in subtropical and tropical region of the world, one of which is heat stress (Orihuela, 2000). The Holstein is the most popular dairy cattle breed in the world. In summer, the ability of Holstein breed to dissipate heat through skin evaporation is limited due to its underdeveloped sweat glands, relatively low surface area to body weight ratio and short, dense body surface hair, all of which burden milk production (Liu *et al*., 2019)

Effects of heat stress

Effect of heat stress on feed intake: As the environmental temperature increases the temperature of the animal's body also increases due to which dry matter intake decrease (West, 2003; Allen *et al*., 2015). Heat stress cause reduction in feed intake and a failure in nutrient availability due to which body weight decreases and ultimately the animals go into physiological negative energy balance (Rhoads *et al*., 2009) escorted by a reduction in the cow's BCS (Collard *et al*., 2000; Rhoads *et al*., 2011).

Effect on the quantity and quality of the milk: High yielding cows are more sensitive to heat stress as compared with dry cows (Purwanto *et al*., 1990; Spiers *et al*., 2004). Dry matter intake is reduced when a cow becomes heat-stressed resulting in the lower availability of nutrients used for milk synthesis (West, 2003; Rhoads *et al*., 2009). In Addition, mild to severe heat stress can increase metabolic maintenance requirements by 7 to 25% (NRC, 2001) further decreasing the nutrients supply for production.

Effect on female reproduction: During summer, season conception rate of cows is decreased ranging between 20 and 30%, with marked seasonal patterns of estrus exposure (De Rensis and Scaramuzzi, 2003). A warm environment harmfully affects the cow's ability to show estrus behavior, due to which both the intensity and duration of estrous expression are reduced (Orihuela, 2000). When dry matter intake reduces, the intensity and duration of estrous expression also reduce due to effects on the production of the hormones. In beef cattle, estrous behavior and frequency decrease during the summer as compared to winter months (Westwood *et al*., 2002).

When European breeds are moved to tropical areas, their estrous behavior observed shorter due to warm environment (Orihuela, 2000). Cows in heat stress have been used as a welfare indicator based on conception rates (De Rensis, 2003), oocyte quality (Roth *et al*., 2001), and pregnancy loss (Silanikove, 2000). Rectal temperature is more sensitive indicator of welfare (Pereira *et al*., 2013). In dairy cow, farm profitability depends on milk production and reproductive success, which is negatively affect by heat stress.

Effects on cow's service period: Cow's service period is defined as the time-period between date of calving and date of conception of a cow. The service period is longer for cows which calve in summer as comparatively to those who calves in winter. In summer, it may as long as for 150+ days but in winter calving cow, its length may up to 120 days (Kaewlamun *et al*., 2011).

Effects on conception rate in cows: Heat stress has adverse effects on cow's conception rate. If THI is more than 72 at the time of insemination, the chance of conception is reduced. It has been seen that if heat stress continues for 3-5 days before insemination and almost 5-7 days after insemination, conception rate is minimized in cows (Morton *et al*., 2007).

Effects on pregnancy rate in cows

It is reported that pregnancy rate decreases when temperature and relatively humidity goes up from 25°C and 50% respectively. Month of insemination has also significant effect on pregnancy rate. It is observed that pregnancy rate is decreased from 34.1% to 15.7% in tropical areas in May to July (El-Wishy, 2013).

Heat stress management

These strategies can reduce the negative impact of hot and humid climate on dairy cows, and enhance the quality and efficiency of milk production in the dairy industry (Liu *et al*., 2019).

Water

Neat and clean water is important for milk production and thermal homeostasis. It is observed that heat-stressed cows must remain well hydrate for optimum production (McDowell *et al*., 1969). If water is abundant and clean, their consumption rate will increase. To keep animal cool water tank should be clear from feed debris and algae (O'Brien *et al*., 2010).

Rumen health

In summer season, normal micro flora of animals change due to heat stress and cause rumen acidosis. Fiber quality has a principal role in ration. During heat stress, it works like a buffer. Rumen pH can also be maintained by dietary HCO3 and monensin. Propionate production increase by monensin that is predominate gluconeogenic precursor in animals and thus improve the glucose status of heat- stressed cows (Baumgard *et al*., 2011). The extensively usage of yeast, a live cultures of *Saccharomyces cerevisiae* enhances the utilization of nutrients in heat-stressed animals (Boyd *et al*., 2010).

Dietary fat

Supplementation of palm oil significantly reduced rectal temperature and respiratory frequency, increased milk yield, reduced DMI and increased feed efficiency in lactating cows (Melo *et al*., 2016). Milk production and milk fat content were increased by saturated fatty acids and reduce body temperature of the cow in mid lactation (Wang *et al*., 2010).

Glucose

During heat-stress, grains feeding causes more ruminal heat increment, so to increase propionate production, propylene glycol can be add in animals feed which is a glucose precursor for the production (Baumgard *et al.*, 2011).

Protein

In summer season, protein should not be increased in animal diet because it generates a lot of heat. The addition of dietary crude protein is not helpful during heat stress (Arieli *et al.*, 2006). It is not well defined how heat stress affects the requirement of dietary protein.

Mineral and vitamin supplements

Total oxidant activity in blood plasma is reduced due to heat stress (Harmon *et al.*, 1997) and it can cause depression in survival of embryo (Ealy *et al.*, 1992). So, at the time of breeding and in lactating cows, administration of antioxidants like b-carotene, vitamin E and selenium is necessary during heat stress period (Ealy at el., 1994). Acidosis, due to heat stress, could be solved by use of sodium bicarbonate that acts as buffer. Some other feed additives that stabilize rumen health and improve fiber digestion include niacin and chromium. (Escobosa *et al.*, 1984; Zimbelman *et al.*, 2010).

By pass technology

As the digestion of energy rich diets causes heat stress, so to alleviate heat stress, rumen bypass fat can be added in animal diet which results in increased milk production (Wang *et al.*, 2010). Bypass protein diet offered during heat stress also has positive effect on milk production (Terada, 1996).

Cooling system

To control heat stress in exotic breed cows, cooling systems are being used in Asian countries. The principle of cooling system is depends on evaporation, which make possible with the use of fans, mist and force ventilation (Berman, 2006). When we spray water on the body of the animals and ventilate air by fans, evaporation is produced through which temperature of the cow's body is decreased resulting in increased milk production and reproduction performance (Armstrong, 1994; Ryan *et al.*, 1992).

If the external temperature is lower than that of the body temperature, only fans are beneficial. Zone cooling reduce the body temperature and respiration rate due to which feed intake and milk production are increased (Saitou *et al.*, 1989).

Shade

To protect animals from solar radiations, shade is basic protecting method. The tree and other plants are most effective source of shade for animals to protect from sun radiations. Evaporation occurs in summer from leaves of plant, which create a cooling effect on animals body (Hahn, 1999). When we use metallic or concrete shade for the animal's production from sun radiation, roof isolation with suitable materials and painting with white color reduces heat stress or solar radiation (Buffington *et al.*, 1983).

Direction of the shade is also very important. East-West direction of the shade reduces heat stress in summer in South Asia. Due to less solar radiations exposure with covered area of the shade, temperature of the shade is reduced and animals feel comfortable (Avendaño, 1995).

Night grazing

In day time, the breathing and body temperature of the animals are increased in summer season. Night grazing is also a tool to prevent the animals from heat stress. In the daytime, solar radiations falling on the body of the animals increase temperature of the animals. On night time there is no problem of such radiation and animals can allow pasturing.

Conclusions

Summer season is the most detrimental for production in animals especially reared in tropical and sub tropical area. Exotic dairy cows are more prone to environmental stress as they have more heat of metabolism. In tropical region, production of the animals can be maintained through nutritional management during heat stress. These strategies include supplementation of monensin, propylene glycol, niacin, yeast, by pass fat as well as sodium bicarbonate.

Author's Contribution

Sohail Akbar: Material collection.
Muhammad Shafiq and Kashif Ishaq: Overall management.
Muhammad Yaqoob and Muhammad Kamran: Technical input.
Muhammad Farooq Iqbal: Drafting the idea.
Shazia Shamas: Introduction
Arbab Sikander: Abstract
Muhammad Hashim: References

Conflict of interest

It is confirmed that there is no any conflict of interest including financial, personal or other relationships with other people or organizations.

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