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LEAF LITTER AS A FOOD RESOURCE FOR RANGE LIVESTOCK

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ABSTRACT

Leaf litter samples from two undisturbed sites in the Tamaulipan Thornscrub vegetation at northeastern Mexico were evaluated monthly, during 2007, for chemical composition, true *in vitro* organic matter digestibility (IVOMD), *in vitro* gas production (IVGP, 24 h), metabolizable energy (ME) and microbial protein (MP), in absence or presence of polyethylene glycol (PEG). Neutral detergent fiber (organic matter; mean = 40.8%), acid detergent fiber (ADFom; 28.8%), lignin (20.2%), crude protein (CP; 11.5%), condensed tannins (CT; 0.6%), ether extract (EE; 2.9%) contents, and IVOMD (63.0%) values and the interactions site*month were different between sites and among months. Gas production without (53.2 ml/200mg) and with PEG (59.1), ME (9.9 and 10.9 MJ/kg, respectively) and MP values (11.5 and 13.8, µmol, respectively) were not different between sites, but were different among months. When leaf litter deposition was high (dry months; January-June) in both sites, NDF, lignin and CP were also higher than in other months. The *in vitro* gas production, ME and MP were higher with the addition of PEG compared with the samples without PEG. Moreover, MP content was higher during the wet months (July-September). Based on chemical composition and fermentation values, litter fall leaves have a high potential to be used as feed resource for range small ruminants.

Keywords: Chemical Composition; *In Vitro* Gas Production Parameters; Litter Fallen Leaves; Polyethylene Glycol; Tamaulipan Thornscrub Vegetation.

INTRODUCTION

The available forage resources should provide adequate nutrients to a number of grazing animals while maintaining or improving the availability resource. Currently there is a need for feeds that have a high proportion of digestible nutrients and information reflecting the digestion in animals. The *in vitro* gas technique complemented with the use of Polyethylene glycol (PEG) has potential application on many areas of ruminant nutrition (Getachew *et al*., 2005; Ammar *et al*., 2008). The Tamaulipan Thornscrub of the semiarid plains of Northeastern Mexico, contains a wide diversity of shrub species (Stienen *et al*., 1989) that have developed morphological and physiological characteristics to adapt to adverse climatic factors; in addition, could be important animal feed resources in times of scarce feed availability to range ruminants (goats and sheep) and wildlife (white-tailed deer) (Gonzalez-Rodriguez *et al*., 2011). The mixture of leaves in this ecological and biological type of scrub represents the main component of the litter fall that remains productive throughout the year, especially in the dry and winter months (González-Rodríguez *et al*., 2004). More research is needed concerning the nutritional quality and fermentative profile of the mixture of litter fall leaves from shrubby native species in the Tamaulipan Thornscrub of northeastern Mexico. Thus, the objectives of this study were to evaluate during 12 consecutive months, the nutritional quality of samples of litter fallen leaves and their fermentation characteristics, treated or not with PEG, in two sites located in the state of Nuevo Leon, Mexico. We hypothesized that the mixture of leaf fall from the Tamaulipan Thornscrub from northeastern Mexico, is a good source of nutrients to meet the metabolic requirements of range small ruminants during dry and winter months.

MATERIALS AND METHODS

The study was conducted in 2 undisturbed sites located at Linares County in the state of Nuevo Leon, Mexico. Site one, was situated in a *Quercus* sp. forest (24º 46' N; 99º 41' W; 550 m above sea level), total annual rainfall of 915 mm and the mean annual temperature of 21°C. Site 2 was located at the Experimental Research Station of the Department of Forest Sciences of the Autonomous University of Nuevo Leon (24º 47' N; 99º 32' W; 350 m above the sea level) with dominant vegetation known as Tamaulipan Thornscrub (SPP-INEGI 1986). Total annual rainfall was 851 mm and the mean annual temperature was 21.8°C. Distribution of rainfall and temperature was similar in both sites. The climate of the region is subtropical and semiarid with warm summer (González-Rodríguez *et al*., 2004).

Litter fall samples were collected in ten litter traps (1.0 m^2), made of wooden sides fitted with a nylon net bottom (1 mm mesh size) that were randomly scattered in each collection site of about 2500 m^2. Each trap was placed at approximately 0.30 m above the soil level to intercept litter fall. Trap contents were collected at 15-day intervals from January-December 2007. Litter contents were manually sorted into the following categories: leaves, reproductive structures (flowers, fruits and seeds), twigs or branches (<2 cm in diameter), and miscellaneous residues. The 15-day leaf litter samples were grouped into only one in each month for chemical and digestion analysis.

Crude protein, EE and ash contents were estimated (AOAC, 1997). Neutral detergent fiber (om), ADF (om), and lignin (sa) were determined according to Van Soest *et al*. (1991). Cellulose (ADF–lignin) and hemicellulose (NDF–ADF) were obtained by difference. Results of CT (butanol-HCl technique) were expressed as leucocyanidin equivalents (Makkar, 2003).

The *in vitro* gas production (24 h) in samples was determined using the procedures described by Menke and Steingass (1988). The technique described by Makkar (2003) was used to estimate the effect of PEG (6000) in samples. The IVOMD in samples was determined a Daisy^{II} incubator (ANKOM Technology, Macedon, New York, USA) using the technique described by Adesogan (2005). The ME content was calculated in accordance with Menke and Steingass (1988):

$$ME\ (MJ/kg\ DM) = 2.20 + 0.136\ GP24_h + 0.057\ CP + 0.0029\ EE^2$$

Where: $GP24_h$ is gas production after 24 h of incubation (ml gas/200 mg DM); CP is the crude protein (g/kg DM); and EE is the ether extract (g/kg DM).

The chemical composition and digestion data were statistically analyzed using one-way analysis of variance with a bi-factorial arrangement with effects of sites (2), months of the year (12) and the double interaction. *In vitro* gas production characteristics with or without PEG, were statistically compared by the T-test procedure (Montgomery, 2004). Statistical analyses were performed with the Statistical Package SPSS (2004) version 13.

RESULTS

Ash and NDF values (ADF, lignin, cellulose and hemicellulose included) were different between sites and among months and the interaction site*month was also significant (Table 1). Samples in site 2 had higher ash content than site 1. During winter months (December, January and March), in both sites, ash content was also higher. Crude protein, EE, CT and IVOMD values were significantly different between sites and among months and the interaction site*month was also significant (Table 2). Higher EE contents were observed in winter and in spring than in other seasons. Site 2 had higher IVOMD values compared to site 1; similarly, values obtained from wet month samples (July-September) were higher.

The *in vitro* gas production, ME and MP content of samples in absence or presence of PEG, were not significantly different between sites, but significant variations were registered among months (Table 3). Site 1, during spring months (April-June), had higher values than in other months. Site 2 in summer months (July-September), had higher values than in other months. Samples treated with PEG had significantly higher *in vitro* gas production than samples without PEG. A similar response as *in vitro* gas production was observed for ME and MP (Table 4).

Table 1. Chemical composition of leaf litter fall samples from the Tamaulipan Thornscrub in the state of Nuevo Leon, Mexico. SEM = standard error of the mean. *(*P*Y0.05); **(*P*Y0.01); ***(*P*Y0.001).

Sites	Months	Ashes, %	NDF (om), %	ADF (om), %	Lignin (sa), %	Cellulose, %	Hemicellulose, %
Site 1	January	10.2	40.4	28.5	20.0	8.5	11.9
	February	11.9	44.4	32.0	25.0	7.0	12.4
	March	5.8	45.4	33.1	24.8	8.3	12.3
	April	11.3	47.5	36.3	22.8	13.5	11.2
	May	4.2	46.6	35.3	21.7	13.6	11.3
	June	9.8	45.6	32.2	21.0	11.2	13.4
	July	7.9	37.2	20.1	11.8	8.3	17.2
	August	9.3	36.8	26.7	12.7	14.0	10.1
	September	4.6	33.4	22.6	15.6	7.0	10.8
	October	5.9	43.4	31.0	23.2	7.8	12.4
	November	9.3	42.8	32.0	25.1	6.9	10.8
	December	9.4	33.3	21.4	16.1	5.2	12.0
Mean of site 1		**8.0**	**44.1**	**32.3**	**22.4**	**9.9**	**11.8**
Site 2	January	14.1	42.0	29.7	21.8	7.9	12.3
	February	16.1	44.6	32.9	25.2	7.7	11.7
	March	18.0	42.2	31.3	20.8	10.5	10.9
	April	17.2	43.7	32.3	23.5	8.8	11.4
	May	17.1	43.4	33.1	20.7	12.4	10.3
	June	16.4	43.5	31.4	22.0	9.5	12.1
	July	16.2	40.0	22.9	18.4	4.6	17.0
	August	15.2	31.8	21.6	15.8	5.8	10.2
	September	16.2	37.1	26.0	19.6	6.4	11.1
	October	14.2	43.2	31.1	21.0	10.1	12.1
	November	15.1	39.8	28.5	23.0	5.6	11.3
	December	15.6	30.3	19.6	13.9	5.6	10.7
Mean of site 2		**16.0**	**40.1**	**25.3**	**18.0**	**7.3**	**12.1**
Grand mean		**12.0**	**40.8**	**28.8**	**20.2**	**8.6**	**11.9**
	SEM	0.4	0.2	0.2	0.2	0.2	0.1
Effects	Site (A)	***	***	***	***	***	*
	Month (B)	*	***	***	***	***	***
	AxB	***	***	***	***	***	***

Table 2. Means of crude protein (CP), condensed tannins (CT), ether extract (EE) and *in vitro* digestibility of organic matter (IVDOM) of leaf litter fall samples from the Tamaulipan Thornscrub in the state of Nuevo Leon, Mexico. SEM = standard error of the mean. *(*P*Y0.05); **(*P*Y0.01); ***(*P*Y0.001).

Sites	Months	CP, %	CT, %	EE, %	IVDOM, %
Site 1	January	11.9	0.9	3.4	64.8
	February	11.3	1.0	3.9	65.9
	March	8.1	0.6	2.9	60.8
	April	10.5	0.4	2.0	55.1
	May	12.8	0.5	2.3	53.6
	June	11.5	0.8	2.4	63.9
	July	11.3	0.3	2.8	66.3
	August	10.6	1.3	2.1	71.3
	September	11.4	0.1	2.4	67.7
	October	11.0	0.3	1.8	56.1
	November	10.9	0.3	2.4	50.5
	December	9.2	0.4	2.2	69.1

Mean of site 1		**10.9**	**0.8**	**2.6**	**62.0**
Site 2	January	13.1	0.9	5.3	62.7
	February	13.1	0.7	3.5	65.2
	March	11.1	0.6	3.4	65.4
	April	12.6	0.9	3.6	61.9
	May	12.6	1.0	3.3	61.5
	June	11.9	1.0	2.6	59.3
	July	12.2	0.6	3.2	67.0
	August	12.5	0.1	3.2	75.1
	September	11.6	0.1	3.5	69.0
	October	11.8	0.5	3.1	60.4
	November	11.3	1.1	2.3	52.3
	December	11.2	0.4	2.6	65.4
Mean of site 2		**12.1**	**0.4**	**3.3**	**64.0**
Grand mean		**11.5**	**0.6**	**2.9**	**63.0**
SEM		0.1	0.02	0.1	0.5
Effects	Site (A)	***	***	*	*
	Month (B)	***	***	***	***
	AxB	*	*	***	**

Table 3. *In vitro* gas production at 24 h incubation time (Pgas 24h), metabolizable energy (ME) and microbial protein of leaf litter fall samples treated with or without polyethylene glycol (PEG). NS = not significant; *(*P*≤0.05); **(*P*≤0.01); *(*P*≤0.001).**

Site	Month	Pgas 24h, ml/200 mg		ME, MJ/kg		Microbial protein, µmol	
		-PEG	+PEG	-PEG	+PEG	-PEG	+PEG
Site 1	January	61.1	69.1	11.2	12.2	9.0	11.9
	February	50.3	57.4	9.7	10.2	8.6	9.3
	March	57.2	65.3	10.4	11.5	7.9	8.9
	April	46.5	51.5	9.2	9.7	14.9	15.4
	May	67.1	74.3	11.9	13.2	15.2	19.0
	June	51.0	55.1	9.8	10.3	13.3	18.5
	July	58.2	66.2	10.8	11.8	13.9	14.8
	August	58.4	63.4	10.5	11.9	11.5	12.4
	September	50.2	56.2	9.6	10.1	9.5	12.4
	October	47.3	51.0	9.2	10.4	11.5	14.9
	November	53.4	56.0	10.0	10.5	10.4	13.2
	December	46.5	52.4	9.0	10.6	11.6	13.2
Mean of site 1		**54.2**	**58.3**	**10.1**	**11.0**	**11.4**	**13.7**
Site 2	January	56.1	59.3	10.7	11.0	10.1	11.4
	February	42.2	52.4	8.6	10.1	11.5	12.9
	March	45.3	56.0	9.0	10.5	10.4	12.6
	April	55.4	66.1	10.4	11.8	12.1	14.2
	May	50.0	56.1	9.0	10.6	12.6	13.4
	June	56.1	59.0	10.5	10.9	8.4	8.7
	July	47.0	53.2	9.3	10.4	12.5	15.7
	August	64.2	76.2	11.5	13.3	14.5	19.5
	September	47.3	54.1	8.6	8.7	12.7	18.5
	October	52.1	57.2	9.4	10.0	10.6	13.1
	November	54.2	58.4	9.2	10.8	11.1	13.5
	December	55.2	59.5	9.1	10.7	11.4	13.1
Mean of site 2		**52.1**	**59.3**	**9.6**	**10.7**	**11.5**	**13.9**
Grand mean		**53.2**	**59.1**	**9.9**	**10.9**	**11.5**	**13.8**
SEM		1.2	1.1	0.3	0.2	0.3	0.3
Effects	Site (A)	NS	NS	NS	NS	NS	NS
	Month (B)	***	***	***	***	*	***
	AxB	*	**	*	**	***	***

Table 4. Effects of polyethylene glycol (PEG) on *in vitro* gas production at 24 h incubation time (Pgas 24h), metabolizable energy (ME) and microbial protein of leaf litter fall samples treated with or without polyethylene glycol (PEG). Means in a column with different letter superscripts are different ($P \leq 0.01$); SEM = standard error of the mean.

	Pgas24h (ml/200 mg)	ME (MJ/kg DM)	Microbial protein (µmol)
Samples without PEG	53.2^{b}	9.9^{b}	11.5^{b}
Samples with PEG	59.1^{a}	10.9^{a}	13.8^{a}
Mean	56.1	10.4	12.7
SEM	1.1	0.2	0.3

DISCUSSION

Ash content recorded in this study was within the range reported for tree fodders (Ramirez *et al*., 2010; Dominguez-Gomez *et al*., 2011; Kasemi *et al*., 2012). Depending upon the stage of maturity of plant parts or plant species, the NDF content can account for 25-80% of forage DM (Mertens, 2003). In this study, the content of NDF varied from 30.3 to 47.5% DM, and was lower, as expected, in wet months than in dry months. Smith *et al*. (2009) also reported low values of NDF in native foliage samples collected during the dry season. Values of NDF of studied samples (<45%) are sufficient for rumen function maintenance, to stimulate chewing, rumination activities and to establish the optimal ruminal pH and thus the adequate ruminal fermentation (Beauchemin and Yang, 2005).

Evaluated samples had CP contents that may meet or exceed the maintenance requirements for adult range goats and sheep and for gaining body mass of white-tailed deer (7-10%; NRC, 2007). The relatively low CT content of studied samples would indicate that the CT in these plants would not affect the digestion processes. Even, low or moderate consumption of CT can improve ruminal fermentation (Waghorn and McNabb, 2003), mainly due to a reduction in the ruminal degradation of the protein and, hence, this leads to greater availability of AA that are to be absorbed in the small intestine of range ruminants (Juarez *et al*., 2004). Values of IVOMD are comparable with previous studies (Acero *et al*., 2010; Melaku *et al*., 2010). Seasonal variations and spatial differences in IVOMD in samples reflect the differences in their chemical and plant species composition of each site (Gonzalez-Rodriguez *et al*., 2011). The addition of PEG to shrub foliage results in increased ME values (Salem *et al*., 2007; Guerrero *et al*., 2012); nevertheless, values of ME (10 MJ/kg DM) of fallen leaves without PEG in this study may satisfy the requirements of maintenance of range ewes (8.4 MJ/kg DM) and meat does (8.0 MJ/kg DM) in early pregnancy with a single fetus (NRC, 2007). High ME content of studied samples might be due to its high IVOMD (63%).

Differences in gas production at 24 h with or without PEG may be a result of observed differences in the ash, lignin, ADF and NDF content in studied samples. Moderate gas production at 24 h (53 ml/200 mg) might reflect the values of IVOMD and ME content, even in fallen leaves without PEG. In agreement with our results, Guerrero *et al*. (2012) reported significant differences among shrub foliage treated with or without PEG, which demonstrates the affinity of PEG to bind tannins. Concentrations of MP in leaf litter samples were higher than those reported previously in foliage of native forbs (Guerrero *et al*., 2010), which might be explained by a good synchronization of fermented soluble carbohydrate (100 - (NDF + CP + EE + ash) = 33%; NRC, 2001) and CP level (> 11%) during the incubation period in this study. The purines content is an indicator of the yield of microbial protein (Getachew *et al*., 2000). Microbial protein high values are important because microbial protein represents between 40 and 90% of the AA that reach the small intestine although it may reach 100%. Thus, due to the role of rumen microorganisms in the digestion of cell wall structures and that microbial protein has a high quality, feedstuffs should be selected to allow a maximum microbial growth (Carro, 2001).

It is concluded that because of their high CP, ME, IVOMD and MP content and low NDF and CT content, it seems warranted that fallen litter leaves could be a good source of nutrients to range ruminants. Leaf litter samples in absence of PEG had good nutritional quality; thus, nutritional value of leaf litter is useful not only to those interested in browse for range ruminants (goats, sheep and white-tailed deer) but also for general information of producers or researchers who observe livestock ingesting considerable amounts of fallen browse leaves.

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