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Effect of THI and other environmental variables on milk constituents in red Kandhari cattle and Marathwadi Buffaloes

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Abstract
The study was undertaken on adult lactating Red Kandhari cattle and Marathwadi buffaloes at Livestock Farm Complex, College of Veterinary & Animal Sciences, Parbhani to observe the effect of heat stress/THI [EC 1 & EC 2] on different milk components. Milk was collected every fortnight and meteorological variable were recorded every week. A significant negative correlation was seen for milk solid not fats [SNF], total solids [TS], protein, lactose and salt at high THI [EC 1 period] in both *red kandhari* cattle and *marathwadi* buffaloes ($P<0.05$). While, THI and high ambient temperature has negative correlation with milk components, no such association was found for wind speed and solar radiations. It was observed that high THI negatively affects milk constituents and the animals required more than 40-50 days to acclimatize from high THI to low THI during EC 2 period where no variation was recorded ($P>0.05$).

Keywords: Red kandhari cattle, marathwadi buffaloes, heat stress, thi, acclimatize, milk components

Introduction

Animal welfare, health and productivity are significantly modulated by interaction between external x internal environments x stressors. In tropical and subtropical regions the summer are prolonged, characterized with high environmental temperatures, humidity, producing high THI and heat stress on animals. The animals under heat stress have altered physiology, metabolism, energy balance, production and reproduction [1, 2, 3, 4]. Heat stress decreases the milk yield, milk components and the impact is more severe on dairy industry, especially on high producers [5, 6]. With the booming rise in global population and urbanization the animal industry is under constant pressure for maximum production and demand for animal products will increase by whooping 70 % by 2050 [7]. The milk production is negatively correlated with heat stress and worldwide 60 % of dairy farms cope up variety of economic losses due to extreme environmental temperatures, humidity, THI, solar radiations [8]. THI over 70 is considered stressful for cattle and immediately there is reduction in milk yield and milk components in dairy animals, mainly because of various thermoregulatory mechanisms and altered energy balance, predisposing the animals to negative energy balance [9].

Indigenous animals are comparatively less affected by heat stress, due to their natural genetic selection. But prolonged high temperatures and humidity constantly challenge the thermoregulation and homeostasis, increasing the energy demands. Thus, less energy is available for productive purposes, leading to decrease in milk production and variation in constituents. In this context the study was conducted to evaluate the effect of environmental temperature, THI, wind speed and solar radiations on *red kandhari* cows and *marathwadi* buffaloes. Also, the acclimatization phase/duration to heat stress needs to be quantified in our native breeds.

Materials and methods

Experimental animals, treatments and sampling

The study was conducted on 10 adult *red kandhari* cattle [RK: > 3 yrs, 250 kg] and four *marathwadi* buffaloes [MB: > 4 yrs, 390 kg] at livestock farm complex [LFC], College of Veterinary & Animal Sciences, (MAFSU), Parbhani. All animals daily went for grazing after which they were stall fed, milked twice and kept under identical managemental and feeding conditions, with *ad libitum* water throughout the experiment [10]. Data was collected during two environmental conditions i.e. EC 1 [Mid November, 2019 – Mid January, 2020] and EC 2 [Mid January – Mid March, 2020]. Milk samples were collected at fortnight's interval from all animals in morning and analyzed immediately. Meteorological variables i.e. dry bulb temperature [Db], wet bulb temperature [Wb], wind speed; solar radiations were recorded at 14.00 hrs every week throughout the experiment.

Analysis

All the collected milk samples were analyzed on automatic milk analyzer [Lactosure] for fat, solid not fats [SNF], total solids [TS], protein, lactose and salt (all in %). Dry bulb (°C), wet bulb temperature (°C) and wind speed (m/sec) were recorded by using fully automatic anemometer [Testo] till maximum readings were reached. Similarly, solar radiations (Lux) were recorded by using luxmeter [Testo] till maximum reading was achieved. Temperature humidity index [THI] was calculated by formula [11],

THI=0.72 (Wb + Db) + 40.6

Statistical analysis

Data were analyzed by the by one way analysis of variance model using SPSS 20.00 software [12] and indicated by their probability value (*P*). Differences among treatments were determined using Tukey's *b* test and indicated by the superscripts a, b, c, d. Correlation between temperature, THI, wind speed and solar radiations was estimated by *Pearson's correlation* and indicated by *r* value. All data were presented as standard error of means & significance was reported at $P<0.05$.

Results

Average environmental conditions during experimental period are presented in Table 1. The mean THI was high at EC1 [80.88±0.51] than recorded at EC 2 [79.87±1.02], similarly average Db temperature was 33.20±0.71 at EC1 and 32.49±0.91 at EC 2, respectively. Also, THI was positively correlated with ambient temperature during the study [r = .825; $P<0.001$].

Table 1: Average meteorological conditions during different environmental conditions

Variable	EC 1	EC 2
Db temperature (°C)	33.20±0.71	32.49±0.91
THI	80.88±0.51	79.87±1.02
Wind speed (M/sec)	1.60±0.23	1.71±0.20
Solar radiation (Lux)	48831.25±2870.87	67772.22±3147.73

*All data are presented means ± SE
EC: Environmental condition

The means ± SE for milk constituents in *red kandhari* cattle & *marathwadi* buffaloes during different environmental conditions is presented in Table 2. There was no significant variation ($P>0.05$) for milk fat, SNF, TS, proteins, lactose and salt (%) in RK cattle and *marathwadi* buffaloes at EC 1 or EC 2. However, milk fat, SNF, TS and lactose were statistically higher at different environmental conditions in buffaloes as compared to RK ($P<0.05$).

Table 2: Variation in milk constituents in *red kandhari* cattle and *marathwadi* buffaloes during different environmental conditions

Period	Fat %	SNF%	Total Solids %	Protein %	Lactose %	Salt %
Red Kandhari cattle						
EC 1	5.22±0.28	8.23±0.29^{a}	13.46±0.51	2.98±0.10	4.48±0.15^{a}	0.63±0.02
EC 2	4.24±0.29^{a}	8.85±0.12	13.10±0.37^{a}	4.14±0.80	4.82±0.06	0.69±0.01
Marathwadi buffalo						
EC 1	5.71±0.43^{b}	9.27±0.33^{b}	14.98±0.64^{b}	3.35±0.12	5.05±0.18^{b}	0.70±0.02
EC 2	6.31±0.23^{b}	9.33±0.08^{b}	15.64±0.26^{b}	3.36±0.02	5.08±0.04^{b}	0.71±0.01

*Means bearing different superscripts a, b differ significantly, within column at a respective parameter during seasons & animals ($P<0.05$),
EC: Environmental condition

The relationship between different meteorological variables with milk constituents for RK and MB at EC 1 is presented in Tables 3. For both RK and MB THI has significant negative correlation ($P<0.05$) with milk components like SNF: r = -.732; $P<0.039$, TS: r = -.732; $P<0.039$, protein: r = -.721; $P<0.044$, lactose: r = -.732; $P<0.039$ and salt: r = -.759; $P<0.029$. But, temperature was only negatively related to salt [r = -.744; $P<0.034$] at EC 1 period. At EC 1 exposure, wind speed and solar radiations had no significant effect ($P>0.05$) on normal milk constituents (Table 3).

Table 3: Correlation between temperature, THI, wind speed & solar radiations on milk constituents in *red kandhari* cattle and *marathwadi* buffaloes during EC 1 period

Variable	THI	Fat	SNF	TS	Protein	Lactose	Salt
THI	1	-.674	-.732*	-.732*	-.721*	-.732*	-.759*
	P	.067	.039	.039	.044	.039	.029
Wind speed	Wind speed	FAT	SNF	TS	PROTEIN	Lactose	SALT
	1	-.316	-.061	-.173	-.082	-.073	-.022
	P	.446	.887	.682	.847	.863	.959
Solar radiations	Solar radiations	FAT	SNF	TS	PROTEIN	Lactose	SALT
	1	.417	-.013	.173	-.014	.001	.036
	P	.304	.975	.683	.974	.997	.933
Temperature	Temperature	FAT	SNF	TS	PROTEIN	Lactose	SALT
	1	-.506	-.701	-.641	-.684	-.696	-.744*
	P	.200	.053	.087	.061	.055	.034

* Correlation is significant at the 0.05 level & ** Correlation is significant at the 0.01 level
SNF: solid not fat, TS: total solids, THI: temperature humidity index

Contrastingly none of the meteorological variables had any effect on milk components in both *red kandhari* cows and *marathwadi* buffaloes during EC 2 period. During this period THI, temperature, wind speed or solar radiations didn't significantly affect (P>0.05) normal milk constituents (Table 4).

Table 4: Correlation between temperature, THI, wind speed & solar radiations on milk constituents in *red kandhari* cattle and *marathwadi* buffaloes during EC 2 period

Variable	THI	Fat	SNF	TS	Protein	Lactose	Salt
THI	1	-.052	-.051	-.055	-.055	-.064	-.103
	P	.894	.897	.889	.888	.869	.791
Wind speed	Wind speed	FAT	SNF	TS	PROTEIN	LACTOSE	SALT
	1	-.182	-.091	-.160	-.112	-.150	.254
	P	.640	.817	.680	.773	.700	.510
Solar radiations	Solar radiations	FAT	SNF	TS	PROTEIN	LACTOSE	SALT
	1	-.085	-.150	-.112	-.205	-.175	-.266
	P	.828	.701	.774	.597	.653	.489
Temperature	Temperature	FAT	SNF	TS	PROTEIN	LACTOSE	SALT
	1	-.191	-.274	-.230	-.312	-.287	-.318
	P	.622	.475	.551	.414	.454	.404

* Correlation is significant at the 0.05 level & ** Correlation is significant at the 0.01 level
SNF: solid not fat, TS: total solids, THI: temperature humidity index

Discussion

The THI reference values for exotic breeds are somewhat different (lower) than that for our indigenous breeds. The critical values for minimum, mean and maximum THI for Holstein cattle is 64, 72 and 76, respectively [13] which are lower than THI recorded during our experimental conditions [EC 1: 80.88±0.51;EC 2: 79.87±1.02]. Although, our animals evolved in tropical conditions but still are affected by heat stress due to critical interaction of external (managemental), internal (physiological, nutritional and metabolic) variants. Lack of any variation in milk constituents at EC 2 period during our study was probably an acclimatization response as the animals were exposed initially to higher THI during EC 1 period and then to lower THI at EC 2 period.

Still, a significant negative relation during EC 1 period (P<0.05) was observed for milk SNF, TS, protein, lactose and salt with THI. It is reported that dry matter intake decreased significantly as THI reached 77, subsequently reducing the milk yield in cattle [14]. Though, *red kandhari* cattle and *marathwadi* buffaloes are not high milk producers and heat stress affects high milkers more severely, as compared to average/low milk producing animals [15].Still, the significant decline (P<0.05) for milk components for RK cattle and *marathwadi* buffaloes confirms alteration of normal physiology and metabolism during heat stress [high THI]. It is earlier reported that, there is decrease in milk fat yield in heat stressed animals mainly due to altered mammary gland and systemic metabolism [16, 17, 18, 19, 20, 4]. Others have reported non significant variation in milk fat in *zebu* cattle during hyperthermia similar to our findings [21, 22].

The decrease in SNF and TS was significant with increasing THI [EC 1] and similar findings are already reported by different researchers in livestock, confirming altered mammary gland metabolism during thermal stress [19, 20, 23, 24]. Similarly, low SNF % [9.11 vs 8.73] was reported in Nili-Ravi buffaloes during heat stress [THI: 85.41; Temperature: 33.34^{o}C] [4]. Contrastingly, in other study on Nili-Ravi buffaloes during hot humid seasons no significant variation for milk fat, SNF and TS was observed as compared to optimum temperatures [22].

The milk protein is produced directly at mammary glands, but majority of amino acids are systemic nutrients. Heat stress is known to cause negative energy balance in animals [25] and there is shift in glucose utilization in non mammary gland tissue affecting milk synthesis adversely [26]. In our study the decreased milk protein (P<0.044) and lactose (P<0.039) at higher THI might be due to negative energy balance or increased gluconeogenesis for thermoregulation, in RK cows and *marathwadi* buffaloes. Our observations are corroborated by other similar studies reporting negative impact of HS on milk components in dairy cattle, buffaloes and goats [9, 24, 27, 28, 29].

The process of acclimation and acclimatization to heat stress utilizes both short term and long term metabolic alterations. Animals affected by thermal stress have negative mineral balance as these minerals are lost in sweat and other body fluids [30, 31]. An altered mineral balance in animals at high THI probably resulted in low salt % recorded in our study. Similar, decrease in salt and milk minerals during summer versus winter season (0.67% vs 0.71%) is also reported in Friesian cows [32].

Heat stress evokes different physio-metabolic responses in animals to maintain homeothermy and associated indispensible hormones are prolactin, growth hormone, thyroid hormones, glucocorticoids, antidiuretic hormone (ADH) and aldosterone [33]. The heat stress was evident by negative associations of milk components to environmental variables like high ambient temperature and THI during EC 1 exposure [temperature: 33.20±0.71; THI: 80.88±0.51]. Wind speed and direct solar radiations don't potentiate the heat stress impact as noted in present study, if animal management and housing are proper. Earlier it was reported that acclimatization of atleast 21 days is essential during heat stress [34]. There were no changes in milk components EC 1 to EC 2 period in both *red kandhari* cows and *marathwadi* buffaloes and it can be concluded that a transition period of atleast 40 days or more is required for stress acclimatization.

Conclusion

Animal in tropics are exposed to high ambient environmental temperatures and humidity [THI] for prolonged periods predisposing them to certain HS. The animals sustain this stressful period by energy partitioning for homeostasis & thermoregulation, thereby less substrates are available for milk production. In present study, both high temperature and THI had a significant negative impact on metabolism, leading to alteration of different milk components in *red kandhari* cows and *marathwadi* buffaloes [EC 1 period]. The prolonged summer months in tropical regions, lead to chronic heat stress on animals. The animals require a long transition period of more than 40-50 days for complete stress acclimatization, which was evident during EC 2 period in our study, where there were no alterations in milk constituents in *red kandhari* cows and *marathwadi* buffaloes.

References

1. West JW. Effects of heat-stress on production in dairy cattle. Journal of Dairy Science. 2003; 86:2131-2144.
2. Marai IFM, Haeeb AAM. Buffalo's biological functions as affected by heat stress — A review. Livestock Science. 2010; 127:89-109.
3. Naik SV, Singh M, Sharma HD. Short term changes in plasma hormones, metabolites, milk yield and physiological responses in epinephrine administrated cows. Journal of Bio Innovation. 2014; 3:63-72.
4. Ahmad M, Bhatti AJ, Abdullah M, Javed K, Din RU, Ali M *et al*. Effect of different ambient management interventions on milk production and physiological performances of lactating Nili-Ravi buffaloes during hot humid summer. Livestock Research for Rural Development. 2017; 29(12):1-17.
5. Kumar SBV, Kumar A, Kataria M. Effect of heat stress in tropical livestock and different strategies for its amelioration. Journal of Stress Physiology and Biochemistry. 2011b; 7(1):45-54.
6. St Pierre NR, Cobanov B, Schnitkey G. Economic losses from heat stress by US livestock industries. Journal of Dairy Sciences. 2003; 86(E Suppl):E52-E77.
7. FAO. Livestock and the environment, 2015. http://www.fao.org/livestock-environment/en/
8. Perorer MF, Vasconcelos JL, Trinca LA, Hansen PJ, Barros CM. Influence of sire and sire breed (Gyr versus Holstein) on establishment of pregnancy and embryonic loss in lactating Holstein cows during summer heat stress. Theriogenology. 2007; 67:692-697.
9. Rhoads ML, Rhoads RP, Vanbaale MJ, Collier RJ, Sanders SR, Weber WJ *et al*. Effects of heat stress and plane of nutrition on lactating Holstein cows:1. Production, metabolism and aspects of circulating somatotropin. Journal of Dairy Science. 2009; 92:1986-1997.
10. NRC. National Research Council, Nutrient Requirements of Dairy Cattle, National Academy Press, Washington, DC, 2001.
11. NRC. National Research Council. A guide to environmental research on animal. National Academy of Sciences, Washington, DC, 1971, 374.
12. SPSS, Inc. SPSS (Statistical Package for Social Sciences) for Windows© 1997; Version 20.00 SPSS Inc Chicago, IL, 1993.
13. Igono MO, Bjotvedt G, Sanford-Crane HT. Environmental profile and critical temperature effects on milk production of Holstein cows in desert climate. International Journal of Biometeorology. 1992; 36:77-87.
14. Johnson HD, Ragsdale AC, Berrry IL, Shanklin MD. Temperature humidity effects including influences of acclimation in feed and water consumption of Holstein cattle. Missouri Agriculture Experimental Station Research Bulletin, 1963, 846.
15. Bernabucci U, Lacetera N, Baumgard LH, Rhoads RP, Ronchi1 B, Nardone A. Metabolic and hormonal acclimation to heat stress in domesticated ruminants. Animal. 2010, The Animal Consortium 2010; 4(7):1167-1183. doi: 10.1017/S175173111000090X.
16. Kadzere CT, Murphy MR, Silanikove N, Maltz E. Heat stress in lactating dairy cows. A review. Livestock Production Science. 2002; 77:59-91.
17. Bryant JR, Lopez Vilialobos N, Pryce JE, Holmes CW, Johnson DL. Quantifying the effect of thermal environment on production traits in three breeds of dairy cattle in New Zealand. New Zealand Journal of Agriculture Research. 2007; 50:327-338.
18. Singh M, Chaudhari BK, Singh JK, Singh AK, Maurya PK. Effects of thermal load on buffalo reproductive performance during summer season. Journal of Biological Science. 2013; 1(1):1-8.
19. Yadav SP, Sikka P, Kumar S, Sarkar S, Pandey AK, Yadav PS *et al*. Variation in milk constituents during different parity and seasons in Murrah buffaloes. Indian Journal of Animal Science. 2013; 83(7):747-751.
20. Hossein ZNG, Mohit A, Azad N. Effect of temperature humidity index on productive and reproductive performances of Iranian Holstein cows. Iranian Journal of Veterinary Research. 2013; 14:106-112.
21. Hansen PJ. Physiological and cellular adaptations of zebu cattle to thermal stress. Animal Reproduction Science. 2004; 82-82:349-360.
22. Singh G, Kamboj ML, Patil NV. Effect of thermal protective measures during hot humid season on productive and reproductive performance of Nili-Ravi buffaloes. Indian Buffalo Journal. 2005; 3:101-04.
23. Bailey KE, Jones CM, Heinrichs AJ. Economic returns to Holstein and Jersey herds under multiple component pricing. Journal of Dairy Science. 2005; 88:2269-2280.
24. Key N, Sneeringer S, Marquardt D. Climate change, heat stress and U.S. dairy production. A report summary from the economic research service, United States Department of Agriculture, 2014. http://www.ers.usda.gov/media/1679930/err175.pdf.
25. Shwartz G, Rhoads MJ, Vanbaale MJ, Rhoads RP, Baumgard LH. Effect of supplemental yeast culture on heat stressed lactating Holstein cows. Journal of Dairy Science. 2009; 92:935-942.
26. Rhoads RP, Baumgrad LH, Suagee JK, Sanders SR. Nutritional interventions to alleviate the negative consequences of heat stress. Advances in Nutrition. 2013; 4(3):267-276.
27. Habeeb AAM, Ibrahim MK, Yousef HM. Blood and milk contents of triiodothyronine (T3) and cortisol in lactating buffaloes and changes in milk yield and composition as a function of lactation number and ambient temperature. Arabian Journal of Nuclear Sciences Application. 2000; 33(2):313-322.
28. Bernabucci U, Lacetera N, Ronchi B, Nardone A. Effects of the hot season on milk protein fractions in Holstein cows. Animal Research. 2002; 51:25-33.
29. Rodriguez LA, Mekonnen G, Wilcox CJ, Martin FG, Krienke WA. Effects of relative humidity, maximum temperature, pregnancy and stage of lactation on milk composition and yeild. Journal of Dairy Science. 1985; 68:973-978.
30. Colleir RJ, Breede DK, Thatcher WW, Israe LA, Wilcox CJ. Influence of environment and its modification on dairy animal health and production. Journal of Dairy Science. 1982; 65:2213-2227.

31. Kumar SBV, Kataria M. Effect of dietary supplementation on electrolyte Profile and lymphocyte proliferation during heat Stress in buffaloes. Journal of Cell and Tissue Research. 2011a; 11(3):2977-2980.
32. Gaffar HMA, El-Gendy ME, Bassiouni ML, Shamiah SM, Halawa AA, El-Hamd MA. Effect of heat stress on performance of dairy Friesian cows 1-milk production and composition. Researcher. 2011; 3:85-93.
33. Beede DK, Collier RJ. Potential nutritional strategies for intensively managed cattle during thermal stress. Journal of Animal Science. 1986; 62:543-554.
34. Wankar AK, Singh AK, Yadav B. Effect of temperature X THI on acclimatization in buffaloes subjected to simulated heat stress: physio-metabolic profile, methane emission and nutrient digestibility. Biological Rhythm Research, 2019, 1-15. https://doi.org/10.1080/09291016.2019.1673652.