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Holstein steers grazing two Bermudagrass varieties in hot and dry summer: forage quality and physiological responses of steers

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ABSTRACT

The objective was to evaluate the forage quality of two varieties of Bermudagrass and some physiological traits of Holstein steers during two grazing periods in summer in an arid zone. Twenty-four Holstein steers (BW=200 ± 5 kg), 20 intact animals, and 4 with rumen cannulas were randomly assigned for grazing to the Bermudagrass varieties Cross 1 (BC1, n=12) and Giant (BG, n=12) in two consecutive periods (P1 and P2) during the summer-fall season in northwestern México. Based on the temperature-humidity index, the climate in P1 was considered as severe heat stress and P2 as moderate heat stress. Levels of CP and ash were higher ($P<0.05$) in BG during P2. Contents of NFD, AFD, and hemicellulose were higher ($P<0.01$) in BG during P2 than BC1 during P1, respectively. Only fat content was higher ($P<0.05$) in BC1 than BG. The *in vitro* digestibility of dry and organic matters showed no differences ($P>0.05$) between varieties or periods. Respiration frequency and all body surface temperatures were higher during the first grazing period and in the afternoon, which coincides with the hottest grazing period and time of day. In conclusion, climatic conditions of the site of the study along with a poor quality of Giant and Cross 1 Bermudagrass varieties under grazing conditions, make the nutritional supplement recommended to reach satisfactory results for growing cattle.

Keywords: *Bermudagrass*, *forage digestibility*, *grazing pastures*, *heat stress*, *Holstein steers*.

INTRODUCTION

The Mexicali Valley is located in the northwestern state of Baja California, and is one of the most important agricultural provinces of México. This valley is irrigated by water from the Colorado River that begins in the state of Colorado, USA. It flows to México in a controlled approach under an international agreement signed between the two countries. In this desert region of northwestern Mexico, beef cattle production is an important component of the livestock industry. It is economically one of the highest contributors to the agricultural segment of the region (Avendaño-Reyes et al., 2020). Around 90% of the meat from beef cattle production is produced in the Mexicali Valley, which provides around 80% of the total economic value of the livestock sub-segment in the state and has fourth place nationwide in beef meat production (SADER-Baja California, 2019). This livestock activity is based on feedlot operations, where calves from different breeds arrive after weaning from several Mexican states, such as Sonora, Chihuahua, Durango, Zacatecas, Jalisco, Veracruz, and Chiapas, among others. However, the recent increment in grain prices has led to grow the calves in irrigated pastures before they enter the corrals for intensive feeding in an attempt to reduce total production costs. In this arid region, summer weather is opposite to winter weather: summer months may reach 50°C, with temperatures above 30°C from May to October; meanwhile, winter temperatures can drop below 0 °C, with an average of about 15°C from November to February (García, 2004). This evident climatic scenario makes the crop establishment very differentiated. For grazing purposes, annual Ryegrass (*Lolium multiflorum L.*) is preferred during wintertime, with excellent results for the growth of cattle (Mejía-Delgadillo et al., 2011). However, during summer, there is no pasture defined, even though some irrigated pastures have been proven with poorer results compared to winter grasses (Vargas and Yáñez, 1996). The use of Bermudagrass for grazing cattle represents a valuable forage resource due to its acceptable nutritional value, rapid regrowth for grazing, great tolerance to extreme climatic conditions, and slight resistance to drought (Hacker and Jank, 1998). The Bermudagrass varieties Giant and Cross 1 are characterized by their resistance to grazing, medium quality forage, and good palatability during grazing; however, the limitation of nutritional values includes low protein crude and energy content, as well as high fiber level (Galloway et al., 1993). One option for the Mexicali Valley can be the establishment of Bermudagrass for growing cattle during summer for a period of 180 - 210 d, depending on the ambient temperatures for growth and rapid regrowth (Scaglia and Boland, 2014). The condition of extreme heat stress occurring during summer is a factor that may affect calves during grazing, increasing animal´s body temperature and reducing their grazing ability. Heat stress can be generated as part of a combination of ambient temperature, relative humidity, and is reflected in a high temperature-humidity index (THI; Hahn et al., 2003). Also, the increase in the fibrous fraction of the grass as the plant grows generates an increase in metabolic heat that raises body temperature and reduces weight gain in cattle (Gebremedhin et al., 2016). There is a lack of scientific information about the influence of grazing periods and varieties of Bermudagrass on physiological and digestive variables. Therefore, the objective of this study was to evaluate the effect of two grazing periods during the summer-fall season on forage quality parameters and physiological variables of Holstein steers grazing two varieties of Bermudagrass in an arid region.

MATERIALS AND METHODS

All procedures involving steers were performed following the guidelines of approved Mexican Official Standards (NOM – 051 – ZOO - 1995: Humanitarian care of domestic and wild animals).

Study Location

The study was carried out in the Experimental Beef Cattle Unit of the Instituto de Ciencias Agrícolas, which belongs to the Universidad Autónoma de Baja California, located in the Ejido Nuevo León, Mexicali Valley, Baja California, México (32° 24´ N and 115° 11´ W). The climate of this arid region is hot and dry, with an average annual temperature of 22°C, being January the coldest and July the hottest month, with averages for maximum and minimum temperatures of 13 and 1.66°C, and 45 and 20 °C, respectively (INEGI, 2010).

Animals and Treatments

Two plots of 1.5 ha, each already established with two varieties of Bermudagrass: Cross 1 (BC1) and Giant (BG), were used. After each grazing, paddocks were fertilized with N (70 kg N/ ha^{-1}) before irrigation of the pasture. Twenty-four Holstein steers and four cannulated with an average live weight of 200 ± 5 kg were randomly divided into two groups of 10 intact animals and 2 with rumen and duodenal cannulas, one for each Bermudagrass variety. Animals were treated with vitamins (A-D-E; 4 mL/steer of Vigantol, Bayer Laboratory, México) and against parasites (6 mL/steer of Ivermectina, Sanfer Laboratory, México). Previous to initiating the study, an adaptation period of 30 d was given to the steers. So two varieties, BC1 and BG, and two periods of 75-d during summer-autumn (June 3rd to October 31st) were evaluated. Periods were characterized by the intensity of heat stress: the first period (P1) covered the first 75 d, while the second period (P2), the next 75 d. Steers had free access to a shaded pen and to the pasture; pens provided with waterers, and there was no supplement offered to the steers.

Forage Sampling

Two cannulated steers per treatment were used for the collection of forage samples with the following schedule: day 1, 09:00, and 21:00 h; day 2, 13:00 and 01:00 h; day 3, 17:00 and 05:00 h. The procedure to take the aliquot of forage consisted of identifying by visual observation the nearest site the animal was grazing, considering similar structure to the animal at the scheduled time defined; from the observed spot, a cut with garden shears was obtained of ~ 50 g of fodder at a similar height to which the animal had grazed. The samples were placed in paper bags and weighed on a digital scale. They were finally dried at 55 ºC for 72 h in a forced-air oven and ground in Willey® mill using 2 mm mesh. Samples of the different days and times per animal and period were combined to take an aliquot of ~ 70 g. This was preserved in a plastic container with airtight closure for later analysis (Laca et al., 1989).

Forage Chemical Composition and Nutritional Value

In the selected forage samples and using the Near-Infrared Spectroscopy (NIRS) method, the following standard determinations of nutritional value were estimated: dry matter (DM), crude protein (CP), ash, fat, neutral detergent fiber (NDF), acid detergent fiber (ADF). The NIR System model 6500 (Foss-NIRSystems Silver Spring, MD, USA) was used for the spectra readings, which included a reflectance detector and a sample rotation module. The equipment was managed using the WinISI 1.04 software38 (ISI Windows Near-Infrared Software, WinISI II, version 1.02A, Foss NIRSystems, Silver Spring, MD, USA) for both processes optical data and to develop calibrations. The absorbance values ([log (1/R)] were kept as the average of the three subsamples. Hemicellulose (HM) was determined according to the method established by Goering and Van Soest (1970) and the digestive variables in vitro digestibility of organic matter (IVDMO) and in vitro digestibility of dry matter (IVODM) according to the method established by Tilley and Terry (1963).

Climatic Variables

The climatic data were obtained from a weather station located in the study site and consisted of hourly registration of ambient temperature (AT) and relative humidity (RH). With this climatic information, the THI was calculated using the following formula proposed by Hahn (1999):

$$THI = 0.81\ AT + RH\ (AT - 14.4) + 46.4$$

Where:

THI = Temperature-Humidity Index (Units),
AT = Ambient Temperature (ºC), and
RH = Relative Humidity (%).

Physiological Variables

Two different physiological variables were recorded in the present study: respiratory frequency (RF) and body surface temperatures (BST). The respiratory frequency was recorded through visual observations by counting the flank movements using a manual counter and a stopwatch for 60 seconds. The body surface temperatures were recorded from the anatomical regions: nose, eye, head, rump, loin, belly, and paddle in 5 steers on each Bermudagrass variety. They were measured during the first three weeks of each sampling, two days (Wednesday and Friday) per week at three different times (07:00 [AM], 13:00 [AFT], and 19:00 [PM] h). A digital infrared thermographic camera (Fluke Ti100, Everett, WA, USA) taking photos at 1.0 - 1.5 m distance from the steers was used. Subsequently, pictures were downloaded to a computer to be collected with the Fluke SmartView® software.

Statistical Analyses

The physiological variables RR and BST were analyzed with a 2x2x3 factorial arrangement under a completely randomized design with repeated measurements over time, where the factors were Bermudagrass varieties (VAR: BC1 and BG), grazing periods (PER: P1 and P2), and time (TIME: AM, AFT, PM). Adjusted means were obtained using the command PDIFF of the PROC MIXED from SAS (SAS, Institute. Inc., Cary, NC) version 9.2. Several covariance structures were tested, and the first-order autoregressive showed the best fit according to the AIC and BIC criteria (Littell et al., 1996). The digestive variables (IVDOM and IVDDM) were analyzed with a 2x2 factorial arrangement under a completely randomized design, considering the variety and period of the factors. The factorial effect averages were estimated using the LSMEANS procedure and the comparison between them by the command PDIFF STDERR. A significance between means was considered only at 0.05 level, using the GLM procedure of the SAS statistical program (SAS Institute Inc., Cary, NC) version 9.2. However, the trend was considered with a probability greater than 0.05 but less than 0.10.

RESULTS AND DISCUSSION

Climatic Variables

The prevailing climatic data during the study period are presented in Table 1. As expected, averages of TA, RH and THI were higher in P1 than in P2. It is observed that in P1, extreme weather conditions were recorded and are typical of a desert region, consequently critical for beef production. The average RH fluctuated between 38.2 and 56.1%, with a general average of 49%, values considered distinctive of desert areas. The overall average of the THI during the study was 76.8 units, with a range of 82.6 and 68.5 units in the months of July and October, respectively. On the other hand, it can be noted that during September and October (P2), the THI decreased even below 70 units (75.2 and 68.5 units, respectively).

Forage Quality Parameters

Results of the analysis of variance for the chemical composition and digestibility parameters used in this study are shown in Table 2. The interaction VAR x PER was significant ($P<0.05$) for the variables CP and ash, while NFD, AFD, and HM were affected independently by both main effects VAR and PER. Fat differed ($P<0.05$) by VAR, and digestibility parameters (IVDDM and IVDOM) showed just a trend ($P<0.10$) to be affected by PER. Percentages of NFD, AFD, and HM were higher ($P<0.01$) in BG than in BC1 (56.1 vs. 45.8%, 34.5 vs. 26.9%, and 21.6 vs. 19.0%, respectively), while fat percentage was higher ($P<0.01$) in BC1 than in BG (2.22 vs. 1.77%). There was a trend ($P<0.10$) for NFD, AFD, and HM, observing higher values during P2 compared to P1 (52.6 vs. 49.4%, 31.9 vs. 29.5%, and 20.8 vs. 19.8%, respectively).

Table 1. Descriptive statistics of climatic variables by month and period during the study.

	Ambient temperature (°C)				Relative Humidity (%)				THI (Units)			
	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
Months												
June	20.1	39.2	29.8	7.4	17.3	83.1	46.8	26.5	66.3	82.9	76.3	6.9
July	26.2	40.3	33.1	5.2	26.2	89.0	56.1	23.2	77.4	88.7	82.6	3.6
August	25.1	41.1	33.2	5.7	22.2	83.5	49.6	23.8	75.1	88.2	81.2	4.9
September	20.0	35.1	27.5	6.4	29.4	81.3	54.4	28.9	67.6	81.3	75.2	7.6
October	15.1	33.5	24.1	6.7	16.7	65.8	38.2	23.2	58.8	76.9	68.5	6.7
Periods												
Period 1	23.8	40.2	32.0	6.1	21.9	85.2	50.8	24.5	72.9	86.6	80.0	5.1
Period 2	20.1	36.6	28.3	6.3	22.8	76.9	47.4	25.3	67.2	82.1	75.0	6.4

THI: Temperature-Humidity Index, Min: Minimum, Max: Maximum, SD: Standard deviation.

Table 2. Effects of Bermudagrass varieties (BC1 and BG) and grazing period (P1 and P2) and their interaction on the nutritional value and in vitro digestibility of the forage during the study.

	VARIETY				PERIOD				Interaction
Items, (% DM)	BC1	BG	SEM	*P-value*	P1	P2	SEM	*P-value*	VAR*PER
CP	4.28	6.46	0.53	0.02	4.13	6.61	0.53	0.01	**<0.01**
Fat	2.22	1.77	0.09	<0.01	2.00	2.00	0.09	1.00	0.78
Ash	3.66	6.10	0.32	<0.01	4.19	5.58	0.32	0.01	**0.01**
NFD	45.8	56.1	0.92	<0.01	49.4	52.6	0.92	0.04	0.06
AFD	26.9	34.5	0.70	<0.01	29.5	31.9	0.70	0.04	0.08
Hemicellulose	19.0	21.6	0.22	<0.01	19.8	20.8	0.22	0.03	0.06
Digestibility, (%) IVDDM	45.2	48.5	1.68	0.20	44.4	49.3	1.68	0.08	0.39
IVDOM	51.8	54.4	1.59	0.28	50.8	55.5	1.59	0.07	0.44

BC1: Bermuda Cross 1; BG: Giant Bermuda; P1: Period 1; P2: Period 2; CP: Crude protein; NFD: Neutral detergent fiber; AFD: Acid detergent fiber; IVDMD: *In vitro* digestibility of dry matter; IVDOM: *In vitro* digestibility of organic matter

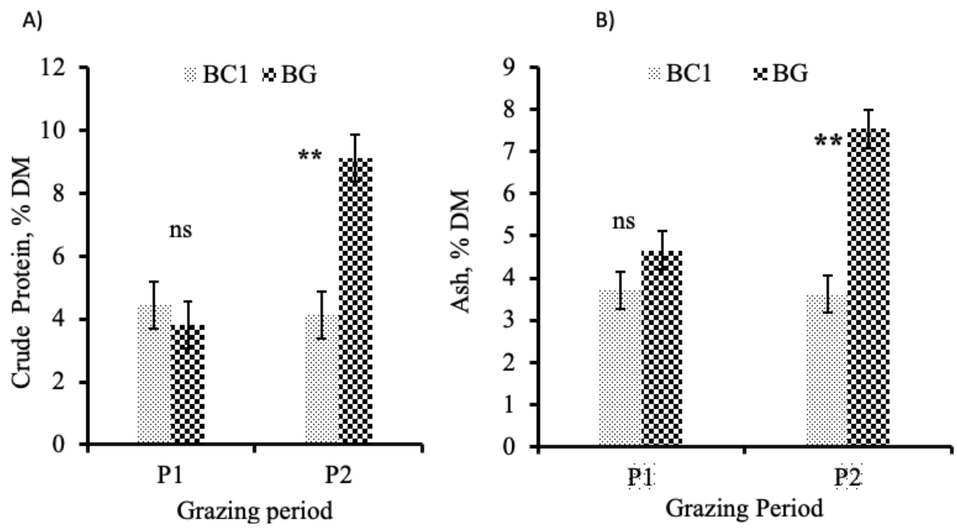

Figure 1. Averages (mean±SEM) of A) crude protein and B) ash for the interaction grazing period * variety during the study (ns: P>0.05; **: P< 0.01). These show the interaction VAR x PER for CP and ash. In P1, BC1 had higher (P<0.01) CP content than BG (4.44 vs. 3.81 %); however, in P2, BG had higher (P<0.01) CP content than BG (9.11 vs. 4.11%). Ash was higher (P<0.01) for BG than BC1 in both P1 (4.66 vs. 3.71%) and P2 (7.54 vs. 3.62%). Finally, the IVDDM and IVDOM tended to be higher (P<0.10) in 10 and 8.5% during P2 compared to P1

Physiological Variables

The influence of Bermudagrass varieties, grazing periods, and time, as well as their interactions on physiological variables of Holstein steers, are presented in Table 3. The interaction VAR x PER x TIME was not significant for any physiological variable. However, RF, and temperatures of rump, paddle, and belly were affected (P<0.05) by VAR x PER and PER x TIME interactions. Meanwhile, temperatures of head, loin, nose and eye were affected (P<0.05) just by PER x TIME interaction. So results of these variables will be explained in terms of interactions (figures) and main effects (tables). Finally, eye temperature was affected (P<0.05) by the Bermudagrass variety.

Figure 2 shows the interactions VAR x PER and PER x TIME for the variable RF. During P1, steers grazing BG exhibit higher (P<0.05) RF than steers grazing BC1 (65 vs. 60 bpm); however, during P2 both groups of steers had similar (P>0.05) RF (~ 45 bpm). On the other hand, RF was higher (P<0.05) at AFT (80 bpm) than PM (58 bpm) and AM (48 bpm) hours during P1; a similar pattern was observed during P2 but with smaller values. Figure 3 shows the interactions VAR x PER and PER x TIME for the variable rump temperature (TRump). Steers grazing BC1 and BG reduced (P<0.05) their TRump from P1 to P2 in 4.8 and 5.8°C; however, TRump of steers grazing both varieties of Bermuda within periods was essentially similar (P>0.05). Daily average TRump at AFT was the highest (P<0.05), followed by TRump at PM; during the morning, TRump reached the lowest (P<0.05) temperature. This scenario was similar for P1 and P2. Figure 4 shows the interactions VAR x PER and PER x TIME for the variable belly temperature (TBelly). Steers grazing BC1 and BG reduced (P<0.05) their TBelly from P1 to P2 in 4.6 and 5.5°C; however, steers grazing both varieties of Bermuda within periods were essentially similar (P>0.05) in TBelly. Figure 5 shows the interactions VAR x PER and PER x TIME for the variable paddle temperature (TPaddle). Steers grazing BC1 and BG reduced (P<0.05) their TPaddle from P1 to P2 in 5.3 and 6.9°C; however, TPaddle of steers grazing both varieties of Bermuda within each period was essentially similar (P>0.05). The results from the interaction PER x TIME for the physiological variables THead, TLoin, TEye, and TNose showed the same pattern as TRump (Figure 6), reaching the highest temperature in the afternoon. Lastly, steers grazing BG exhibited higher (P<0.05) TEye than steers grazing BC1 (Table 3).

A) B)

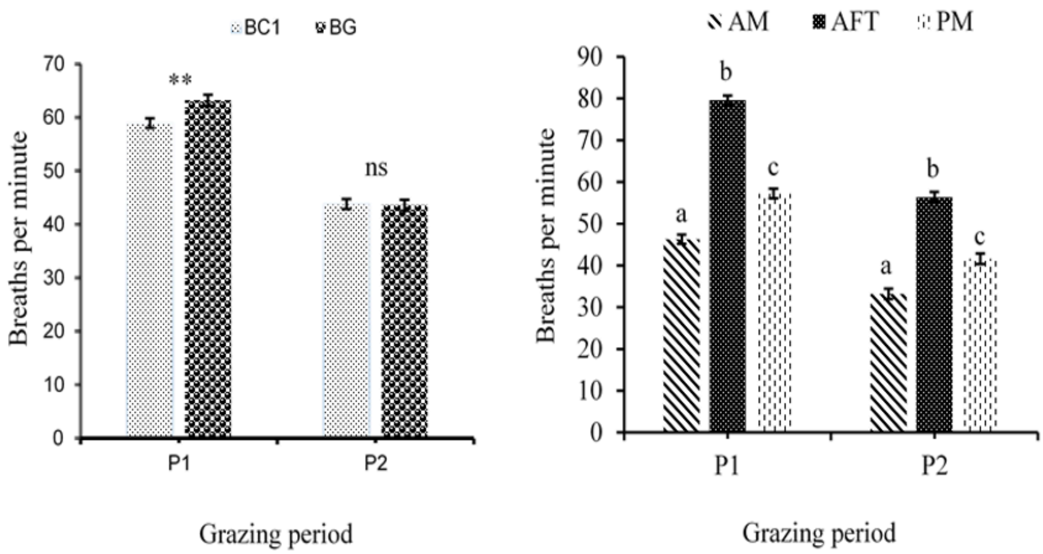

Figure 2. Averages (mean±SEM) of respiration frequency (RF) of Holstein steers for the interactions A) grazing period * variety and B) grazing period * time of day during the study (ns: P>0.05; *: P< 0.05; ** P< 0.01). [abc]Means of time of day within grazing period with different superscript differ (P< 0.05).

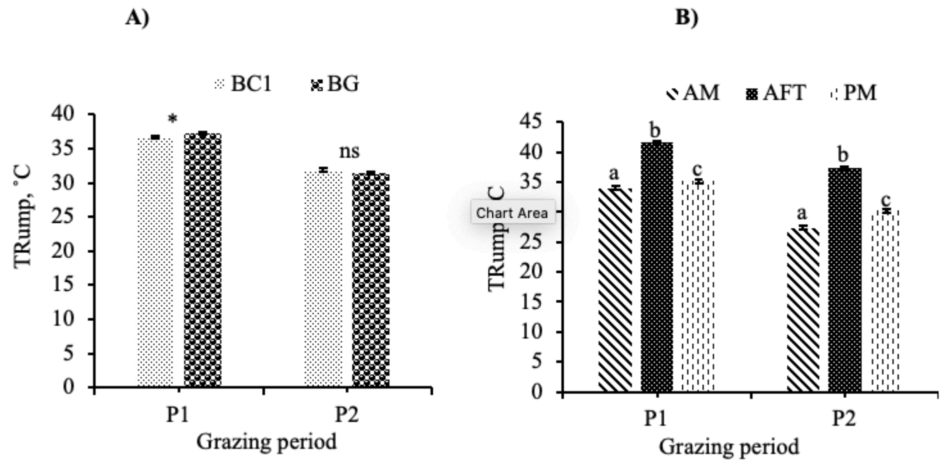

Figure 3. Averages of rump temperature (TRump) of Holstein steers for the interactions A) grazing period * variety and B) grazing period * time of day during the study (ns: P>0.05; *: P< 0.05). [abc]Means of time of day within grazing period with different superscript differ (P< 0.05).

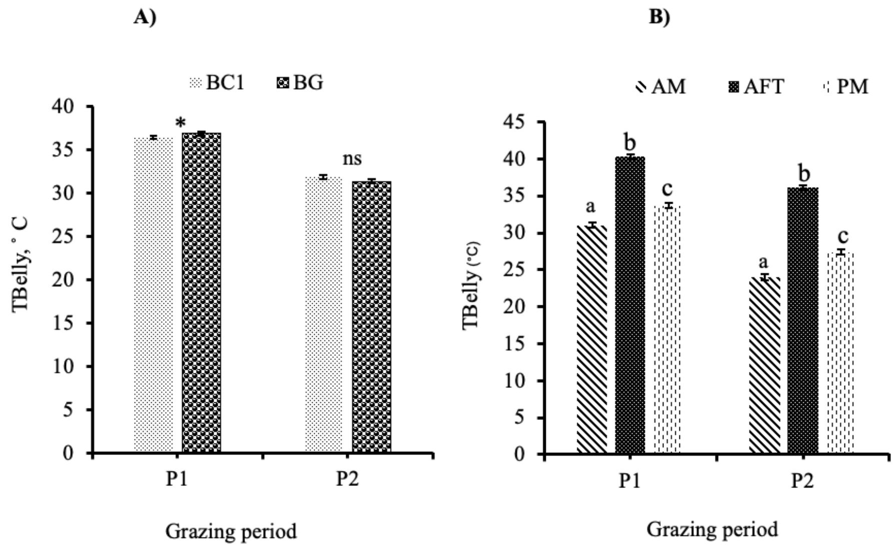

Figure 4. Averages of belly temperature (TBelly) of Holstein steers for the interactions A) grazing period * variety and B) grazing period * time of day during the study (ns: P>0.05; *: P< 0.05). [abc]Means of time of day within grazing period with different superscript differ (P< 0.05).

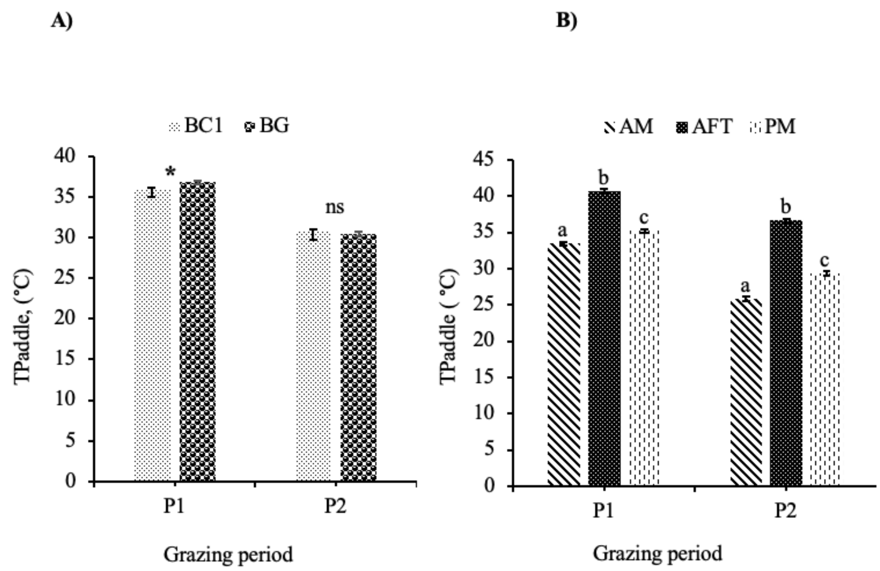

Figure 5. Averages of paddle temperature (TPaddle) of Holstein steers for the interactions A) grazing period * variety and B) grazing period * time of day during the study (ns: P>0.05; P< 0.05;). [abc]Means of time of day within grazing period with different superscript differ (P< 0.05).

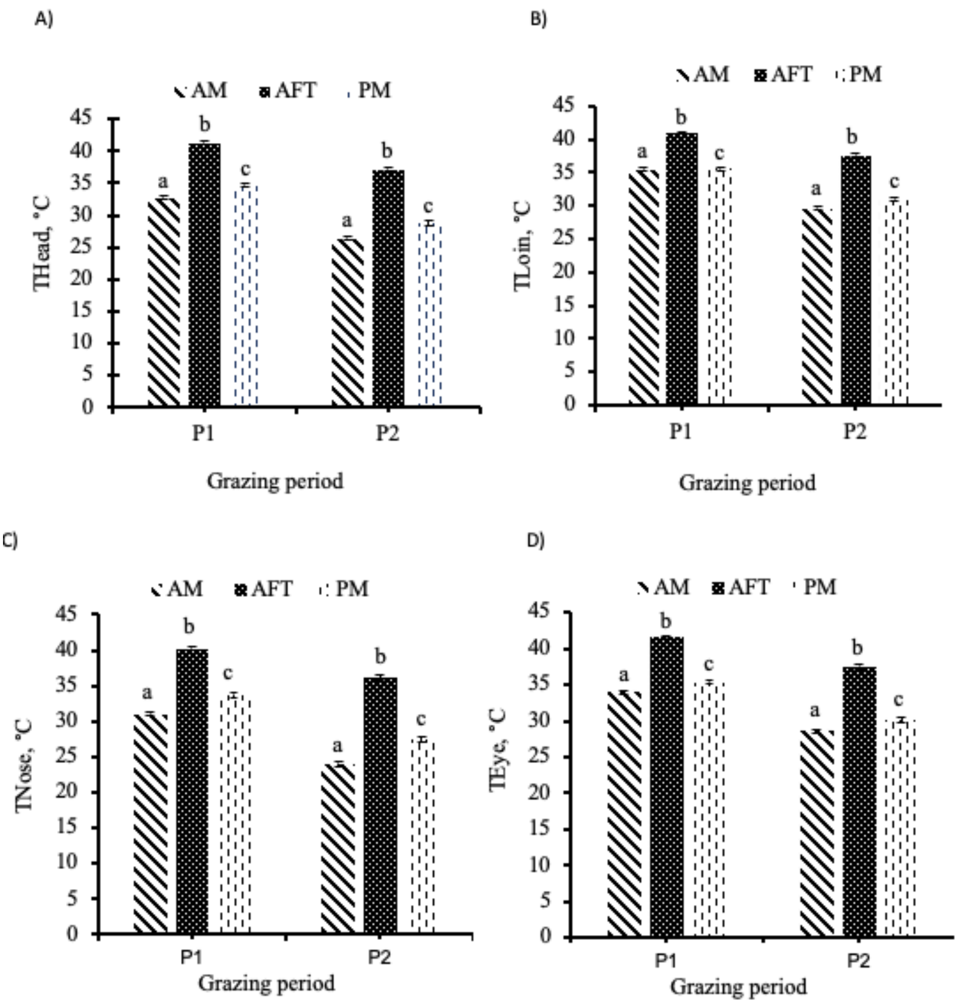

Figure 6. Averages of A) head temperature (THead), B) loin temperature (TLoin), C) nose temperature (TNose), D) eye temperature (TEye) of Holstein steers for the interactions grazing period * time of day during the study. [abc]Means of time of day within grazing period with different superscript differ ($P < 0.05$).

Table 3. Effects of the bermudagrass varieties (BC1 and BG), grazing periods (P1 and P2), times of day (AM, AFT, and PM), and their interactions on physiological variables (respiration frequency and body surface temperature) of Holstein steers.

	Varieties				Periods				Times of day					Interactions			
Item	BC1	BG	SEM	P-value	P1	P2	SEM	P-value	AM	AFT	PM	SEM	P-value	V*P	V*T	P*T	V*P*T
RF, (bpm)	51.2	53.5	0.70	0.02	61.0	43.7	0.71	<0.01	39.5	68.3	49.3	0.86	<0.01	0.02	0.23	<0.01	0.49
Thead (˚C)	33.4	33.6	0.16	0.30	36.2	30.8	0.16	<0.01	29.6	39.1	31.8	0.19	<0.01	0.30	0.18	<0.01	0.86
TLoin (˚C)	35.1	34.9	0.15	0.28	37.3	32.7	0.15	<0.01	32.6	39.2	33.2	0.18	<0.01	0.10	0.45	<0.01	0.32
TRump (˚C)	34.2	34.3	0.16	0.61	36.9	31.6	0.16	<0.01	30.8	39.4	32.7	0.20	<0.01	0.02	0.91	<0.01	0.64
TNose (˚C)	32.0	32.1	0.21	0.76	35.0	29.1	0.21	<0.01	27.6	38.1	30.6	0.26	<0.01	0.72	0.62	<0.01	0.90
TEye (˚C)	34.3	34.7	0.16	0.05	36.9	32.0	0.16	<0.01	31.3	39.5	32.7	0.20	<0.01	0.15	0.13	0.03	0.67
TPaddle (˚C)	33.4	33.7	0.16	0.21	36.5	30.6	0.16	<0.01	29.8	38.6	32.2	0.20	<0.01	0.02	0.16	<0.01	0.50
TBelly (˚C)	34.1	34.1	0.16	0.87	36.6	31.6	0.16	<0.01	30.8	38.8	32.8	0.19	<0.01	0.05	0.59	<0.01	0.66

bpm: breaths/min; BC1: Bermuda Cross 1; BG: Giant Bermuda; P1: Period 1; P2: Period 2; AM: Morning; AFT: Afternoon; PM:Night; V*P:VAR*PER; V*T: VAR*TIME; P*T: PER*TIME; V*P*T:VAR*PER*TIME; T:Temperature

Climatic Variables

According to Ravagnolo et al. (2000), a THI greater than 72 units is the threshold where dairy cattle start to exhibit symptoms of heat stress. Moreover, Berman (2006) and Mader et al. (2002) consider that a THI ≥ 74 is an indicator that beef animals make physiological adjustments to prevent a rise in their body temperature due to hot environmental conditions. In the present study, the average THI from June to September was higher than 74 units, which is the threshold for heat stress in beef cattle. Only the month of October showed a THI lower than 74 units. However, when the THI was estimated by period, P1 and P2 were in average 80 and 75 units, respectively. The intensity of heat stress in the first period is classified as severe heat stress, while the second period is classified as mild heat stress. In average, both periods were classified as heat stress for grazing cattle. Temperature alone is not considered a good method to measure heat stress in domestic animals, and this is because heat stress is also associated with relative humidity. However, in arid zones, humidity is not as high as in tropical ecosystems but should be considered (Hahn et al., 2003). The Mexicali Valley is an arid zone with temperatures during the hottest months of summer that can reach 50°C, which occurs in July and August; after these months, ambient temperature decreases so that September was the month with the lowest ambient temperature during the study.

Forage Quality Parameters

Bermudagrass is a C4 grass well adapted to the transition warm-arid ecological system since their exposure to high environmental temperatures results in changes in physiological, metabolic, and biochemical processes. These changes provided them the ability to attain thermotolerance to prolonged heat stress episodes (Kumar et al., 2013). Acquisition of high-quality forages for grazing purposes helps to reduce purchases of additional feedstuffs for cattle during summer months; however, in general quality of Bermudagrass during this season is considered low. Our results showed that protein, fat, and ash levels agree with this statement; nevertheless, BG exhibited better quality than BC1 in both grazing periods during summer. However, all the composition values observed in the two Bermudagrass varieties studied here were lower than those reported by other authors in different latitudes such as Jones et al. (1988), Galloway et al. (1993), Wheeler et al. (2002), and Juárez-Reyes et al. (2009). It is important to mention that a CP content of at least 8% is considered the beginning for microbial growth in the rumen and to provide amino acids to the animal´s body (Kearl, 1982; Stern and Hoover, 1979). In our particular case, this nutritional requirement was not covered by any Bermudagrass variety. Despite forage quality slightly improved when environmental conditions were less drastic, which is from P1 to P2, minimum thresholds were not reached. Gutiérrez (2013), in the same experimental site, reported similar differences in the chemical composition for BC1 between subsequent periods (1 and 2) during summer. The fiber content of grass is determined by the content of NDF percentage, which varies in grass grazed from 30% in fresh spring grasses to 50% in stem grasses. In the present study, BG exceeded this threshold of NDF, reaching 56%, which was 10.3% higher than NDF content of BC1. Grasses with high fiber content are associated with a restriction of voluntary feed intake, reduction of body condition, and production losses (Minson, 1990). Also, the body heat increment (given by the higher RF and TEye) was associated with high fiber levels in steers consuming Giant Bermudagrass.

Even though digestibility results were not significant, they indicate a trend towards increasing as the weather changed from severe to mild HS conditions. The results of IVDOM by period agree with those obtained in the study carried out by Gutiérrez (2013), who found an increase in IVDOM of BC1 from the first to the last grazing period, using 3 grazing periods during his study. The observed values of IVDDM in both varieties were lower than those reported by Cabanillas et al. (2017) in pastures BC1, Cross 2, and Santo Domingo, which is attributed to the fact that the varieties used in the present study had lower CP levels. Mathews et al. (1994) estimated the average of IVDOM in Holstein heifers grazing Bermudagrass in a tropical region, and they found similar values of IVDOM to those reported in the present study.

Physiological Variables

Studies in cattle under heat stress report that when the respiratory frequency ranges between 20 and 60 breaths per minute, animals are in thermoneutral conditions, but when it increases from 80 to 120 breaths per minute, they are considering moderate to severe heat stress (Gaughan et al., 1999; Lees et al., 2019); this effect was observed in the present study. A similar result in grazing cattle during summer was reported by Brown-Brandl et al. (2003), with an ambient temperature of 18, 30, and 34 oC, the RF raised from 56 to 84 and then to 103 breaths per minute, respectively.

In the present study, the higher RF was observed when the ambient temperature rises afternoon (13:00 h) and during P1, compared with 07:00h and 17:00 hours and P2; this coincides with Echeverri-Echeverri et al. (2018), who used Holstein steers for grazing during summer at 31.4 °C of ambient temperature, where the respiratory frequency was greater than autumn at 30.4 ° C (80 vs 56 breaths per minute, respectively). In the same way, O'Brien et al. (2010) observed an increase in RF of heifers of 135 kg of live weight at TR of 29.4 and 40.0 °C from 80 to 117 breaths per minute at 07:00 h and 18:00 hours, respectively. Yadav et al. (2017) exposed crossbred cattle to 25, 35, and 40°C for 5 h/d during 21 d in a climatic chamber, finding that rectal temperature, respiration rate, and pulse rate increased linearly as temperature increased.

In general, BST followed a circadian rhythm of cattle during summer: the lowest BST was during the morning, then the maximum BST was obtained in the afternoon and reduced again during the nighttime. Also, differences between periods were observed, which was totally attributed to the climatic conditions. For instance, when the measurements were considered in the afternoon in P1, the belly temperature of the steers grazing BG was 40.8 ° C, while at the same time, during P2 was only 37 °C. Echeverri-Echeverri et al. (2018) reported higher loin than rump temperature, which was attributed to the fact that this anatomical region is located near the rumen so that effects of animal physiology are combined with the metabolic heat produced to increase body temperature.

In a study conducted by Anzures-Olvera et al. (2015) using Holstein multiparous lactating cows under confinement and heat stress conditions, temperature of head was lower than those reported in the present study. The fact that steers had a shaded pen for resting and that grazing was with no restriction may account for avoiding high solar loads to find a comfortable site for protection. Yadav et al. (2019) exposed crossbred cattle to 25 and 40°C for 21 days in a climatic chamber to assess their acclimatization to heat stress. They found that cattle needed a period of 6 to 21 days for acclimatization to extreme temperatures since factors such as biochemical, physiological, and endocrine processes are involved.

The BST registered at different anatomical sites in ruminants can be used as a signal of stress and precision farming under different production systems (Poikalainen et al., 2012). The disparity in BST at several locations indicated that the temperature of skin surface not only varied with changes in ambient temperature but also varied in some anatomical regions of the body at a specific time of the day and grazing period (Roberto and De Souza, 2014). In this study, temperatures of paddle, eye, and loin at 13:00 h were the highest; meanwhile, nose and paddle registered the lowest surface temperatures during P1. So rump and loin were anatomical regions where grazing steers experimented with more heat loss activity. This heat interchange is because when animals are grazing outdoors, paddle, loin, and head are subjected to intense heat loads from the environment (Yadav et al., 2017). Evaluating the BST of Hanwoo, a Korean *Bos taurus* breed, Kim et al. (2014) reported temperatures of eyes (37.9, 42.2, and 39.6 °C) and ears (36.8, 41.8, and 38.5 °C) during summer at 07:00, 13:00, and 19:00 h respectively; these surface temperatures followed the circadian pattern of the THI which was 76, 85.6 and 78.7 units in the same order of time of day. They concluded that the eye showed the temperature more stable, reflecting effectively the temperature surrounding animals. Even though our steers had access to a shaded pen and to water *ad libitum* in the corral, the high ambient temperatures avoid them to maintain body temperatures under normal conditions (~ 39°C). In general, the physiological responses were affected by heat stress conditions as a consequence of the ITH observed in the first period and the higher NDF content of the Giant Bermuda grass.

CONCLUSIONS

Bermudagrass Giant variety showed better nutrient quality than Cross 1 based on protein and ash content, but *in vitro* digestibility of organic and dry matter was similar between these two varieties established under hot and dry climatic conditions of the arid zone studied. Holstein steers had more signs of heat stress during the first grazing period than the second one because THI was more intense. Body surface temperatures of loin and rump presented higher temperatures taken with infrared thermography. Use of Bermudagrass varieties Giant or Cross 1 for grazing purposes under extremely arid conditions should be accompanied by a feed supplement since the nutritional quality of those forages is considered medium-low.

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