INFLUENCE OF HOT-DRY AND HOT-HUMID CONDITIONS ON HEMATOLOGICAL AND BIOCHEMICAL PROFILE OF SURTI BUFFALOES (*BUBALIS BUBALIS*) UNDER DIFFERENT COOLING SYSTEM

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ABSTRACT

Present study was conducted on twenty four Surti buffaloes in their mid lactation to study the change in heamato-biochemical profile under different cooling system in hot-dry and hot-humid conditions.These animals were divided randomly into four groups based on body cooling systems provided i.e., without body cooling system (control, T_1), fogging (T_2), showering (T_3), and wallowing (T_4). Study was conducted in two phases with hot-dry (April-May, 2012) and hot-humid (June-July, 2012) climate.

Overall result of treatments showed that the afternoon percent THI was significantly ($P<0.05$) lower under showering (T_3-80.65±0.17) than other treatments (T_1-83.31±0.17, T_2-81.94±0.15 and T_4-83.31±0.17).Overall results showed that the mean value of Hb in gm % (T_1-10.18±0.05 Vs. T_2-10.87±0.08, T_3- 11.54±0.05 and T_4-11.53±0.05), RBC count in million/mm^3 (T_1-6.54±0.04 Vs. T_2-6.99±0.04, T_3-7.19±0.04 and T_4-7.08±0.04) and WBC count in cells/µl (T_1-15.56±0.08 Vs. T_2-16.62±0.08, T_3-16.74±0.07 and T_4-16.83±0.08) of Surti buffaloes was significantly lower in control group (T_1) than cooling treatments (T_2, T_3 and T_4). The mean value of PCV (%) during hot-humid condition was significantly ($P<0.05$) higher as compared to hot-dry condition in their respective treatments. Overall mean value of blood glucose in mg/dl (T_1-61.48±0.55, T_2-65.26±0.76, T_3-71.99±0.74 and T_4-67.42±0 .65), total protein in gm/dl (T_1-7.74±0.05, T_2-8.08±0.07, T_3-8.15±0.09 and T_4-8.44±0.07), BUN in mg/dl (T_1-33.64±0.35, T_2-35.23±0.41, T_3-35.56±0.45 and T_4-35.02±0.35), total cholesterol in mg/dl (T_1-57.49±0.82, T_2-71.26±1.25, T_3-82.64±1.16 and T_4-89.26±1.14) and triglyceride in mg/dl (T_1-31.76±0.68, T_2-34.02±0.65, T_3-35.80±0.66 and T_4-34.44±0.67) was significantly ($P<0.05$) lower in control (T_1) than cooling groups (T_2, T_3 and T_4).However, total protein in g/dl did not differed significantly between T_1 and T_2. Overall albumin concentration was significantly ($P<0.05$) higher under control (T_1-3.99±0.04) than cooling systems (T_2-3.38±0.05, T_3-2.96±0.06 and T_4-3.13±0.07). No definite trend was observed for various blood metabolites between hot-dry and hot-humid conditions.

Keywords: hot-dry, hot-humid, hematological, biochemical, Surti buffalo

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INTRODUCTION

The riverine buffalo or the milking buffalo is heavier and is found more in India and Pakistan. The riverine buffaloes are adaptable to a large range of environmental conditions. Buffaloes are more prone to heat stress when exposed to direct radiation and denied access to a wallow or cooling showering (Frisch and Vercoe, 1979). In many countries, cooling treatment have been tried to keep the animals in comfort during hot condition of the year with varying results. Evaporative cooling through fans, foggings, sprinklers and splashing of water has become a common practice to improve milk production (Avendano-Reyes *et al*., 2006 and Fulsoundar *et al*., 1985), feed utilization (Kamboj *et al*., 2000; Davis and Mader, 2002; West, 2003) and to decrease rectal temperature, pulse and respiration rate (Marai *et al*., 1995; Davis *et al*., 2002; Singh *et al*., 2005; Aggarwal and Singh, 2008; Rahangdale *et al*., 2010) in dairy animals. Surti is reputed breed of buffalo in south and middle Gujarat state; reared by most of the small farmers for milch purpose. Climatic conditions in south Gujarat are such that temperature is high with high relative humidity. South Gujarat falls in agro-ecological zone sub region 19.1 (coastal ecosystem). This region is characterized by fairly warm summer, mild winter and warm humid monsoon with an average rainfall of 1500 mm. In this agro-climatic zone systematic evaporating cooling system was not adopted in existing housing conditions in field. No systematic work has been done from adaptability point of view on this breed. Heat production and accumulation coupled with compromised cooling capabilities because of environmental conditions, causes heat load in buffaloes to the point that body temperature rises, intake declines and ultimately the productivity declines. Keeping in view the above researchable issues in consideration, the present study was under taken to study the effect of different cooling systems on physio-biochemical parameters in lactating Surti buffaloes during hot-dry and hot-humid condition.

MATERIALS AND METHODS

Twenty four Surti buffaloes in their mid lactation, maintained at Livestock Research Station, NAU, Navsari were selected for study. These animals were divided randomly into four groups based on body cooling systems provided i.e., without body cooling system (control, T_1), fogging (T_2), showering (T_3), and wallowing (T_4). Study was conducted in two phases with hot-dry (April-May, 2012) and hot-humid (June-July, 2012) climate. The fogging system was automatically controlled by an electronic timer and run for 3 min after an interval of every 2 minutes (36 minutes/h) throughout the experimental period. The showering was manually controlled and run for 2 minutes after an interval of every 15 minutes from 12:00 to 15:00 hours throughout the experimental period. In wallowing group animals were allowed in pond from 12:00 to 15:00 hours every day during study period.

The green and dry fodders used in the experiment were available at LRS. Pelleted concentrate (Sumul Dan) mixture and cotton seed cake were fed as the concentrate feed. The quantity of concentrate required to each animal was calculated and adjusted every 15 days according to the change in their body weight and milk production as per ICAR (1998) feeding standard. The microclimatic variables like temperature (^oC) and relative humidity (%) at animal level in three sheds were recorded with 15 minutes

intervals in three experimental sheds. The sensor humidity data loggers were placed 2 m above the floor for recording the temperature and percent humidity inside the barn.Blood samples were collected fortnightly thought-out the experiment. Each of these samples were analyzed for serum concentration of glucose, total protein, albumin, blood urea, total cholesterol, triglycerides and hematology parameters like Hb, RBC, WBC and PCV. The mean differences between conditions were tested for significance using independent sample t-test at 5% level of significance. The mean differences between treatments were tested for significance using DMRT (Ducan multiple rang test) at $P<0.05$.

RESULTS AND DISCUSSION

Hemoglobin

The mean value of Hb (%) of Surti buffaloes was significantly lower in control group than cooling groups during both conditions whereas, within cooling treatments it was observed that the fogging (T_2) was significantly lower than showering (T_3) and wallowing (T_4), moreover it was not varies significantly between showering and wallowing. Overall results show that the mean value of Hb (%) of surti buffaloes was significantly lower in control group than cooling groups. The analysis of variance of Hb (%) data indicated a significant ($P<0.05$) difference among conditions in their respective treatments. This might be due to haemo-dilution caused by a shift in body water from intracellular and interstitial spaces of animals as a consequence of the effects of hot environmental conditions. This finding was in agreement with the findings of Chaiyabutr *et al.* (2011) and Vijayakumar *et al*. (2011) who observed significantly ($P<0.01$) higher hemoglobin values in cooling system as compared with the animals with only fan (T_2) and control group (T_1). Similar finding were also observed by Radadia (1979); Kumar and Gupta (1991) and Chandra Bhan *et al.* (2012). However reverse to the present finding Fulsoundar (1985); Koubkova *et al.* (2002) and Pandey and Khan (2012) reported decrease in hemoglobin content in cooling system.

Red Blood Cell (RBC) Count

The mean of RBC count of Surti of buffaloes was significantly lower in control group than cooling groups during both conditions. In cooling groups the mean of RBC count in fogging (T_2) was significantly ($P<0.05$) lower than showering (T_3), it was not different significantly ($P<0.05$) with wallowing (T_4). Overall results also showed similar trends as above. The mean values of RBC count of Surti buffaloes during hot-humid conditions was significantly ($P<0.05$) lower as compared to hot-dry condition in their respective treatments groups. Similar to the present finding Chaiyabutr *et al.* (2011) reported that the RBC count was 4.71 and 4.87×10^6/µl in control Vs cooling system respectively. In contrast to present finding Koubkova *et al.* (2002); Michelle *et al*. (2012); Chandra Bhan *et al* (2012) reported that RBC count was higher in hot-humid condition as compared to hot-dry condition. Pandey and Khan (2012) also observed increase in RBC count in hot-humid condition however it was not significantly different with hot-dry condition.

White blood cell (WBC) count

The mean of WBC count of Surti of buffaloes was significantly ($P<0.05$) lower in control group than cooling groups during both conditions. However, it was not significantly ($P<0.05$) different within cooling treatments.

Overall results also showed similar trend as that of both conditions. The mean values of WBC count of Surti buffaloes during hot-humid conditions was significantly (P<0.05) lower compared to hot-dry condition in their respective treatments groups. Similar finding was observed by Koubkova *et al.* (2002); Chandra Bhan *et al.* (2012); Das *et al*. (2014); Chaiyabutr *et al.* (2011) who also reported higher WBC count (9.58×10^6/µl) in cooling system as compared to control (8.1610^6/µl). Contradictory to our findings, Michelle *et al*. (2012) reported increase in leucocytes count in animal on exposure to stressful condition. Similarly Pandey and Khan (2012) also observed significantly higher leukocyte count during stress (evening) in both hot-dry and hot-humid conditions.

Packed cell volume (%)

The PCV (%) recorded was significantly (P<0.05) lower under showering (T_3) and wallowing (T_4) than fogging (T_2) and control (T_1) in both the condition. Moreover. it was significantly (P<0.05) higher under control (T_1) than fogging (T_2); Moreover, it was not significantly different between showering (T_3) and wallowing (T_4). The mean values of PCV (%) of Surti buffaloes during hot-humid condition was significantly (P<0.05) higher as compared to hot-dry condition in their respective treatments groups. Overall PCV (%) was significantly (P<0.05) lower in treatment (T_1, T_2 and T_4) groups as compared to T_1 (control). Within treatment group it was highest in T_2 followed by T_4 and T_3; Moreover, T_2, T_3 and T_4 were significantly (P<0.05) different with each other. The present finding was in agreement with Chandra Bhan *et al.* (2012); Pandey and Khan (2012). Contradictory was also reported by Vijayakumar *et al*. (2011) who observed similar PCV in cooling system and control.

SERUM BIOCHEMICAL PROFILES

The condition and treatment wise mean values of serum biochemical profiles have been presented in Table 3.

Blood glucose

In both condition the mean value of blood glucose was significantly (P<0.05) higher in showering and wallowing (T_4) than control (T_1) and fogging (T2). The mean of blood glucose of showering (T_3) and Fogging (T_2) was significantly (P<0.05) higher than control (T_1) during hot-dry condition. Whereas in hot-humid condition the level of blood glucose was higher in showering (T_3) followed by wallowing (T_4) Fogging (T_2), and control (T_1) and these values were significantly (P<0.05) different from each other. Overall results of blood Glucose showed similar trend as hot-humid condition. While comparing hot-dry and hot-humid condition the blood glucose level was significantly (P<0.05) lower in control (T_1), Fogging (T_2) and wallowing (T_4) group of hot-humid condition, moreover the blood glucose level was lower in hot-humid condition in showering (T_3) treatments although the difference was not significant (P<0.05).

This decrease blood glucose in control as compared to cooling system might be due to the fact that, they consumed less dry matter compared to the cooling group and also under hot climate high respiration rate causing high utilization of glucose by the respiratory muscles. The present findings were similar to the report of Kamal *et al*. (1962); Shafferi *et al.* (1981); Aboulnaga *et al.* (1989); Kumar and Gupta (1991); Verma *et al*. (2000); Vijayakumar *et al*. (2011); Singh *et al*. (2012); Pandey and Khan (2012). Contradictory to our findings, Flarnenbaum *et al.* (1995) reported

Table 1. Average environmental parameters of microclimate under different treatment groups (Control Vs Cooling) and macroclimate during hot-dry and hot-humid conditions.

Climate	Treatments	Max. (°C)		Min. (°C)		RH (%)		THI			
								Morning		Afternoon	
		HD	HD	HD	HD	HD	HD	HD	HD	HD	HD
Micro climate	T1 (Control)	$33.89^{b\beta}\pm0.29$	$31.61^{b\lambda}\pm0.19$	$26.41^{b\lambda}\pm0.20$	$27.62^{b\beta}\pm0.14$	$65.53^{b\lambda}\pm1.00$	$79.09^{a\beta}\pm1.09$	$78.54^{a\lambda}\pm0.35$	$81.04^{a\beta}\pm0.16$	$82.43^{b\lambda}\pm0.21$	$84.20^{c\beta}\pm0.21$
	T2 (Fogger)	$32.28^{a\beta}\pm0.23$	$30.74^{a\lambda}\pm0.14$	$26.61^{b\lambda}\pm0.20$	$27.81^{b\beta}\pm0.14$	$76.84^{c\lambda}\pm0.73$	$85.10^{b\beta}\pm0.86$	$78.90^{a\lambda}\pm0.30$	$81.49^{a\beta}\pm0.17$	$80.22^{a\lambda}\pm0.20$	$82.29^{b\beta}\pm0.23$
	T3 (Shower)	$33.17^{b\beta}\pm0.26$	$31.09^{a\lambda}\pm0.16$	$26.75^{b\xi}\pm0.20$	$27.96^{b\beta}\pm0.14$	$67.83^{b\lambda}\pm0.95$	$80.58^{a\beta}\pm1.05$	$78.86^{a\lambda}\pm0.32$	$81.40^{a\beta}\pm0.17$	$80.38^{a\lambda}\pm0.21$	$80.71^{a\lambda}\pm0.20$
	T4 (Wallowing)	$33.89^{b\beta}\pm0.29$	$31.61^{b\lambda}\pm0.19$	$26.41^{b\lambda}\pm0.20$	$27.62^{b\beta}\pm0.14$	$65.53^{b\lambda}\pm1.00$	$79.09^{a\beta}\pm1.09$	$78.54^{a\lambda}\pm0.35$	$81.04^{a\beta}\pm0.16$	$82.43^{b\lambda}\pm0.21$	$84.20^{c\beta}\pm0.21$
Macro climate	Open	$35.10^{c\beta}\pm0.29$	$32.46^{c\lambda}\pm0.20$	$24.43^{a\xi}\pm0.26$	$26.85^{a\beta}\pm0.17$	$55.64^{a\lambda}\pm1.07$	$79.94^{a\beta}\pm1.12$	$78.19^{a\lambda}\pm0.36$	$81.01^{a\beta}\pm0.21$	$83.50^{c\lambda}\pm0.21$	$84.07^{c\lambda}\pm0.20$

(Mean with superscript (λ,ß) in a row and (a,b,c,d) in a column differ significantly between conditions and treatments respectively at $P<0.05$).

Table 2. Hematological profile of Surti buffaloes under different treatment groups (Control Vs Cooling) during hot-dry and hot-humid seasons.

Parameters	Season	T_1 (Control)	T_2 (Fogging)	T_3 (Showering)	T_4 (Wallowing)
Hemoglobin content (gm %)	HD	$10.32^{a\lambda}$±0.07	$11.34^{b\lambda}$±0.07	$11.77^{c\lambda}$±0.07	$11.75^{c\lambda}$±0.07
	HH	$10.04^{a\lambda}$±0.06	$10.39^{b\lambda}$±0.06	$11.30^{c\lambda}$±0.06	$11.30^{c\lambda}$±0.06
	overall	**10.18^{a}±0.05**	**10.87^{b}±0.08**	**11.54^{c}±0.05**	**11.53^{c}±0.05**
Red Blood Cell (million/ mm3)	HD	$6.66^{a\lambda}$±0.06	$7.10^{b\lambda}$±0.06	$7.31^{c\lambda}$±0.06	$7.18^{bc\lambda}$±0.06
	HH	$6.43^{a\lambda}$±0.06	$6.88^{b\lambda}$±0.06	$7.08^{c\lambda}$±0.06	$6.97^{bc\lambda}$±0.06
	overall	**6.54^{a}±0.04**	**6.99^{b}±0.04**	**7.19^{c}±0.04**	**7.08^{bc}±0.04**
White blood cells (cells/µl)	HD	$15.85^{c\lambda}$±0.09	$16.93^{b\lambda}$±0.09	$17.02^{b\lambda}$±0.08	$17.13^{b\lambda}$±0.09
	HH	$15.27^{a\lambda}$±0.09	$16.31^{b\lambda}$±0.09	$16.46^{b\lambda}$±0.08	$16.53^{b\lambda}$±0.09
	overall	**15.56^{a}±0.08**	**16.62^{b}±0.08**	**16.74^{b}±0.07**	**16.83^{b}±0.08**
Packed cell Volume (%)	HD	$34.96^{c\lambda}$±0.13	$33.64^{b\lambda}$±0.15	$32.73^{a\lambda}$±0.13	$33.03^{a\lambda}$±0.13
	HH	$35.44^{c\lambda}$±0.13	$34.20^{b\lambda}$±0.13	$33.24^{a\lambda}$±0.13	$33.92^{b\lambda}$±0.21
	overall	**35.20^{d}±0.10**	**33.92^{c}±0.11**	**32.98^{a}±0.10**	**33.47^{b}±0.14**

Mean with superscript (a,b,c,d) in a row and (λ,ß) in a column differ significantly between treatments and seasons respectively at $P<0.05$.

Table 3. Biochemical profile of Surti buffaloes under different treatment groups (Control Vs Cooling) during hot-dry and hot-humid seasons.

Parameters	Season	T_1 (Control)	T_2 (Fogging)	T_3 (Showering)	T_4 (Wallowing)
Glucose (mg/dl)	HD	$62.01^{a\beta}\pm0.75$	$66.40^{b\beta}\pm1.05$	$72.86^{c\lambda}\pm1.08$	$68.18^{c\beta}\pm0.94$
	HH	$60.94^{a\lambda}\pm0.81$	$64.12^{b\lambda}\pm1.13$	$71.12^{d\lambda}\pm1.00$	$66.66^{c\lambda}\pm0.90$
	overall	**$61.48^{a}\pm0.55$**	**$65.26^{b}\pm0.76$**	**$71.99^{d}\pm0.74$**	**$67.42^{c}\pm0.65$**
Total protein (g/dl)	HD	$7.87^{a\beta}\pm0.07$	$8.31^{b\beta}\pm0.09$	$8.35^{b\beta}\pm0.13$	$8.59^{b\beta}\pm0.10$
	HH	$7.60^{a\lambda}\pm0.06$	$7.84^{ab\lambda}\pm0.07$	$7.94^{b\lambda}\pm0.13$	$8.28^{c\lambda}\pm0.08$
	overall	**$7.74^{a}\pm0.05$**	**$8.08^{b}\pm0.07$**	**$8.15^{b}\pm0.09$**	**$8.44^{c}\pm0.07$**
Albumin (g/dl)	HD	$3.96^{c\lambda}\pm0.08$	$3.24^{b\lambda}\pm0.05$	$2.77^{a\lambda}\pm0.08$	$2.89^{a\lambda}\pm0.09$
	HH	$4.02^{c\lambda}\pm0.04$	$3.51^{b\beta}\pm0.07$	$3.16^{a\beta}\pm0.09$	$3.36^{b\beta}\pm0.08$
	overall	**$3.99^{d}\pm0.04$**	**$3.38^{c}\pm0.05$**	**$2.96^{a}\pm0.06$**	**$3.13^{b}\pm0.07$**
BUN (mg/dl)	HD	$34.48^{a\beta}\pm0.45$	$35.65^{ab\lambda}\pm0.45$	$35.91^{b\lambda}\pm0.48$	$35.86^{b\beta}\pm0.45$
	HH	$32.80^{a\lambda}\pm0.48$	$34.80^{b\lambda}\pm0.67$	$35.21^{b\lambda}\pm0.76$	$34.18^{ab\lambda}\pm0.48$
	overall	**$33.64^{a}\pm0.35$**	**$35.23^{b}\pm0.41$**	**$35.56^{b}\pm0.45$**	**$35.02^{b}\pm0.35$**
Cholesterol (mg/dl)	HD	$57.72^{a\lambda}\pm1.03$	$71.73^{b\lambda}\pm1.98$	$84.34^{c\lambda}\pm1.85$	$90.72^{d\lambda}\pm1.66$
	HH	$57.27^{a\lambda}\pm1.30$	$70.79^{b\lambda}\pm1.56$	$80.93^{c\lambda}\pm1.36$	$87.80^{d\lambda}\pm1.53$
	overall	$57.49^{a}\pm0.82$	$71.26^{b}\pm1.25$	$82.64^{c}\pm1.16$	$89.26^{d}\pm1.14$
Triglyceride (mg/dl)	HD	$35.83^{a\beta}\pm0.47$	$37.86^{b\beta}\pm0.46$	$39.80^{c\beta}\pm0.42$	$38.55^{bc\beta}\pm0.42$
	HH	$27.69^{a\lambda}\pm0.46$	$30.17^{\lambda b}\pm0.46$	$31.80^{c\lambda}\pm0.47$	$30.33^{b\lambda}\pm0.46$
	overall	**$31.76^{a}\pm0.68$**	**$34.02^{b}\pm0.65$**	**$35.80^{b}\pm0.66$**	**$34.44^{b}\pm0.67$**

Mean with superscript (a,b,c,d) in a row and (λ,ß) in a column differ significantly between treatments and seasons respectively at $P<0.05$.

that glucose levels in cooled and uncooled cows were 3.17 and 3.29 mmol/L respectively.

Total protein

In hot-dry condition the total protein level was highest in wallowing (T_4) followed by showering (T_3), fogging (T_2), and control (T_1). It was significantly (P<0.05) lower in control than other cooling systems; however, it was not significantly (P<0.05) different between the cooling systems. In hot-humid condition the total protein level was highest in wallowing (T_4) followed by showering (T_3), fogging (T_2), and control (T_1).The total protein was significantly (P<0.05) higher in showering (T_3) and wallowing (T_4) as compared to control (T_1). It was significantly (P<0.05) higher in wallowing (T_4) as compared to showering (T_3) and fogging (T_2). The overall results show the total protein value was highest in wallowing (T_4) followed by showering (T_3), fogging (T_2), and control (T_1). It was significantly higher in T_2, T_3 and T_4 as compared to control. Within cooling systems it was significantly (P<0.05) higher in T_4 as compared to T_2 and T_3. It might be due to significant decrease in feed intake as a function of heat stress, contributes to the heat-induced decrease in blood total proteins (Marai *et al*., 2007) While comparing hot-dry and hot-humid condition the total protein was significantly (P<0.05) higher in hot-dry condition in all the treatments in their respective groups. Findings of this study were in accordance with the findings of Kamal *et al.* (1962); Shafferi *et al.* (1981); Kumar and Gupta (1991); Habeeb *et al.* (1992); El-Khashab (2010); Chaiyabutr *et al.* (2011) and Vijayakumar *et al*. (2011). Contradictory to our findings, Mehta *et al.* (1981) and Das *et al.* (2013) noted that the total protein was slightly higher in control than the treatment group during HD condition.

Albumin

In hot-dry condition the albumin level was lowest in showering (T_3) followed by wallowing (T_4), fogging (T_2), and control (T_1). It was significantly lower in cooling systems as compared to control, Moreover within cooling systems it was significantly (P<0.05) lower in T_3 and T_4 as compared to T_2. In hot-humid condition the albumin level was lowest in showering (T_3) followed by wallowing (T_4), fogging (T_2), and control (T_1). It was significantly (P<0.05) lower in cooling systems as compared to control. Moreover within cooling systems it was significantly (P<0.05) lower in T_3 as compared to T_2 and T_4. The overall results show the albumin value was lowest in showering (T_3) followed by wallowing (T_4), fogging (T_2), and control (T_1).It was significantly lower in cooling systems as compared to control. Within cooling systems it was significantly (P<0.05) different from each other. While comparing hot-dry and hot-humid condition the total albumin was significantly lower in hot-dry condition in all the treatments in their respective groups except control group. Findings of this study were in accordance with the findings of Kumar and Gupta (1991); Chaiyabutr *et al.* (2011); Vijayakumar *et al*. (2011) and are contradictory to results reported by El-Khashab (2010) and Das *et al.* (2013).

Blood urea nitrogen (BUN)

In hot-dry condition the BUN level was highest in showering (T_3) followed by wallowing (T_4), fogging (T_2), and control (T_1). It was significantly (P<0.05) higher in T_3 and T_4 as compared to control (T_1), Moreover within cooling systems it was not significantly (P<0.05) different. In hot-humid condition the BUN level was highest in showering (T_3) followed by fogging (T_2), wallowing (T_4) and control (T_1). It was

significantly (P<0.05) higher in cooling systems as compared to control (T_1) except wallowing (T_4), Moreover within T_2 and T_3 it was not significantly (P< 0.05) different. The overall results show the BUN value was significantly (P<0.05) higher in cooling systems as compared to control. Moreover, within cooling systems the difference was not significant (P<0.05). This might be due to blood urea-N associated with heat stress which causes more reabsorption of urea-N from the blood towards the rumen to compensate the decrease in rumen ammonia-N as a result of the decrease in each of feed intake (El-Fouly *et al*., 1978; Yousef, 1990). Comparison of mean between hot-dry and hot-humid condition showed significantly (P<0.05) higher BUN in hot-dry condition in T_1 and T_4, however there was no significant (P<0.05) variation between T_2 and T_3 groups. The present findings were similar to the report of Segura *et al.* (1979); Shafferi *et al*. (1981); Kamal *et al*. (1989a,b); Ahmed (1990); Verma *et al.* (2000) and are contradictory to the results reported by Chaiyabutr *et al.* (2011) and Das *et al.* (2013).

Cholesterol

In both of the conditions, cholesterol level was highest in wallowing (T_4), followed by showering (T_3), fogging (T_2), and control (T_1) group. It was significantly (P<0.05) higher in cooling systems as compared to control, Moreover within cooling systems it was significantly (P<0.05) different to each other. Overall results of cholesterol showed similar trend as hot-dry or hot-humid conditions. While comparing the mean of hot-dry and hot-humid condition cholesterol showed no significant difference in their respective treatments group. This might be due marked decrease in cholesterol concentration which causes dilution as a result of the increase in total body water or the decrease in acetate concentration. The acetate is supposed to be the primary precursor for the synthesis of cholesterol. The marked increase in glucocorticoid hormone level in heat stressed animals may be another factor causing the decline in blood cholesterol. The present findings were similar to the report of Das *et al.* (2013) who reported that buffaloes under HD condition had significantly higher plasma cholesterol and HDL cholesterol in T1 (80.07 mg/dL and 31.63 mg/dL) than T2 (62.83 mg/dL and 24.20 mg/dL) group and are contradictory to results reported by Chaiyabutr *et al.* (2011).

Triglycerides

In both hot-dry and hot-humid condition the triglycerides value was highest in showering (T_3) followed by wallowing (T_4), fogging (T_2), and control (T_1) group. Whereas, in hot-humid condition the triglycerides value was highest in showering (T_3) followed by wallowing (T_4), fogging (T_2) and control (T_1). In both condition it was significantly (P<0.05) higher in cooling systems as compared to control, Moreover within cooling systems it was significantly (P<0.05) lower in T_2 and T_4 as compared to T_3. The overall result showed significantly (P<0.05) higher triglycerides values in cooling systems as compared to control. Moreover, within cooling systems the difference was not significant (P<0.05). While comparing hot-dry and hot-humid condition the triglycerides value was significantly (P<0.05) lower in hot-dry condition in all the treatments in their respective groups including control group. The present findings were similar to the report of Das *et al.* (2013) and are contradictory to result was reported by Chaiyabutr *et al.* (2011).

CONCLUSIONS

The biochemical and hematological parameters revealed that experimental animals felt comfort in showering followed by wallowing and fogging. It can be concluded from the above findings, that experimental Surti buffaloes were more comfortable in all the three different cooling systems during hot dry condition as compared to hot humid condition. Whereas, during hot humid condition they were in better comfort under showering followed by wallowing system of cooling systems.

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