EFFECT OF HOT HUMID AND WINTER SEASON ON CIRCULATORY CATECHOLAMINE, MILK COMPOSITION AND PHYSIOLOGICAL RESPONSES IN COWS

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ABSTRACT

Two sets of experiments were carried out on lactating crossbred cows during hot humid (HH) (temp. 24-34°C, RH 98%) and winter season (temp. 1.97-19.90°C, RH 60-70%). The cows were managed in a loose housing system and was producing milk yield of 9.00 to 10.11 kg/d. Samples of milk and blood were collected and the physiological responses were recorded at weekly interval in the morning and afternoon (interval). Maximum, minimum and dry and wet bulb temperatures were recorded in both the seasons. Temperature humidity index (THI) was significantly higher in hot-humid season (p < 0.01) than the winter season. Higher THI score during HH season resulted in increased cortisol level and physiological responses (ST, RT, RR, and PR) was greater (p < 0.01) in comparison to winter season. However, epinephrine (E), nor-epinephrine (NE), glucose, NEFA, and milk composition was not influenced. Low THI score in winter season significantly (p < 0.01) decreased plasma E, NEFA and increased NE concentration however plasma cortisol, milk composition and physiological responses were unaffected. Plasma E concentration was higher (p < 0.01) in HH season while NE was more (p < 0.01) in winter season. Plasma glucose concentration was significantly higher (p < 0.01) in morning then in the afternoon in winter season but was non-significant in HH season. The diurnal variation in morning and evening PR, RR, RT and ST was significant (p < 0.01) in HH season and varied non-significantly in winter. It was concluded that increase or decrease in THI score significantly influence plasma NE and cortisol levels and are reliable marker of heat and cold stress in crossbred cows. Further THI score (> 75) adversely influence physiological responses and milk composition in HH season.

Keywords: Catecholamine’s, physiological responses, THI, season, cows, milk composition

No. of Figures: 5 No. of Tables: 1 No. of References: 24
INTRODUCTION

Low and high ambient temperature adversely affect milk production through altered metabolic hormone profile and physiological responses in cows and buffaloes that lead to economic losses to the dairy farmers (Aggarwal and Singh, 2006; 2007; 2009). Crossbred cattle perform better at 15-25°C ambient temperature and milk production starts declining beyond 30°C. It has been recognized that environmental stressors activate hypothalamo-pituitary-adrenal axis (HPA) and sympatho-adrenal medullary axis which results in increased plasma cortisol and catecholamine’s secretion (Minton, 1994). Catecholamines are called as hormones of acute stress and defined as a fight (nor-epinephrine) or flight/anxiety hormone (epinephrine). When stress is prolonged, the hypothalamus is activated resulting in final release of cortisol hormone from the adrenal cortex. Lactating animals exhibit increased respiration rate and pulse rate and decrease in milk yield and feed intake during summer season (Aggarwal and Singh, 2006). Measurements of stress hormone (catecholamine and cortisol) may provide valuable information on the extent of response of animals to the climatic stress in conjunction with physiological responses. Temperature humidity index score is widely used to measure the combined effect of high ambient temperature and humidity stress on animals. The information on THI score on plasma catecholamines, cortisol and physiological responses during summer and winter seasons is very scanty (El-Noughtyet et al., 1989). In the present study effect of season on plasma hormones, physiological responses and milk composition in relation to THI was investigated in crossbred cows.

MATERIALS AND METHOD

Management of Experimental Animals: Eleven apparently healthy lactating crossbred cows (2-3 parity, milk yield-9.00 kg/d, 150±8 daySOL) in hot humid season (August-September) and similar number of cows (2-3 parity, milk yield-10.01 kg/d, 156±3 day SOL) in winter season (December-January) was selected from the institute herd. The cows were managed in a loose housing system with brick floor for an experiment period of six week in each season. Minimum and maximum, dry and wet bulb temperatures were recorded daily and THI score was calculated (McDowells, 1972). Animals were offered ad lib green fodder berseem (trifoliumalexandrium) / maize (Zea maize) and drinking water. The concentrate mixture was given based on milk yield at the time of morning. Cows were milked in morning, noon and evening by milking machine. Aliquots of milk samples were analyzed for fat, protein, lactose, solid not fat, SNF (lactoscan, Mega lactose) and somatic cell counts, SCC (Singh and Ludri, 2001). Jugular blood samples were collected in heparinized vacutainer tubes at weekly intervals in the morning (8.00 A.M) and afternoon (2:30 P.M). Physiological responses viz., ST and RT was recorded with non-contact tele-thermometer (Model Raynger ST2L) and clinical thermometer, while RR and PR was recorded by observing flank movement and pulsation of coccygeal artery. Plasma epinephrine (E), nor-epinephrine (NE) and cortisol levels were measured by RIA method/EIA kits (Singh and Ludri, 1999). The radio-iodination of epinephrine and non-epinephrine was carried out by Iodine 125 in a column prepared with sephadex G 75-120. The inter-assay and intra-assay coefficient of variation for E, NE and cortisol was 7.91 &, 12.5, 9.90 & 13.5 and 10.12 & 12.32 %, respectively. The statistical analysis of data was carried out by Sigma Stat software package and the correlations among the
parameters were found out (Snedecor and Cochran, 1980).

RESULTS & DISCUSSION

THI score was higher (P<0.05) in the afternoon in comparison to morning in summer season and was normal (72±2) in afternoon of winter season (Fig.1). Mean maximum and minimum ambient temperatures in hot-humid season and winter season were 32.00±0.70 and 25.53±0.70°C and 5.69±0.80 and 17.80±0.65°C, respectively. Higher THI score significantly (p<0.01) increased plasma cortisol and NEFA levels during HH season. Low THI score in winter season increased (p<0.01) plasma NE level leading to more plasma NEFA concentration. Plasma cortisol was higher (P<0.01) at lower THI score than at higher THI score (figures 4, 5). Plasma E, NE and cortisol levels were in normal range with a THI score of 68-72.

Plasma E concentration was more (p<0.01) in morning than in afternoon in hot-humid season in comparison to winter season. The variation in E was also reflected by significant (p<0.01) interaction of season × week. NE concentration was lower (P<0.01) in hot-humid season in comparison to winter season. NE varied between week, between interval, season × week and season × interval (P<0.01) in winter. The morning and evening levels of E, NE and glucose varied non-significantly in summer season, but cortisol was more (p<0.01) in the afternoon than in the morning hour. Contrary to this E, NE cortisol and glucose level varied (p<0.05) in samples collected in the morning and afternoon of winter season. Diurnal variation indicated higher plasma NE and cortisol level (p<0.05) in the morning than the afternoon in winter season. Contrary to this higher level (p<0.05) of E was observed in the afternoon of summer season (Fig.2). Comparison of two seasons revealed higher plasma E level (P<0.05) in humid season and more NE level (p<0.01) in winter season (Fig.3). Epinephrine concentration varied between 0.11±0.20 to 0.33±0.01 ng/ml in the morning and 0.12±0.02 to 0.30±0.03 ng/ml in the afternoon samples. Plasma NE concentration varied between season (P<0.01) and between interval (p<0.01). NE level ranged between 0.16±0.01 to 0.56±0.09 ng/ml in the morning and 0.15±0.2 to 0.62±0.09 ng/ml in the afternoon during different week of experiment. Plasma cortisol varied significantly between week, between season and interval of sampling (p<0.01) in hot-humid and winter season. Cortisol level was higher in the morning than the evening in winter season but was higher (p<0.01) in the afternoon in HH season (Fig.4).

The diurnal variation in plasma glucose concentration in HH season was non-significant but varied (P<0.01) in morning and afternoon of winter season. NEFA concentration was similar in the morning and afternoon of winter season, however between week (p<0.01) and interaction of week × interval was significant (p<0.05) in HH season. During winter season NEFA level was lower (p<0.05) in comparison to HH season.

Physiological responses: ST varied (p<0.01) between season, between week and between interval. The diurnal variation in ST was significant (p<0.01) in both the seasons of experiment. RT, RR and PR also varied significantly (p<0.01) between season and between week of experiment in HH season, however these parameters were non-significant in winter season. PR varied significantly (p<0.01) between interval and was less (p<0.01) in winter season in comparison to HH season;

Milk yield and composition: Milk yield of lactating cows varied non-significantly in different week of experiment in both the seasons as cows were selected based on milk yield (Table 1). Milk fat varied significantly (p<0.01) between week of experiment. SNF content varied (p<0.01) between season and the overall
SNF was 9.62±0.16 %. Lactose significantly varied between week (p<0.01) and between season while milk protein varied non-significantly. Milk SCC decreased (p<0.01) from 3rd to 6th week of experiment in HH season and ranged between 1.10±0.01 to 1.40±0.06×10^5 cells/ml. Milk SCC was higher (p<0.01) in HH season in comparison to winter season.
**Table 1**: Diurnal variation in hormones, metabolites, physiological responses in lactating cows during summer and winter season.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Summer (°C-°C)</th>
<th>Winter (°C-°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Morning</td>
<td>Afternoon</td>
</tr>
<tr>
<td>Cortisol (ng/ml)</td>
<td>3.34±0.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.23±0.17&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Epinephrine (ng/ml)</td>
<td>0.24±0.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.21±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Norepinephrine (ng/ml)</td>
<td>0.30±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.36±0.05&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Plasma glucose (mg%)</td>
<td>53.56±0.55</td>
<td>51.96±0.58</td>
</tr>
<tr>
<td>NEFA (mM/ml)</td>
<td>0.31±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.34±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Milk Yield</td>
<td>9.00±0.67</td>
<td>10.11±1.09</td>
</tr>
<tr>
<td>Fat %</td>
<td>4.20±0.17</td>
<td>4.13±0.10</td>
</tr>
<tr>
<td>SNF %</td>
<td>9.62±0.16</td>
<td>9.87±0.09</td>
</tr>
<tr>
<td>Protein %</td>
<td>3.32±0.13</td>
<td>3.47±0.07</td>
</tr>
<tr>
<td>Lactose %</td>
<td>4.32±0.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.97±0.11&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>SCC (x 10&lt;sup&gt;5&lt;/sup&gt;cells/ml)</td>
<td>1.28±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.95±0.21&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Physiological responses

<table>
<thead>
<tr>
<th></th>
<th>Skin temperature (°F)</th>
<th>Rectal temperature (°F)</th>
<th>Respiration rate (Beats/min)</th>
<th>Pulse Rate (breath/min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>85.83±0.73</td>
<td>99.05±0.27</td>
<td>34.83±1.32</td>
<td>69.67±0.90</td>
</tr>
<tr>
<td></td>
<td>89.95±0.70</td>
<td>100.88±0.24</td>
<td>38.00±1.62</td>
<td>72.33±0.70</td>
</tr>
<tr>
<td></td>
<td>84.35±0.83</td>
<td>100.55±0.20</td>
<td>29.00±0.80</td>
<td>69.50±0.45</td>
</tr>
<tr>
<td></td>
<td>89.86±0.80</td>
<td>100.84±0.38</td>
<td>29.17±0.13</td>
<td>70.00±0.51</td>
</tr>
</tbody>
</table>

The values with different superscript differ (p<0.05) in a row.

Correlations
During HH season plasma NE level was positively correlated with the maximum temperature (P<0.01) and minimum temperature (P<0.01). THI was positively correlated with cortisol and negatively with glucose (P<0.05). No correlation was found between THI and epinephrine and plasma NEFA concentration. Maximum temperature was positively correlated with plasma NEFA (P<0.01), SCC (P<0.05) and skin temperature (P<0.01). SCC was negatively correlated with plasma NEFA (P<0.01). Cortisol and E concentrations non-significantly varied during hot-humid season (higher THI score) to prevent rise in metabolic heat production (Aggarwal and Singh, 2006; Kamal et al., 1989) and corroborates the earlier report (Habeebet al., 1992) that a non-significant change in plasma cortisol reduces thermogenic effect of cortisolin summer (Dhamiet al., 2006). Cortisol concentrations in the present study was lower than the previously reported level in cattle due to effect of season (Whisnant et al., 1985; Faltys et al., 1987; Lefcourt et al., 1993; Habeebet al., 2000). The increased NE concentration than the E in hot-humid season and in morning samples of winter seasons suggest that physiological reaction of Karan Fries cows to high or low THI “here we called as stressors” control the body functioning as “Fight hormone”. The rise in E in afternoon in HH season is supposed to prepare the body for physical exertion by increasing respiration rate, blood glucose and NEFA concentration. However such changes were not observed in winter season due to lower E levels. Kalandakanand et al. (2004) reported NE and E concentrations of 3.89 ± 0.51 nM and 0.82±0.12 nM in dairy cows. Relatively few studies have measured catecholamine in farm animals because of high cost of assay, practical difficulties in collection and measurement of catecholamine, their low concentration and short half-life (1-2 min) in plasma (Frohli and Blum, 1988; Hjemdahl, 1993). Nessim, (2004) reported significant increases in plasma glucose concentration during acute heat stress exposure while a decrease in glucose was reported by Ronchiet al.(1995). The increase in glucose concentration in winter morning observed in this study also corroborates similar findings by Itoh et al.(1997) and could be attributed to elevated NE associated with non-shivering thermogenesis. Plasma NEFA and glucose are the indicators of energy status. Holteret al. (1996) reported that minimum daily THI was more closely correlated with DMI than maximum THI in Jersey cows. The higher milk SCC in HH season in comparison to winter season was due to unfavorable climatic condition for the cows and favorable climate for the pathogen (Singh and Ludri, 2001). Milk SCC is influenced by factors like stage of lactation, parity, and management practices in cows, buffaloes and goats (Marcus and Dale, 1994). The significant changes in sympathetic physiological responses (ST, RT, RR and PR) and catecholamine levels are indicative of more stress on cows due to higher THI score in HH season (Broom and Johnson, 1993), however intense sympathetic responses at low ambient temperateresulted in higher NE than the E or cortisol levels in this study. The significant
diurnal variation in ST of cows in both the seasons is also indicative of more climatic stress in HH and winter season as cows were maintained in a loose housing system and skin is the most sensitive part of the body to be affected by the change of ambient temperature. It was clearly elucidated that both increase and decrease of THI score from the normal value (THI= 72) significantly influence plasma NE, E and cortisol levels during HH and winter season. Further THI score >75 significantly increased physiological responses and altered milk composition in HH season.

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