Effect of different temperature humidity indices on antioxidant parameters in Surti buffaloes

Arjun B. Odedara, Sandhya S. Chaudhary*, Virendra Kumar Singh, Pankaj A. Patel, Gopal Puri and V.B. Kharadi

Department of Veterinary Physiology & Biochemistry, Vanbandhu College of Veterinary Sciences & Animal Husbandry, Navsari Agricultural University, Navsari-396 450, Gujarat, India.

ABSTRACT

The present study was conducted on 20 Surti buffalo heifers of 16 to 21 months age maintained under standard feeding and management practices. They were categorized based on their exposure to natural environment as Group I (Hot dry season: THI₁), Group II- (Hot humid season: THI₂) and Group III as Control group (Comfortable season: THI₃). Whole blood and serum samples were collected from all the groups and analyzed for antioxidant parameters, viz., superoxide dismutase (SOD), glutathione peroxidase (GPx), catalase, lipid peroxidation (LPO) and total antioxidant status (TAS). The temperature humidity index (THI) calculated for Group I, Group II and Group III were 81.70 (THI₁), 80.30 (THI₂) and 70.00 (THI₃). For Group I, Group II and Group III, concentration of SOD (U) was 5.29±0.06, 4.65±0.04 and 2.94±0.09; GPx (U/ml) was 43.63±0.71, 36.40±0.56 and 25.84±1.00; catalase (μmoles/min/ml) was 1,609.17±45.93, 1,322.00±18.65 and 1,06.35±45.07; LPO (nM of MDA/ml of packed cells) was 6.00±0.13, 3.45±0.09 and 2.87±0.14 and TAS (mmol/l) was 5.18±0.11, 2.90±0.09 and 2.37±0.13, respectively. Significantly (P<0.01) higher levels of SOD, GPx, catalase, TAS and LPO were observed in hot dry season (THI₁) as compared to hot humid (THI₂) and comfortable (THI₃) seasons. Increased levels of SOD, GPx, catalase, TAS and LPO indicated that hot dry season is more stressful for animals as compared to hot humid season in Surti buffaloes as they are inhabitants of hot humid region.

Key words: Antioxidants, Heat stress, Surti buffalo, Temperature humidity indices.

INTRODUCTION

The sustainability of livestock husbandry, however, is affected by a wide range of environmental challenges, not the least of which is climate change (Kabubu-Mariera, 2009; Wall and Ellse, 2011). A clear, strategic and long-term understanding of the challenges of climate change is needed, on a global scale, to allow its appropriate management (Gjerris et al., 2011). India is one of the world’s most vulnerable countries to climate change (INCCA, 2010). Animal productivity and efficiency are significantly influenced by environmental factors. Heat stress is one of the most important stressor especially in hot/tropical regions of the world like India thus posing one of the greatest challenges to dairy farmers by affecting the production of dairy animals (Key and Sneeringer, 2014; Kohli et al., 2014).

Under thermoneutral environmental conditions, most of the large domestic animals are able to maintain equilibrium between the heat production and heat loss. But, in stressful conditions, the physiological and behavioral responses will vary in relation to genetic make-up and environmental factors. High ambient temperature accompanied by high air humidity causes an additional discomfort and enhances the stress level which in turn results in depression of the physiological and metabolic activities of animals. As per Johnson (1980), Temperature Humidity Index (THI) (single value representing the combined effects of air temperature and humidity) is the most extensively employed index for assessing heat stress.

Buffaloes are well known to thrive in the hot and humid climatic conditions but exhibit signs of great distress when exposed to direct solar radiation or when working in the sun during a hot weather.

Compared to lactating adults, heifers generate far less metabolic heat, have greater surface area relative to internal body mass and would be expected to suffer less from heat stress. However, environmental stress can delay puberty and age at first calving. It is necessary to determine precisely the effects of heat stress on heifer metabolism as they have higher genetic potentials.

Ample amount of study is required to know the adverse impacts during and after heat stress as well as due to acute and chronic heat stress. Most of the studies have been conducted on exposure of buffaloes especially adults to adverse climatic conditions in climatic chambers while the studies in relation to the effect of natural microenvironment on buffaloes especially heifers are meager. Therefore, present study was undertaken to measure the

*Corresponding author’s e-mail: sandhyachaudhary6@gmail.com.
1Livestock Research Station, Navsari Agricultural University, Navsari-396 450, Navsari, Gujarat, India.
comparative influence of heat stress on antioxidant parameters at different THIs during different seasons in Surti buffalo heifers.

MATERIALS AND METHODS

Twenty apparently healthy Surti buffalo heifers, aged between 16 to 21 months, were selected for the experiment and were categorized based on their exposure to natural environment as Group I (Hot dry-THI1), II (Hot humid THI2) and III as Control group (Comfortable-THI3). The animals were maintained at Livestock Research Station, Navsari Agricultural University, Navsari, under standard feeding management practices which consist of feeding ad libitum roughages and water; concentrate mixture as per the ICAR feeding standards.

Location of study was Navsari which is geographically located approximately at an altitude of 11.89 M above mean sea level, at latitude of 20°-57′0″ north and longitude of 72°-54′0″ east. The climate of the area forms the part of tropical and coastal area. Generally, winter is cool and dry while summer and monsoon remain hot and humid.

The meteorological variables like temperature and relative humidity were recorded inside the shed with the help of automatic data logger. Temperature and relative humidity were recorded for 15 days before the blood sample collection. Observations recorded were used for calculation of temperature humidity index (THI). On the basis of mean temperature and relative humidity, THI was calculated using the formula of Mader et al. (2006).

\[
\text{THI} = (0.8 \times T_{db}) + [(RH/100) \times (T_{db} - 14.4)] + 46.4
\]

where, \(T_{db}\) = dry bulb temperature and \(RH\) = relative humidity.

Blood samples were collected from the experimental animals. In treatment groups, \(i.e.,\) Group I and Group II, the blood collection was done thrice with an interval of approximately 20 days, while blood was collected only once from control group. Five ml of whole blood from each animal was collected from jugular vein in sterile vacutainer tubes containing anticoagulant and processed further to assess antioxidant parameters as per standard procedures. GPx concentration was estimated by UV method of Paglia and Valentine (1967) using Randox kit. Catalase concentration was estimated by using catalase assay kit (Sigma-Aldrich, Inc., USA). Superoxide dismutase activity was estimated as per the method described by Madesh and Balasubramanyam (1998). Lipid peroxidation was determined in terms of Malondialdehyde (MDA) production by the method suggested by Rehman (1984). Total antioxidant status was estimated by the method suggested by Miller et al. (1993) using Randox kit.

The data for all the parameters were analyzed using Randomized Block Design as per standard statistical procedure cited by Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

Mean temperature, relative humidity and Temperature Humidity Index (THI) during the period under study are presented in Table 1. The THI calculated for Group I, Group II and Group III were 81.70 (THI1), 80.30 (THI2) and 70.00 (THI3). Even though THI1 value was comparable and slightly higher than that of THI2, THI2 had higher mean temperature and THI3 had higher relative humidity.

The values of antioxidant parameters are presented in Table 2. Values for Group I, Group II and Group III for SOD (U) were 5.29±0.06, 4.65±0.04 and 2.94±0.09; for GPx (U/ml) were 43.63±0.71, 36.40±0.56 and 25.84±1.00; for catalase (µmoles/min/ml) were 1,609.17±45.93, 1,322.00±18.65 and 1,106.35±45.07; for LPO (nM of MDA/
ml of packed cells) were 6.00±0.13, 3.45±0.09 and 2.87±0.14 and for TAS (mmol/l) were 5.18±0.11, 2.90±0.09 and 2.37±0.13, respectively. Significantly (P<0.01) higher levels of SOD, GPx, catalase, TAS and LPO were observed at THI, and THII, as compared to THI. SOD and LPO showed significant (P<0.05) increase with increase in ambient temperature while catalase, GPx and TAS differed non-significantly within Group I and II.

Oxidative stress results when reactive forms of oxygen are produced faster than they can be safely neutralized by antioxidant physiological mechanisms. Biomarkers to assess oxidative stress include total antioxidant status, lipid peroxides and antioxidant enzymes such as superoxide dismutase, glutathione peroxidase and catalase.

In the present study, elevated levels of SOD, GPx and LPO were observed during hot dry and hot humid seasons as compared to comfortable season. Similarly, higher GPx and SOD during summer have been reported in transition dairy cattle by Bernabucci et al. (2002) and in calves by Chigerwe et al. (2013). Higher SOD level in prepartum crossbred cow during summer as compared to winter indicating effect of hot summer season on the oxidative status of transition dairy cows have also been reported by Chandra and Aggarwal (2009).

In this study, higher erythrocyte SOD activity found in the hot dry season was probably a response to higher superoxide (•O₂⁻) generation. SOD catalyzes the dismutation of •O₂⁻ into oxygen and hydrogen peroxide (H₂O₂) and it is an important antioxidant defense mechanism. The dismutation of •O₂⁻ results in rise in H₂O₂. Since SOD activity increases H₂O₂ production, protection from reactive oxygen would only be conferred by a coordinated increase of catalase and GPx activities (Frei, 1994; Kehrer and Smith, 1994). In support of this, GPx as well as catalase activity was found to be increased in the hot dry season in the present study.

Decomposition of H₂O₂ or its interaction with •O₂⁻ would generate hydroxyl radical. Hydroxyl radicals can attack lipid membrane and can result in initiation of lipid peroxidation. Lipid peroxidation is commonly measured in terms of thiobarbuturic acid reactive substance (TBARS), i.e. MDA. The erythrocyte TBARS concentration increased in heat exposed cattle and buffaloes (Kumar et al., 2007). Similar increase in TBARS concentration was observed in heat exposed Holstein cows by Bernabucci et al. (2002). Dietary supplementation of ascorbic acid resulted in lower TBARS concentration (Tanaka et al., 2007). This is due to the fact that ascorbic acid acts as a chain blocker of lipid peroxidation. In the present study also, higher LPO value was observed in hot dry season as compared to hot humid and comfortable seasons. This indicates that the animals are in oxidative stress during summer season.

In the present study, total antioxidant status (TAS) was found to be slightly higher than the values reported by several authors including a reported value for buffalo (0.48 ± 0.06 to 1.44 ± 0.08 mmol/l) by Zaher and Ahmed, (2008) except the comparable levels which were found by Heidarpour et al. (2012) in dairy cows using similar analytical method by Randox kit. This difference may be due to difference in analytical method as well as species of animals.

Seasonal alteration in the oxidative stress depends more on weather conditions such as temperature and humidity. In the present study also total antioxidant status, lipid peroxides and antioxidant enzymes such as superoxide dismutase, glutathione peroxidase and catalase were higher in the hot dry season indicating maximum oxidative stress during hot dry season.

From the present study, it can be concluded that both hot dry and hot humid seasons are stressful for Surti buffalo heifers as seen by associated increase in levels of SOD, GPx, catalase, LPO and TAS. Also, it can be deduced that heat stress due to high ambient temperature or hot dry season is more as compared to hot humid season even if the THIs are comparable. Hot dry season is more uncomfortable because the Surti buffaloes are the inhabitants of hot humid climate and must have been adapted to it.

ACKNOWLEDGMENT

The authors are highly thankful to the Dean, Vanbandhu College of Veterinary Science and Animal Husbandry for financial assistance and research facilities to conduct this experiment. The authors also thank Research Scientist, Livestock Research Station, NAU for making availability of experimental animals.

REFERENCES


INCCA Indian Network for Climate Change Assessment (2010). Climate change and India: a 4X4 assessment – a sectorial and regional analysis for 2030s.


