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Seasonal variations in chemical composition and dry matter degradability of the forage consumed by goats in a highly deteriorated rangeland of North Mexico

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Abstract

The aim of this study was to determine the seasonal variations in chemical composition and dry matter (DM) degradability of the diet of grazing goats on a thorn scrubland in a semi-arid region of Durango, México. Extrusa samples from four oesophageal fistulated goats (33 kg liveweight) were used. The samples were obtained two consecutive days each month from October 1992 to September, 1993. Approximately five g of sample DM were incubated in the rumen of three sheep fed alfalfa hay *ad libitum* (120 g/kg CP; 400 g/kg NDF) for 0, 3, 6, 12, 24, 48, 72 and 96 h. Degradability data were fitted to the model: $P = a+b\ (1 - e^{-ct})$. Then, the immediately soluble fraction *a*, the insoluble but rumen degradable fraction *b*, the potential degradation $a + b$, the degradation rate *c* and the effective degradability (ED) were determined. The data were analyzed according to a completely randomized experimental design. Annual means of crude protein (CP), CP intake (CPI) and metabolisable energy intake (MEI) (90.0 g/kg, 47.8 g/d and 2.8 MJ/d, respectively), were insufficient to meet the maintenance requirements of goats. Degradation parameters differed between the studied seasons. Mean values for *a*, *b* and *c* were 41.0%, 45.1% and 2.7%/h, respectively and are considered low, whereas mean value for ED (63.5%) is moderate. Results indicated that the low values of CPI and MEI as well as the *c* fraction may negatively influence body condition and reproductive activity of the animals.

Keywords: *In situ,* degradability, grazing goats, semi-arid region
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Introduction

Goat production is relevant in pastures where rainfall and forage availability are scarce. In such areas, characterized as arid and semi-arid, goats provide the main if not the sole economical income to farmers (Devendra, 2001). Therefore, it is important to evaluate the quality of the diet consumed by goats in order to improve any feeding constraints. Forage evaluation implies the description of the feedstuffs with respect to their capacity to sustain diverse kinds and levels of production (France *et al*., 2000). Thus, to improve the quality of the forage consumed by range animals, it is necessary to obtain information on the nutritional value of the diet in relation to the requirements (Preston & Leng, 1989). An approach to determine the nutritional potential of the forage consumed by grazing animals is the utilization of the in situ method. The objective of this study was to determine the seasonal variations in chemical composition and dry matter (DM) degradability parameters of the diet consumed by goats grazing a thorn scrubland in a semi-arid region of North Mexico.

Materials and Methods

The study was conducted in a highly deteriorated vegetative community characterized as thorn scrubland. The site was located at 24° 04' and 25° 15' NL and 103° 23' and 104° 37' WL with a dry climate, altitude from 1435 to 1982 mosl, mean annual temperature of 21 °C and rainfall of 278 mm per annum. The vegetative community was composed of only 18 vegetative species. *Jatropha dioica*, locally known as sagregado, was the most common species (Molina & Fresnillo, 1992). Extrusa samples were obtained from four oesophageal fistulated goats (33 kg liveweight) (Stevens *et al*., 1985). The sampling was performed two consecutive days each month, morning (11:30) and afternoon (15:30), for periods of 45 minutes during 12 months (October 1992-September 1993). The samples were stored on ice, dried in an air forced oven for 48 h and milled through 1 and 2 mm screens for chemical analyses and *in situ* degradability determinations, respectively. The samples of all four animals were further composited to obtain a representative extrusa

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sample of each month. Organic matter intake (OMI) was calculated by: OMI = OM faecal production/1- diet digestibility (Handl & Rittenhouse, 1975). To estimate diet digestibility, the pepsin (24 h)-cellulase (24 h) enzymatic procedure was utilized (Aufrère, 1982). Diet crude protein (CP) and organic matter (OM) were determined according to AOAC (1985) and digestible energy (DE) and metabolisable energy (ME) according to Kearl (1982). Cell wall contents were determined according to Van Soest *et al*. (1991). About five g of dry oesophageal extrusa were incubated *in situ* in the rumen of three sheep fed lucerne hay *ad libitum* (120 g CP/kg; 400 g NDF/kg) for 0, 3, 7, 12, 24, 48, 72 and 96 h. The data were fitted to the exponential equation: $P = a + b\ (1 - e^{-ct})$ (Ørskov & McDonald, 1979), then, the immediately soluble fraction *a*, the insoluble but rumen degradable fraction *b*, the potential degradation *a* + *b*, the degradation rate *c* at time *t*, were determined. The effective degradability was calculated considering a rate of passage of 2%/h using $a + ((b * c)/(c + 0.02))$ (AFRC, 1993). Data were analyzed using ANOVA for a completely randomized block design. Degradation parameters were obtained by PROC NLIN, and analyzed by PROC GLM. Mean differences were determined using Tukey's test (SAS, 1997).

Results and Discussion

The CP concentration differed between seasons ($P < 0.05$), with an annual mean of 90 g/kg (Table 1). The higher value for NDF ($P < 0.05$) was registered in winter (512.2 g/kg) and the lower value in spring (407.0 g/kg); the same trend was observed for ADF with values of 422.0 and 255 g/kg for winter and spring, respectively. Differences ($P < 0.05$) were registered in lignin concentration between seasons; the annual mean for this variable was 148.0 g/kg. The annual mean OM digestibility (OMD) was 43.9% and differed between seasons ($P < 0.05$). The higher value was obtained in spring (54.5%) when the animals consumed elevated amounts of cactae species which have a digestibility of higher than 67% (Granados & Castañeda, 1991). The values for DE and ME in the diet were higher ($P < 0.05$) in spring (DE = 8.3 and ME = 6.7 MJ/kg) than in the other seasons. The ME intake (MEI) was lower (2.8 MJ/d) than the requirements for maintenance of goats (NRC, 1981). The CPI maintenance requirements for 33 kg grazing goats are 74 g/d (NRC, 1981). In this study CPI was 43.0, 41.0, 40.0 and 67.0 g/d during autumn, winter, spring and summer, respectively. Only during summer (July-September) did the goats almost approach (67 g/d) their CP requirements for maintenance (NRC, 1981). Low values registered for MEI and CPI contributed to the poor body condition and low reproductive performance of the animals in the study area.

Table 1 Chemical composition (DM basis) and energy and crude protein intake by goats grazing a thorn scrubland in North Mexico

	Seasons					
Item	Autumn	Winter	Spring	Summer	Mean	s.e.*
Crude protein (g/kg)	71.0^{b}	65.1^{b}	62.1^{b}	161.0^{a}	90.0	0.54
Neutral detergent fibre (g/kg)	465.0^{b}	512.2^{a}	407.0^{c}	456.0^{b}	468.0	0.67
Acid detergent fibre (g/kg)	385.0^{a}	422.0^{a}	255.0^{c}	342.0^{c}	351.0	0.92
Lignin (g/kg)	197.1^{a}	137.0^{b}	98.0^{c}	16.1^{b}	148.0	0.55
Organic matter digestibility (%)	40.7^{bc}	38.4^{c}	54.5^{a}	42.3^{b}	43.9	1.00
Digestible energy (MJ/kg)	6.2^{bc}	5.8^{c}	8.3^{a}	6.3^{bc}	6.7	0.04
Metabolisable energy (MJ/kg)	4.2^{bc}	4.2^{bc}	6.7^{a}	4.6^{b}	4.9	0.04
Metabolisable energy intake (MJ/d)	2.5^{b}	2.5^{b}	4.5^{a}	1.9^{c}	2.8	0.04
Crude protein intake (g/d)	43.0	41.0	40.0	67.0	47.8	1.91

$^{a, b, c, d}$ Row means with common superscript do not differ ($P > 0.05$)
*s.e. = Standard error of the mean

The degradation parameters of the diet consumed by the goats during the various seasons are presented in Table 2. Differences were registered between seasons ($P < 0.05$) in all the fractions. The fraction *a* (lost during washing of bags at zero time) in winter (41.3%), spring (44.6%) and summer (41.0%) was higher than that registered in autumn (37.3%). High values for this fraction, which constitute 64.5% of the *ED*, appear to be explained by high levels of cell soluble compounds in browse (Schacht, 1992). The fraction *b* (slowly

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degraded in the rumen) was higher ($P < 0.05$) in spring (49.0%) and summer (62.7%) than in autumn (35.0%) and winter (33.6%). The degradation rate (*c*, %/h) was higher ($P < 0.05$) in autumn (4.5%/h) than in spring (1.7%/h), summer (1.5%/h) and winter (2.9%/h). The *PD* was higher ($P < 0.05$) in spring (93.5%) and summer (90.3%) than in winter (74.8%) and autumn (72.3%). The *ED* was different ($P < 0.05$) between seasons; the annual mean was 63.5%. Higher values were registered in spring (67.2%) and summer (64.9%). Lower values for this fraction were 61.5% for both autumn and winter. The relevance of the *c* fraction is based on the fact that it represents the rate at which the food is degraded in the rumen and its effect on the rate of passage of the food through the rumen and on intake (Khazaal *et al*., 1995).

Table 2 Dry matter degradation parameters of the diet of goats grazing a thorn scrubland in North Mexico

Parameters	Seasons				Mean	s.e.*
	Autumn	Winter	Spring	Summer		
a	37.3[b]	41.3[a]	44.6[a]	41.0[a]	41.0	1.4
b	35.0[c]	33.6[c]	49.0[b]	62.7[a]	45.1	11.3
c	4.5[a]	2.9[ab]	1.7[b]	1.5[b]	2.7	0.1
PD	72.3[b]	74.8[ab]	93.5[a]	90.3[a]	82.2	3.0
ED	61.0[b]	61.1[b]	67.2[a]	64.9[a]	63.5	1.2

[a, b, c, d] Row means with common superscript do not differ ($P > 0.05$)
a = Highly degradable fraction (%); *b* = Slowly degradable fraction (%); *c* = Degradation rate (%/h);
PD = Potential degradation (%); *ED* = Effective degradability (%); * s.e. = Standard error of the mean

Moreover, the *ED* is a function of *a*, *b*, *c* and the rate of passage of *b* fraction through the rumen (Ørskov & Mc Donald, 1979). In consequence, the rate of passage exerts a direct effect on the digestion process, absorption of nutrients and forage intake. Results from this study in relation to the degradation rate *c* (2.7%/h) are lower than those reported by Alvarez (2003) in a scrubland community (4.7 %/h).

Conclusions

The mean level and intake of CP of the diet throughout the year (90.0 g/kg and 47.8 g/d) as well as the ME intake (2.8 MJ/d) on the highly deteriorated rangeland were inadequate to meet the maintenance requirements of goats. The degradation rate (*c* = 2.7 %/h; annual mean) is low compared to results reported in vegetative communities in other semi-arid regions, and *ED* (63.5%) is moderate. Although the *a* fraction constituted an elevated proportion of *ED* (64.5%), low intakes of CP, and ME, and low degradation rate *c*, may have contributed to the poor body condition and lack of reproductive activity of the goats observed in the study area.

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