Australian Journal of Basic and Applied Sciences, 5(3): 500-504, 2011
ISSN 1991-8178

Seasonal Dynamic in Nutritive Quality, Passage Rate and *in Vitro* Gas Production of Diets by Grazing Steers in Native Range of North Mexico.

[1]M. Murillo Ortiz, [1]O. Reyes Estrada [1]E. Herrera Torres, [2]E. Gutiérrez Órnelas, and [1]M.A. Cerrillo Soto

[1]Facultad de Medicina Veterinaria y Zootecnia de la Universidad Juárez del Estado de Durango, Durango, Dgo. 34000, México.
[2]Facultad de Agronomía, Universidad Autónoma de Nuevo León, México

Abstract: The objective of this study was to evaluate the seasonal dynamic of the nutritive quality, rate passage and *in vitro* gas production in the diet of grazing steers. Study was carried during 2004 and 2005. For the statistical analysis a repeated measure design was used. We didn't found significant differences on organic matter (OM) diet's between years and seasons (P>0.05), but we found differences in crude protein (CP) content, true *in vitro* digestibility dry matter (TIVDDM), and metabolizable energy (ME) between years (P<0.05). The higher values were obtained in 2004. However, neutral detergent fiber (NDF) content was 8% higher in 2005 that in 2004, while CP content was 20% higher in 2004. The CP content, TIVDDM, and ME were higher in summer and fall as compared to winter and spring (P<0.05). The passage rate (Kp) was 53.5 % higher in 2004 that in 2005 (P<0.05); while diet Kp was higher in summer and fall compared to winter and spring (P<0.05). The gas produced by the soluble fraction a gas produced by the insoluble but slowly fermenting fraction b and constant gas production rate c were different between years, with the highest values in 2004 and the lowest in 2005 (P<0.01). However, the values of the lag time L were greater in 2005 that 2004 (P< 0.01). The values of **a** and b were greater in summer and fall as compared to winter and spring (P<0.01). The value of **c** were affected by season of the year (P<0.01), with the highest values in summer (4.5%h^{-1}) and the lowest in winter (2.3%h^{-1}). The duration of L was greater in spring and the lowest in summers (P< 0.01). We conclude that seasonal weather changes affected in the diet selected by grazing steers.

Key words: Steers, grazing, nutritive quality, rate passage, *in vitro* gas production.

INTRODUCTION

Some studies report that, as a result of drastic climate change, the animals in the region of north of Mexico have periods of 90 to 100 days of favorable grazing conditions and if the number of days is reduced, the survival of these animals may be in jeopardy (González, *et al.* 2007). Under long-term drought conditions, the evaluation of nutritive quality of the diet selected by grazing cattle across seasons is essential to establishing strategic programs of dietary supplementation (Klopfenstein, *et al.* 2001). However, these evaluations may be complemented by analyses of ruminal digestion and *in vitro* gas production of diet of grazing ruminants to establish dietary supplementation needs. The disappearance of digesta from the gastrointestinal tract of ruminant is a function of the competing processes of digestion and passage of undigested residues (Van Soest, 1994). Studies directed toward evaluation of rates of passage in ruminants grazing native rangelands should provide insight into the mechanism controlling voluntary intake in such animals (McCollum and Galyean, 1985). Moreover, the *in vitro* gas production method is widely used to evaluate the nutritive value of different classes of forages (Getachew, *et al*. 2002). The gas production technique is more efficient the other *in vitro* techniques in determining the quality nutritive of feeds (Adesogan, *et al.* 2005). The objective of this work was examined seasonal changes in nutritive quality, rate passage and in the *in vitro* gas production of the diet selected by grazing steers during two consecutive years.

MATERIALS AND METHODS

Study area. The study was carried during two consecutive years (2004 and 2005) in a medium-sized shrub-

Corresponding Author: M. Murillo Ortiz, Facultad de Medicina Veterinaria y Zootecnia de la Universidad Juárez del Estado de Durango, Durango, Dgo. 34000, México.

grassland east of the city of Durango, Mexico (24° 22' N, 104° 32' W, at an altitude of about 1938 m above sea level), which has a dry temperate (BS_1k) climate with average annual temperature and rainfall of 17.5°C and 450 mm, respectively. Rainfall in 2004 was above average at 547.5 mm and 2005 was drier than normal at 238.0 mm (Table, 1).The study area covers 2,000 ha (6 ha/AU) with an average of forage biomass of 1,796 kg of DM/ha. During the two years of the study, we estimated vegetation cover using minimum area sampling with nested points (Franco, *et al.* 1985). Dominant grass species included *Melinis repens* Willd (rose natal grass), *Chloris virgata* (feather fingergrass), *Bouteloua gracilis* (blue grama), *Aristida adscensionis* (sixweeks threeawn) and *Andropogon barbinodis* (cane bluestem); bushes: *Acacia tortuosa* (poponax), *Prosopis juliflora* (mezquite), *Opuntia spp* (prickly pears and chollas), *Mimosa biuncifera* (mimosa); plus a wide variety of annual herbs.

Animals and Collection of Diet Samples:

We used four steers with fistulated in the esophagus and three heifers cannulated of the rumen both with a live weight of 350 ± 3 kg. Surgery was performed on the steers and heifers according to procedures approved by the University of Durango Laboratory Care Advisory Committee. We collected diet samples with the steers fistulated of esophagus on four consecutive days at 07:00 during a 45-minute period (Karn, 2000), eight times annually: (1) Jan 2-5, (2) Feb 4-7, (3) Apr 13-16, (4) May 15-18, (5) Jul 20-23, (6) Aug 11-14, (7) Oct 12-15 and (8) Nov 20-23. The first two collection periods were considered to be in winter; 3 and 4, spring; 5 and 6, summer; and 7 and 8, fall. Collection periods were conducted at these times to reflect phenological changes in the plant community.

Nutritive Quality of Diet:

Esophageal samples were dried at 60ºC for 48 h and ground through a 2 mm screen in a Wiley mill. Dry matter (DM), CP, and, organic matter (OM) contents, were determined by standard procedures (AOAC, 1999), and the NDF with procedures proposed by Van Soest *et al*. 1991. The TIVDDM of diets was estimates using techniques of ANKOM, 2008. We estimated ME content with the formulas used by Waterman *et al.* 2007: digestible energy (DE; Mcal/kg) = [0.039 x (OMD g %)] – 0.10; ME (Mcal(kg) = DE (Mcal/kg) x 0.82. Where OMD g is the organic matter degradability obtained after 48 h incubation in the rumen.

Rate of passage (Kp):

We used three heifers with a live weight of 350 ± 3 kg surgically fitted with rumen canula. These heifers were in the study area during all experimental period beside the steers that were fistulated in the esophagus. Upon concluding periods collection of diet samples and before initiating grazing, we removed all ruminal contents in each heifer and placed them in black polyethylene bags, weighed them, we took 0.5 kg samples and immediately reintroduced the contents into the rumen of the heifer from which it came. We determined the acid-insoluble ash (AIA) in samples of ruminal contents and determined Kp by dividing AIA content in the diet consumed by the steers by total AIA in the ruminal content (Ogden, *et al.* 2005).

In Vitro Gas Production:

The *in vitro* gas production was carried out using the method proposed by Menke and Steingass, 1988. Approximately 500 mg of sample of diet ground to 1 mm, were placed in triplicate in 100 ml calibrated glass syringes. Buffer and mineral solutions were added in a 2:1 ratio to rumen liquid collected from two fistulated heifers fed with alfalfa hay. Forty milliliters of this mixture were introduced in each syringe for incubation. Alfalfa hay whose gas production was known was used control. Syringes were shaken gently at each reading and the gas volume was recorded at 0, 3, 6, 9, 15, 24, 36, 48, 72 and 96 h of incubation. Data obtained of gas production were adjusted at the model $P= a+b*(1-e^{-c*(t-L)})$ proposed by McDonald, 1981; where P is the amount of gas produced by in time t; a is the gas produced by the soluble fraction; b the gas produced by the insoluble but slowly fermenting fraction; c is the constant gas production rate and L the lag time.

Statistical analysis:

Data over month were analyzed as a repeated measure (split-split plot) design using the MIXED procedure of SAS (2003). The model included fixed effects for years, season and years x season interaction. The repeated effects was month and steers within years x season was used as the error term for the split-split plot. Autoregressive Order 1 was used as the covariance structure, because it was better fitting structure, based on comparison of covariance structures with Akaike and Bayesiano information criterions (Littell, *et al*. 1998). The comparison of means between years and season was performed using the LSMEANS (least squares means) statement of MIXED procedure of SAS, 2003.

RESULTS AND DISCUSSION

Nutritive Quality and Rate of Passage:

There was not year x season interaction for OM, PC, NDF, TIVDDM and ME (P>0.05; Table, 2). Neither, we find significant differences in OM in the diet over years and seasons of this study (P>0.05), but we found differences in CP content, TIVDDM, ME and Kp between years (P<0.05). The higher values were registered in 2004. However, NDF content was 8% higher in 2005 that in 2004, while CP content was 20% higher in 2004. These differences may be result of registered rainfall during the experimental period (Cline, *et al.* 2009). CP, TIVDDM, and ME content were higher in summer and fall (P<0.05). Grings *et al.* 2004 and Olson *et al.* 2002 report similar results across seasons. Also, Chávez and González, 2009 report that nutritive quality of the diet of grazing cattle in northern Mexico is higher in summer and fall versus winter and spring and they attribute the differences to the phenology of grasslands. Consequently, these variables were also higher in the months of summer (July and August) and fall (October and November) that in the months of spring (April and May) and winter (January and February) (P<0.05). There was not year x season interaction for Kp (P>0.05) (Table, 2). Likewise, the diet Kp was higher in summer and fall compared to winter and spring (P<0.05). Haugen *et al.* 2006 report higher Kp values for spring (4.3%h^{-1}) than those we obtained, but similar values for summer (3.7%h^{-1}). McCollum *et al.* 1985 report a Kp of 3.9%h^{-1} near the end of summer, which is higher to our findings. Differences in dietary fiber content can explain, in part, differences in Kp that we found between seasons of the year (Pereira, *et al.* 2002).

In Vitro Gas Production:

Values of a, b and c were different between years, the highest values were registered during 2004 and the lowest in 2005 (P<0.01; Table, 3). Nevertheless, the values of the lag time were greater in 2005 that 2004 (P<0.01). The gas produced by the soluble fraction a and gas produced by the insoluble but slowly fermenting fraction b; were greater in summer and fall as compared to winter and spring (P<0.01). The constant gas production rate c were affected by season of the year (P<0.01), the highest values were obtained in summer (4.5%h^{-1}) and the lowest in winter (2.3%h^{-1}). The duration of lag time L was higher in spring and the lowest in summers (P< 0.01). To our knowledge, there are not peer-reviewed articles that detail information about *in vitro* gas production of diets by grazing steers in native range. However, the differences between years and seasons in values of a, b and c may be attributed to concentration of soluble carbohydrates in diet selected by grazing cattle (La O, *et al.* 2008). Akinfemi *et al.* 2009, suggested that gas production from protein fermentation is relatively small as compared to carbohydrate fermentation while contribution of fat to gas production is negligible. The variations observed between years and season in the lag time may be explicated by the neutral fiber detergent and lignin content of the diet consumed by grazing cattle, to delay the onset of degradation of nutrients in the rumen (Fievez, *et al.* 2005).

In conclusion, the results from this study indicate that drought induced by spring and winter results in decreased diet quality nutritive because to the decreased of CP and increase of NDF. This change was accompanied by decreased digestibility diet, rate passage and *in vitro* gas production. The protein supplementation and energy might be beneficial for cattle grazing during spring and winter. Further, optimal type and level of protein and energy supplementation under spring drought condition have yet to be determined. The *in vitro* gas production can be used to determine the quality nutritive across of the seasons of year and identify deficiencies in the energy content of diet consumed by grazing cattle. Finally, our results allow us to conclude that nutritive quality, rate passage and *in vitro* gas production the diet selected by free-grazing steers were affected by seasonal weather changes.

Table 1: Temperature and total rainfall by month during 2004 and 2005

	Years			
	2004		2005	
Month	Temp. ^{0}C	R.F mm	Temp. ^{0}C	R.F mm
January	10.6	59.5	13.3	1.6
February	12. 2	0.8	13.7	1.3
March	16.8	6.1	15.1	0.7
April	18.6	0.6	20.9	0
May	22.4	3.2	22.3	0.5
June	21.7	80.0	25.6	5.4
July	21.2	70.9	22.2	96.8
August	20.4	152.0	20.8	66.4

Table 1: Continue

September	19.1	159.6	21.0	61.0
October	18.8	14.1	20.8	2.1
November	13.7	0.67	15.5	2.2
December	12.4	0	13.1	0
Total	17.3	547	18.6	238.0

Source: meteorological station located 10 Km from the study area.. R.F. Rain fall

Table 2: Least squares means for nutritive quality and rate passage in the diet of grazing steers.

	OM (% DM)	CP(%DM)	NDF (% DM)	TIVDDM (% DM)	ME (Mcal/Kg)	Kp ($\%h^{-1}$)
Years						
2004	88.2	11.7^a	69.9^b	64.2^a	2.4^a	2.8^a
2005	87.7	9.6^b	75.6^a	60.1^b	2.1^b	1.3^b
SEM	2.2	2.1	1.1	1.3	1.1	1.6
P<	0.41	*	*	*	*	*
Season						
Spring	87.9	6.2^b	74.0^b	57.1^b	2.1^b	1.4^b
Summer	88.3	11.9^a	67.5^a	65.5^a	2.5^a	3.0^a
Fall	88.8	11.2^a	68.5^a	64.2^a	2.4^a	2.5^a
Winter	89.0	5.9^b	73.7^b	57.3^b	2.0^b	1.5^b
SEM	1.2	0.99	1.1	0.98	0.87	1.1
P<	0.93	*	*	*	*	*
Year x Season						
P<	0.26	0.71	0.52	0.18	0.73	0.22

[ab]Means with different superscripts, within column, are significantly different ($p < 0.05$).
SEM: Standard error of mean.
*($p < 0.05$)

Table 3: Least squares means for parameters of *in vitro* gas production in the diet of grazing steers.

	a (ml/gDM)	b (ml/gDM)	c ($\%h^{-1}$)	L (h)
Year				
2004	4.4^a	99.0^a	3.5^a	2.2^b
2005	3.2^b	88.1^b	2.6^b	3.4^a
SEM	1.6	2.4	2.2	1.8
p<	**	**	**	**
Season				
Spring	3.2^b	79.9^c	2.5^c	3.9^a
Summer	4.9^a	99.4^a	4.5^a	2.3^b
Fall	4.8^a	97.2^a	4.0^b	2.6^b
Winter	2.9^b	77.0^b	2.3^d	3.3^c
SEM	3.3	1.5	3.8	1.6
p<	**	**	**	**
Years x Season				
p<	0.23	0.15	0.37	0.18

[abcd]Means with different superscripts, within column, are significantly different ($p < 0.05$).
SEM: Standard error of mean.
**($p < 0.01$)

ACKNOWLEDGEMENTS

We thank the CONACYT-State Government of Durango Mixed Fund (FOMIX-DGO; Project: DGO-2002-CO1-2522) for funding our investigation.

REFERENCES

Adesogan, A.T., N.K Krueger and S.C. Kim, 2005. A novel wireless automated system for measuring fermentation gas production kinetics of feeds and its application to feed characterization. Animal Feed Science and Technology, 123(1): 211-223.

Akinfemi, A., A.O. Adesanya and V.E. Aya, 2009. Use of an *in vitro* gas production technique to evaluate some Nigerian feedstuff. American Eurasian Journal Eurasian of Scientific Research, 4(4): 240-245.

ANKOM Technology. Procedures for fiber and *in vitro* analysis. 2008.

AOAC., 1999. Official Methods of Analysis (16th Ed.) Assoc. Off. Anal. Chem., Arlington, VA. USA.

Chávez SAH, and G.F. González, 2009. Estudios Zootécnicos (Animales en Pastoreo). En: Chávez, S.A.H. (ed). Rancho Experimental la Campana, 50 años de Investigación y Transferencia de Tecnología en Pastizales y Producción Animal. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias., pp: 113-206.

Cline H.J., B.W. Neville, G.P. Lardy and J.S Caton, 2009. Influence of advancing season on dietary composition, intake, site of digestion and microbial efficiency in beef steers grazing a native range in western North Dakota. Journal of Animal Science, 87(1): 375-383.

Fievez, V., O.J. Babayemi and D. Demeyer, 2005. Estimation of direct and indirect gas production in syringes: A tool to estimate short chain fatty acid production that requires minimal laboratory facilities. Animal Feed Science and Technology, 123-124: 197-210.

Franco, L.J., A.G. De la Cruz, R.A. Rocha, S.N. Navarrete, M.G. Flores M.E. Kato, C.S. Sanchez, A.L.G.Abarca, S.C.M. Bedia y A.L. Winfield, 1985. Manual de Ecologia. Editorial Trillas. Mexico.

Getachew, G., H.P.S Makkar and K. Becker, 2002. Tropical browses: contents of phenolic compounds *in vitro* gas production and stoichiometric relationship between short fatty acid and *in vitro* gas production. Journal of Agricultural Science, 139: 341-352.

Gonzáles, R.H, O.F. Carrete y F. Meraz 2007. Cadena Agroalimentaria Bovinos Carne en Durango: Diagnostico y Perspectivas. SAGARPA-INIFAP. Publicación Técnica nº 2: 22-35.

Grings, E.E., M.R. Shorth, M.R. Haferkamp and R.K. Heitschmidt, 2004. Late summer protein supplementation for yearling cattle. Journal of Range, Management, 57(4): 358-364.

Haugen, H.L., M.J. Lamothe, T.J. Klopfenstein, D.C. Adams and M.D. Ullerich, 2006. Estimation of undegradable intake protein in forages using neutral detergent insoluble nitrogen at a single *in situ* incubation time point. Journal of Animal Science, 84(3): 651-659.

Karn, J.F., 2000. Supplementation of yearling steers grazing northern Great Plains rangelands. Journal of Range Management, 53(2): 170-175.

Klopfenstein, T.J., R.A. Mass, K.W. Creighten and H.H. Patterson, 2001. Estimating forage protein degradation in the rumen. Journal of Animal Science., 79(Suppl 1): 217.

La O, O., R. García, O. Ruiz, Y. Castillo, A. Muro, C. Rodríguez, C. Arzola, H. González y B. Ortiz, 2008. Potencial fermentativo ruminal *in vitro* de dos árboles (*Pithecellobium dulce* y *Tamarindos indica*) de importancia para la ganadería en ecosistemas frágiles, salinos y de alta sequia, situados en el Oriente de Cuba. Nota Técnica. Revista Cubana de Ciencia Agrícola, 42(1): 57-60.

Litell, R.C., P.R. Henry, W.W. Stroup, and C.B. Ammerman, 1998. Statistical analysis repetead measures data using SAS procedures. Journal of Animal Science., 76: 1216-1231.

McCollum, F.T., M.L. Galyean., L.J. Krysl and J.D. Wallace, 1985. Cattle grazing blue grama rangeland. I. Seasonal diets and rumen fermentation. Journal of Range Management, 38(1): 539-542.

McCollum, F.T. and M.L. Galyean, 1985. Cattle grazing blue grama rangeland II. Seasonal forage intake and digesta kinetics. J. Range Manage., 38: 543-546.

McDonald, J., 1981. A revised model for the estimation of protein degradability in the rumen. Journal of Agricultural Science, 96: 251-252.

Menke, K.H., H. Steingass, 1988. Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid, Animal Research Development., 28: 7-55.

Ogden, R.K., W.K. Coblentz, K.P. Coffey, J.E, Turner, D.A. Scarbrough, J.A. Jennings and M.D. Richardson, 2005. Ruminal *In situ* disappearance kinetics of dry matter and fiber in growing steers for common crabgrass forages sampled on seven dates in northern Arkansas. Journal of Animal. Science, 83(5): 1142 - 1152.

Olson, K.C., J.R. Jaeger, J.R. Brethour and T.B. Avery, 2002. Steer nutritional response to intensive-early stocking on short-grass rangeland. Journal of Range Management, 55(3): 222-228.

Pereira, J.C., M. de Queiro Suzart, A.C, P.R. Cecon and S. Pereira, 2002. Physical characteristic of digesta and resistance of particles to escape of rumen-reticulum in steers grazing native pasture. Revista Brasileira de Zootecnia, 31: 731-739.

SAS, 2003. SAS User´s Guide (Release 9.1): SAS Inst, Inc., Cary, NC.

Van Soest, P., 1994. Nutritional Ecology of the Ruminant. 2nd ed. Cornell Univ Press Ithaca, New York, USA: Academic Press

Van Soest, P.J., J.B. Robertson and B.A Lewis, 1991. Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science, 74(10): 3583-3588.

Waterman, RC., E.E. Grings, T.W. Geary, A.J. Roberts, L.J. Alexander and M.D. MacNeil, 2007. Influence of seasonal forage quality on glucose kinetics of young beef cows. Journal of Animal Science, 85(10): 2582-2595.