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Nutrient Profile, Floristic Compositions and Preference Index of Shrubs and Herbs Consumed by Goats in Semiarid Region of Northeastern Mexico

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Abstract: In the semiarid and subtropical regions of Northeastern Mexico, leaves, young stem, fruit and pods of shrubs and herbs are important forage complement into ruminant feeding. In order to determine the effectiveness of the use of shrubs as fodder by goats, floristic compositions, voluntary intake and nutritive value of diets were determined. It was observed in a total of 100 goats (10 goats month^{-1}) grazing in a semiarid shrubland Northeastern Mexico during 10 months. Plant selectivity by goats was obtained using the Multi-Minute Method. Crude Protein (CP), Ether Extract (EE), ash, Crude Fiber (CF), Nitrogen Free Extract (NFE), cellulose and hemicellulose content were determined. Leaves and stem were also analyzed for lignin and condensed tannins. Data on both the consumption of plants and their chemical composition were analyzed using the ANOVA Model. Results from chemical analysis revealed significant ($p<0.05$) differences in nutrient values between species. Shrub species constituted 78% of the animal diet during the growing season followed by herbs (12-18%) and grasses (6-10%). Furthermore, during the fruit production stage shrub species such as *Cordia boissieri*, *Prosopis* sp. and *Acacia* sp. ranked the highest percentage in the diet (>80%). Among the shrubs most consumed with higher preference index were *Cordia boissieri* (10.4%), *Pithecellobium pallens* (10.2%), *Acacia rigidula* (9.4%), *Celtis pallida* (8.4%), *Acacia farnesiana* (8.1%) and *Forestiera angustifolia* (5.7%). These species offered a good nutritional level with values between 16.5 and 21.9% of crude protein, 13.8-22.9% crude fiber, 11.1-22.4% cellulose and 30.7-50.5% nitrogen free extract.

Key words: Goat, nutritive value, shrub legumes, feed, fodder trees, Mexico

INTRODUCTION

The study on the improvement of small ruminant productions in rural zones is an economical issue of interest. Most of the researches about the chemical composition of forage consumed by ruminants are essentially based on the relationship between the nature of the vegetal components and their degradation in the digestive apparatus (Martin *et al*., 1995; Ramirez *et al*., 1996). However, the available information about the floristic compositions, preference index, voluntary intake and nutritive value of diets is still insufficient for the case of forage from trees and shrubs. Browse plants constitute a major source of feed for goats in arid and semiarid regions of the world (Wilson, 1977; Le Houerou, 1980; Momcal, 1984; Pfister and Malechek, 1986; Schacht and Malechek, 1989). It has been assumed that browse generally contains adequate protein for the growing of goats based on comparisons between protein quality of both temperate grasses and legume species with their proper availability.

To this day a few woody forage species have been subjected to agronomical and nutritional studies which have resulted in a lack of knowledge on the alimentary use of trees and shrubs.

Many shrubs and trees in Northeastern Mexico can provide feed material but only a few of them have been actually incorporated into ruminant feeding systems. The scattered information on the nutritive value of forages from shrubs and trees suggests that in general, leaves from shrub and trees contains higher levels of crude protein the many common forages despite some browse forages are high in deleterious components (Devendra, 1994).

The feeding of goats in Mexico is based primarily on the use of native vegetation. Young leaves, stalks, seeds and floral parts of the vegetation components have a high nutritional value. However, the occurrence of high nutritional quality plant species in the rangeland is not enough to meet their nutrient demands.

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The way to determine what an animal consumes in rangeland conditions is not an easy task. Information about plants consumed by goats is essential and necessary for any study on the proper management of vegetation in arid and semiarid areas. Therefore, in this study researchers attempt to get a floristic list of plants consumed and their classification according to the degree of utilization by goats in arid and semiarid Northeastern Mexico. Then, researchers will determine the organ or vegetal part consumed and their nutritive value for goats.

MATERIALS AND METHODS

This study was conducted over a 250 ha of a semiarid zone allotted to grazing goats with 192 animals at that moment. It is geographically located between 24°54' and 24°58'N latitude and between 99°28' and 99°32'W longitude at an altitude of 300 masl. The climate of that region is defined as semi-hot with two rainy seasons and a dry season between November and April. Average annual rainfall is 710 mm. The annual temperature is 23°C with extreme temperatures beyond 40°C in Summer and frost events during the Winter (Foroughbakhch *et al*., 2009).

Shrubby vegetation in this area is dominated by species such as *Acacia rigidula* (blackbush), *Acacia berlandieri*, *Cordia boissieri*, *Pithecellobium pallens*, *Celtis pallida* (Hackberry), *Porlieria angustifolia* (soapbrush) and *Cercidium macrum.* Dominant herbs in the study area are *Dyssodia* sp., *Cynanchum* sp. and *Zephyrantes* sp. Important dominant grasses are *Cenchrus ciliaris* (buffelgrass), *Hilaria berlandieri* (curly mesquite), *Setaria macrosrachya* (plains bristlegrass) and *Panicum hallii* (Hall's panicum).

To evaluate the plant selectivity by goats, observations were carried out throughout 6-7 h of grazing and data was obtained using the Multi-Minute Method (Altmann, 1974) consisting of recording one consumption event every 5 min by annotating the species and the organ that was being consumed at the time of the event. Thus, the name of the plant species, its most palatable part and the time of consumption by goats was recorded. Field observations were made during 10 months from March to December 2005. Every month 10 different animals were selected in each period of observation. Thus, a total of 100 animals were randomly chosen and processed in the experiments.

According to Rosiere *et al*. (1975), the Degree of Preference (DP) of a given species is calculated using the following equation:

$$DP = \frac{\text{Number of consumption events on a specific species}}{\text{Total number of events (of all species consumed)}}$$

To determine the nutritive value, leaves and young stalk of shrub, herbs and grasses were removed manually from branches and grounded in a Wiley mill (2 mm screen). Dry matter (105°C), Crude Protein (CP), Ether Extract (EE), Crude Fiber (CF) and Nitrogen Free Extract (NFE) were determined (AOAC, 1990). Leaves and stem were also analyzed for lignin and condensed tannins using the Vanillin-HCL procedure (Burns, 1970) as modified by Price *et al*. (1978).

Statistical analysis: To apply the analysis of variance, the data for the proximate analysis and the percentage of preference of the plants were subjected to the Arcsine transformation according to Zar (2010).

The main effects for the species consumed, their period of feeding and the interactions for the involved variables were analyzed. The mean values and standard errors were calculated for each species and for the proximate analysis values. The model were applied using the statistical package SPSS (Version 15.0). Least significant differences were calculated with a 5% probability level (LSD 0.05).

RESULTS AND DISCUSSION

The most preferred parts by goats are sprouts (young shoots), leaves and fruits in the fruiting season of woody species, especially in the Summer and Autumn. The goats have a very strong preference in the consumption of fruits of *Cordia boissieri* (10.4±1.5), *Pithecellobium pallens* (10.2±1.9), *Acacia rigidula* (9.4±0.9), *Forestiera angustifolia* (8.4±0.6), *Acacia farnesiana* (8.1±1.1%) and *Celtis pallida* (Table 1).

Herbs in this type of vegetation are relatively abundant and placed second in importance when selected by goats (15-18%) during the Summer. The consumption of herbs is higher in July and October after the rainy season. The main herbs consumed by goats in grazing conditions were: *Clematis drummondii* (2.6±0.2), *Malva parviflora* (1.8±0.1) and *Euphorbia maculate* (2.0±0.1). Grasses contributed to 8-14% of plants eaten by goats. *Cenchrus ciliaris* (2.1±0.2), *Setaria macrostachya* (1.7±0.3) and *Panicum hallii* (2.5±0.5%) were consumed in greater quantity compared to *Bouteloua trifida* (1.3±0.2), *Eleusine indica* (0.5±0.1) and *Chloris* sp. (0.4±0.1%) in the Spring and fall (Table 2).

A wide range of variation was observed for quality parameters amongst the shrubs. The results of ANOVA indicate highly significant differences ($p<0.01$) for the chemical components for the species and the feeding period. Table 3 and 4 show some parameters of the chemical composition of the main species consumed by

Table 1: Preferential shrubs and usable parts of the plant by goats during the observation period (March to Decembre, 2005)

Species	Family	Usable parts of the plant (%)			Preferential degree	Percentage of diet Mean±SE
		Leaf	Fruit	Shoot		
Cordia boissieri D.C.	Borraginaceae	0.9	8.4	3.1	1*	10.4±1.5^{A}
Pithecellobium pallens (Benth.) Standl.	Mimosaceae	7.4	2.8	1.1	1	10.2±1.9^{A}
Acacia rigidula Benth.	Mimosaceae	7.8	1.6	-	1	9.4±0.9^{B}
Celtis pallida Torr	Ulmaceae	3.6	3.8	1.0	1	8.4±0.6^{BC}
Acacia farnesiana (L.) Wild	Mimosaceae	4.0	2.5	1.6	1	8.1±1.1^{C}
Pithecellobium ebano (Benth.) Coulter	Mimosaceae	5.0	2.1	0.4	1	7.5±0.5^{D}
Forestiera angustifolia Torr.	Oleaceae	3.8	-	1.3	1	5.7±0.8^{E}
Prosopis laevigata M.C. Johnst.	Mimosaceae	1.1	3.0	0.8	1	5.1±0.3^{EF}
Acacia berlandieri Benth.	Mimosaceae	1.9	2.1	-	1	4.3±1.0^{F}
Parkinsonia aculeata L.	Caesalpinaceae	0.5	1.1	0.6	2	2.2±0.7^{G}
Eysenhardtia polystachya (Ort.) Sarg.	Papilionaceae	1.6	0.4	-	2	2.0±0.9^{G}
Acacia wrightii Benth.	Mimosaceae	1.1	0.8	-	2	1.9±0.7^{G}
Caesalpinia mexicana A. Gray	Caesalpinaceae	1.0	0.6	0.2	2	1.8±0.6^{GH}
Mimosa biuncifera Benth.	Mimosaceae	1.3	-	0.2	2	1.7±0.2^{H}
Bernardia myricaefolia (Scheele) Wats.	Euphorbiaceae	0.8	0.6	-	2	1.6±0.2^{H}
Diospyros palmeri Eastw.	Ebenaceae	-	0.7	0.3	2	1.2±0.1^{I}
Zanthoxylum fagara (L.) Sarg.	Rutaceae	1.0	-	-	2	1.0±0.1^{I}
Leucophyllum frutescens Benth.	Scrophulariaceae	0.5	-	-	3	0.9±0.1^{J}
Cercidium macrum I.M. Johnst.	Caesalpinaceae	0.3	-	0.1	3	0.8±0.1^{J}
Porlieria angustifolia (Engelm.) Gray	Zygophyllaceae	0.3	0.1	-	3	0.6±0.2^{J}
Lantana macropoda Torr.	Verbenaceae	0.3	-	-	3	0.5±0.1^{J}
Helietta parvifolia (Gray) Benth.	Rutaceae	0.2	-	-	4	0.2±0.1^{K}
Parthenium lozanianum Barthett	Compositae	0.2	-	-	4	0.2±0.0^{K}
Croton fruticulosus Engelm.	Euphorbiaceae	0.1	-	-	4	0.1±0.0^{K}
Opuntia engelmmanniii Salm-Dyck	Cactaceae	0.1	-	-	4	0.1±0.0^{K}
Amyris texana (Buckl). Willson	Rutaceae	0.1	-	-	4	0.1±0.0^{K}
Salvia ballotaeflora Benth.	Labiateae	0.1	-	-	4	0.1±0.0^{K}
Herbs	-	3.5	-	-	1	13.3±1.1^{F}
Grasses	-	4.3	-	-	1	7.6±0.8^{F}

1: Plants very palatable; 2: Relatively palatable plants; 3: Barely grazed; 4: Rarely grazed. *SE = Standard Error; Values in columns with different superscripts differ ($p<0.05$)

Table 2: Major grasses and herbs consumed by grazing goats on vegetation in semiarid regions of Northeastern Mexico

Species	Family	Preference	Percentage of diet Mean±SE
Grasses			
Aristida purpurea Nutt.	Poaceae	2	0.5±0.1
Bouteloua trifida Thurb.	Poaceae	1	1.3±0.2
Bouteloua gracilis (H.B.K.) Lag	Poaceae	1	1.2±0.3
Cenchrus ciliaris L.	Poaceae	1	2.1±0.2
Panicum hallii Vasey	Poaceae	1	2.5±0.5
Setaria macrostachya H.B.K.	Poaceae	1	1.7±0.3
Eleusine indica (L.) Gaertin.	Poaceae	2	0.5±0.1
Chloris ciliata Sw	Poaceae	2	0.4±0.1
Herbs			
Acleisanthes obtusa (Choisy) Standl.	Nictaginaceae	1	2.4±0.3
Clematis drummondii Torr. et Gray	Ranunculaceae	1	2.6±0.4
Euphorbia maculata L.	Euphorbiaceae	1	2.0±0.2
Malva parviflora	Malvaceae	1	1.8±0.1
Parthenium hysterophorus L.	Compositae	2	1.9±0.2
Polianthes maculosa (Hook.) Shinners	Amaryllidaceae	2	1.0±0.1
Physalis wrightii Gray	Solanaceae	2	0.9±0.1
Ambrosia artemisiifolia L.	Compositae	1	1.7±0.3
Ruelia nudiflora (Engelm. and Gray) Urb.	Acanthaceae	2	0.8±0.1

goats. The Crude Protein (CP) content was higher ($p<0.05$) in *P. pallens* (24.0±2.0), *A. berlandieri* (21.9±0.6), *A. wrightii* (20.2±1.7), *C. p allid* (20.6±2.3) and *P. laevigata* (20.0±1.1%) than in *D. texana* (10.7±1.3), *B. myricaefolia* (11.6±1.6), *C. macrum* (12.2±1.1), *F. angustifolia* (12.8±0.7) and *L.* macropoda (13.9±1.2%). Tree and shrub species have high CP content (16.7±0.9%) compared to grasses (12.6±1.1) during drought periods (Neira *et al*., 1994) and therefore, browsing from trees and shrubs is often a protein source for both livestock and wildlife. However, there is a wide range in CP content among tree and shrub species.

Values of CP found in this study are in agreement to those found by Blair (1990) and Hoffman (1987) who reported values of CP between a range of 12 and 32% with an average of 18%.

It has been reported that the CP content is reduced as the plant goes throughout maturation. In this respect, the results are in good concordance with those obtained by Devasena *et al.* (1994) who found that the CP content was higher in autumn for most of the plants since, samples were collected at the end of each station. Furthermore, during drought periods forage from shrubs and trees generally have a higher content of CP compared to grasses (buffelgrass 4.9-12.6%).

High levels of specific protein in the diet are evidence of the selection mechanisms that these small ruminants

Table 3: Approximate chemical analysis of leaves and young green stems (based on DM%) of the most preferred shrubs in the diet of goats

	Mean±SE*				
Species	CP	CF	Ash	EE	NFE
Acacia berlandieri	21.9±0.6^{AB}	17.3±1.4^{C}	2.0±0.1^{h}	3.6±0.30^{EF}	46.5±2.1^{AB}
Acacia farnesiana	19.1±1.1^{C}	22.2±1.6^{A}	5.5±0.6^{G}	7.5±0.20^{AB}	36.5±1.7^{DEF}
Acacia rigidula	16.5±1.1^{D}	22.9±1.2^{A}	12.1±1.0^{BC}	2.6±0.20^{G}	38.0±1.1^{CDE}
Acacia wrightii	20.2±1.7^{B}	21.7±0.8^{B}	5.8±0.5^{G}	3.6±0.20^{EF}	35.1±1.3^{EF}
Bernardia myricaefolia	11.6±1.6^{F}	16.0±0.9^{CD}	7.0±0.5^{EF}	3.7±0.20^{EF}	36.0±2.0^{DEF}
Celtis pallida	20.6±2.3^{B}	13.8±0.5^{E}	8.7±0.8^{DE}	3.6±0.40^{EF}	38.3±2.4^{CDE}
Cercidium macrum	12.2±1.1^{F}	15.6±0.8^{D}	10.7±1.0^{CD}	5.0±0.50^{C}	36.3±2.0^{DEF}
Condalia hookeri	14.2±1.5^{E}	18.8±0.9^{C}	11.0±1.1^{C}	2.3±0.60^{GH}	40.5±1.3^{BCD}
Cordia boissieri	18.1±1.4^{C}	14.2±0.9^{DE}	13.8±1.0^{B}	6.7±0.40^{B}	39.8±1.1^{CD}
Diospyros texana	10.7±1.3^{FG}	14.0±1.1^{DE}	5.5±0.3^{G}	5.3±0.30^{C}	39.2±1.5^{CD}
Eysenhardtia polystachya	18.0±0.9^{C}	24.4±1.1^{A}	8.0±0.7^{DE}	3.1±0.50^{FG}	42.5±1.3^{BCD}
Forestiera angustifolia	12.8±0.7^{F}	20.9±1.2^{B}	10.9±0.7^{CD}	6.40±0.4^{B}	32.8±1.0^{FG}
Lantana macropoda	13.9±1.2^{E}	12.2±1.0^{EF}	8.9±0.4^{DE}	5.1±0.60^{C}	30.7±0.9^{H}
Leucaena leucocephala	19.8±2.0^{C}	15.2±1.3^{D}	9.0±0.9^{DE}	4.1±0.10^{DE}	41.6±2.7^{BCD}
Mimosa biuncifera	14.3±0.8^{E}	15.0±0.7^{D}	9.7±0.9^{D}	3.9±0.30^{E}	34.3±1.9^{EFG}
Pithecellobium pallens	24.0±2.0^{A}	14.5±1.5^{DE}	8.2±0.5^{DE}	4.1±0.40^{DE}	50.6±2.8^{A}
Porlieria angustifolia	15.1±0.9^{DE}	24.5±1.2^{A}	6.0±0.4^{G}	1.8±0.40^{H}	30.2±1.8^{h}
Prosopis laevigata	20.0±1.1^{B}	15.2±1.3^{D}	6.0±0.4^{G}	8.5±0.60^{A}	37.4±1.6^{CDE}
Zanthoxylum fagara	13.3±0.5^{E}	13.4±1.0^{E}	20.0±1.5^{A}	4.5±0.70^{D}	44.3±2.1^{BC}
Mean±SE	16.7± 0.9	17.5±1.2	8.9±0.6	4.5±0.30	38.9±1.7
Sig. level	*	**	***	**	***

*SE = Standard Error; Sig. level *p<0.05; **p<0.01; ***p<0.001; Values in columns with different superscripts differ (p<0.05), DM = Dry Matter; CP = Crude Protein; CF = Crude Fiber; EE = Ether Extract; NFE = Nitrogen Free Extract

Table 4: Cellulose, hemicelluloses, lignin and tannins determinations of leaves and young green stem (based on DM%) of the most shrubs preferred in the diet of goats

	Mean±SE*			
Species	Cellulose	Hemicellulose	Lignin	Tannins
Acacia berlandieri	12.4±0.6^{EFG}	10.7±1.3^{EFG}	17.7±1.1^{AB}	0.95±0.23^{FG}
Acacia farnesiana	11.1±1.2^{FG}	13.6±0.6^{D}	12.9±1.1^{D}	1.29±0.15^{F}
Acacia rigidula	18.2±1.2^{BC}	16.7±0.7^{BC}	19.1±0.7^{A}	0.36±0.11^{I}
Acacia wrightii	23.2±1.8^{AB}	9.8±0.5^{FG}	11.6±0.8^{DE}	0.75±0.07^{H}
Bernardia myricaefolia	15.8±0.6^{CD}	5.1±0.2^{079IJ}	7.3±0.8^{FGH}	0.46±0.31^{I}
Celtis pallida	12.1±1.2^{EFG}	6.4±0.6^{HI}	4.2±1.0^{I}	0.38±0.03^{I}
Cercidium macrum	5.9±0.6^{I}	11.4±0.8^{EF}	10.1±1.2^{E}	2.12±0.1^{E}
Condalia hookeri	16.4±1.3^{CD}	12.3±1.4^{E}	10.9±1.0^{E}	17.18±0.22^{A}
Cordia boissieri	22.5±0.8^{AB}	8.2±1.4^{GH}	7.1±0.7^{FGH}	3.64±0.62^{C}
Diospyros texana	12.5±1.9^{EFG}	13.2±1.9^{D}	18.8±1.3^{A}	0.26±0.06^{I}
Eysenhardtia polystachya	12.4±1.7^{EFG}	16.9±2.1^{BC}	7.7±0.9^{FGH}	0.24±0.04^{I}
Forestiera angustifolia	10.1±1.1^{GH}	27.3±2.1^{A}	12.8±1.1^{D}	0.75±0.13^{G}
Lantana macropoda	13.2±0.8^{DE}	8.6±1.4^{GH}	9.2±0.6^{EF}	1.89±0.24^{E}
Leucaena leucocephala	24.6±2.1^{A}	15.2±0.9^{C}	8.9±1.1^{EFG}	3.12±0.25^{C}
Mimosa biuncifera	19.2±1.3^{BC}	5.8±1.5^{IJ}	7.5±0.5^{FGH}	2.87±0.56^{D}
Pithecellobium pallens	16.4±0.7^{CD}	12.8±1.3^{E}	8.1±0.4^{FG}	0.42±0.02^{I}
Porlieria angustifolia	15.6±0.8^{CD}	11.4±0.8^{EF}	15.3±0.9^{C}	1.18±0.23^{F}
Prosopis laevigata	13.7±0.9^{DE}	11.6±1.1^{EF}	13.2±1.2^{D}	5.62±0.18^{B}
Zanthoxylum fagara	12.8±1.5^{EFG}	17.7±1.5^{B}	10.3±0.7^{E}	1.14±0.14^{F}
Mean±SE	15.1±1.2**	12.3±1.3***	11.1±1.3**	2.35±0.45**

*SE = Standard Error; Sig. level **p<0.01; ***p<0.001; DM = Dry Matter. Values in columns with different superscripts differ (p<0.05)

have which are governed largely by their low reticule-rumen capacity that does not enable them to survive on voluminous low quality forage although, such a highly selective behavior means more walking time looking for fodder. The Crude Fiber (CF) content, however was higher (p<0.05) in *P. angustifolia* (24.5%), *E. polystachya* (24.4%), *A. farnesiana* (22.2%), *A. rigidula* (22.9%) and *F. angustifolia* (20.9) compared to *L. macropoda* (12.2%), *Z. fagara* (13.4%) and *C. pallida* (13.8%). Finally, the Nitrogen Free Extract (NFE) was similar in *Acacia* sp. (35-46%), *B. myricaefolia*, *C. pallid*, *C. macrum*, *M. biuncifera* and *P. laevigata* (34-38%).

The protein content, moisture and the nitrogen free extract vary accordingly to the season and period of observation, being the start of Summer and Autumn the periods of higher content of crude protein, NFE and cellulose. However, in the case of semi-arid shrub it is important to note that there is a great variability in the nutritional values between different components and sections of the branches.

Low cellulose values were found in plants during the Winter and Spring seasons whereas during Summer and fall plants were high in cellulose content. *L. leucocephala* (24.6±2.1), *A. wrightii* (23.1±1.8) and *C. boissieri*

(22.5±0.8%) showed the highest value of cellulose in comparison to *C. macrum* (5.9±0.6), *F. angustifolia* (10.1±1.1) and *A. farnesiana* (11.1±1.2%). The significant differences ($p<0.05$) were found in the cellulose content between the different seasons for the *Acacia* sp. (11-23%), *B. myricaefolia* (15.3%), *P. pallens* (16.4%) and *P. laevigata* (13.7%). In general terms, shrub species reached cellulose levels inferior to the values shown by the reference forage feed. This fact could be a disadvantage for the rumen microorganisms since a lower energy amount is obtained through the degradation of these shrub components than that obtained with *M. sativa* as it was also reported by Moor and Hatfield (1994).

In the period of observation, hemicellulose content (Table 4) was low (5.1-16.8%) compared to cellulose. This finding was also reported by Norton and Poppi (1995) who acknowledged that leaves from temperate legume species had lower hemicellulose content than cellulose while in tropical grasses the concentration of both plant constituents were comparable. According to the results, all species except *F. angustifolia* (27.2%) showed a hemicellulose content varying significantly ($p<0.05$) during the four annual seasons.

Thus, hemicellulose levels were high in Summer and Autumn. Furthermore, the species *A. rigidula* (16.7%), *E. polystachya* (16.9%) and *Z. fagara* (17.7%) reached hemicellulose values higher than herbs and grasses (12-14%) The high hemicellulose content might be considered as a potential energy source for the rumen microorganisms. In Winter and Spring the hemicellulose content was low.

According to Haresign and Cole (1988), the amount of cellulose digested in the rumen depends largely on the degree of lignification of the plant since, lignin is resistant to bacterial attack and hinders the breakdown of cellulose. The results on the quantification of lignin (Table 4) clearly show that the species *Acacia rigidula* (19.1%) *Diopyros Texana* (18.7%), *Acacia berlandieri* (17.7%) and *Porlieria angustifolia* (15.2%) were very high in lignin content compared to *Celtis pallida* (4.2%), *Bernardia myricaefolia* (7.3%), *Eysenhardtia polystachya* (7.7%) and *Mimosa biuncifera* (7.5%). Species with higher content of cellulose such as *L. leucocephala* (24.6%), *C. boissieri* (22.5%) and *A. wrightii* (23.1%) showed least lignin amount (7-11%).

In general terms, lignin content was low in most evaluated plants during the Spring but it was high in Summer. It has been reported that lignin content is related to the low *in vitro* DM digestibility found in forage from trees and shrubs (Ramirez *et al*., 1996). It has been also demonstrated that the high lignin content exert a negative effect in the digestibility of the cell walls which in turn causes a reduction in forage consumption (Jung and Allen, 1995). The condensed tannins contents were low in most of the plants (0.4-5.6% p/p) during 10 months of observations (Table 4), except for *C. hookeri* (17.1% p/p) which showed high values in the Summer. However, the variation of tannin content was significant ($p<0.05$) during the whole seasons for almost all the species except *D. texana*. Furthermore, this species present allelopathic characteristics due to the presence of certain chemicals that limit their use as forage feed for domestic ruminants and wild life. Condensed tannins are also related to low digestibility in trees and shrubs. Ramirez *et al.* (1996) and Mangione *et al.* (2000) reviewed the tannin content of 69 trees and shrubs reported from four literature reports and found that tannins negatively affected ($r = -0.39$) the *in vitro* DM digestibility of browse. These researchers found that those shrub species are only consumed by grazing ruminants during drought and critical periods when there is no forage availability.

The plant nutrient content shows a tendency to rise to its maximum rate and then fall back down. These variations in the nutritional value of the shrubs are closely related to the climate and soil in the area.

Although, wildlife and domestic species have shown some degree of palatability for certain herbaceous native plants, it is likely that these are of a relatively low nutritional value compared to other woody species of forage importance. However, it is important to take also into account the components of the herbaceous plant communities of northeastern Mexico under different ecological conditions.

CONCLUSION

In this study, goats consumed a greater amount of shrubs (75-80%) than high herbs (12-18%) and grasses (6-10%). The main shrubs selected were *C. boissieri*, *P. pallens*, *A. rigidula*, *A. farnesiana*, *F. angustifolia* and *C. pallida*. The leaves and branch debris of these shrubs were consumed during all periods of observation. The fruits of *C. boissieri*, *F. angustifolia*, *M. biuncifera* and *P. glandulosa* also figured prominently in the diet of goats. On the other hand, herbs contributed to the diversification of the diet while grasses were included in the diet but to a lesser extent compared to scrub bushes and trees. The main herbs and grasses consumed were *C. drummondii*, *M. parviflora*, *E. maculata*, *P. hallii* and *S. macrostachya*.

Based on the nutritional value, *A. berlandieri*, *A. farnesiana*, *A. rigidula*, *A. wrightii*, *C. pallida*, *E. polystachya*, *L. leucocephala*, *P. pallens* and *P. glandulosa* present high crude protein content (above 15%) in diets selected by goats, a value that may be

considered sufficient to cover its requirements during the favorable period of grazing. The crude protein content of almost all shrubs decreases as aging occurs in leaves and stalks likely due to the translocation of nitrogen to younger leaves and branches. This is also the reason why it is difficult to predict average nutritional values of leaves and other shrub since, there are many factors to consider. Determining the chemical composition of fodder trees may be useful for the inclusion of specific shrubs in different feeding systems of small ruminants in arid and semiarid zones anywhere. Higher protein, excellent cellulose and low lignin content of the shrubs when compared to arid and semiarid grasses indicates their potential use as a supplement for these small ruminant diets.

Regarding the tannin content in the evaluated species it was found that this nutritional factor was higher in Summer in comparison to fall and Winter. This variation is owed mainly to environmental factors, especially the amount of precipitation during September and October. In summary goats can choose their feed in a broader way from groups or types of plants than other ruminants allowing them to have a wide ecological distribution in extreme conditions particularly in arid and semiarid areas. However, it is reasonable to consider that the ideal diet of goats is not only limited to browsing on scrub or shrub components but it also varies according to the pasture conditions and the availability of the existing vegetation. Those native species that maintain a high nutritive during periods of adverse environmental conditions are those with good value for animal feeding and they should be incorporated into ruminant feeding systems under grazing conditions.

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