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Comparative Efficacy of Physiological Responses and Skin Temperatures in Indigenous and Crossbred Cattle Supplemented with *Chlorophytum borivilianum* in Summer Season

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ABSTRACT

Background: Heat stress causes oxidative stress and declines milk production potential of cows. The physiological responses and skin temperature of heat stressed animals are good indices for deterring the heat stress. The efficacy of medicinal herb *Chlorophytum borivilianum* (CB) was tested in lowering the rise in values of physiological responses and skin temperature in crossbred vis a vis Indigenous cows.

Methods: Eighteen Tharparkar (TP) and Crossbred KF cows in mid-lactation were given; No supplement (control), a low (T1, n=6) and a high dose (T2, n=6) of CB @ 40 and 80 mg/kg BW/day, respectively for 90 days during hot-humid season. Respiration rate (RR), pulse rate (PR), rectal temperature (RT) and skin temperature (ST) was recorded at the site of forehead, neck, rear body, and udder surface in the morning and afternoon at weekly intervals. Temperature-humidity index (THI) was calculated to assess the degree of thermal stress in animals.

Result: Physiological responses and skin temperatures were higher ($p<0.01$) in the afternoon than morning intervals in TP and KF cows. CB feeding significantly lowered physiological responses and ST ($p<0.01$) in high dose as compared to low dose. It was concluded that CB feeding @ 80 mg/kg BW/day effectively alleviates the heat stress. Indigenous cows were found more heat tolerant in comparison to crossbred cows.

Key words: CB, Heat stress, Karan fries, Physiological responses, Tharparkar.

INTRODUCTION

Climate change is a major threat to the sustainability of livestock systems globally. The body temperature begins to rise when the environmental temperature exceeds leading to hyperthermia. The severe change in climatic factors such as temperature and humidity are considered a potential challenge in the growth and productivity of domestic animals (Hansen, 2004). The hot-humid season's higher temperature and humidity cause more discomfort and distress in the animals. It is well established that Tharparkar cows are better adapted to withstand the harsh climatic conditions and perform fairly well with a limited supply of feed (Kumar *et al*. 2016). Indigenous cattle have a better ability to maintain body temperature under heat stress due to their lower metabolic rate and increased heat loss capacity due to superior heat loss mechanisms (Hansen, 2004). The animal's ability to withstand the climatic stress has been physiologically evaluated through changes in body temperature, respiration rate and pulse rate (Sethi *et al*. 1994). Rectal temperature is known to be an appropriate indicator of physiological status and for stress measurement in animals (Falkenberg *et al*., 2014). Heat stress can increased the formation of endogenous free radicals, resulting in oxidative stress (Gonzalez-Maldonado *et al*., 2019). The decrease in dry matter intake during thermal stress leads to increased energy demands due to the disruption of homeostasis, thermoregulation, and repairing of damaged tissues (Rhoads *et al*., 2011). Although crossbreeding has increased milk productivity, but also increased vulnerability to disease and heat stress (Yadav *et al*., 2016). Since cross-bred cattle are more vulnerable to high temperature mainly due to low sweat gland density and less surface area per unit body weight than Indigenous cattle, a 1-2°C rise in temperature caused by global warming will have a greater impact on the growth, puberty and productivity of cross-bred cattle. Different housing, management practices and nutritional strategies help to minimize heat stress in lactating animals during hot-dry and hot-humid seasons in tropical climates (Das *et al*., 2016). To alleviate heat stress in dairy cows, several herbal feed supplements such as Shatavari, Jivanti, and Methi have been tested (Patel *et al*., 2016).

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Chlorophytum borivilianum, also known as 'Safed Musli,' is a well-known herb for boosting body immunity (Thakur *et al*., 2007). CB roots are rich in carbohydrates, protein, fiber, saponins, and alkaloids (Singh *et al*., 2012). This herb has a wide range of therapeutic properties and it acts as a total rejuvenator, antioxidant and immunomodulator. Chlorophytum borivilianum improved function in humans by increasing energy, improving body stamina, resistance to stress and also help to normalize blood pressure and glucose level (Kumar and Singh, 2016). The antioxidant potency of this herb is due to powerful nitric oxide, superoxide and free radicals scavenging activity in rats (Ahmad *et al*., 2014; Visavadiya *et al*., 2010). CB root powder also improved antioxidant enzymes and vitamin C levels in the liver, improving its antioxidant ability. Antistress property of CB was evidenced by swim endurance stress, anorexic stress, and despair swim test in rats (Deore and Khadabadi, 2009). Dietary inclusion of CB has been beneficial in enhancing cows' immunity by downregulating pro-inflammatory and anti-inflammatory cytokine levels, reducing stress hormones and optimizing plasma metabolites levels (Devi *et al*., 2021a) and improving the udder health and quality of milk production in crossbred cows during the hot-humid season (Devi *et al*., 2021b). Feeding of CB may ameliorate heat stress of cows by restoring physiological responses and skin temperature. Therefore, the current study was designed to test the effect of *Chlorophytum borivilianum* supplementation on the rhythmicity of physiological responses and skin temperatures in Indigenous vis a vis crossbred cattle during the hot-humid season.

MATERIALS AND METHODS

Selection and management of animals

The experiment was conducted at NICRA shed of ICAR-NDRI. The experimental plan was duly approved by the Institutional Animal Ethics Committee (IAEC Approval No. 41-IAEC-18-27). Apparently healthy crossbred Karan Fries (n=18) and Indigenous Tharparkar cows (n=18) in mid-lactation (av.130 d) were divided based on body weight (av. 420.43, 383.94 kg) and milk yield (av. 14.14, 6.77 kg/d) into three groups of six animals each. The control group cows did not receive any treatment and cows of T1 and T2 groups were supplemented with *Chlorophytum borivilianum* root powder mixed with concentrate @ 40 and 80 mg/kg BW/ day, respectively. Dry root powder of CB was purchased from Jeevan Herbs and Agro Farms, Sagar (M.P.). All the experimental animals were fed concentrate mixture (CP=19.81% and TDN=70%) and roughages in the ratio 40:60 (ICAR, 2013) based on milk yield. The experiment was carried out for 90 days from July-September 2018. The Animals were housed in an asbestos roof shed with a brick floor and fresh tap water was made available *ad libitum* for drinking.

Recording of climatic variables

Climatic variables *viz.*, dry bulb temperature (T_{db}) and wet bulb temperatures (T_{wb}) were recorded at 7:30 A.M. and 2:30 P.M. using dry and wet bulb hygrometer (Zeal, UK) daily. Temperature-humidity index (THI) was calculated by the McDowell (1972) equation: $THI = 0.72 (T_{db}+T_{wb}) + 40.6$. The heat stress on animal was assessed based on the THI score *i.e.* between 66-71 (no stress), 72-78 (moderate stress) and 80-89 (severe stress).

Recording of physiological responses and Skin Temperatures

Physiological responses *viz*. respiration rate (RR), pulse rate (PR), rectal temperature (RT) and skin temperatures (ST) were recorded at weekly intervals during the experiment in the morning (8.00 A.M.) and afternoon intervals (2.30 P.M.). RR was recorded by observing the movement of the flank in one minute and PR was counted by palpating the pulsation of the middle coccygeal artery for one minute. A clinical thermometer (°C) was used to record the rectal temperature (RT). Skin temperatures were measured at various body sites (forehead, neck, rear body, and udder) using a non-contact thermometer (Raytek R, model Raynger ST 2L).

Statistical analysis

The data was statistically analyzed using SPSS software version (22) and Prism 5. Two-way analysis of variance (ANOVA) was carried out to find out significant difference at 5% between treatments, weeks, and intervals. The pair-wise comparison of mean was carried out using Tukey's multiple comparison tests.

RESULTS AND DISCUSSION

Mean values of THI_{min} and THI_{max} during the hot-humid season were ranged between 74.48-80.34 and 78.57-89.96, respectively (Table 1). The mean minimum and maximum temperatures ranged from 21.88 to 27.12°C and 28.48 to 35.23°C, respectively.

Table 1: Mean values of temperature-humidity index (THI) during the hot-humid season.

Weeks	THI_{min}	THI_{max}	THI_{avg}
I	78.12±0.62	89.96±0.94	84.04±0.75
II	77.71±0.41	88.01±0.62	82.86±0.43
III	75.81±0.63	86.97±0.61	81.39±0.53
IV	78.24±0.82	86.30±1.23	82.27±0.47
V	79.00±0.88	83.16±1.25	81.08±1.01
VI	80.34±0.49	82.38±0.96	81.36±0.52
VII	79.31±0.52	82.62±0.81	80.97±0.39
VIII	79.04±0.17	82.54±1.42	80.79±0.70
IX	76.47±0.24	81.68±1.07	79.07±0.54
X	77.03±0.35	82.77±0.37	79.90±0.25
XI	74.52±0.47	81.22±0.92	77.87±0.64
XII	74.48±1.15	78.57±1.09	76.52±0.70

The mean respiration rate (RR) of KF cows was lower in the morning and higher (p<0.01) in the afternoon interval (46.50 vs. 55.50 bpm) in the control group. The mean RR declined significantly (p<0.01) in treatment groups over the control, however, decrease was more (p<0.01) in T2 (52.69 bpm) as compared to the T1 group (53.77 bpm). The values of RR were significantly lower (p<0.01) in Tharparkar in comparison to KF cows. *Chlorophytum borivilianum* was effective in high dosage to maintain RR in Indigenous in comparison to crossbred cows (Fig 1). The feeding of herb reduced (p<0.01) mean PR in the afternoon interval in both CB supplemented groups of KF cows. The mean pulse rate was significantly lower in TP cows in control (74.69 bpm), T1 (73.50 bpm) and T2 (72.36 bpm) groups as compared to KF cows. The high dose of CB decreased the mean PR during morning and afternoon intervals in comparison to the low dose. Mean morning and afternoon RT in crossbred cows was 38.70 vs. 39.16, 38.64 vs. 39.02 and 38.57 vs. 38.89°C in C, T1 and T2 groups, respectively. The RT of TP cows was significantly lower (p<0.01) in comparison to KF cows during the experiment (Fig 1). Lower values of physiological responses during heat stress conditions may be due to lower production of free radicals in Karan Fries and Tharparkar cows supplemented with Chlorophytum borivilianum in the present study which have strong antioxidant activity. Water showering during peak hot times of the day has helped greatly to reduce the heat load, as evident by lowering RT and breathing rates in the evening (Narayan *et al*. 2007). Kumar and Singh, (2020) reported low physiological indices (RR, PR and RT) of both Karan Fries and Sahiwal heifers fed with astaxanthin in comparison to control. The difference in breeds depicted higher levels of physiological indices in crossbred than Indigenous heifers as observed in this study. Numerically lower values of RT in astaxanthin, astaxanthin with prilled fat supplemented lactating Murrah buffaloes were reported earlier in buffaloes (Somagond *et al.,* 2019). The significant increase in physiological responses in Karan Fries than Tharparkar revealed that Indigenous Tharparkar cows are more thermo-tolerant than Karan Fries cattle (Indu *et al*., 2016). Contrary to this, Zhang *et al*. (2014) reported that dietary betaine supplementation had no effect on RT, RR, and PR in lactating Holstein cows. Sivakumar *et al*. (2010) also observed that during thermal stress, heat stress goats had higher RT and RR than vitamin C and vitamin E with Selenium (antioxidants) treated goats.

Skin temperatures at different sites

Supplementation of CB in higher dose decreased (p<0.01) mean forehead temperature (FHT) in the afternoon interval (38.25°C) in comparison to lower dose (38.68°C) in KF cows

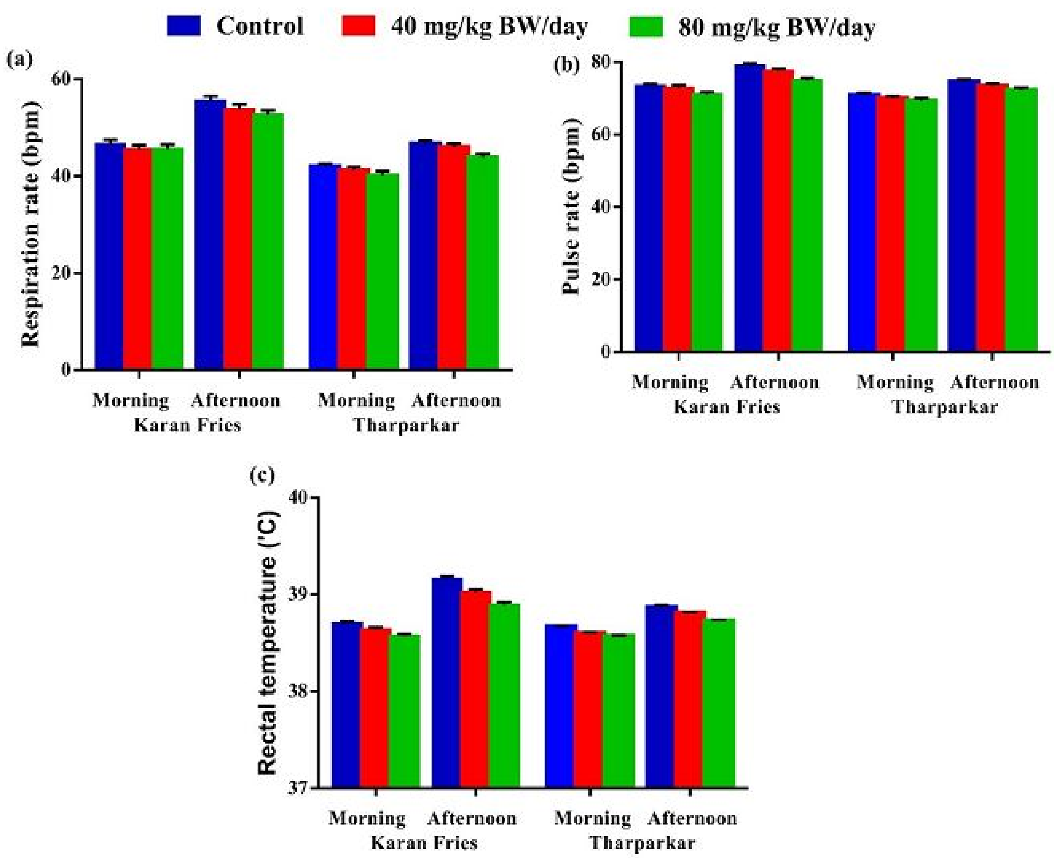

Fig 1: Effect of *Chlorophytum borivilianum* supplementation on physiological responses (a) Respiration rate (b) Pulse rate, and (c) Rectal temperature of Karan Fries and Tharparkar cows during the hot-humid season. Different bars indicating control group, *Chlorophytum borivilianum* supplementation at 40mg/kg BW/day and 80mg/kg BW/day.

(Fig 2). The FHT of TP cows was significantly lower ($p<0.01$) in C, T1 and T2 in comparison to corresponding groups of KF cows. Mean neck temperature (NT) in the T2 was lower ($p<0.01$) than the T1 group of KF cows (Fig 2). Mean NT was 35.83 vs. 37.17°C and 35.55 vs. 36.81°C during morning and afternoon intervals in low and high dose groups, respectively. Mean NT in TP cows was low ($p<0.01$) in comparison to KF cows. Further mean rear body temperature (RBT) was lower in the morning ($p<0.01$) in comparison to afternoon intervals. However, mean RBT was lower ($p<0.01$) in Tharparkar than in KF cows (Fig 2). Mean udder temperature (UT) was higher ($p<0.01$) in the afternoon than the morning intervals in control groups of KF cows and decreased ($p<0.01$) in T2 than T1. The mean morning and afternoon UT was 37.31 vs. 38.76°C, 37.16 vs. 38.53°C, 36.92 vs. 38.30°C in C, T1 and T2 groups, respectively. The mean udder temperature of Indigenous TP cows was lower in comparison to KF cows.

The skin temperature at the forehead, neck, and rear body indicates the effect of microclimate surrounding the animals in the shed. The significantly higher values of all the parameters in the afternoon in comparison to the T1 and T2 group indicated that CB as an antioxidant stimulates vasodilation to improve body heat loss. The temperature of udder is very crucial as it is mainly associated with the functional status of the mammary gland *i.e*. lactating or dry conditions (Jessica, 2017). The significant decline in the UT in KF and TP cows suggests normal functioning of the mammary gland in treatment groups compared to control as sweating causes evaporative heat loss from the skin surface and vasodilatation on the trunk region maintain thermal balance under hot conditions (Ehrlemark and Sallvik, 1996). The heat dissipation through the skin is measured by the amount of thermal energy circulating from the body core to the hide and the temperature differential between them. The rate of heat flow to the surrounding reduces and heat accumulates with the skin temperature approaching core temperature, hence elevating the body temperature (Gebremedhin *et al*. 2008). The increase in skin temperature in control group cows was due to an increase in THI which impacts ST (Singh and Upadhyay, 2009). The increase in UT observed in this study corroborates the findings of Montanholi *et al.* (2008) that udder skin has a high temperature compared to other regions due to thinner skin and lesser hair density. Mean UT remains high during the period of peak lactation probably due to higher metabolic activity, increased blood supply and greater generation of heat during milk production (Jessica, 2017). During heat

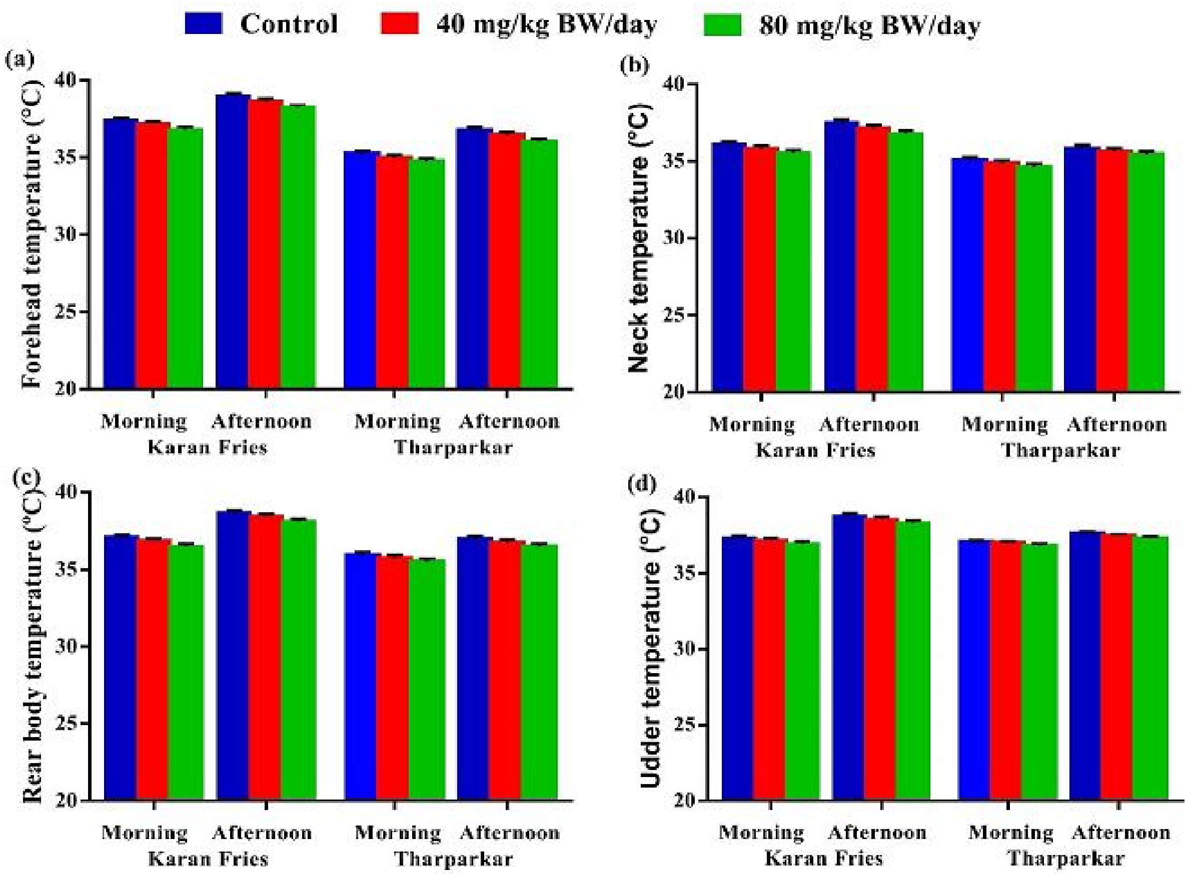

Fig 2: Effect of *Chlorophytum borivilianum* supplementation on skin temperature (a) Forehead temperature (b) Neck temperature (c) Rear body temperature and (d) Udder temperature of Karan Fries and Tharparkar cows during the hot-humid season. Different bars indicating control group, *Chlorophytum borivilianum* supplementation at 40mg/kg BW/day and 80mg/kg BW/day.

stress, cows treated with niacin had lower skin temperatures than control (Khan and Kewalramani, 2012). The feeding of astaxanthin and prilled fat significantly lowered the ST as compared to the non-supplemented group during the hot-humid season (Somagond *et al*., 2020). The positive correlation of THI ($p<0.01$) to RT, PR, forehead, and neck temperature during HH season further suggest the importance of physiological responses to assess the heat stress on animals.

CONCLUSION

The comparative efficacy of *Chlorophytum borivilianum* on physiological responses reveals that a higher dose of 80mg/kg BW/day effectively reduced stress level by lowering the values of physiological responses (RR, PR, RT) and skin temperatures at various sites of the body (Forehead, neck, rear body, and udder) indicating comfort to the animals. Tharparkar cows are more heat tolerant due to lower physiological responses and skin temperatures even at high THI in comparison to crossbred Karan Fries cows.

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Conflict of interest

No potential conflict of interest was reported by the authors. Authors also certify that neither article nor its any data send elsewhere for publication.

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