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Body Heat Storage and Physiological Responses of Peripartuient Karan Fries and Sahiwal Cows During Summer and Winter Season

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ABSTRACT

Ten each of periparturient Karan Fries and Sahiwal cows were selected separately during summer and winter season. These animals were equally divided (five each) into two groups i.e. high and low yielding on the basis of their earlier lactation milk yield. The cows were maintained on standard conditions of feeding and management followed at the Institute farm. The physiological responses (RR, PR, T_{re} and T_{skin}) and climatic variables (T_{db}, T_{wb}, T_{max}, T_{min}, RH and THI) were recorded -45, -30, -15, and 15, 30, and 45 with respect to day of parturition (day 0) and the heat storage of these animals were calculated. The physiological responses and heat storage were significantly ($P<0.05$) higher during summer compared to winter season. The magnitude of increase in physiological responses were higher ($P<0.05$) in high and low yielding Karan Fries cows compared to both the groups of Sahiwal cows during both the seasons. The mean values of heat storage increased by 6.20 and 1.80% in high and low yielding Sahiwal cows during summer season, whereas, in high and low yielding Karan Fries cows the increase was 6.70 and 5.40%, respectively, on the day of calving from the pre-calving values (45th day). During winter season the values of heat storage, increased by 2.60 and 4.40% in high and low yielding Sahiwal cows, whereas, the respective increase in high and low yielding Karan Fries cows was 6.10 and 6.04%, respectively, on the day of calving from the pre calving values (45th day). The overall mean values showed significantly ($P<0.05$) higher values of heat storage during summer, in high yielding and in KF cows compared to winter season, low yielder and Sahiwal cows respectively. Based on the results, it can be stated that high yielding KF cows are more sensitive compared to Sahiwal cows during summer season. Therefore, KF cows needs to be provided better microenvironment and improved managemental practices for normal physiology and productive performances.

Keywords: Heat storage, Karan Fries, Periparturient, Sahiwal, Temperature humidity index

INTRODUCTION

Mammalians have the ability to maintain homoeothermic condition in order to maintain their core body temperature within narrow limits despite wide fluctuations in ambient temperature. High ambient temperature and relative humidity are the primary factors that cause heat stress in dairy animals. Increased respiration rate is the first reaction, when animals are exposed to temperature above the thermoneutral zone (Moran, 1999). Silanikove (2000) suggested that recording the respiration rate appears to be the most accessible and easiest approach for evaluating the degree of heat stress in farm animals (low: 40 – 59, medium high: 60 – 79, high: 80 – 120, and severe stress: >150 breaths per minute in cattle). The outermost surface of the skin, fur, or feathers and the shell of an animal, is the transducing surface across which the environment interacts with the internal physiology of the animal (Gebremedhin *et al.,* 2007). Banerjee (2008) found a positive correlation between physiological responses and antioxidant status during climatic chamber exposure study. Mayengbam (2008) reported an increased in rectal temperature during climatic chamber exposure at 40 and 45°C with 50% RH and during summer stress in crossbred cattle. Thankachan (2007) reported increased in skin temperature of Murrah buffaloes at the end of four hours exposure in climatic chamber. Dandage (2009) also observed similar results in Sahiwal and Karan Fries cattle. Thermal stress is a unique and complex mechanism that causes alterations of the normal physiological mechanisms, which elicits a stressful response that often reflects in the failure to

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achieve genetic potential for production traits (Dobson and Smith, 2000). The skin on the limbs seems to be much more active in heat dissipation as compared with that of the hide of the trunk. Singh *et al.* (2017) reported an increase in skin temperature with the increase of ambient temperature. Increased heat storage in Brahman x Hereford-Shorthorn and Shorthorn was observed, when air temperature exceeded rectal temperature (Finch, 1985). Keeping all above facts in mind, the present study was planned to find out the changes in physiological parameters and heat storage in zebu and crossbred periparturient cows during summer and winter season and correlate them with temperature humidity index.

MATERIALS AND METHODS

Ten each of periparturient Karan Fries and Sahiwal cows were selected separately during summer and winter season from Livestock Research Centre of ICAR- NDRI, Karnal. Further, these animals were equally divided (five each) into high and low yielding group during both the seasons on the basis of their earlier lactation milk yield. All the pregnant cows were fed a ration consisting of roughages (berseem, oats, maize or jowar fodder) as per the availability at farm. Throughout the experimental period cows were given concentrate mixture at 8.30 AM at the rate of 1 kg per cow per day, then 1.50 kg per cow per day 15 days before calving. After calving, the cows were given concentrate mixture @ 1 kg per 2.50 kg of milk production. Concentrate mixture consisted of 28% maize, 10% groundnut cake, 13% mustard cake, 15% wheat bran, 11% rice polish, 15% soyabean deoiled, 5% bajra, 2% mineral mixture and 1% salt. Fresh tap water was available for drinking to all the animals round the clock. The physiological parameters *viz.* respiration rate (RR), pulse rate (PR), rectal temperature (RT), skin temperature (ST) were recorded at fortnightly intervals i.e. -45, -30, -15, and 15, 30, and 45 with respect to parturition (day 0) and the heat storage of the animals were calculated. The environmental variables (T_{db}, T_{wb}, T_{max}, T_{min}, RH and THI) were also recorded on the day of sampling throughout the study. The THI varied from 79.31-85.24 during summer and 61.67-74.35 during winter season.

Respiration rate was recorded from visual observation of inward and outward abdominal movement. One complete inward and outward movement of abdomen was counted as one respiration. The respiration rate is expressed as breaths per minute.

Pulse rate was counted by observing the pulsation of middle coccygeal artery at the base of the tail and the results are expressed as pulse rate per minute.

Rectal temperature was recorded using digital thermometer by keeping the thermometer in contact of rectal mucosa for about 2 minutes.

Peripheral skin temperature of the animals at different anatomical sites, *viz.* forehead, ears, neck, shoulder region (proximal scapula) and flank regions were recorded using non-contact tele-thermometer by keeping it 2-3 inches away from the desired surface site.

Increment in body heat storage due to heat exposure was calculated from the changes in rectal temperature and skin temperature. The body heat storage was calculated using the following formula.

Heat storage (KJ) = 3.47x BW (kg) ($0.8\Delta T_{re} + 0.2\ \Delta T_{skin}$) Where,

T_{re} and T_{skin}= Rectal temperature and Skin temperature respectively

3.47 kJ kg^{-1} $°C^{-1}$ is the Specific heat of tissues

BW = Body weight (kg)

Data obtained during the study were analyzed statistically for mean, standard error of means and multiple comparisons using SPSS.

RESULTS AND DISCUSSION

During summer season the mean values of respiration rate in high and low yielding Sahiwal cows were 24.60± 0.96 and 23.40±1.08 breaths/min on 45th day of prepartum and the values increased to 27.60±0.46 and 25.00±1.17 breaths/min, respectively, on the day of calving. In high and low yielding Karan Fries cows the respiration rate were 23.40±1.08 and 25.00±1.17 breaths/min. on 45th day of prepartum and the values increased to 30.00±0.57 and 28.80±0.33 breaths/min,

respectively on the day of calving (Table 1). Silanikove (2000) indicated respiration rate as most accessible and easiest approach for evaluating the degree of heat stress in farm animals. Bianca (1965) showed a linear relationship among environmental temperature and respiration rate. Aggarwal and Upadhyay (1998) also reported similar high RR in Karan Fries compared to Sahiwal cows after 4 hrs of direct sun exposure. Respiration rate was higher in KF cattle compared to Sahiwal during different seasons, but the magnitude of increase in RR was higher during summer season compared to winter season (Chandra *et al.,* 2013). The mean values of respiration rate in high and low yielding Sahiwal cows increased by 12.20 and 6.80%, and 28.20 and 15.20% in Karan Fries cows, respectively on the day of calving from the pre calving values (45th day) during summer season (Table 1).The respiration rate differed significantly (P<0.01) among Sahiwal and Karan fries cows. Gaughan (2002) concluded that a decreasing respiration rate with rising ambient temperature is not always indicative of an animal coping with the hot conditions, but may indicate a failure to cope. Koubkova *et al*. (2002) found maximum respiratory rate at the beginning of exposition, and then there was a progres-sive fall, though the ambient temperature was at the constant level of 32°C. During winter season, the mean values of respiration rate of high and low yielding Sahiwal cows were 18.60±0.88 and 18.00±0.94 breaths/min on 45th day of prepartum and the values increased to 22.60±0.36 and 23.20±0.33 breaths/min on the day of calving, respectively (Table 1). In high and low yielding Karan Fries cows the respiration rate were 21.20±0.52 and 21.60±0.22 breaths/min. on 45th day of prepartum and the values increased to 25.80±0.33 and 24.20±0.33 breaths/min, respectively on the day of calving during winter season. The mean values of respiration rate of Sahiwal and KF cows increased by 21.50 and 28.80% and 21.60 and 12% in high and low yielding groups on the day of calving from the pre calving values (45th day), respectively during winter season (Table 1). The least square mean values of RR of Sahiwal and Karan Fries cows, during summer and winter season and in high and low yielding groups were 21.64±0.92 and 24.17±0.71 breaths/min; 25.26±0.99 and 20.54±0.64 breaths/min and 23.46±0.79 and 22.35±0.84 breaths/min, respectively and differed significantly (P<0.05) among them (Table 2).

During summer season the mean values of pulse rate in high and low yielding Sahiwal cows were 70.40±0.67 and 71.00±1.10 beats/min on 45th day of prepartum and the values increased to 74.20±0.52 and 75.40±0.96 beats/min, respectively on the day of calving. In high and low yielding Karan Fries cows the pulse rate were 74.00±0.40 and 70.60±1.08 beats/min on 45th day of prepartum and the values increased to 78.20±0.52 and 77.00±0.40 beats/min on the day of

Table 1. Respiration rate (breaths/min) of periparturient Sahiwal and Karan Fries cows during summer and winter season (Mean ± SEM)

Season	Summer				Winter			
Breed	Sahiwal		Karan Fries		Sahiwal		Karan Fries	
Days	HY	LY	HY	LY	HY	LY	HY	LY
-45	24.60^{b}±0.96	23.40^{b}±1.40	23.40^{b}±1.08	25.00^{b}±1.17	18.60^{b}±0.88	18.00^{b}±0.94	21.20^{b}±0.52	21.60^{b}±0.22
-30	26.00±0.40	20.60^{b}±1.28	26.20^{b}±1.78	25.00^{b}±1.10	19.20^{b}±0.59	18.60^{b}±0.83	21.80^{b}±0.66	21.00^{b}±0.49
-15	25.60±0.36	22.60^{b}±0.96	27.20^{b}±1.00	26.80^{b}±0.52	19.20^{b}±0.87	19.20^{b}±1.07	21.20^{b}±0.44	21.00^{b}±0.57
0	27.60^{a}±0.46	25.00^{a}±1.17	30.00^{a}±0.57	28.80^{a}±0.33	22.60^{a}±0.36	23.20^{a}±0.33	25.80^{a}±0.33	24.20^{a}±0.33
15	25.80^{b}±0.52	22.00^{b}±1.02	26.40^{b}±1.56	27.80^{b}±0.44	18.60^{b}±0.92	18.20^{b}±1.18	21.80^{b}±0.91	21.00^{b}±0.40
30	25.00^{b}±1.02	20.80^{b}±0.82	25.60^{b}±1.46	25.60^{b}±1.85	17.60^{b}±1.00	18.80^{b}±0.52	21.20^{b}±0.72	20.60^{b}±0.67
45	26.40^{b}±0.83	21.60^{b}±1.31	27.00^{b}±1.02	25.60^{b}±1.46	18.60^{b}±0.46	18.40^{b}±0.54	22.60^{b}±0.54	21.40^{b}±0.61

The columns with similar superscripts do not differ significantly

Table 2. Respiration rate (breaths/min) during periparturient period with respect to breed, season and yield

Effects	Days	-45	-30	-15	0	15	30	45	Mean ± SEM
Breed	Sahiwal	21.15	21.10	21.65	24.60	21.15	20.55	21.25	21.64^{a}±0.92
	Karan Fries	22.80	23.50	24.05	27.20	24.25	23.25	24.15	24.17^{b}±0.71
Season	Summer	24.10	24.45	24.55	27.85	25.50	24.25	25.15	25.26^{a}±0.99
	Winter	19.85	20.15	20.15	23.95	19.90	19.55	20.25	20.54^{b}±0.64
Group	High Yielding	21.95	23.30	23.30	26.50	23.15	22.35	23.65	23.46^{a}±0.79
	Low Yielding	22.00	21.30	22.40	25.30	22.25	21.45	21.75	22.35^{b}±0.84

Overall least square means with similar superscripts do not differ significantly from each other for particular effects

calving, respectively during summer season (Table 3). The mean values of pulse rate in high and low yielding Sahiwal cows increased by 5.30 and 6.10% and in Karan Fries, the values increased by 5.60 and 9%, respectively on the day of calving from the pre calving values (45th day), respectively during summer season. The mean values of pulse rate differed significantly (P<0.01) among both the groups of Sahiwal and Karan Fries cows. Our results are in accordance with the finding of Chandra *et al.* (2013), who observed higher PR during summer and hot humid season over the spring season. During winter season, the mean values of pulse rate in high and low yielding Sahiwal cows were 60.40±1.61 and 63.00±1.74 beats/min on 45th day of prepartum and the mean values increased to 71.6±0.46 and 71.00±0.63 beats/min, respectively on the day of calving. In high and low yielding Karan Fries cows the pulse rate were 66.40±1.34 and 63.60±1.08 beats/min on 45th day of prepartum, respectively and the values increased to 72.20±0.33 and 71.80±0.77 beats/min, respectively on the day of calving (Table 3). The mean values of pulse rate in high and low yielding Sahiwal cows increased by 18.00 and 12.60% and in Karan fries the values increased by 8.70 and 12.80%, respectively on the day of calving from the pre calving values (45th day) during winter season. The mean values of pulse rate differed significantly (P<0.01) in both the groups of Sahiwal and Karan Fries cows. The least square mean values in Sahiwal and Karan Fries; during summer and winter season and in high and low yielding groups were 67.21±1.03 and 69.90±1.02 beats/min; 72.60±0.88 and 64.62±1.17 beats/min and 68.81±0.85 and 68.40±1.20 beats/min, respectively. The least square mean values of PR were higher by 4.10% in Karan Fries cows

Table 3. Pulse rate (beats/min) of periparturient Sahiwal and Karan Fries cows during summer and winter season (Mean ± SEM)

Season	Summer				Winter			
Breed	Sahiwal		Karan Fries		Sahiwal		Karan Fries	
Days	HY	LY	HY	LY	HY	LY	HY	LY
-45	70.40^{b}±0.67	71.00^{b}±1.10	74.00^{b}±0.40	70.60^{b}±1.08	60.40^{b}±1.61	63.00^{b}±1.74	66.40^{b}±1.34	63.60^{b}±1.08
-30	69.80^{b}±0.82	71.60^{b}±1.54	75.20^{b}±0.18	73.20^{b}±1.73	60.80^{b}±1.78	63.40^{b}±1.73	66.00^{b}±1.44	63.80^{b}±1.21
-15	70.20^{b}±0.52	72.00^{b}±1.47	75.60^{b}±0.73	72.20^{b}±1.34	61.60^{b}±1.51	63.20^{b}±1.63	65.80^{b}±1.15	64.40^{b}±0.36
0	74.20^{a}±0.52	75.40^{a}±0.96	78.20^{a}±0.52	77.00^{a}±0.40	71.60^{a}±0.46	71.00^{a}±0.63	72.20^{a}±0.33	71.80^{a}±0.77
15	69.80^{b}±0.33	71.20^{b}±0.52	74.60^{b}±1.15	74.80^{b}±1.15	61.80^{b}±0.77	61.40^{b}±1.46	66.20^{b}±1.78	66.80^{b}±1.31
30	70.20^{b}±0.66	70.00^{b}±1.06	75.00^{b}±0.63	70.80^{b}±1.66	61.60^{b}±1.00	62.80^{b}±1.53	64.40^{b}±0.78	65.00^{b}±1.33
45	71.00^{b}±0.40	70.80^{b}±1.04	73.80^{b}±0.72	70.80^{b}±1.37	61.20^{b}±0.59	61.40^{b}±0.88	64.20^{b}±1.04	61.60^{b}±1.46

The columns with similar superscripts do not differ significantly

Table 4. Pulse rate (beats/min) during periparturient period with respect to breed, season and yield

Effects	Days	-45	-30	-15	0	15	30	45	Mean ± SEM
Breed	Sahiwal	66.20	66.44	66.82	73.11	66.10	66.22	66.11	67.21^{a}±1.03
	Karan Fries	68.65	69.61	69.52	74.81	70.60	68.81	67.62	69.90^{b}±1.02
Season	Summer	71.50	72.50	72.51	76.23	72.61	71.50	71.61	72.60^{a}±0.88
	Winter	63.35	63.52	63.83	71.71	64.12	63.51	62.10	64.62^{b}±1.17
Group	High Yielding	67.80	68.01	68.31	74.13	68.11	67.80	67.60	68.81^{a}±0.85
	Low Yielding	67.05	68.05	68.00	73.81	68.63	67.20	66.21	68.40^{a}±1.20

Overall least square means with similar superscripts do not differ significantly from each other for particular effects

compared to Sahiwal cows, 12.30% during summer season compared to winter season and 0.59% in high yielding compared to low yielding groups (Table 4).

During summer season the mean values of rectal temperature in high and low yielding Sahiwal cows were 38.80±0.10 and 38.80±0.06°C on 45th day of prepartum and the values increased to 39.40±0.10 and 39.40±0.09°C, respectively on the day of calving. Whereas in high and low yielding Karan Fries cows the rectal temperature were 39.40±0.09 and 39.40±0.13°C on 45th day of prepartum and the values increased to 39.90±0.02 and 39.80±0.03°C, respectively on the day of calving (Table 5). During the present study higher RT was observed during summer compared to winter season in both the breeds of cattle. The magnitude of increase in RT was higher in KF than Sahiwal cows. Similar observations have also been reported by Chandra *et al.* (2013) and Kumar and Singh (2018) i.e. higher magnitude of increase in rectal temperature in Karan Fries cows during summer seasons compared to winter among different breeds of cattle. Bernabucci *et al.* (2002) also reported similar effects of hot season in transition dairy cows. Soly and Singh (2001) reported an increase in rectal temperature as the ambient temperature increased in both the group of animals maintained inside and outside the shelter. Silanikove (2000) stated that rectal temperature is an indicator of thermal balance and may be used as an effective tool to quantify the harshness of the thermal environment. Amakiri and Funsho (1979) observed a diurnal rhythm of core body temperature in domestic animals which depends mainly on the climatic conditions. The mean values of rectal temperature in high and low yielding Sahiwal cows increased by 1.50 and 1.54% and in Karan Fries the values increased by 1.20 and 1.01%, respectively on the day of calving from the pre calving

Table 5. Rectal temperature (°C) of periparturient Sahiwal and Karan Fries cows during summer and winter season (Mean ± SEM)

Season	Summer				Winter			
Breed	Sahiwal		Karan Fries		Sahiwal		Karan Fries	
Days	HY	LY	HY	LY	HY	LY	HY	LY
-45	70.40^{b}±0.67	71.00^{b}±1.10	74.00^{b}±0.40	70.60^{b}±1.08	60.40^{b}±1.61	63.00^{b}±1.74	66.40^{b}±1.34	63.60^{b}±1.08
-30	69.80^{b}±0.82	71.60^{b}±1.54	75.20^{b}±0.18	73.20^{b}±1.73	60.80^{b}±1.78	63.40^{b}±1.73	66.00^{b}±1.44	63.80^{b}±1.21
-15	70.20^{b}±0.52	72.00^{b}±1.47	75.60^{b}±0.73	72.20^{b}±1.34	61.60^{b}±1.51	63.20^{b}±1.63	65.80^{b}±1.15	64.40^{b}±0.36
0	74.20^{a}±0.52	75.40^{a}±0.96	78.20^{a}±0.52	77.00^{a}±0.40	71.60^{a}±0.46	71.00^{a}±0.63	72.20^{a}±0.33	71.80^{a}±0.77
15	69.80^{b}±0.33	71.20^{b}±0.52	74.60^{b}±1.15	74.80^{b}±1.15	61.80^{b}±0.77	61.40^{b}±1.46	66.20^{b}±1.78	66.80^{b}±1.31
30	70.20^{b}±0.66	70.00^{b}±1.06	75.00^{b}±0.63	70.80^{b}±1.66	61.60^{b}±1.00	62.80^{b}±1.53	64.40^{b}±0.78	65.00^{b}±1.33
45	71.00^{b}±0.40	70.80^{b}±1.04	73.80^{b}±0.72	70.80^{b}±1.37	61.20^{b}±0.59	61.40^{b}±0.88	64.20^{b}±1.04	61.60^{b}±1.46

The columns with similar superscripts do not differ significantly

values during summer season (Table 5). The overall mean values of rectal temperature were significantly (P<0.05) different in both the groups of Sahiwal and Karan Fries cows. The results of the present study corroborate well with the findings of Robertshaw (1985) who found significantly higher diurnal variation in rectal temperature in open environment compared to under shade, irrespective of seasons. Zhang *et al.* (1994) and Mader *et al.* (1999) also reported the similar trend in RT of the animals exposed to natural environmental conditions. During winter season, the mean values of rectal temperature in high and low yielding Sahiwal cows were 37.90±0.09 and 38.20±0.02°C on 45th day of prepartum and the values increased to 38.70±0.09 and 38.80±0.04°C, respectively on the day of calving. Whereas in high and low yielding Karan Fries cows, the rectal temperature were 38.70±0.06 and 38.50±0.07 °C on 45th day of prepartum and the values increased 39.10±0.05 and 39.20±0.02°C on the day of calving, respectively during winter season. Zhang *et al.* (1994) found a circadian rhythm in rectal temperature of beef calves exposed to hot and cold stress conditions. The mean values of rectal temperature in high and low yielding Sahiwal cows increased by 2.10 and 1.50% and in Karan Fries the values increased by 1.03 and 1.80%, respectively on the day of calving from the pre calving values (45th day) during winter season. The mean values of rectal temperature were significantly (P<0.01) higher in high yielding groups of Sahiwal and Karan Fries cows as compared to low yielding groups of both the breeds. The least square mean values in Sahiwal and Karan Fries cows; summer and winter season and in high and low yielding cows were 38.60±0.05 and 39.10±0.07°C; 39.30±0.09 and 38.40±0.03°C and 38.80±0.10 and 38.80±0.09°C, respectively (Table 6). The least square mean values of RT were higher by 1% in Karan Fries cows and 2.20% in summer season compared to Sahiwal cows and winter season respectively.

During summer season, the mean values of skin temperature in high and low yielding Sahiwal cows were 38.00±0.66 and 37.30±0.32°C on 45th day of prepartum and the values increased to 38.80±0.30 and 38.70±0.13°C, respectively on the day of calving. In high and low yielding Karan Fries cows the skin temperature were 38.10±0.25 and 38.50±0.14°C on 45th day of prepartum and the mean values of skin temperature increased to 39.00±0.18 and 38.90±0.08°C, respectively on the day of calving (Table 7). Results of the present study are in agreement with that of Chandra *et al.* (2013) who reported the significantly (P<0.05) higher skin temperature in Karan Fries cows among different breeds of cattle during different seasons, but the mean values of ST (38.5°C) was higher during summer season. Somagond *et al.* (2019) reported elevated skin temperature in response to increased environmental temperature and humidity in buffaloes. Ashour (1993) found an increase in skin temperature due to high ambient temperature that leads to increased heat storage in the body of calves. The mean values of skin temperature in high and low yielder Sahiwal cows increased by 2.10 and 3.70% and in Karan Fries the values increased by 2.30 and 1.03%, respectively on the day of calving from the pre-calving values (45th day) during summer season. The overall mean values of skin temperature were significantly (P<0.05) different among

Table 6. Rectal temperature (°C) during periparturient period with respect to breed, season and yield

Effects	Days	-45	-30	-15	0	15	30	45	Mean ± SEM
Breed	Sahiwal	38.40	38.50	38.50	39.10	38.60	38.70	38.50	38.60^{a}±0.5
	Karan Fries	39.00	39.00	39.00	39.50	39.10	39.00	38.80	39.10^{b}±0.07
Season	Summer	39.10	39.10	39.20	39.60	39.40	39.40	39.00	39.30^{a}±0.09
	Winter	38.30	38.40	38.30	39.00	38.20	38.30	38.30	38.40^{b}±0.03
Yield	High Yielding	38.70	38.70	38.80	39.30	38.80	38.80	38.70	38.80^{a}±0.10
	Low Yielding	38.70	38.70	38.80	39.30	38.80	38.80	38.60	38.80^{a}±0.09

Overall least square means with similar superscripts do not differ significantly from each other for particular effects

Table 7. Skin temperature (°C) of periparturient Sahiwal and Karan Fries cows during summer and winter season (Mean ± SEM)

Season	Summer				Winter			
Breed	Sahiwal		Karan Fries		Sahiwal		Karan Fries	
Days	HY	LY	HY	LY	HY	LY	HY	LY
-45	38.00^{b}±0.66	37.30^{b}±0.32	38.10^{b}±0.25	38.50^{b}±0.14	20.10^{b}±0.44	20.70^{b}±0.37	21.90^{b}±0.23	21.90^{b}±0.51
-30	38.10^{b}±0.32	37.30^{b}±0.71	37.80^{b}±0.22	37.80^{b}±0.32	21.30^{b}±0.47	20.50^{b}±0.24	22.10^{b}±0.15	21.50^{b}±0.64
-15	38.50^{b}±0.40	37.80^{b}±0.30	38.70^{b}±0.15	38.30^{b}±0.17	20.90^{b}±0.53	21.90^{b}±0.46	22.70^{b}±0.32	22.50^{b}±0.52
0	38.80^{a}±0.30	38.70^{a}±0.13	39.00^{a}±0.18	38.90^{a}±0.08	23.70^{a}±0.32	22.90^{a}±0.70	24.90^{a}±0.44	24.10^{a}±0.25
15	38.60^{b}±0.28	38.40^{b}±0.10	38.40^{b}±0.16	38.50^{b}±0.15	21.30^{b}±0.54	20.80^{b}±0.30	22.10^{b}±0.26	21.50^{b}±0.57
30	38.00^{b}±0.93	38.30^{b}±0.13	38.40^{b}±0.22	38.40^{b}±0.51	20.90^{b}±0.48	20.30^{b}±0.28	21.00^{b}±0.53	21.70^{b}±0.18
45	37.60^{b}±0.57	37.60^{b}±0.14	38.20^{b}±0.33	37.70^{b}±0.05	20.90^{b}±0.24	20.80^{b}±0.36	22.40^{b}±0.28	21.60^{b}±0.20

The columns with similar superscripts do not differ significantly

high and low yielding Sahiwal and Karan Fries cows. Singh and Upadhyay (2009) reported increase in skin temperature with the increase in ambient temperature. Similar findings have been reported by Sailo *et al.* (2017) in crossbred dairy cattle and Dandage (2009) in Sahiwal and Karan Fries cattle. During winter season the mean values of skin temperature in high and low yielding Sahiwal cows were 20.10±0.44 and 20.70±0.37°C on 45th day of prepartum and the values increased to 23.70±0.32 and 22.90±0.70°C, respectively on the day of calving (Table 7). In high and low yielding Karan Fries cows the skin temperature were 21.90±0.23 and 21.90±0.51°C on 45th day of prepartum and the values increased to 24.90±0.44 and 24.10±0.25°C on the day of calving, respectively during winter season (Table 7). The mean values of skin temperature in high and low yielding Sahiwal cows increased by 17.90 and 10.60% and in Karan Fries the values increased to 13.60 and 10.10%, respectively on the day of calving from the pre calving values (45th day) during winter season. The overall least square mean values in Sahiwal and Karan Fries; during summer and winter season and in high and low yielding groups were 29.60±0.39 and 30.30±0.29°C; 38.20±0.29 and 21.70±0.39°C and 30.10±0.36 and 29.90±0.32°C, respectively (Table 8). The overall least square means of ST increased by 2.30% in Karan Fries compared to Sahiwal cows and 76% during summer than winter season (Table 8).

During summer season the mean values of heat storage in high and low yielding Sahiwal cows were 2206.90±33.0 and 2271.20±37.2 kJ/h on 45th day of prepartum and the mean values increased to 2344.30±21.8 and 2314.10±17.5 kJ/h, respectively on the day of calving. In high and low yielding Karan Fries cows the heat storage were 2576.60±79.40 and 2401.80±56.0 kJ/h on 45th day of prepartum and the

Table 8. Skin temperature (°C) during periparturient period with respect to breed, season and yield

Effects	Days	-45	-30	-15	0	15	30	45	Mean ± SEM
Breed	Sahiwal	29.01	29.30	29.70	31.00	29.80	29.30	29.20	29.60^{a}±0.39
	Karan Fries	30.12	29.80	30.60	31.70	30.20	29.90	30.00	30.30^{b}±0.29
Season	Summer	38.00	37.80	38.30	38.90	38.50	38.30	37.80	38.20^{a}±0.29
	Winter	21.20	21.30	22.00	23.90	21.40	21.00	21.40	21.70^{b}±0.39
Yield	High Yielding	29.50	29.80	30.20	31.60	30.10	29.60	29.80	30.10^{a}±0.36
	Low Yielding	29.60	29.30	30.10	31.10	29.80	29.70	29.40	29.90^{a}±0.32

Overall least square means with similar superscripts do not differ significantly from each other for particular effects

Table 9. Heat storage (kJ/h) in periparturient Sahiwal and Karan Fries cows during summer and winter season (Mean ± SEM)

Season	Summer				Winter			
Breed	Sahiwal		Karan Fries		Sahiwal		Karan Fries	
Days	HY	LY	HY	LY	HY	LY	HY	LY
-45	2206.90^{b}± 33.0	2271.20^{b}± 37.2	2575.60^{b}± 79.4	2401.80^{b}± 56.0	1794.80^{b}± 37.0	1774.70^{b}± 35.0	2071.30^{b}± 70.5	1924.20^{b}± 48.7
-30	2261.80^{ba}± 32.5	2283.90^{ba}± 46	2626.70^{ba}± 72	2447.00^{ba}± 47	1814.50^{ba}± 31	1818.70^{ba}± 27	2100.00^{ba}± 67	1962.90^{ba}± 50.8
-15	2318.90^{a}± 22.3	2326.20^{a}± 30.5	2684.40^{a}± 75.2	2494.30^{a}± 55.3	1850.70^{a}± 16.7	1855.90^{a}± 29.2	2131.60^{a}± 8.1	1976.60^{a}± 42.8
0	2344.30^{a}± 21.8	2314.10^{a}± 17.5	2748.80^{a}± 67.5	2532.80^{a}± 53.7	1841.90^{a}± 26.3	1854.20^{a}± 18.8	2197.60^{a}± 54.5	2040.60^{a}± 49.6
15	2209.80^{c}± 22.1	2201.10^{c}± 16.9	2469.10^{c}± 258.4	2249.10^{c}± 41.3	1753.90^{c}± 23.0	1770.10^{c}± 29.1	1922.70^{c}± 45.3	1750.90^{c}± 37.4
30	2180.00^{c}± 15.1	2163.50^{c}± 12.8	2416.70^{c}± 58.4	2212.40^{c}± 22.2	1745.50^{c}± 23.9	1762.70^{c}± 29.6	1893.30^{c}± 45.6	1723.20^{c}± 39.4
45	2158.50^{c}± 36.1	2163.40^{c}± 19.0	2383.00^{c}± 58.5	2166.50^{c}± 33.1	1737.80^{c}± 24.1	1760.70^{c}± 28.6	1878.40^{c}± 43.8	1741.10^{c}± 30.7

The columns with similar superscripts do not differ significantly

mean values increased to 2748.80±67.50 and 2532.80±55.30 kJ/h, respectively on the day of calving during summer season. Finch, (1985) reported maximum heat storage in Brahman x Hereford-Shorthorn and Shorthorn cattle, when air temperature exceeded rectal temperature. The mean values of heat storage in high and low yielding Sahiwal cows increased by 6.20 and 1.80% and in Karan Fries the values increased by 6.70 and 5.40%, respectively on the day of calving from the pre calving values (45th day) during summer season (Table 9). The mean values of heat storage were significantly (P<0.01) different in high and low yielding groups of Sahiwal and Karan Fries cows during summer season compared to winter season. The results of the present study are in agreement with that of Finch *et al.* (1984) who showed linear increase in heat storage as the intensity of solar radiation increased. During winter season the mean values of heat storage in high and low yielding Sahiwal cows were 1794.80 ±37.00 and 1774.70±35.00 kJ/h on 45th day of prepartum and the values increased to1841.90±26.30 and 1854.20±18.80 kJ/h on the day of calving, respectively. In high and low yielding Karan Fries cows the heat storage were 2071.30±35.00 and 1924.20±48.70

Table 10. Heat storage (kJ/h) during periparturient period with respect to breed, season and groups

Effects	Days	-45	-30	-15	0	15	30	45	Mean ± SEM
Breed	Sahiwal	2011.90	2044.70	2087.90	2088.60	1983.70	1962.90	1955.10	2019.30^{a}±26.52
	Karan Fries	2243.20	2284.10	2321.70	2380.00	2098.00	2061.40	2042.20	2204.40^{b}±52.30
Season	Summer	2363.90	2404.90	2456.00	2485.00	2282.30	2243.10	2217.90	2350.40^{a}±40.80
	Winter	1891.20	1924.00	1953.70	1983.60	1799.40	1781.20	1779.50	1873.20^{b}±38.02
Group	High Yielding	2162.20	2200.70	2246.40	2283.10	2088.90	2058.90	2039.40	2154.20^{a}±43.59
	Low Yielding	2093.00	2128.10	2163.30	2185.40	1992.80	1965.40	1957.90	2069.40^{b}±35.24

Overall least square means with similar superscripts do not differ significantly from each other for particular effects

kJ/h on 45th day of prepartum and the values increased to 24.90±0.44 and 24.10±0.25 kJ/h, respectively on the day of calving (Table 9). The mean values of heat storage in high and low yielding Sahiwal cows increased by 2.60 and 4.40% and in Karan Fries the values increased by 6.10 and 6.04%, respectively on the day of calving from the pre calving values during winter season. The mean values of heat storage were significantly (P<0.01) different among high and low yielding groups of Sahiwal and Karan Fries cows (Table 10). The overall least square mean values in Sahiwal and Karan Fries; summer and winter season and high and low yielding groups were 2019.30±26.52 and 2204.40±52.30 kj/h; 2350.40±40.80 and 1873.20±38.02 kJ/h and 2154.20±43.59 and 2069.40±35.24 kJ/h, respectively (Table 10). The overall least square mean values increased by 9.1% in Karan Fries cows compared to Sahiwal cows. The heat storage was higher by 25.40% during summer season compared to winter season whereas it was 4.10% higher in high yielding groups than low yielding groups of both the breeds (Table 10).

CONCLUSIONS

The rise in ambient temperature influenced physiological reactions (respiration rate, pulse rate, rectal temperature and skin temperature) at different magnitude in both the breeds. The physiological responses and heat storage were higher in KF compared to Sahiwal cows and during summer than winter season. The magnitude of increase in physiological reactions and heat storage was found to be higher in high yielders ascompared to low yielders during both the season. The results indicating that KF and high yielders are sensitive to heat stress. Therefore, KF cows / high yielder groups of both breed needs to be provided better microenvironment and improved managemental practices for normal physiology and productive performances.

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