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Role of mineral and vitamin in heat stress

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Abstract

The average daily milk yield for crossbred cattle is 7.1 kg per day. Which is still significantly lesser than the United Kingdom. Climate change is perceived as a major threat to the survival of many species. Farm animals have known zones of thermal comfort that primarily dependent on the species, physiological status of the animals, relative humidity and the severity of solar radiation. High environmental temperature and humidity are detrimental to the productivity of commercial farm animals. Heat stress in livestock can be defined as a physiological condition in which the core body temperature is higher than the normal activity range. Zinc plays an integral role in regulating the wide variety of body functions including cell division, growth, hormone production, metabolism, appetite control and immune function. There are some vitamin and mineral which help for regulating heat stress. Chromium, iodine, nicotine and Vitamin E which reduce the effect of heat stress.

Keywords: heat stress, vitamin E, chromium, iodine

Introduction

India cattle population 199.1 million in which crossbred contribute 39.73 millions The exotic/crossbred milch cattle increased from 14.4 million to 19.42 million on the percentage basis 34.78% (19th Livestock Census-2012) The average daily milk yield for crossbred cattle is 7.1 kg per day, which is still significantly lesser than the United Kingdom. Climate change is perceived as a major threat to the survival of many species and ecosystems as well as to the financial sustainability of pastoral systems in various parts of the world especially in developing countries. Farm animals have known zones of thermal comfort that primarily dependent on the species, physiological status of the animals, relative humidity and the severity of solar radiation. High environmental temperature and humidity are detrimental to the productivity of commercial farm animals. Heat stress results in reduced gut motility, ruminal contractions and depresses appetite, by having a negative effect on appetite centre of the hypothalamus. Heat stress in livestock can be defined as a physiological condition in which the core body temperature is higher than the normal activity range. Core body temperature is the result of total heat load (internal heat production and environmental heat) minus the ability of the animal to dissipate heat from the body. If the heat load is above the animal's heat dissipation capability, the animal will respond to it through behavioral and physiological changes (Bernabucci *et al*. 2010) [3]. Heat stress can occur in dairy cattle when temperatures are above 25 ºC when combined with high humidity, low air flow and direct sun light (Hahn, 1999) [9]. In beef cattle the threshold temperature above which dry matter intake is adversely affected, is 30 ºC with a relative humidity of below 80%. If the relative humidity is above 80% the threshold temperature for beef cattle drops to 27 ºC. High ambient temperature not only affects performance parameters but various physiological and immunological parameters also.Thermal stress occurs in animals when there is an imbalance between heat production within the body and its dissipation (Kumar *et al.* 2012) [13]. Mild to severe heat stress in dairy cattle has been estimated to cause an increase in maintenance requirements by 7 to 25% (NRC, 2001) [20] Due to the reductions in feed intake and increased maintenance cost heat-stressed cows enter into a state of negative energy balance (Moore *et al.* 2005) [16]. Heat stress also increases mineral excretion (El Husseiny and Creger, 1981) [7], whereas it decreases serum and liver concentrations of vitamins (e.g. vitamin C, E, and A) and minerals (e.g. Fe, Zn, Se, and Cr) (Klasing, 1998; Sahin *et al*. 2005) [12, 22]. Moreover, mobilization of minerals and vitamins from tissues and their excretion (Siegel, 1995) [23] are increased under stress conditions, and consequently, stress may exacerbate a marginal vitamin and mineral deficiency or lead to increased mineral and vitamin requirements.

Role of mineral in mitigation of heat stress

Zinc: It plays an integral role in regulating the wide variety of body functions including cell division, growth, hormone production, metabolism, appetite control and immune function. Zinc is required for the activity of over 300 enzymes and participates in many enzymatic and metabolic functions in the body. One of the most important functions of Zn is its participation in the antioxidant defense system. Zinc deficiency increases oxidative damage of cell membranes caused by free radicals. Synthesizing antioxidant enzymes such as superoxide dismutase (SOD) is an important regulation, in terms of animal response to stress conditions. However, this response will be effective only if cofactors such as Cu, Zn, and Mn for SOD are available (Underwood, 1977; McDowell, 1989) [15]. At the cellular level, elevated temperature and different stress factors such as chemical and physiological stress factors and toxins increase the synthesis of heat shock proteins (HSP), also known as stress proteins. Increased HSP protect cells against the additional stress, via protecting the cells against harmful insults and making the cells resistant to apoptosis, Constitutive expression of a major HSP, HSP70, mediates the protection against cell lysis induced by the toxic effect of NO, a reactive oxygen intermediate created through oxygen-derived free radical action.

Vitamin E: is an antioxidant that plays important role in the maintenance of cellular membranes, immunity and reproduction Feeding of additional vitamin E as antioxidant in the summer is needed due to the greater oxidative stress caused by elevated temperature and humidity. The form that is most common in feeds and is most biologically active is α-tocopherol. Unlike vitamin A, it is not thought to be degraded by ruminal microorganisms. A specific requirement for vitamin E has not been defined yet because titration studies are lacking.

Vitamin E is implicated in stimulation of serum antibody synthesis, particularly igG antibodies (Tengerdy, 1980) [24]. Vitamin E has been observed to enhance the functions of bovine mammary gland macrophages and peripheral blood lymphocytes (Ndiweni and finch, 1995) [17]. Vitamin E modulates prostaglandin release from activated macrophages during infection (Likoff *et al.* 1981) [14].

Chromium: In domestic livestock, Cr has been demonstrated as an essential trace mineral (Offenbacher and Pi-Sunyer, 1988) [21] Heat stress in animal causes oxidative stress which cannot be neutralized by natural antioxidant present in body. Due to more stress reactive oxygen species and glucocorticoid produce which suppresses the growth of animal. (Garg and Bansal, 2000) [8] Reported that the detrimental effect of environmental stress can be reduced by chromium supplementation. Chromium can facilitate vasodilation and may also help to improve radiant heat dissipation. Primary role of Cr in metabolism is to potentiate the action of insulin through its presence in an organometallic molecule, the glucose tolerance factor (GTF). Cr deficiency can disrupt carbohydrate and protein metabolism, reduce insulin sensitivity in peripheral tissues and impair growth rate. The recommendation of National Research Council (NRC) 300 μg/kg Cr for the laboratory animals diet (NRC, 1997) [19]. For livestock, the maximum tolerable concentration of Cr in the diet recommended by NRC is 3000 mg/kg for the oxide form and 1000 mg/kg for the chloride form of the trivalent forms of Cr. Chromium demand increases during stress e.g. fatigue, trauma, gestation and different forms of nutritional (high-carbohydrate diet), metabolic, physical, and emotional stress as well as environmental effects. Addition of chromium picolinate to diets of calves increases glucose clearance rate following intravenous glucose administration (Bunting *et al*. 1994) [4]. The predominant physiological role of chromium is to potentiate the action of insulin.

Iodine

Supplementation of Iodine in high environmental temperature reduce feed intake and decrease the synthesis of thyroxine by reducing plasma concentration of TSH. Plasma T_3 concentration decreases without change in heat production thereby helps in temperature regulation. T_3 level was found to decrease in spring with maximum in winter and minimum value in summer in both buffaloes and Friesians (Kamal and Ibrahim, 1969) [11]. In young (aged 6 months) and old buffalo calves, acute heat exposure (33-43 °C, 40-60 RH %) induced decrease in plasma T_3 (35.25%) and T_4 (17.59%) (Nessim, 2004) [18]. Iodine is an essential element for all animals. Thyroid hormones regulate cell activity and growth in virtually all tissues and therefore are essential in intermediary metabolism, growth and development, hematopoiesis, circulation, neuromuscular functioning, and thermoregulation. In all farm animals, deficiency is accompanied by thyroid hyperplasia or "goiter" and a decrease in thyroglobulin concentration within the follicles of the thyroid gland.

In the ruminant, the rumen is the major site of absorption of iodine and the abomasum is the major site of endogenous secretion (Barua *et al.* 1964) [1]. The regulation of thyroid metabolism is a complex process which involves the thyroid, anterior pituitary, hypothalamus, and peripheral tissues (Hetzel and Welby, 1997) [10].

High ambient temperature markedly suppressed thyroid hormone levels due to lower feed intake. Heat production and body temperature regulation are effectively controlled by thyroid. There exists a seasonal variation in thyroid gland activity which is related to ambient temperature and air humidity. Production of more H_2O_2 under stress condition might have reduced the level of thyroid hormone. Free radical H_2O_2 serves as substrate for the thyroperoxidase enzyme which catalyses the synthesis of thyroid hormone.

Niacin

Niacin, nicotinic acid, or vitamin B3 induced skin vasodilatation and increased heat loss at the periphery (Di Costanzo *et al*. 1997) [6]. The vasodilatory effects of niacin are the result of prostaglandin D (PGD) produced by epidermal Langerhans cells (Benyó *et al*. 2006) [2] acting on vascular endothelial PGD2 receptors (Cheng *et al*. 2006) [5]. Increased skin blood flow was associated with increased sweating rate and inhibiting blood flow by inhibiting nitric oxide synthase, reducing sweating rate during exercise in human. Skin temperatures decreased during periods of mild to severe heat stress in cows supplemented with 24g/day of raw niacin (Di Costanzo *et al*. 1997) [6]. This may have been associated with increased sweating and evaporative heat loss from skin surface.

Conclusions

Heat stress is a major problem in tropical country it can be decrease by proper feeding, maintain energy requirement and also by proper mineral supplement. It improves growth of animal and productivity by proper mineral balance.

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