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Seasonal Dynamics of the Leaf Nutrient Profile of 20 Native Shrubs in Northeastern Mexico

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Abstract: The quality of cattle feed supplements may be enhanced by the addition of certain vegetable components which improve its nutritional value. However, these structural components may vary according to the climate conditions prevalent during the seasonal changes in temperate or subtropical areas. In this sense a characterization of dry leaves from several shrub species was carried out in comparison to alfalfa hay to determine their partial dry weight, crude protein, ash, cell walls, acid detergent fiber, acid detergent lignin and condensed tannins contained during the four seasons. Results showed significant variations between species and seasons in all the variables studied. Thus the importance value of each constituent varies according to the season and so the energy contributed by them to the rumen microorganisms for feed digestion. Likewise, overall high nutritional values are maintained by shrubs even in unfavorable climate conditions, therefore their incorporation in livestock feeding should be normally accomplished.

Key words: Digestibility, feed supplementation, cattle, forage, seasonal dynamics, shrubs

INTRODUCTION

The nutritive value of the different components of trees and shrubs has been studied in ovine livestock and goat cattle (Chadhokar, 1982; Cooper and Owen-Smith, 1985; Smith and Van Houtert, 1987; Cooper *et al*., 1988; Rodriguez, 1992). Thick grounding of dry leaves and their incorporation to feed concentrates enhances the quantity and quality of the animal diet. However, this practice may be combined with others to preserve the resources and increase the economical output (Hentgen, 1985; Ramirez, 1995; Webb, 1988).

The nutritive value of forage is determined by its chemical composition and ease of digestibility, but chemical composition is determined by the nature of the plant (Baxton and Fales, 1994). Plant tissues contain Nitrogen (N) in the form of soluble and insoluble proteins, free amino acids, amides, ureides, nitrates and ammonia, although proteins are the major N component (Norton and Poppi, 1995). Primary Cell Walls (CW) consist mainly of cellulose microfibrils interlaid with hemicelluloses molecules (xylans, arabans) and separated from adjoining cells by a middle lamella. Cell walls vary in digestibility but usually are only partially available for digestion, whereas the cell contents within them are nearly completely digestible. Lignification also restricts availability of CW to animals that consume them (Buxton and Fales, 1994). This study was conducted with the objective to determine and compare, during the four seasons, the chemical composition of 20 native shrubs that grow in northeastern Mexico.

MATERIALS AND METHODS

Choice of plants species: The choice of species was made only after careful consideration of their nutritive importance value for ruminant feed supplementation, uses and preference by grazing animals and their use by the rural population.

All the species used in the experiment are native from arid and semiarid zones with the exception of *Leucaena* species which have been brought from tropical and subtropical zones of northeastern Mexico.

The tree species selected to determine the leaf nutrient profile are presented in the Table 1.

Branches from legume and non legume species were collected in summer, fall, winter and spring. The sampling area corresponded to the Tamaulipan scrubland (125,000 km^2) that occurs in the state of Nuevo León, extending from the coastal plain of the Gulf of Mexico to

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Table 1: List of species, family and use of twenty plant species selected to determine the leaf nutritional profile

Species	Family	Uses
Acacia rigidula Benth.	FABACEAE	Fodder, soil conservation
Amyris texana (Buckl.) P. Wils.	RUTACEAE	Fodder, soil conservation, shade, timber
Bernardia myricaefolia (Scheele) Wats.	EUPHORBIACEAE	Fodder, soil conservation
Bumelia celestrina H. B. K.	SAPOTACEAE	Fodder, soil conservation, shade, timber
Caesalpinia mexicana Gray.	FABACEAE	Fodder, bee forage, soil conservation
Castela texana (T. and G.) Rose.	SIMAROUBACEAE	Fodder,
Celtis pallida Torr.	ULMACEAE	Fodder, food (fruit),
Diospyros texana Scheele.	EBENACEAE	Fodder, food (fruit), bee forage,
Ebanopsis ebano (Berl.) Barneby and Grimes	FABACEAE	Fodder (leaves and pods), food (seeds), ornamental
Eysenhadtia polystachya (Ortega) Sarg.	FABACEAE	Fodder, soil conservation
Gymnosperma glutinosum (Spreng.) Less.	ASTERACEAE	Fodder, soil conservation
Harvardia pallens (Benth.) Britt. and Rose	FABACEAE	Fodder, bee forage
Helietta parvifolia (Gray) Benth.	RUTACEAE	Fodder, ornamental, timber, shade
Leucaena greggii S. Wats.	FABACEAE	Fodder, food (pods and seeds)
Leucaena leucocephala (Lam.) de Wit.	FABACEAE	Fodder, food (pods and seeds), soil conservation
Leucaena shannoni Donn.	FABACEAE	Fodder, food (pods and seeds), soil conservation
Parkinsonia aculeata L.	FABACEAE	Fodder, timber
Prosopis glandulosa Torr.	FABACEAE	Fodder (leaves and pods), bee forage, timber
Schaeferia cuneifolia Gray.	CELASTRACEAE	Fodder
Zonthoxylum fagara (L.) Sarg.	RUTACEAE	Fodder, soil conservation

the southern rim of Texas, USA. The selection of the vegetal material was carried out under a simple random sampling considering at least 5 shrub trees per species. Leaves were taken from these trees at 1.6 m height from the ground for their corresponding analysis. The climate of the sampling area is semiarid and the mean annual precipitation is about 750 mm. Mean annual temperature is 22.3°C. Most soils of the region are a rocky type of Upper Cretaceous calcite and dolomite. The dominant soils are deep, dark grey, lime-clay vertisols which are the result of alluvial and colluvial processes. They are characterized by high clay and calcium carbonate contents (pH 7.5-8.5) and low organic matter content (Foroughbakhch *et al*., 2006).

Collected branches from each shrub were allowed to dry during 20 days. Leaves were removed manually and partial Dry Matter (DM) was recorded. Then, leaves were ground in a Wiley mill (2-mm screen) and dry matter, Crude Protein (CP), ash (AOAC, 1999), CW, Acid Detergent Fiber (ADF), acid detergent lignin (Goering and Van Soest, 1970) and condensed tannins (Burns, 1971; Price *et al*., 1978) were determined.

The significance of plant effects on the nutrient profile was determined by analysis of variance using a completely randomized block design. The general linear models procedure of SAS (1988) was used. The seasons were considered as blocks while plants were the treatments.

RESULTS AND DISCUSSION

The annual mean of partial DM was high in *B. myricaefolia* (74.1%), *C. texana* (70.1%) and *E. polystachya* (63.0%) and the lowest value corresponded to *P. aculeate* (43.2%), *L. leucocephala* (43.3%) and *L. shannoni* (44.5%), as indicated in Table 2. Organic matter (OM) content was low in L*eucaena species* (between 82.3% and 87.3%), *C. pallida,* (86.8%), *B. myricaefolia,* (86.0%) and *Z. fagara* (88.6%), but *B. celestrina* (90.4%), C. texana (90.7%), *H. pallens* (91.2%), *P. aculeate* (90.8%), *G. glutinosum* (91.9%) *and E. ebano* (90.3%) were high in OM content. High ranges of ash were obtained in *Leucaena* sp. (15.0-17.7%) and *B. myricaefolia* (14.0%); however, low ranges of ash were determined in *H. pallens* (8.8%), *P. glandulosa* (7.1%), *S.,cuneifolia* 7.7%) and *G. glutinosum* (8.1%). During the summer, leaves of the following plants had high CP values: *L.shannoni* (22.7%), *H. pallens* (20.6), *L. leucocephala* (19.8%) and *E. ebano* (19.4%), but during the fall and winter seasons the CP content was low in *A. texana* (13.4%), *C. texana* (14.3%), *G. glutinosum* (14.0%) and *H. parvifolia* (14.3%). In this study, alfalfa hay (*Medicago sativa*) was included as a reference plant with high CP content (22%). Species such as *A. rigidula* (18.4%), *B. myricaefolia* (17.5%), *C. pallida* (17.5%), *P. glandulosa* (17.4%), *S. cuneifolia* (17.1%) and *Z. fagara* (18.6%) had the same variation in CP content, comparable and in some cases equal or higher than *M. sativa* (Table 2). Tree and shrub species have high CP content compared to grasses 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. The mean value of 277 species reviewed from 22 literature reports (Ramirez, 1996) was 17%, within a range of 11.1-41.7%.

It has been reported, that the CP content is reduced as the plant goes throughout maturation. In this respect, our results are in good concordance with those obtained by Devasena *et al.* (1994) who found that the CP content

Table 2: Seasonal variation of the dry, organic matter, ash and crude protein (% of DM) of leaves of twenty shrubs species

	Dry matter				Organic matter				Ash				Crude protein			
Species	Range	M	SE	Sig	Range	M	SE	Sig	Range	M	SE	Sig	Range	M	SE	Sig
Acacia rigidula	45 su-51 w	48.7	1.1	*	86 su-88 w	87.0	0.3	***	10.1f-14.6 w	13.0	0.8	***	16.5 f-21.3 sp	18.4	1.3	***
Amyris texana	51 sp-55 w	52.6	0.5	***	87 f-90 w	89.1	0.8	*	10.6 f-11.0 su	10.9	0.3	NS	13.1 sp-14.2 f	13.4	0.5	**
Bernardia myricaefolia	62 sp-78 w	74.1	0.2	***	83 w-87 f	86.0	0.3	**	13.5 f-15.4w	14.0	0.6	***	17.1 sp-17.8 su	17.5	0.8	NS
Bumelia celestrina	48 sp-51 f	49.5	0.7	*	88 f-91 w	90.4	1.2	**	9.6 su-11.2 w	9.6	0.2	***	13.4 su-16.5 w	15.1	0.2	***
Caesalpinia mexicana	39 sp-47 w	44.1	0.5	**	85 w-91 sp	88.4	0.6	***	10.1 sp-13.7 w	11.6	0.3	***	11.8 w-17.3 f	14.4	0.1	***
Castela texana	66 sp-72 f	70.1	1.5	***	89 w-91 su	90.7	0.9	**	8.6 f-11.2 w	9.3	0.6	***	13.6 f-15.7 su	14.3	0.8	***
Celtis pallida	52 w-54.f	53.6	0.3	NS	74 w-89 sp	86.8	0.4	***	12.6f-17.0w	13.2	0.2	***	17.4 f-18.0 su	17.5	0.4	NS
Diospyros texana	57 sp-61su	59.3	02	*	87 f-88 su	88.3	0.3	NS	11.8 su-13.5 f	11.7	0.4	*	11.6 w -14.1 su	13.1	0.3	**
Ebanopsis ebano	49 f-53 w	52.0	0.4	*	88 f-91 w	90.3	1.0	NS	9,6 w-11.2 f	10.7	04	**	14.6 sp-23.1 su	19.4	0.2	***
Eysenhadtia polystachya	57 su-64 w	63.0	0.2	***	85 su-92 w	89.3	0.1	***	8.9 w- 14.3 sp	10.7	1.4	***	17.4 su-22.6 sp	20.8	0.6	**
Gymnosperma glutinosum	45 su-48 f	46.4	0.7	NS	90 f-94 su	91.9	0.2	*	7.8 su-9.1 sp	8.1	0.1	**	13.1 su-18.1 f	14.0	0.5	***
Harvardia pallens	48 sp-58 w	55	1.1	**	89 sp-93 su	91.2	0.2	***	7.4 su-9.3 sp	8.8	01	***	17.0 sp-23.5 su	20.6	1.1	***
Helietta parvifolia	44 sp-59 f	52.1	0.1	**	85 su-88 f	87.1	0.4	***	12.2 f-14.1su	12.9	0.6	**	12.7 f-14.3 su	14.3	0.5	*
Leucaena greggii	46 su-50 w	48.7	0.9	**	80 w-84 f	82.3	0.7	**	13.7 f-18.9 w	17.7	1.0	***	12.8 w-16.2 su	14.7	1.7	***
Leucaena leucocephala	39 sp-45 w	43.3	0.9	***	84 w-85 f	85.0	0.4	**	12.8 f- 16.5 w	15.0	0.3	***	16.3 w-22.5 su	19.8	1.1	***
Leucaena shannoni	38 sp-47 w	44.5	1.3	**	86 su-90 f	87.3	0.6	**	10.1f-14.3 f	12.7	0.9	***	19.6 w-26.9 su	22.7	1.4	***
Parkinsonia aculeata	40 sp-46 w	43.2	0.1	***	88 w-92 su	90.8	0.2	***	7.7 su- 11.4 w	9.2	0.1	***	15.9 f- 21.0 su	18.1	0.8	***
Prosopis glandulosa	46 sp-54 w	49.3	0.6	***	90 su-94 f	92.9	0.6	***	6.5sp- 7.6 su	7.1	0.9	***	14.6 f-19.3 sp	17.4	0.8	***
Schaeferia cuneifolia	51 f-55 sp	54.0	1.1	**	91w-93 sp	92.3	0,1	***	6.5 f-8.1 sp	7.7	0.5	**	14.1 f-19.5 sp	17.1	0.7	***
Zonthoxylum fagara	47 w-48 f	47.5	0.3	***	86 w-90 sp	88.6	0.8	***	8.6 f-12.5 w	11.4	1.3	***	17.9 f-25.2sp	18.6	0.2	***
Medicago sativa					87				13.0				22.0			

DM = Dry Matter; M = Mean; SE = Standard Error; Sig = Significance; su = summer; f = fall; w = winter; sp = spring; *(p= 0.05); **(P = 0.01); ***(p= 0.001); NS = Not Significant

Table 3: Seasonal variation of cell wall, acid detergent fiber and cellulose (% of DM) of leaves of twenty shrubs species

	Cell wall				Acid Detergent Fiber (ADF)				Cellulose			
Species	Range	M	SE	Sig	Range	M	SE	Sig	Range	M	SE	Sig
Acacia rigidula	31.2 w-33.4 f	32.5	0.8	N.S	23.8 f-36.1 su	31.5	0.7	***	14.3 f-19.5 sp	17.4	0.8	***
Amyris texana	19.3 w-21.9 sp	20.5	0.5	***	18.4 sp -20.9 su	19.3	0.1	***	14.3 w-14.9 su	14.4	0.6	NS
Bernardia myricaefolia	28.4 w-31.1 su	29.4	0.2	**	25.0 f-25.2 sp	25.1	0.4	N.S.	17.4 w-18.4 f	18.1	0.3	NS
Bumelia celestrina	33.6 sp-37.9 su	35.8	0.7	*	18.8 w-33.5 sp	29.4	0.8	***	13.9 sp-15.9 w	14.6	0.9	NS
Caesalpinia mexicana	24.6 f-33.4 su	28.5	0.3	***	18.6 f-25.3 su	20.4	0.1	***	10.2 f-15.5 su	13.4	04	***
Castela texana	36.0 w-41.5 f	38.2	0.8	*	22.6 f-35.7 su	32.6	0.8	***	2.1 w-14.1 su	8.4	1.8	***
Celtis pallida	19.1 w-27.0 sp	23.5	0.5	***	15.1 w-21.3 sp	17.2	0.6	**	9.6 w-13.3 su	11.4	0.6	*
Diospyros texana	30.4 w-37.6 f	33.1	0.4	***	19.6 sp-30.7 f	25.3	03	***	13.3 sp-16.7 su	15.4	0.5	*
Ebanopsis ebano	40.3 sp-52.1 su	48.5	0.7	***	23.1 sp-38.4 su	31.6	0.4	***	11.0 f-14.4 su	12.0	1.0	NS
Eysenhadtia polystachya	29.6 sp-39.3 f	34.5	1.0	**	16.4 su-21.2 f	19.4	03	***	8.1 su-12.4 f	11.1	0.5	**
Gymnosperma glutinosum	16.2 w-33.1 su	25.6	0.3	***	16.5 w-29.4 su	21.4	04	***	7.0 w-12.4 su	11.3	0.2	***
Harvardia pallens	30.5 sp -38.7 f	35.2	0.7	***	20.2 su-28.4 f	26.3	0.5	**	15.2 sp-18.4 su	17.4	05	N S
Helietta parvifolia	18.6 w-21.2 su	19.5	0.3	**	17.7 sp -20.4 su	18.5	0.1	***	13.5 w-15.2 f	14.4	0.3	NS
Leucaena greggii	36.4 sp-43.5 su	41.2	0.8	***	12.9 w-16.8 su	14.8	08	**	10.8 sp-12.1 su	11.6	0.7	*
Leucaena leucocephala	20.9 w-28.6 f	24.1	0.3	***	16.2 f-19.1 su	17.3	0.6	***	12.2 sp-14.4 f	13.0	0.2	***
Leucaena shannoni	18.4 sp-25.1 su	22.2	0.9	**	17.8 sp-22.0 f	19.4	0.1	***	14.1 sp-17.0 f	15.1	0.6	**
Parkinsonia aculeata	46.2 w-50.9 su	49.7	0.3	***	32.6 w-37.7 su	34.5	0.2	***	21.8 w-27.6 sp.	23.9	0.7	*
Prosopis glandulosa	28.6 sp-35.7 su	32.8	0.4	**	21.3 f-32.4 sp	29.4	1.2	***	10.4 w-17.6 su	15.2	1.2	*
Schaeferia cuneifolia	25.9 w-31.0 su	27.3	0.6	*	19.5 f-28.9 sp.	23.2	0.9	***	9.3 sp-23.1 su	15.4	1.1	***
Zonthoxylum fagara	20.5 w-27.3 f	23.9	0.2	***	16.1 f-26.3 sp	21.8	0.6	***	6.9 f-11.1 sp	8.5	0.7	***
Medicago sativa		30.0				26.0				18.0		

DM = Dry Matter; M = Mean; SE = Standard Error; Sig = Significance; su = summer; f = fall; w = winter; sp = spring; *(P=0.05); **(P =0.01); ***(P= 0.001); NS = Not Significant

was higher in autumn for most of the plants since samples were collected at the end of each station. Furtehermore, during drought periods forage from shrubs and trees generally have a higher content of CP compared to grasses (buffelgrass 2.9% sp-12.6% su).

Seasonal ranges and annual means of CW in plants are presented in Table 3. In general terms, most of the plants evaluated had low CW content in all seasons, except for *P. aculeate* (49.7%; p<0.001)*, E. ebano* (48.5%; p<0.001), *L.greggii* (41.2%; p<0.001), *C. texana* (38.2%; p<0.05) and *B. celestrina* (35.8%; p<0.05) which showed CW contents higher than *M. sativa* hay (30%). Low CW and consequent high cell content give these plants high nutritional value compared to grasses (Lowry *et al*., 1992). In this study, during the winter season most of the plant species showed low CW content, but during summer and fall values were high (Table 3).

The same pattern as for CW was found for the ADF content of plants (Table 3). With the exception of *B. myricaefolia* the rest of the shrub species showed significant differences (p<0.01) in the four seasons. ADF content was higher in spring and winter. However, ADF

Table 4: Seasonal ranges of hemicellulose, Lignin and condensedtannins (% of DM) of leaves of twenty shrubs species

	Hemicellulose				Lignin				Tannins			
Species	Range	M	SE	Sig	Range	M	SE	Sig	Range	M	SE	Sig
Acacia rigidula	10.2 sp-16.5 w	12.7	1.5	**	10.9 f-16.5 w	13.0	0.9	***	0.1 w-0.6 su	0.3	0.1	***
Amyris texana	0.2 w-1.6 su	1.3	0.2	**	2.9 sp-6.1 su	5.0	0.1	**	0.0 w .-0.4 f	0.3	0.03	***
Bernardia myricaefolia	2.2 w-5.4 su	4.3	0.1	***	6.2 f-7.3 w	5.0	0.2	*	0.00 w-1.3 f	0.4	0.03	***
Bumelia celestrina	2.8 f -5.6 w	3.7	0.8	**	11.3 f-19.4 sp	14.8	0.8	***	1.6 su-4.2 w	2.1	0.1*	**
Caesalpinia mexicana	6.0 f-9.1 sp	7.2	0.1	***	6.4 w-10.5 su	8.4	0.4	**	0.0 w-0.5 su	0.3	0.03	***
Castela texana	10.3 f-13.7 sp	11.5	1.3	NS	17.3 su-28.2 w	22.5	1.4	***	1.1 w-3.5 sp	2.3	0.3	**
Celtis pallida	5.1 f-10.4 sp	6.8	0.1	***	4.4 w-6.2 su	5.3	0.5	NS	0.00 f-0.3 su	0.08	0.05	***
Diospyros texana	4.3 su-12.3 sp	7.4	0.1	***	6.3 sp-14.4 f	11.2	0.6	**	1.7 sp-2.6 su	2.1	0.2	NS
Ebanopsis ebano	17.4 w-23.1 f	19.2	0.1	***	11.2 sp-24.5 f	20.4	1.8	**	0.6 f-1.5 sp	0.7	0.1	**
Eysenhadtia polystachya	12.4 w-18.7 f	15.0	0.1	***	5.4 sp-11.1 w	8.3	0.2	***	0.0 f-0.6 sp	0.2	0.04	***
Gymnosperma glutinosum	0.2 f-8.2 sp	4.4	0.1	***	8.4 sp-14.4 su	10.5	0.3	*	0.8 f-9.7 su	4.4	0.7	**
Harvardia pallens	9.3 sp-12.1 su	11.3	0.1	***	4.2 sp-9.1 su	7.0	0.1	***	0.0 f-1.4 su	0.6	0.04	***
Helietta parvifolia	0.1 w-1.2 su	1.1	0.1	***	3.4 sp-5.2 su	4.3	0.3	*	0.0 w-0.3 f	0.2	0.06	NS
Leucaena greggii	12.2 sp-16.8 f	14.9	1.0	**	13.7 sp-19.4 f	16.0	1.2	**	0.8 f-7.6 su	5.7	0.4	**
Leucaena leucocephala	8.7 sp-11.7 f	10.5	0.4	***	5.3 w-8.9 su	6.9	0.2	***	0.5 w-3.8 f	3.0	0.2	***
Leucaena shannoni	6.7 sp-10.8 f	9.1	0.8	**	4.8 sp-7.1 f	6.5	0.6	**	0.2 sp-2.8 su	2.1	0.1	***
Parkinsonia aculeata	13.0 sp-18.2 f	15.3	0.1	***	7.4 sp-15.1 su	11.5	0.2	***	0.0 f-0.2 su	0.04	0.03	*
Prosopis glandulosa	9.5 sp-14.1 f	12.8	0.9	***	8.1 sp-18.3 f	14.2	0.3	***	0.5 w-5.2 f	3.2	0.2	**
Schaeferia cuneifolia	12.6 w-19.2 su	16.9	0.7	***	6.6 f-18.9 sp	11.7	1.1	***	0.0 w-1.2 su	0.7	0.1	**
Zonthoxylum fagara	8.2 w-18.4 sp	13.6	1.0	***	7.8 f-9.8 sp	8.3	1.0	NS	0.0 w-1.9 su	1.1	0.1	***
Medicago sativa		14.0				10.0				0.00		

DM = Dry Matter; M = Mean; SE = Standard Error; Sig = Significance; su = summer; f = fall; w = winter; sp = spring; *(p = 0.05); **(p = 0.01); ***(p = 0.001); NS = Not Significant

values were inferior to *M. sativa* (26) in *L. greggii* (14.8), *C. pallida* (17.2), *L. leucocephala* (17.3), *H. parvifolia* (18.5) and *A. texana* (19.3). On the contrary, lower ADF content was shown in autumn, mostly with values inferior to *M. sativa*. The higher content of ADF showed during spring and summer seasons is likely owed to the accumulation of lignin-cellulose as a result of the higher temperatures (Nelson and Moser, 1994).

Low cellulose values were found in plants during the winter and spring seasons, whereas during summer and fall plants were high in cellulose content. *P. aculeate* (23.9; $p<0.05$) showed the highest value of cellulose in comparison to *Medicago sativa* (18%). No significant differences were found in the cellulose content between the different seasons for the species *A. texana* (14.4), *B. myricaefolia* (18.1), *B. celestrina* (14.6) *E. ebano* (12.0) and *H. pallens* (17.4) ($p<0.05$). 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 trough the degradation of these shrub components than that obtained with *M. sativa*, as it was also reported by Moor and Hatfield (1994).

In all seasons, hemicellulose content (Table 4) was low 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 our results, all species except *C. texana* showed a hemicellulose content varying significantly ($p<0.05$) during the four annual seasons. Thus hermicellulose levels were high in summer and autumn. Furthermore, the species *E. ebano*, *E. polystachya*, *P. aculeata* and *S. cu*neifolia reached hemicellulose values higher than *M. sativa* (14%) with 19.2, 15.0, 15.3 and 16.9%, respectively. 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.

In this study, lignin content was low in most evaluated plants during the spring but it was high in summer (Table 4). Species such as *A. rigidula* (13.0%), *B. celestrina* (14.8%), *C. texana* (22.5), *E. ebano* (20.4%) and *L. greggii* (16.0%) and *P.glandulosa* (14.2%) had a higher lignin content than other plants and even *M. sativa* (10.0%) as the reference feed. It has been reported, that lignin content is related to the low *in vitro* DM digestibility found in forage from trees and shrubs (Ramirez, 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 during all seasons (Table 4), except for *L. greggii* (5.7%), *G. glutinosum* (4.4%), *L. leucocephala* (3.0%) and *P. glandulosa* (3.2%), 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* and *H. parvifolia*. Furthermore, these two 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 (1996), Mangione *et al.* (2000) and González (1989) 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 authors found that those shrub species are only consumed by grazing ruminants during drought and critical periods when there is no forage availability.

CONCLUSION

It was found that during the summer season leaves from evaluated plants showed high CP content whereas during fall and winter CP values were low. Cell wall and its derivatives were low during the winter season; however, they were high in summer. Annual cellulose and hemicellulose mean values from the shrub species were lower than the values shown by *M. sativa* (the reference feed) while annual lignin average content was higher than lignin content for *M. sativa*. The high levels of cellulose and hemicellulose in summer and fall is attributed to its availability and represent the most important energy source for ruminants although this energy contibution depends on the degree of binding of nutriments to lignin. Regarding the tannin content in the evaluated species it was found that this nutritional factor was higher in summer in comparisson to fall and winter. This variation is owed mainly to environmental factors, especially the amount of precipitation during September and October. The chemical composition suffers changes as the plan matures and may be further modified by the environmental conditions during growth (soil fertility, season, temperature, shade, water stress). These effects will vary in different plant species. Those native species that maintain a high nutritive value 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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