Influence of the season on nutritional and metabolic indicators of grazing cattle in the North of Mexico

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In grazing cattle, the nutritive quality, digestion and ruminal fermentation of the diet, blood glucose levels (GLU), urea nitrogen (UN) and non-sterified fatty acids (NSFA) were evaluated during the dry and rainy seasons. An analysis of variance according to a complete random block designs (CRBD) and with successive measurements was applied. Dry matter intake (DMC), organic matter intake (OMC), digestible energy (DEC), metabolizable energy (MEC), passage rate (Kp), and mean ruminal retention time of the diet were affected by the season of the year ($P < 0.05$). The crude protein (CP) and the effective protein degradation (EPD) of the diet, as well as the concentrations of ruminal ammonia nitrogen ($N\text{-}NH_3$) and UN were higher in the rainy than in the dry season ($P < 0.01$). The contents of neutral detergent fiber (NDF) and the effective NDF degradation were also different between both periods of the year ($P < 0.01$). Similarly, the concentrations of acetic, propionic and butyric acids differed between seasons ($P < 0.01$). GLU concentrations were higher in the rainy season compared to the dry season ($P < 0.01$), while NSFA were higher during the latter ($P < 0.05$). Nutrient deficiencies recorded suggest the need of feeding supplementation for the animals, mainly protein and energy, during the dry season.

Key words: *cattle, degradation, glucose, urea-nitrogen, NSFA*

In the Northern region of Mexico, the nutritive quality of the diet chosen for grazing ruminants depends on the season of the year. For this reason, the evaluation of the quality of the diet is considered of great importance, taking into account the season of the year, in order to establish adequately strategic feeding supplementation programs for this species. This type of assessment must be complemented with studies of ruminal degradation and fermentation of the diet selected, as well as with the analysis of the blood concentrations of some metabolites (GLU), UN and NSFA which are, probably, the most affected by the season of the year (Juárez *et al*. 2008). According to Preston and Leng (1990), the high values of dry matter ruminal degradation are associated with the potential of the ruminants for maintaining adequate production levels, while the blood levels of GLU, UN and NSFA allow to assess the nutritional status of the grazing cattle (Romero *et al*. 2007).

The study was aimed to evaluate the influence of the season of the year on the nutritive quality, digestion and ruminal fermentation of the diet and its effect on some blood metabolites in grazing cattle.

Materials and Methods

Description and botanical composition of the area under study. The experiment was conducted in a medium size grassland with fruit trees and a forage production of 1796 kg of DM/ha, localized between 104º 3' of West longitude and 24º 22' of North latitude at 1 938 m a.s.l., dry BS1K climate, temperate with rainfall in the summer, with an annual mean temperature and precipitation of 17.5º C and 450 mm, respectively (INEGI 2003). The botanical composition of the area under study was estimated by the minimum sampling area with located points (Franco *et al*. 1985). The dominant pasture species were *Melinis repens* Willd (zacate rosado), *Chloris virgata*, (zacate mota), *Bouteloua gracilis* (zacate navajita), *Aristida adscencionis* (tres barbas annual) and *Andropogon barbinodis* (popotillo plateado). Also de shrub-like *Acacia tortuosa* (huizache), *Prosopis juliflora* (mesquite), *Opuntia spp.* (nopales) and *Mimosa biuncifera* (gatuño), were included as well as a great variety of annual grasses.

Animals, periods and sampling procedures. Four Brangus steers, rumen fistulated, of 350 ± 3 kg LW, and ten Charolais calves, of 210 ± 10 kg LW, from the herd grazing the area under study, were used. Each sampling period lasted twelve days, in the dry season (February, March, April and May) and in the rainy period (July, August, September and October) of 2008. In the 1st, 2nd, and 3rd, day of each sampling period the dry matter (DMC) and organic matter (OMC) intakes were estimated from total feces production (TFP) and of the non-digestible diet fraction (Villanueva *et al*. 2003). For the estimation of TFP, chromium sesquioxide was used as marker (10 g/animal/d). In the 4th, 5th and 6th day, samples of the diet and of the ruminal content were obtained according to the technique of ruminal evacuation (Cline *et al*. 2009). From diet samples taken from the rumen OM, CP (AOAC 1999), NDF, ADF, lignin (L), acid ash insoluble in acid detergent (AAI) (van Soest *et al*. 1991); *in vitro* dry matter digestibility (IVDMD) and organic matter (IVOMD)(Huntington and Burns 2007), chromium to the feces (Jordon *et al*. 2002) were determined. Digestible (DE) and metabolizable energy (ME) of the diet (Waterman *et al*. 2007) were

estimated. The passage rate (Kp) and the mean ruminal retention time (MRRT) were calculated according to the methodology of Ogden *et al*. (2005). From the 7th day of each period, *in situ* degradation was determined by bag incubation, with 10 g of forage sample in the steers' rumen, at 0, 6, 12, 24, 36, 48, 72 and 96 h interval. With the model proposed by Orskov and McDonald (1979) the indicators "a" (soluble fraction), "b" (potentially degradable fraction), "c" (constant degradation rate of "b") and a + b (potential degradation, PD), were estimated. With the model ED = (a + b* c)/(c + Kp) the effective DM degradation of DM (EDMD), CP (EDCP) and NDF (EDNDF) were determined.

The A and B fractions of the NDF were estimated. Particle losses by bag washing were represented with A. The fermentable insoluble fraction was represented with B, defined as B = (a + b) – A (Khazaal *et al*. 1995). The 11th and 12th day of each period and before the beginning of grazing (7:30 a.m.), 30 mL of rumen liquor were taken and the pH was immediately measured. The 10 mL sub-samples were separated for determining later the volatile fatty acids (VFA) and N-NH_3 (Abdelhadi and Santini 2006). Once this process finished, the animals left for grazing. The described procedure was repeated at 4, 8 and 12 h after grazing started. The 12th day blood samples (12 mL) were taken to the ten Charolais calves through the puncture of the jugular vein using Vacutainer, without anticoagulant. Samples were centrifuged at 1700 rpm for 20 min for obtaining serum and they were maintained under freezing conditions at -20ºC until their analysis (Obeidat *et al*. 2002). Concentrations of GLU, UN and NSFA in serum were determined with the commercial packages (2614 for GLU; Ureasa/ Berhelot 640 for UN and 115 for NSFA, of RANDOX). In the determinations of GLU, UN and NSFA (essays, n = 4) were obtained CV within the essays of 1.8, 2.4 and 4.3%, respectively.

Statistical analysis. Analysis of variance (ANOVA) were carried out for complete random block designs, where the seasons of the year were considered as treatments and the months included in each season, as blocks. The variables measured by time were submitted to an ANOVA for a design of complete random blocks with repeated measurements, including the effects of season, animal, time of the day and their respective interactions (Litell *et al*. 1996). In the data analysis the procedures GLM, MIXED and NLIN of SAS (2003) were used.

Results and Discussion

Nutritive quality. The crude protein of the diet was 52.8% higher in the rainy season regarding the dry season ($P < 0.01$) (table 1). However, the contents of NDF, ADF and L were 14.1, 12.8 and 33.8%, respectively higher in the dry season compared the rainy season ($P < 0.01$). The contents of IVDMD, IVOMD, DE and ME were higher in the rainy season ($P < 0.05$). Andrade *et al*. (2009) reported similar results, indicating that the nutritive quality of the diet of grazing cattle was higher in the rainy period. Variations between seasons regarding nutritive quality of the selected diet by the animals, could be attributed to the phenologic phase of the grasslands, since in the region the maturity and forage latency are normally found between March and July.

Intake, passage rate and ruminal retention time. DMC, OMC, DEC and EMC, Kp and MRRT were affected by the season of the year ($P < 0.05$ (table 2). DMC, of 5.6 and 7.7 kg/d in grazing cattle, reported by Soltero *et al* (1988) in the dry and rainy seasons, respectively, were higher than those obtained in this study. These differences could be attributed to the fiber contents of the diet consumed by the animals (Sowell *et al*. 2003). The Kp of the diet recorded in the rainy season was the fastest ($P < 0.05$), coinciding with a lower MRRT registered in this period ($P < 0.05$). The lower fiber content of the diet consumed in the rainy season, compared to the dry season consumption could account for this result, since the fibrous particles are more resistant to ruminal degradation (Bhatti *et al*. 2008).

In situ dry matter degradation. The values of a, b, c,

Table 1. Nutritive quality of the diet of grazing cattle in the two seasons of the year

Indicator	Season		SE±	Sig
	Dry	Rainy		
OM (%)	91.0	89.3	1.10	NS
CP (%)	4.9	10.4	0.53	**
NDF (%)	74.9	64.3	0.96	**
ADF (%)	56.3	46.7	0.86	**
L (%)	7.1	4.7	0.88	**
In vitro DM digestibility (%)	61.1	68.9	1.06	*
In vitro OM digestibility (%)	59.2	67.3	1.11	*
Digestible energy (MJ/kg DM)	9.2	10.4	1.21	*
Metabolizable energy (MJ/kg DM)	7.5	8.4	2.88	*

*P < 0.05 **P < 0.01

Table 2. Intake, rate of passage and mean ruminal retention time of the diet of grazing cattle in two seasons of the year

Indicator	Season		SE±	Sig
	Dry	Rainy		
DM intake (kg/d)	4.5	6.7	1.80	*
OM intake (kg/d)	4.2	6.4	1.30	*
DE intake (MJ/ d)	25.9	50.1	4.09	*
ME intake (MJ/ d)	21.7	38.3	2.76	*
Passage rate (%/h)	1.6	2.5	0.97	*
Mean ruminal retention time (h)	60.0	39.7	1.20	*

a + b and EDDM were higher in the rainy season compared to the dry one ($P < 0.01$) (table 3). These differences could be attributed to the NDF contents affecting ruminal DM digestion of the diet of grazing ruminants (Ramírez *et al*. 2004). Reyes (2005) reported similar results to those obtained in this study and indicated that in the dry season the increase of lignocellulosic compounds in the cell wall blocks the action of the ruminal microorganisms to degrade perfectly the DM of the forages.

In situ protein degradation. In this study, the values of a, b, c, a + b and EDCP in the rainy season were higher than in the dry season ($P < 0.01$) (table 4), and similar to those reported by Peyro (2006) for both seasons of the year. The lignin-carbohydrate complex could account for the differences found between seasons. This, on advancing the maturity hinders the activity of the microbial proteases to degrade the available forage protein (Foster *et al*. 2007). In the "a" soluble fraction, a considered criterion for determining if this is in an acceptable range so that the ruminal $N\text{-}NH_3$ is well assimilated by the ruminal microorganisms is that it does not exceed 40% of the EDCP of the forage (AFRC 1993). In the evaluated seasons, the mean value of the soluble protein "a" fraction represented, approximately, 45.9% of the EDCP of the diet consumed. This indicates that the ammonia nitrogen capture capacity by the ruminal microorganisms was slightly surpassed.

In situ NDF degradation. The A, B, A + B and EDNDF fractions were different between seasons of the year ($P < 0.01$) (table 5). The NDF portions incorporated in the "A" fraction are more associated with losses of small particles in the bags than with the solubility of the components of the cell wall (Ogden *et al*. 2005). Consequently, the NDF washing losses could be attributed to the different lignin contents of the forage consumed in both periods of the year (Flores *et al*. 2007). Differences observed in the values of B, PD and EDNDF could be explained by the phenological status of the grassland due to the fact that these fractions are affected by the maturity of the pasture (Ramírez *et al*. 2004). The constant NDF degradation rate was faster in the rainy season ($P < 0.05$), but it was lower than that reported by Funk *et al*. (1987) in the diet consumed by grazing cattle (4.2% h).

*Ruminal fermentation pattern*s. Since there were no interaction between seasons of the year and time of the day in the ruminal fermentation variables, only the averages through time are shown (table 6). The highest ruminal pH value was recorded in the dry season (6.6) differing from that of the rainy season (6.3) ($P < 0.05$). For Elías *et al* (2000), the pH values are in an acceptable range for the optimum rumen microbial activity. The concentrations of $N\text{-}NH_3$, recorded in the rainy season were higher than in the dry season ($P < 0.01$). These differences can be attributed to the CP contents of the diet consumed in the two seasons of the year (van Soest 1994). Brokaw *et al*. (2001) found higher ruminal concentrations of $N\text{-}NH_3$ in the

Table 3. *In situ* ruminal degradation indicators and effective degradation of the dry matter of the diet of grazing cattle in two seasons of the year

Indicator	Season		SE±	Sig
	Dry	Rainy		
a (%)	17.3	22.4	0.77	**
b (%)	42.7	54.3	0.64	**
c (%/h)	2.3	4.5	0.09	**
a + b (%)	60.0	76.7	0.97	**
ED (%)	39.6	56.8	0.96	**

**$P < 0.01$

Table 4. *In situ* ruminal protein degradation indicators of the grazing cattle diet in two seasons of the year

Indicator	Season		SE±	Sig
	Dry	Rainy		
a (%)	25.8	33.4	0.93	**
b (%)	43.0	47.4	0.52	**
c (%/h)	3.6	5.2	0.03	**
a + b (%)	68.8	80.8	0.74	**
ED (%)	47.9	61.7	0.83	**

**P < 0.01

Table 5. *In situ* ruminal NDF degradation fractions of the cattle diet in two seasons of the year

Indicator	Season		SE±	Sig
	Dry	Rainy		
A (%)	2.4	5.5	0.66	**
B (%)	37.4	48.4	1.39	**
c (%/h)	2.1	3.4	0.03	*
A+B (%)	39.8	54.0	1.95	**
ED (%)	23.1	33.8	1.10	**

*P < 0.05 **P < 0.01

rainy season (6.6 mg/dL) in grazing cattle. In this study, the concentrations of acetic and butyric acids in the dry period were higher than in the rainy period (P < 0.01). However, the concentrations of propionic acid in the dry season were lower than in the rainy season (P < 0.01). These differences could be due to the structural carbohydrate contents of the diet consumed by the animals (Mendoza *et al*. 2000). The concentration of acetic, propionic and butyric acids coincide with those reported by Choat *et al*. (2003). Short chain VFA concentrations were higher in the rainy season (P < 0.01). VFA are increased with growth and flowering, and decline with grassland maturity (van Soest 1994).

Blood metabolites. GLU concentrations were higher in the rainy season (P < 0.01) (table 7). Probably, the best quality of the diet consumed by the animals during this period, could account for these differences. The diet supplied in this stage greater amount of gluconeogenic cofactors, as the propionic acid and the protein degraded in the rumen (van Soest 1994). However, the GLU concentrations observed in the two seasons of the year were maintained in normal concentrations (45 to 75 mg/dL) for beef cattle (Kaneko *et al*. 1997). In grazing steers, Hersom *et al*. (2004) found similar

Table 6. Values of ruminal pH, ammonia nitrogen concentrations and volatile fatty acids of the diet of grazing cattle in two seasons of the year

Indicator	Season		SE±	Sig
	Dry	Rainy		
pH	6.6	6.3	0.95	*
N-NH_3 (mg/dL)	4.7	11.5	1.27	**
Total VFA (mmol)	68.3	71.4	1.16	*
mol/100 mol				
Acetic	66.4	63.8	0.98	**
Propionic	13.8	16.6	0.73	**
Butyric	7.1	4.8	1.10	**
A:P	4.8	3.8	1.32	NS
Short chain VFA[1]	12.3	15.7	0.43	**

[1]Isobutyric + isovaleric + valeric

*P < 0.05 **P < 0.01

Table 7. Concentrations of blood metabolites in grazing cattle in two seasons of the year

Indicator	Season		SE±	Sig
	Dry	Rainy		
Glucose (mg/dL)	49.1	71.1	1.81	**
Urea-N (mg/dL)	6.1	9.3	0.11	**
NSFA (mmol/L)	0.13	0.13	0.09	*

*P < 0.05 **P < 0.01

GLU concentrations (69.4 mg/dL) in the rainy season. Also the UN concentration was higher in the rainy season compared to the dry season (P < 0.01). The UN concentrations recorded in both seasons of the year were lower to those found by Waterman *et al*. (2006) (10.5 mg/dL) in grazing cattle. However, they agree with the UN concentrations found by Romero *et al*. (2007) in grazing cattle during the dry season (6.4 mg/dL). Arias and Nesti (1999) consider as normal the NU concentrations of 10 to 14.8 mg/dL, in bovine serum. However, Sowell *et al*. (2003) indicate that UN concentrations in blood, lower than 7 mg/dL, show protein deficiencies as consequence of low consumption of RDP. NSFA concentrations were higher in the dry season regarding the rainy (P < 0.05).

Regularly, blood concentrations of NSFA increase with the advance of forage maturity and serve as an alternative energy source for grazing cattle, when they show negative energy balances o are under caloric stress conditions (Abeni *et al*. 2004), although the NSFA function in the maintenance of the caloric homeostasis is not well defined (Bowden 1971). The NSFA concentrations registered were higher than those obtained by McCraken *et al*. (1993) (0.110 mmol/L) in grazing steers. The differences in the energy content of the diet selected by the animals could account for this result.

It is concluded that the season of the year influences significantly on the nutritive quality and degradation of the diet, as well as in the blood concentrations of GLU, UN and NSFA in free grazing cattle. Nutrient deficiencies were recorded in the dry season, though feeding supplementation to the animals, mainly protein and energy during this period of the year, is suggested.

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