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Heat Stress-induced Changes in Milk Composition and Physiological Responses of Lactating Kankrej Cow during Summer Season as Compared to Thermo-neutral Period

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ABSTRACT

Background: The Kankrej cattle is the heaviest and most priced of the Indian breeds of cattle. It is adapted to the geo-climatic conditions of North Gujarat and Kutch, which is normally hot and dry. It is reared in the district of Banaskantha in the state of Gujarat and also distributed in other parts of India and abroad. The experiment was carried out to study the effect of the summer season on the milk composition and physiological responses in lactating Kankrej cow compared to the thermoneutral period.

Methods: For the experiment, total number of 16 clinically healthy Kankrej cows were randomly selected from Livestock Research Station (LRS), Sardar Krushinagar Dantiwada Agricultural University, Banaskantha, Gujarat and categorized into two different groups according to seasons. Physiological responses *i.e.* respiration rate and rectal temperature were recorded and milk samples were collected from each animal during the summer and thermoneutral period at fortnight intervals. The milk samples were analyzed by using an automated milk analyzer.

Result: The results demonstrate that fat, SNF and density were significantly higher in the summer season. The physiological responses include respiration rate and rectal temperature were found significantly higher during summer than thermoneutral period. Milk protein was significantly higher during the thermo-neutral period as compared to summer.

Key words: Kankrej, Milk composition, Rectal temperature, Respiration rate, Summer stress, Thermo-neutral period.

INTRODUCTION

Kankrej cow is a good milk producer and bullocks are very powerful, so it is suitable for draft purposes and well known for their “SAWAI CHAL means a particular walking style where the hind limbs of cow reach faster to the ground than the front limb which helps in faster plowing the fields. Due to this advantage, Kankrej bulls are used for road transportation. The population of Kankrej cattle was reviewed and found that its population was 5.0 lakh during 1951 and it has been increased to 30.28 lakh during 2013. It has been estimated that the average standard lactation milk yield of Kankrej cattle is 2523.33 litre, the average lactation length is 301.58 days and the calving interval is 443.72 days at the organized farm of Livestock Research Station, Sardar Krushinagar Dantiwada Agricultural University, Sardar Krushinagar, Gujarat.

Livestock keeping is an integral part of Indian society, which helps to provide nutritional security to rural people and opens the employment opportunities. However, most of the world’s human and domestic animal population lies in regions where seasonal stressors adversely influence productivity. Stress is the condition where there is undue demand for physical and mental energy due to excessive and aversive environmental factors (stressors) and causes deformations identifiable through physiological disequilibrium. Seasonal stress imparts physical and economic losses to livestock production in temperate, subtropical and tropical regions. Each species, breed or animal with its physiological state has a comfort zone, in which the energy expenditure of the animal is minimal, constant and independent of environmental temperature. When environmental temperatures move out of the thermo-neutral zone (or comfort zone) during a different season, dairy cattle begin to experience heat stress in summer or cold stress in winter. These seasonal stresses negatively impact a variety of dairy parameters including milk yield and reproduction which created a significant financial burden in many dairy-producing areas of the world.

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Under seasonal stress, many physiological and behavioral responses vary in intensity and duration in relation to the animal genetic makeup and environmental factors by integrating many organs and systems *viz.* behavioural, endocrine, cardio-respiratory and immune system Altan *et al.* (2003). Nonetheless, with the ever-increasing interest in indigenous livestock breeds as a possible solution to increase the efficiency of production in harsh conditions. There is an urgent need to study the seasonal stress-induced physiological and production changes in such indigenous breeds to plan and implement health and disease monitoring programs to ensure their sustainable development and economic viability. In addition, these parameters can be used to evaluate animal stress and welfare levels Anderson *et al.* (1999).

MATERIALS AND METHODS

Selection of animals

The experiment was conducted at Livestock Research Station, Sardar Krushinagar Dantiwada Agricultural University, Banaskantha, Gujarat. A total number of 16 clinically healthy animals were selected which having second to fifth parity with average body weight around 430 kg. All the cows were clinically healthy, maintained under standard management conditions and allowed to take ad-libitum food. Prior approval of the Institutional Animal Ethics Committee (IAEC) was taken before conducting an experiment.

Experimental design

An experiment was carried out in two periods according to the temperature and relative humidity recorded: From May 2018 to June 2018 (maximum temperature-42.1 and maximum relative humidity-77, minimum temperature-23.9 and minimum relative humidity-50) for the summer season and from February 2019 to March 2019 (maximum temperature-36.5 and maximum relative humidity-68, minimum temperature-11.8 and minimum relative humidity-38) for a thermo-neutral period. During each season, eight animals were selected (n=8).

Milk sampling

Milk samples were collected during each season at fortnight intervals from animals to measure milk fat, milk protein, lactose, SNF and density. These milk parameters were measured by Automated Milk Analyzer (Ekomilk, Milk Analyzer Milkana KAM98-2A, Ultra pro). Physiological parameters viz rectal temperature (RT, °F) and respiration rate (RR, breaths/min) were recorded by Digital thermometer (N and B Medical Products Co., New Delhi) and by observation of flank movement respectively at fortnight intervals during the experimental periods. Respiration rate and rectal temperature were taken in the morning (9 a.m.) and milk samples were collected in the afternoon (4 p.m.) on the same day of physiological parameters recorded.

Statistical analysis

The data were analyzed by applying one way ANOVA test using the Sigma stat 32 software package. $P<0.05$ was considered to be statistically significant.

RESULTS AND DISCUSSION

Rectal temperature (°F)

The recorded mean and standard error (mean±S.E.) values of rectal temperature (°F) during different seasons in lactating Kankrej cow were presented in the Table 1 and Fig 1. It was observed that rectal temperature was significantly ($p<0.05$) higher in the summer season than thermoneutral period. The mean rectal temperature determined in the present study corroborated the values of Haque *et al.* (2012) and Yadav *et al.* (2016); who reported higher RT during summer months in buffaloes and cattles respectively. The core body temperature of cows in thermo-neutral conditions is maintained by the thermoregulation system of the animal's body with a range of about 1°C (between 38 to 39.2°C) (Ammer *et al.*, 2016). Under these ambient conditions, the exchange of animal heat within the animal (across cellular and vascular membranes) and between the animal and its environment are kept in balance; however, it is always a dynamic equilibrium (Taylor *et al.,* 2014). During periods of excess heat (heat stress), homeostatic mechanisms of the body are activated to re-establish the internal environment's thermal status or regulate it within acceptable physiological limits (Werner *et al.,* 2008). During the study, the higher rectal temperature in summer indicates that the animals could not dissipate the excess heat by usual means (conduction, convection, evaporation), which increased body temperature. A similar increase in the RT at higher temperatures/heat stress have been reported in cattle by Marai *et al.* (1995); and Nessim (2004) in buffalo, Korde *et al.* (2007) and Krishnan *et al.* (2009). Bewley *et al.* (2008) mentioned that the rectal temperature is directly affected by the ambient temperature and increasing during warmer weather. Rectal temperature is an indicator of thermal balance and may be used to assess the adversity of the thermal environment, which can affect the growth, lactation and reproduction of dairy cows (Hansen and Arechiga, 1999) and West, 1999).

Respiration rate (Breaths/min)

The recorded mean and standard error of respiration rate (Breaths/min) in lactating Kankrej cow was shown in Table 1 and Fig 2. It was observed that the respiration rate was significantly ($p<0.05$) higher during the summer season in compared to the thermoneutral period. The mean respiration rate determined in the present study corroborates the values previously reported by Haque *et al.* (2012). They reported a non-significant difference at 42°C and 45°C in the respiration rate in adult animals, except in the case of 45°C, a significant higher ($P<0.05$) respiration rate was observed in young animals than adults. The increase in respiration rate with the increasing temperature may be due to the more demand for oxygen by the tissues in stressful conditions. A similar increase in

Table 1: Physiological parameters in Lactating Kankrej cow during Summer and Thermoneutral periode.

Parameters \ Seasons	Season-I Summer (May-June) Temp-Min-23.9, Max-42.1 RH-Min-50, Max-77	Season-III Thermoneutral (February-March) Temp-Min-11.8, Max-36.5 RH-Min-38, Max-68
Rectal temperature (°F)	100.91±0.21[b]	99.90±0.06[a]
Respiration rate (breaths/min)	29.00±0.62[b]	20.12±0.36[a]

*Means with different superscripts (a, b) within a row differ significantly from each other.

*(Source of Temperature (Temp) and Relative Humidity (RH) data- Department of Meteorology, Chimanbhai Patel College of Agriculture, Sardar Krushinagar Dantiwada Agriculture University, Gujarat).

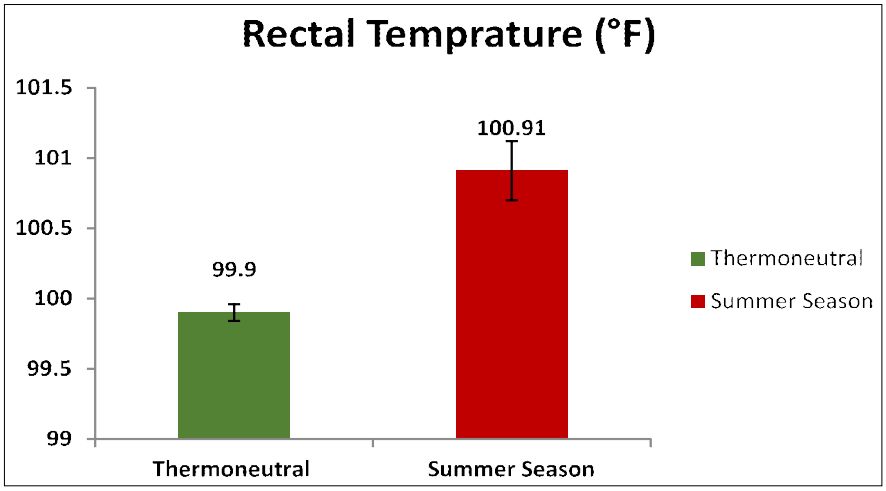

Fig 1: Rectal temperature during different seasons in lactating Kankrej cow.

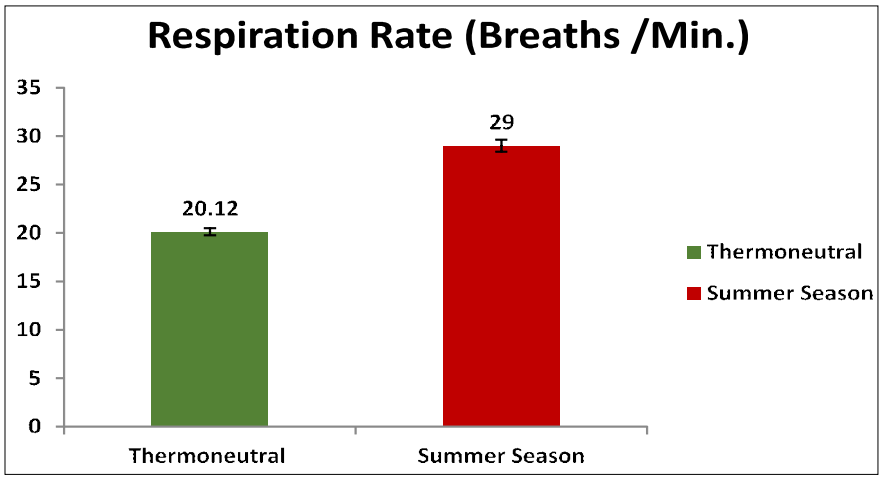

Fig 2: Respiration rate during different seasons in lactating Kankrej cow.

the respiration rate at higher temperatures/heat stress have been reported by Gaughan *et al.* (2000), Nonaka *et al.* (2008) and Pereira *et al.* (2008) in cattle and Korde *et al.* (2007) and Zhang *et al.* (2010) in buffaloes.

The respiratory rate (RR) was highly affected by ambient air temperature changes because the respiratory rate is considered one of the major physiological reactions that can keep body temperature within the normal range Frangiadaki *et al.* (2003). McLean (1963) observed the significance of the increase in respiration rate under heat stress and enables the animal to dissipate the excess of body heat by vaporizing more moisture in the expired air, which accounts for about 30% of the total dissipation. On the other hand, McDowell (1972) and Gaughan *et al.* (1999) observed contradictory results; they reported a low respiratory rate under hot weather and identified animals with lesser discomfort. This fact is evident when comparing respiration rates of *Bos taurus* versus *Bos indicus* under hot summer weather conditions where *Bos indicus* (Zebu) cattle maintain lower respiration rates. There was a

significant ($p<0.05$) increase in respiration rate to maintain body temperature in the present study. Still, animals could not maintain their body temperature andthere was a significant ($p<0.05$) increase in rectal temperature, which indicates heat stress felt by animals during the extreme summer season.

Milk composition

Fat (%)

Hot and humid environment not only affects milk yield but also effects milk quality. It was observed that the values of the fat content (%) in milk during the summer season and thermoneutral period were depicted in Table 2 and Fig 3. Results showed that the fat content of milk during the summer season was significantly ($p<0.05$) higher than the thermoneutral period. An increase in fat% might be due to an increase in roughage intake during the summer season, leading to higher acetate formation responsible for the increase in milk fat%. Similar result were also reported by Bernadin (1972); Sharma *et al.* (2001); Prasad (2009); Verma *et al.* (2018); Salim Bahashwan (2014) and Sarkar *et al.* (2006) that milk composition traits were highest in hot humid season but lowest in compared to other seasons. The daily yield of fat was observed to be higher during summer ($p<0.05$) than winter season. Contraindication to result Kadzere *et al.* (2002) and Bouraoui *et al.* (2002) observed lower milk fat in the summer season. When THI value goes beyond 72, milk fat content declines. Zheng *et al.* (2009) observed that the higher environmental temperature significantly reduces the percentage of milk fat in milk.

Protein (%)

The milk protein values during the summer season and thermoneutral period were presented in Table 2 and Fig 4. It was observed that milk protein was significantly ($p<0.05$) higher during a thermoneutral period than the summer season. The result was similar to Zheng *et al.* (2009) observed that heat stress significantly reduces the production of milk and the percentage of protein in milk. Bouraoui *et al.* (2002) observed lower milk protein in the summer season. When THI value goes beyond 72, milk protein content declines. Heat stress significantly reduced milk protein contents from 3.20% during the winter season to 3.07% during summer season (Gaafar *et al.,* 2011). While Radhika *et al.* (2012) reported that, the protein content was significantly lower ($p<0.05$) during winter than summer season.

Table 2: Milk composition during different seasons in lactating Kankrej cow.

Parameters \ Seasons	Season-I Summer (May-June) Temp-Min-23.9, Max-42.1 RH-Min-50, Max-77	Season-II Thermoneutral (February-March) Temp-Min-11.8, Max-36.5 RH-Min-38, Max-68
Fat	3.56±0.17[b]	2.80±0.23[a]
Milk protein	2.47±0.04[b]	3.36±0.03[a]
Lactose	4.18±0.06[a]	4.50±0.04[a]
SNF	9.60±0.10[b]	8.47±0.07[a]
Density	38.29±0.44[b]	30.63±0.38[a]

Means with different superscripts (a, b) within a row differ significantly from each other.

(Source of Temperature (Temp) and Relative Humidity (RH) data- Department of Meteorology, Chimanbhai Patel College of Agriculture, Sardar Krushinagar Dantiwada Agriculture University, Sardar Krushinagar, Gujarat).

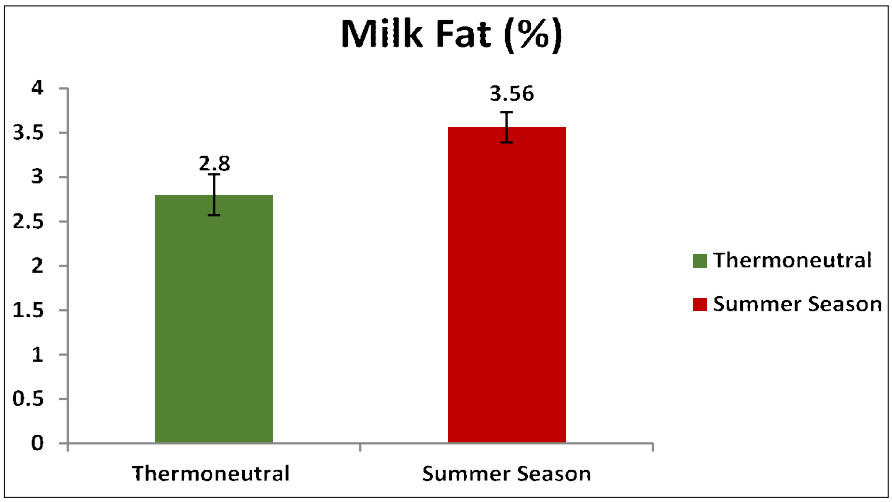

Fig 3: Milk fat (%) during different seasons in lactating Kankrej cow.

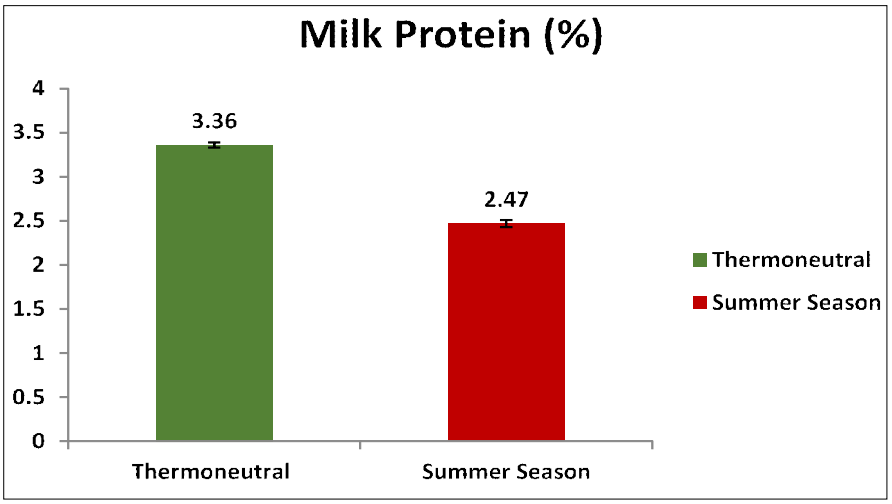

Fig 4: Milk protein level (%) during different seasons in lactating Kankrej cow.

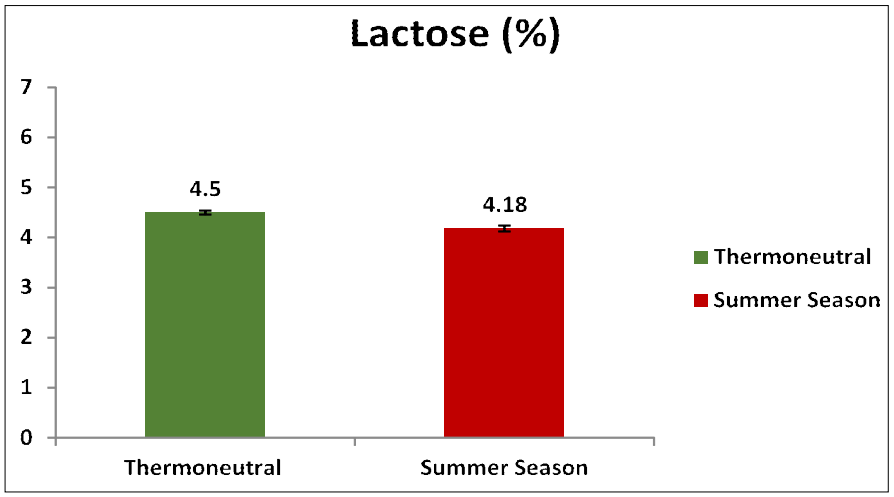

Fig 5: Lactose concentration during different seasons in lactating Kankrej cow.

Lactose (%)

It was observed that the values of lactose during the summer season and thermoneutral period were shown in Table 2 and Fig 5. No significant change was found in lactose content during the summer season and thermoneutral season. The result was similar to Zheng *et al.* (2009) observed that the higher environmental temperature has no significant effect on the lactose content in the milk. Contraindication to result of Gaafar *et al.* (2011) reported that the heat stress significantly reduced milk lactose contents from 4.78% during the winter season to 4.59% during summer season.

Solid not fat (SNF%)

It was observed that the values of the solid not fat in milk during the summer season and thermoneutral period were presented in Table 2 and Fig 6. It was observed that solid not fat of milk was significantly ($p<0.05$) higher during the summer season than the thermoneutral period. The result was contraindicated to Gaafar *et al.* (2011) who claims that higher temperature significantly reduced the milk SNF contents from 8.69% during the winter season to 8.34% during summer season. Similar results were also reported by Bernadin (1972) and Verma *et al.* (2018).

Density

It was observed that the values of milk density during the summer season and thermoneutral period were presented in Table 2 and Fig 7. It was observed that the density of milk was significantly ($p<0.05$) higher during the summer season as compared to the thermoneutral period.

In the present study, there were a significant ($p<0.05$) increase in fat%, concentration, solid not fat and density found during the summer season, while there was a significant ($p<0.05$) increase in milk protein level during the thermoneutral period.

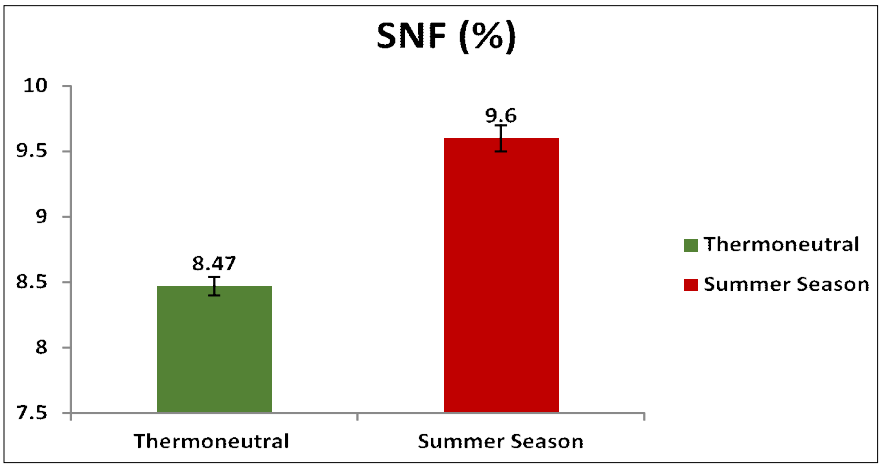

Fig 6: Solid not fat (%) during different seasons in lactating Kankrej cow.

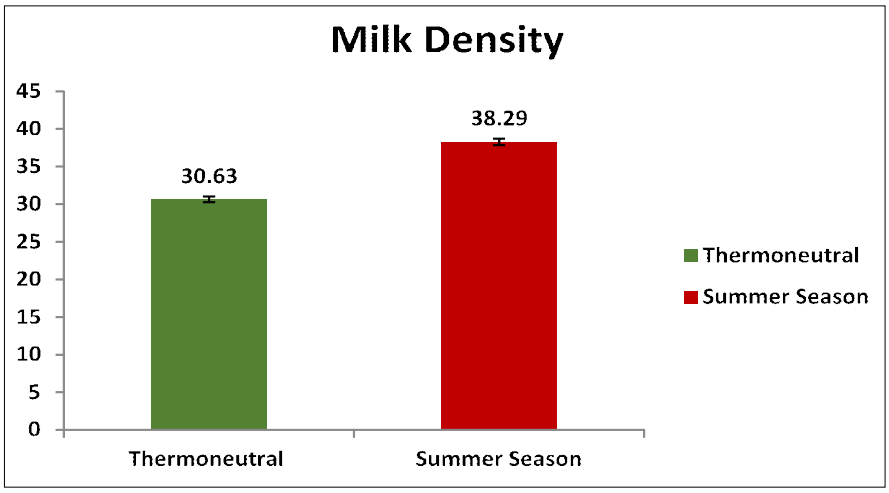

Fig 7: Density of milk during different seasons in lactating Kankrej cow.

CONCLUSION

In present study, during the thermoneutral period the values of physiological responses and milk composition were found within the normal range so it may be considered as the physiologically most comfortable season for lactating Kankrej cow.

Conflict of interest

All authors declare that they have no conflict of interest.

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