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EFFECT OF CLIMATE ON NUTRIENT INTAKE AND METABOLISM AND COUNTERING HEATSTRESS BY NUTRITIONAL MANIPULATION

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INTRODUCTION

The term "climate" is derived from the Greek word, Klima, meaning inclination. India is a tropical country with hot and humid summer and relatively less stressful winter season. During summer (May-June), the atmospheric temperature goes as high as 45^0C during day time and 30^0C during night and photoperiod extends up to 12-14 hours. Dairy animals are homeotherms (maintain constant body temperature) and therefore, when the environmental temperature rises or falls abnormally, the animals are put to different types of stress resulting from the quality of feed, physical environment. In a thermoneutral zone, animal neither loses nor gains heat and within the limit of the zone body activities are not influenced by ambient temperature. However, minimum and maximum limit of extremes below or above which temperature influence body activities, are known as critical. In general, for crossbred cows the critical temperature leading to a decline in milk yield at higher level is 90 to 95^0F. The exotic cows have lower range of critical temperature 70 to 85^0F. The comfort zone for crossbred cattle is between 65 to 75^0F.

One way to measure the combined effect of temperature and humidity is to use the temperature-humidity index (THI). A THI exceeding 72 is sufficient to cause minor heat stress and cause a response such as reduced feed intake in the cows. With high relative humidity, the temperature that causes a THI of 72 can be quite low.

The effect of hot and humid weather cause economic losses to dairyman through reduced milk yield (15-40%), lower milk fat content, impaired reproductive performance and greater susceptibility to diseases and environmental stress during hot weather. Feed intake declines and the energy which is consumed by the cow is used less efficiently for milk production because large part is lost in maintaining body temperature.

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Buffaloes, because of their relatively darker colour and lower density of sweat gland suffer more from heat stress than cattle during summer months and innate thermoregulatory mechanism in buffaloes is inadequate compared to cattle. In addition, generally the black skin of buffaloes absorbs more radiant heat and thereby is under greater environmental stress.

EFFECT OF CLIMATE ON NUTRIENT INTAKE AND METABOLISM

Nutrient Acquisition and Metabolism

Nutrient acquisition encompasses three major functions: diet consumption having potentially absorbable nutrients, digestion of the diet and nutrient absorption from alimentary tract mucosa. All of these three functions are affected by thermal stress.

Consumption of Feed and Nutrients

There is a negative correlation between Temperature Humidity Index (THI) and dry matter intake (DMI). However, genetic differences exist for heat tolerance of cattle as *Bos indicus* breeds are more heat tolerant than *Bos taurus* because of greater sweating capacity and lower metabolic rates. Reduction in DMI in Jersey cows when minimum THI exceeded 56 and continued until THI reached 72.

During heat stress, DMI was reduced to 22% for multiparous and 6% for primiparous cows because of smaller body size and lower metabolic rate in primiparous cows. Reduced DMI and therefore heat generated during ruminal fermentation and body metabolism, aid in maintaining heat balance. Moreover, increased environmental temperature elevates the respiratory rate and water intake, reduces the gut motility, rumination, ruminal contractions and depresses appetite by having a direct negative effect on appetite centre of the hypothalamus.

The feed intake of cows at 40^0C is reduced by 20-40 per cent compared with cows in thermoneutral environment. There is an increase in water intake, increase in body temperature and respiration rate which results in reduced milk yield, milk fat, SNF and total solids.

The effect of environment may be indirect, by affecting the plane of nutrition of animals or direct by stimulation of the neuroendocrine system resulting in the loss or conservation of heat to maintain the body temperature. During this period of time, if lactating cows are given *ad libitum* green fodder and water, the decline in milk production can be minimized. If animals are not adequately protected from hot environmental conditions, milk production declines by 1 kg for each degree (^{0}C) rise in rectal temperature. The decrease in yield and composition of milk of dairy cattle as a result of exposure to heat might be due to the decline

in protein, carbohydrate, lipid, mineral and vitamin metabolism which lead to a negative balance in nitrogen, energy and minerals.

Other factors such as variation in managemental practices, stage of lactation, breed and age and diet composition also affect the nutrient intake. Grazing animals are more affected than intensively managed ruminants.

Thus, results in low protein turnover, less heat production and fewer minerals for biosynthesis of milk, depression in thermogenic hormones such as insulin, thyroxine and cortisol. This causes a decrease in milk production and distortion of its composition. Exposure to severe heat suppresses milk production by influencing the hormone releasing factors from hypothalamic center causing a decrease in pituitary hormonal secretion. The effects are slow metabolic pathways, drastic impairment of protein utilization due to shortage of energy substrates, hormones and enzymes, a dramatic decline in dry matter intake, poor digestibility and volatile fatty acid production. Under these conditions, protein synthesis becomes unable to counteract the glucocorticoid induced protein catabolism which leads to negative nitrogen balance.

Digestion

Digestibility is affected by many factors eg., rate of feed consumption, feed quality, nutrient composition, rate of passage of digesta and volumes of ruminal and postruminal digestive organs. All of these factors are influenced by thermal stress. At high temperature, decreased feed intake evokes increased digestion by decreasing the passage of digesta and increasing the ruminal volume. These physiological alterations are more helpful for animals consuming higher forage diets.

Absorption of Nutrients

Thermal stress decreases the energy metabolism (basal metabolic rate) and increases water and electrolyte metabolism. Maximum water intake during the hot period was at least doubled from the control period, from 4.8 to 9.8% in *Bos taurus* and 3.8 to 9.3% in Bos indicus. This is mainly due to lower plasma concentrations of metabolic hormones such as thyroxine, growth hormone (GH) and corticoids.

COUNTERING HEATSTRESS BY NUTRITIONAL MANIPULATION

Dietary modification will help cows cope with heat stress more effectively. Therefore, following recommendations should be considered for summer feeding.

Ration adjustments

The goal is to adjust rations to increase energy and protein intake while maintaining rumen and cow health. To increase the quantity of grain fed and decrease the quantity of forage in the ration. This shift will frequently induce rumen acidosis and impair cow health. The following ration adjustments should be considered:

1. Select and feed higher quality forages if possible.
2. Lower ration fibre (ADF, NDF) levels slightly while maintaining effective fibre levels. This may require the use of some non-fibre byproduct feeds such as soy hulls, beet pulp or citrus pulp.
3. Adding some additional fat to the ration. Total ration fat levels should not exceed 5- 5.5% of total ration dry matter.
4. Select feed ingredients that have a high digestibility in the animal. This lowers the heat produced by nutrient utilization within the animal.
5. Balance ration protein levels to minimize high levels of soluble and rumen degradable protein. The animal must expend energy to excrete excess protein from the body.
6. Adding buffers (sodium bicarbonate, magnesium oxide, and sodium sesquicarbonate) to help in maintaining a normal rumen environment.
7. Increasing ration potassium levels to counteract the higher potassium losses in heat-stressed cows. Ration magnesium levels may also need to be increased.
8. Adding yeast or yeast cultures to the ration.

Feeding management

1. Fresh, palatable, high quality feed should be in the feed at all times to provide maximum opportunity for feed consumption. If the feed is warm, musty or spoiled, it needs to be removed and discarded.
2. Rations mixed and delivered uniformly on a daily basis.
3. All cows feed at the same time.
4. Shift feeding times to match cow behavior. Cows tend to change meal patterns and eat more feed during the cooler times during the day.
5. Simple nutritional management includes increasing the number of feeds (up to 6-8 times) per day after providing more palatable high quality and low fibre diet. Forage generates a greater heat increment than concentrate, therefore decreased dietary fibre may decrease heat production by the animals and low quality forage diet can result in increased rumen passage rate and decreased rumen fill leads to stimulating intake.

6. To maintain energy intake with decreasing DM intake. The energy of diets should be increased. This can be achieved by decreasing the forage concentrate ratio and increasing forage quantity and by adding fat to the ration. This provides greater energy density during hot weather. It has been found that 3-5% fat can be added to the ration without toxic effect on ruminal microflora.
7. Proportion of green fodder should be increased.
8. During heat stress dietary protein density should be increased to compensate for lower intake and buffaloes offered 21% CP have greater DM intake and milk yield.
9. Dietary mineral concentration should be increased during heat stress to compensate for decreased DM intake and increased excretion of certain minerals. Potassium, major mineral secreted during sweating and sodium excretion increases in urine during heat stress in buffaloes. Supplementing dietary sodium and potassium increases milk yield during the period of heat stress.
10. Various additives can be used in diets for lactating buffaloes during hot weather. DM intake and milk yield increase when heat stressed animal supplemented with sodium bicarbonate.
11. Supplementation of niacin and fungal culture (*Aspergillus oryzae*) in the diet of heat stressed buffaloes reduces body temperature and respiration rate and increases milk yield because of improvement in ruminal function.

Water

1. It is important that water supply should be continued and in close proximity to the animals.
2. Water should be of good quality, clean and devoid of undesirable odour and taste.
3. A minimum of 20 cm / buffalo drinking water space should be provided during summer season.

Grazing

1. Taking the buffaloes for grazing only in the morning (before 10 am) and / or late in the afternoon (after 5 pm) may prove beneficial, if only green pasture / grasslands are available.
2. If possible, even night grazing can be practiced. This has two fold benefits. First, during night buffaloes will not be exposed to heat stress. Secondly, they can then get rid of most of the gained during day time by radiation.

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