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Impact of Climate Change on Milk Production and Milk composition: A Review

Bipasha David[1], Chinmaya Kumar Sahu[2]*, A Balakrishna[2] and J David[3]

[1]*Department of Animal Husbandry and Dairying, SHUATS, India*
[2]*Student, Department of Agro Meteorology, SHUATS, India*
[3]*Warner College of Dairy Technology, SHUATS, India*

Abstract

Climate change is likely to affect milk production because of the sensitivity of dairy cows and buffalo to excessive temperature and humidity. It has a definite bearing on milk production for a sub-tropical country like India where mercury hover around 45°C and above. Heat stress has a severe problem for milch animal in India. Temperature Humidity Index (THI) is widely used index to measure the magnitude of heat stress in animal. Severe heat stress cause low productivity in farm animals and composition of milk is also affected. During the dry period heat stress reduce mammary cell proliferation resulting in lower milk production. Milk productivity loss due to heat stress can be reduced by adopting proper summer oriented housing, animal cooling system, development of heat tolerant breeds, high energy feeding.

Keywords: Climate Change; Heat Stress; THI; Milk Production; Milk yield

Introduction

All around the world today climate change & its effects are getting high attention. International community putting its efforts to minimize the future hazard and trying to mitigate the present situation created by climate change, the awareness levels of the individual and society on the climate change and its effect should motivate them to adopt the mitigation strategies [1]. The dairy farming sector which is one of the major sources of income for rural farmers is also getting affected due to the climate changes in the country. The increase in thermal stress in day due to the rise in temperature will lead to additional loss of milk production of 1.6 million tons in 2020. Climate change directly influence on animal performance: growth, milk production, wool production and reproduction [2]. Heat stress is one of the greatest challenges faced by dairy farmers in many regions of the world. Warm climates depress feed intake, milk production, and reproductive performance in cows. India is a largest milk producing country in the world, but the production performance of the milking animal is very low. Breed, age, stage of lactation, parity and milking frequency also influence performance production [3,4].

Excessive heat and humidity cause heat stress in dairy cows and a resulting decrease in milk production. As temperatures increase above the thermo neutral zone of a cow, the animal will undergo physiological changes to cool itself to maintain a constant body temperature. Decreased dry matter intake and increased water intake (i.e., cows eat less and drink more) are the most common behavioral changes when cattle are exposed to heat stress. Both changes increased energy spent on physiological responses to high temperatures and decreased intake of food result in a decrease in milk production. Even with recent advancements in facilities and cooling strategies, recent severe heat stress episodes were estimated to result in losses of over $1 billion.

In India, the summer temperature goes beyond 45°C which is 18°C above the upper critical temperature of dairy cattle. When the temperature exceeds 27°C even with low humidity, the temperature is above the comfort zone for the high producing dairy cows. Humidity plays significant role in heat stress. The most common index of heat stress (temperature humidity index or THI) is calculated from the temperature and Relative Humidity (RH). At high ambient temperature the animals waste their feed energy in Panting and Sweating the nature's way of cooling animals by evaporation. During summer the milk production is reduced to the extent of 50%. The crossbred / exotic animals are more prone to the heat stress losses as compared to indigenous cattle [5].

Heat stress and THI

All Animals have Thermal comfort zone, which is a range of ambient environmental temperatures that are beneficial to physiological functions. During the day, livestock keep a body temperature within a range of ± 0.5°C [6]. When temperature increases more than the upper critical temperature of the range (varies by species type), the animals begin to suffer heat stress. Animals have developed a phenotypic response to a single source of stress such as heat called acclimation. Acclimation results in reduced feed intake, increased water intake, and altered physiological functions such as reproductive and productive efficiency and a change in respiration rate [7]. Heat stress when animal loses the ability to dissipate sufficient heat to maintain thermal balance and her body temperature rises. Marai and Habeeb defined heat stress as the state at which the animal body physiological mechanisms activate to maintain the body's thermal balance, when exposure to elevated temperature. This has a negative effect on many factors such as dry matter intake, reproduction, and milk production. Animal will also reduce feed intake to produce less metabolic heat, which is a protective mechanism. Animals typically react to heat stress conditions by eating less food, thus naturally controlling the rise in deep body temperature caused by digestion. Respiratory rate rises and there is a marked increase in insensible heat loss by evaporation of water from the

***Corresponding author:** Chinmaya Kumar Sahu, Department of Agro Meteorology, SHUATS, India, Tel: +91 6387188091, E-mail: chinmayasahu1995@gmail.com

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lungs. They also drink at least 5 times the amount of water they would under temperate conditions, urine output increases and many mineral ions are lost. In addition, Heat stressed cows are less likely to exhibit standing estrus and often only exhibit signs of estrus at night when temperatures are cooler but when they are less likely to be observed. In addition, duration of estrus is shorter for cows subjected to heat stress [8]. Some responses of animals to heat stress are including

- Increased body temp. (> 102.6 F), the normal body temperature of a dairy cow is 101.5 F
- Increased respiratory rate, panting > 80 breaths per minute (35-45 normal)
- Reduced activity
- Reduced feed intake (> 10-15% reduction)
- Reduced Milk Yield (10-20% or more)
- Increased peripheral blood flow and sweating.
- Reduced fertility levels
- Increased mortality

Heat stress has adverse effects on the reproductive performances of dairy cattle and buffaloes. The dairy sector is a more vulnerable to global warming and climate change. The Temperature Humidity Index (THI) is the widely used index to measure the magnitude of heat stress in animals [9]. Table 1 shows different Temperature Humidity Index (THI) formulae for calculation of heat stress. Table 2 shows Classification of THI values and stress levels in cattle and buffaloes.

Climatic changes and effect on milk production

Dairy cattle

Climatic changes greatly influence the behavior of animals due to neuroendocrine response to environmental variables that directly affect production and health status of animals. Climate change mainly affects the high producing animals particularly those high producing animals which are raised under tropical conditions, due to high air temperatures and relative humidity. One of the most important impacts of climate change is heat stress that adversely affects milk production and its composition, especially to those animals that have high genetic trait. Environmental temperature above 35°C is enough to activate the stress response mechanisms in lactating dairy cows. In response to heat stress dairy cows reduce feed intake leading to negative energy balance responsible for the drop in milk production. Up to 50% drop in milk production in dairy animals is due to reduced feed intake and rest due to metabolic adaptations to heat stress as heat stress response markedly changes post-absorptive nutrient metabolism. During the dry period (i.e. last 2 months of gestation) heat stress reduce mammary cell proliferation result in decreased milk production. Moreover, heat stress during the dry period negatively affects the function of the immune cell in lactating cows facing calving and also extended to the following lactation [10].

Buffaloes

Milk production and reproductive functions of buffaloes are negatively impacted by temperature rise during summer and also by sharp temperature decline in winter. The high temperature causes stress due to increased body heat leading to low heat dissipation from the body surface. High heat load in lactating buffaloes reduces their milk production and shorten duration of lactation periods. The negative impact of sudden temperature change i.e. cold wave or heat wave on milk yield of buffaloes were not only observed on following day but also on the next or subsequent day (s) after extreme event, thereby indicating that extreme events cause a cumulative effect change on milk production of Murrah buffaloes. The return to normal milk yield took 2-5 days with a variable response in individual buffaloes. The decline and return to normal yield was also dependent on T max and T min on days following extreme event and time period of thermal stress/ event occurrence. Very low for cool period observed during Feb-April/Sept-Nov and actual effect on milk production was

Formulae for THI	References
[0.4 × (Tdb+Twb)] × 1.8+32+15	[18]
(0.35 × Tdb+0.65 × Twb) × 1.8+32	[19]
(Tdb+Twb) × 0.72+40.6	[20]
(1.8 × Tdb+32) − (0.55 − 0.0055 × RH) × (1.8 × Tdb − 26)	[20]
(0.55 × Tdb+0.2 × Tdp) × 1.8+32+17.5	[20]
Tdb+(0.36 × Tdp) + 41.2	[21]
(0.8 × Tdb) + [(RH/100) × (Tdb − 14.4)] + 46.4	[22]
Where , Tdb = Dry bulb temperature, Twb = Wet bulb temperature,Tdp = dew point temperature RH = Relative Humidity (%), THI = Temperature Humidity Index	

Table 1: Different Temperature Humidity Index (THI) formulae for calculation of heat stress.

THI	Stress level	Symptoms in cattle	Symptoms in buffalo
< 72	None	Optimum productive and reproductive Performance	Optimum productive and reproductive performance
72-78	Mild	Dairy cows seek for shade, increase in respiration rate and dilation of blood vessels.	Elevation in rectal temperature and respiration rate
79-88	Moderate	Increase in respiration rate and saliva secretion Reduction in feed intake and water consumption. Body temperature is increased and reproductive performances are severely affected in cattle.	Respiration rate is significantly increased Dry matter intake of buffalo is decreased and ratio of forage to concentrate intake is decreased. Water intake in buffalo is significantly increased
89-98	Severe	There is rapid increase in respiration and excessive saliva production. The reproductive performances in animals are significantly decreased.	Excessive panting and restlessness are observed. Rumination and urination are lowered along with a negative impact on reproductive performances in buffaloes.
> 98	Danger	Heat stress is extreme and cows may die.	Heat stress is extreme and buffaloes may die.
THI = Temperature Humidity Index			

Table 2: Classification of THI values and stress levels in cattle and buffaloes.

minimum. This indicated that low THI (75) had a relatively small effect on milk production performance. The lactation period of buffaloes was shortened by several days (3-7 days) during extreme summer when THI were more than 80 [11, 12].

Effects quality of milk

Hot and humid climate not only affects quantity but also effects quality of milk too. On comparing milk production during summer and spring in a dairy herd it was found that lower milk yield (-10%), and also lower casein percentages and casein number in summer (2.18 vs. 2.58% and 72.4 vs. 77.7% respectively). The fall in casein was due to the reduction in α-casein and β-casein percentages. No differences were found between the two seasons for κ-casein, α-lactoalbumin and β-lactoglobulin, whereas serum protein contents were higher in summer than in spring [13-15].

Strategies to combat heat stress

This Milk productivity loss during summer due to heat stress can be reduced substantially by adopting the following heat stress management coupled with good health management

- Proper summer oriented housing
- Animal cooling system
- Development of breeds tolerant to heat stress
- High energy feeding
- Roofing material with hay or straw
- Color of roof and walls
- Feeding and nutritional management
- Evaporative cooling systems
- Foggers

Conclusion

Heat stress is a major factor that reduces milk production in dairy cows. The effect of heat stress on dairy production should be minimized by combining strategies with a low investment cost together with good management practice for farm animals. Utmost care should be developed as discussed above through combine process like proper cooling system, apt housing for animals and developing heat tolerant breeds.

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