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Review Article

FEEDING STRATEGIES TO AMELIORATING THE IMPACT OF HEAT STRESS IN BOVINE

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ABSTRACT
Heat stress negatively impacts economic parameters associated with profitable milk production. Implementing heat stress abatement strategies is crucial to minimize monetary losses. There are several nutritional strategies to consider during heat stress. A common strategy is to increase the energy and nutrient densities (reduced fiber, increased concentrates, and supplemental fat) of the diet, as feed intake is markedly decreased during heat stress. The concentration of all nutrients will need to be increased in diets as DMI decreases during heat stress. The ration should be correctly balanced, and generally the energy density should be increased in the summer to help compensate for decreased dry matter intake of the cow. In addition to the energy balance concern, reducing the fiber content of the diet is thought to improve the cow's thermal balance and may reduce body temperature. Some feed additives also helpful in boosting immunity as well as act as a buffering agent for balancing pH of rumen.

KEY WORDS: Heat stress, feeding strategies, Bovine

INTRODUCTION
The term stress can be defined in different ways, but it is used to explicate influences outside of a body system, which can swing the internal mechanisms away from their resting state (Lee, 1965). Therefore, the term heat stress is used to show the effects of rising environmental temperature on different physiological systems. This is of concern to the dairy industry because of the detrimental changes (production, metabolic, and reproductive) which are induced by heat stress (West, 2003; Bernabucci *et al.*, 2005). In tropical countries like India, heat stress due to high ambient temperature and humidity elicits harmful effect on growth, production and reproduction of farm animals (Marai *et al*., 1995; Pandey *et al.*, 2014). Yadav *et al.* (2015) reported that the crossbred cattle can readily adapt to a thermal exposure of 25 and 30°C and may well acclimatize at 35°C with sustainable biochemical and physiological changes but fail to do so at the thermal exposure of 40°C. Heat stress occurs in animals when there is an imbalance between heat production within the body and its dissipation. The primary non-evaporative means of cooling (*e.g.* conduction, convection and radiation) becomes not as much of effective with rising ambient temperature and hence under such conditions, an animal becomes more and more dependent upon evaporative cooling in the form of sweating and panting to alleviate heat stress (Kimothi and Ghosh, 2005). Thermal stress lowers feed intake of animal which in turn reduces their productivity in terms of milk yield, milk quality and composition, rumen health, growth, body weight and reproductive performance therefore it is a significant economic burden (Pierre *et al.,* 2003). There is normally a decrease in milk production for cattle and buffaloes under heat stress (Singh and Upadhyay, 2009) and this decrease in milk production can range from l0 to >25% in Indian conditions.

Physical modifications of micro or macro climate, selection of breeds that are heat resistant and nutritional management are the three major key aspects to maintain production in hot environment (Beede and Collier, 1986). Advances in management (i.e. cooling systems; Armstrong, 1994; VanBaale *et al*., 2005) and nutritional strategies (West, 2003) have improve some of the negative impact of heat stress on cattle, but productivity continues to decline during the summer. Supplementation of feed additives ie., anti stress vitamins like vitamin C, A, E and Niacin (Ramachandran *et al*., 2002; Seyrek *et al.*, 2004; Padilla *et al.*, 2006, Zimbelman *et al*, 2007; Sunil Kumar *et al.*, 2011; Chase, 2013;), buffers (Chase, 2013), high density diet (NRC, 1981), Minerals or mineral with vitamins (Picco *et al.*, 2004, Sunil Kumar *et al.*, 2011), feeding of antioxidant (Mac Dowell, 1989; Mac Arthur, 2000; Bhar *et al.*, 2003), balanced rations, cool and fresh water (Sastry and Tripathi, 1988) helps to ameliorate heat stress in bovine.

BIOLOGICAL CONSEQUENCES OF HEAT STRESS
The biological mechanism by which heat stress impacts production and reproduction is partially explained by reduced feed intake but also includes changed endocrine status, decreased rumination and nutrient absorption, and increased maintenance requirements (Collier and Beede, 1985; Collier *et al*., 2005) resulting in a net decrease in

nutrient/energy available for production. This decrease in energy results in a reduction in energy balance (EB), and partially explains (reduced gut fill also contributes) why dairy cattle lose significant amounts of body weight when subjected to unabated heat stress (Rhoads *et al.*, 2009b; Shwartz *et al*., 2009; Wheelock *et al.*, 2010). Reductions in energy intake during heat stress consequences in a majority of dairy cows entering into a negative energy balance (NEBAL), regardless of the stage of lactation. Essentially, the heat-stressed cow enters a bioenergetic state similar (but not to the same extent) to the negative energy balance observed in early lactation. The NEBAL related with the early postpartum period is associated with increased risk of health problems and metabolic disorders (Goff and Horst, 1997; Drackley, 1999), and decreased milk yield and reproductive performance (Lucy *et al*., 1992; Beam and Butler, 1999; Baumgard *et al.*, 2002; 2006). It is to be expected that many of the negative effects of heat stress on production, animal health, and reproduction indices are mediated by the reduction in EB (similar to the transition period). However, it is not clear how much of the reduction in milk production and reproduction performance can be attributed by the biological parameters affected by heat stress (i.e. reduced feed intake and increased maintenance costs).

NUTRITIONAL STRATEGIES FOR HEAT STRESS

There are numerous nutritional strategies to think about during heat stress. A common strategy is to increase the energy and nutrient densities (reduced fiber, increased concentrates, and supplemental fat) of the diet, as feed intake is noticeably decreased during heat stress. In addition to the energy balance concern reducing the fiber content of the diet is considered to improve the cow's thermal balance and may reduce body temperature. However, increasing ration concentrates should be considered with care as heat-stressed cows are highly prone to rumen acidosis. Select and feed fresh, palatable and high quality forages as per as possible and feed ingredients that have a high digestibility in the animal to lower the heat increment by nutrient utilization within the animal (Chase, 2013). Balanced rations provide adequate energy to reduce health and reproduction problems of herd associated with reduced DMI and TDN intake during heat stress (Pathak, 2013).

Fiber

Adequate effective fiber is necessary for maintaining rumination, buffering the rumen contents, and efficiently digesting forages and grain components of the diet; current recommendations state a minimum dietary neutral detergent fiber (NDF) of 25% with the proportion of NDF from roughages equaling 75% of total NDF (NRC, 2001). However, its digestion and metabolism generate more heat than compared to concentrates (Van Soest *et al.,* 1991). One common nutritional strategy involves reducing dietary fiber during an increased heat-load. Grant (1997) established that a roughage NDF value of 60% still provides sufficient fiber for production of fat-corrected milk. On the other hand, Kanjanapruthipong and Thaboot (2006) hypothesized that the minimum dietary NDF of 23% DM and roughage NDF proportion of 55% dietary NDF have sufficient effective NDF for dairy cows in the tropics.

Protein

Heat stressed cattle often have a NEBAL, therefore, both the quantity and quality of proteins in the diet should be improved. It is thought that because of reduced feed intake, dietary protein levels may need to be increased during heat stress (West, 1999). However, there are inconsistencies within the literature as benefits and negative consequences of increased protein and altered protein solubility have both been reported (Huber *et al.*, 1993, 1994). The negative effects of increased dietary protein agrees with recent recommendations which suggest that addition of dietary CP, more specifically rumen undegradable protein, is not helpful during heat stress (Arieli *et al.*, 2006). A possible reason why highly degradable protein diets appear to be deleterious during heat stress is that both rumen motility and rate of passage decline. This allows for a longer residence time and thus more extensive protein degradation (Linn, 1997). We have demonstrated that blood urea nitrogen is elevated in heat-stressed cows compared to pair-fed controls (Wheelock *et al.,* 2010).

Fat

Increasing the amount of dietary fat has been a widely accepted strategy within the industry in order to reduce basal metabolic heat production. As stated above, the heat increment of fat is over 50% less than typical forages, so it is seemingly a rational decision to supplement additional lipid and reduce fiber content of the diet. Additional fat feeding can sometimes decrease DMI in thermal neutral cows (Chillard, 1993), but reduced nutrient intake is usually not observed in heat-stressed cows fed supplemental fat (Moody *et al*., 1967; Skaar *et al.*, 1989; Knapp and Grummer, 1991; Drackley *et al*., 2003; Warntjes *et al.*, 2008; Wang *et al*., 2010). Milk yield responses to additional fat are variable and some authors report no diet effect (Moody *et al.*, 1967; Knapp and Grummer, 1991; Chan et al., 1997; Moallem *et al.,* 2010), while others report an increase in milk yield (Skaar *et al.*, 1989; Drackley *et al*., 2003; Warntjes *et al.,* 2008; Wang *et al.,* 2010). Since animal will be consuming less as temperatures increase (NRC, 1981), increasing the energy density of the diet can in part compensate for the decrease in dry matter intake. Feed dietary fats for providing extra energy during negative energy balance as fats have a low heat increment and thus provide energy without a negative thermal side effect.

Vitamin

Heat stress decreased the plasma vitamin C concentration in lactating cows (Padilla *et al*., 2006). Both vitamin C and vitamin E have antioxidant properties. Antioxidant vitamins have proved to protect the biological membranes against the damage of reactive oxygen species (ROS) and the role of vitamin E as an inhibitor 'chain blocker' of lipid peroxidation has been well established (Seyrek *et al.*, 2004). Studies have shown that supplementation of vitamins C, E & A and Zinc are effective in preventing the negative effect of environmental stress (Mac Dowell, 1989). Vitamin C has a paradoxical effect as it can also produce ROS by its action on transition metal ions (Lutsenko *et al.*, 2002). Both ascorbate and Zinc are known to scavenge reactive oxygen species (ROS) during oxidative stress (Prasad, 1979). Frey (1991) reported that vitamin C has an ability to spare other antioxidants in relieving oxidative stress in human subjects. Vitamin C along with electrolyte supplementation was found to ameliorate the heat stress in buffaloes (Sunil Kumar *et al.*, 2010).

Minerals

Unlike humans, bovines utilize potassium (K+) as their primary osmotic regulator of water secretion from sweat glands. As a consequence, K+ requirements are increased (1.4 to 1.6% of DM) during the summer, and this should be adjusted for in the diet. In addition, dietary levels of sodium (Na+) and magnesium (Mg+) should be increased as they compete with K+ for intestinal absorption (West, 2002). Several reports have shown the impact of Cu and Zn deficiency on the antioxidant defense system and oxidative damage to cellular components (Picco *et al.*, 2004). A good mineral mixture containing potassium, sodium, magnesium, copper, selenium, zinc, and phosphorus etc. should be available 24 hours a day every day during the summer.

Dietary cation-anion difference (DCAD)

Having a negative DCAD during the dry period and a positive DCAD during lactation is a good strategy to maintain health and maximize production (Block, 1994). It appears that keeping the DCAD at a healthy lactating level (a+20 to +30 meq /100 g DM) remains a good strategy during the warm summer months (Wildman *et al.,* 2007).

FEED ADDITIVES

Buffers: Feeding buffers can be beneficial during heat stress periods for two reasons. First, if fiber content of the diet is minimized and/or cows are selecting against eating forages, buffers can help prevent a low rumen pH and rumen acidosis problerns. Secondly, the most common macromineral in a buffer is usually Na, exception of K in KHCO3, which when increased in diets fed during heat stress has increased DMI and milk production. Feed ingredients should have buffering capacity or some buffers like sodium bicarbonate, magnesium oxide and sodium sesquicarbonate, to maintain a normal rumen environment by lowering the incidence of acidosis effectively in the rumen which is commonly occurring during hot weather (Chase, 2013).

Fungal cultures: Experiments have shown that feeding *Aspergillus oryzae* reduced heat stress in cows through lowering rectal temperatures. Milk production increased in some studies and was attributed to improved fiber digestion in the rumen (Huber *et al.*, 1994).

Niacin: In a study feeding niacin during the summer increased milk production across all cows by an average of about 2 pounds per day, but cows producing over 75 pounds per day increased over 5 pounds per day (Muller *et al.*, 1986). Supplementation of lactating cows with niacin reduced vaginal temperature, but had differing effects on milk production (Zimbelman *et al,* 2007).

Immunomodulators

Feeding of antioxidant (Vit-A & E, Selenium, Zinc etc.) help reduce the heat stress and improve immunity. The immunostimulant effect of antioxidant depends on age and immune state of organisms as well as on the kind of immune function studied (Victor *et al,* 1999). The effect of heat stress can be neutralized by complex antioxidant system that can organism develops (Mac Arthur, 2000). Vitamin C and trace minerals like zinc have proved to play a vital role as modulators of antibody response and enhances of wound healing in domestic animals (Vegad and Katiyar, 1995). Studies have shown that supplementation of vitamins C, E & A and Zinc are effective in preventing the negative effect of environmental stress (Mac Dowell, 1989).

Water

Water intake is vital for milk production (milk has 87% water), but it is also essential for thermal homeostasis. This stresses how important water availability and waterer/tank cleanliness becomes during the summer months. Water should easily available, cool or cold ice block can be mixed time to time for cooling the water (Sastry and Tripathi, 1988). Keeping water tanks clear of feed debris and algae is a simple and cheap strategy to help cows remain cool (Baumgard and Rhoads, 2007).

CONCLUSION

Heat stress negatively impacts economic parameters associated with profitable milk production. Implementing heat stress abatement strategies is crucial to minimize monetary losses. In addition to physical barn management, nutritional strategies can be implemented to help ameliorate summer-induced losses. Maintaining rumen health is of primary importance as heat-stressed cows are more prone (for a variety of reasons) to rumen acidosis. A reduction in DMI is the primary reason milk production declines during heat stress periods. At the same time DMI decreases, maintenance cost of the cow increases in an attempt to maintain body temperature and thus, the overall availability of nutrients and energy for milk production is decreased. The concentration of all nutrients will need to be increased in diets as DMI decreases during heat stress. The ration should be correctly balanced, and generally the energy density should be increased in the summer to help compensate for decreased dry matter intake of the cow.

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