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Investigation note

Nutritional evaluation of *Eysenhardtia polystachya* (kidneywood) in Cuauhtémoc, Zacatecas, Mexico

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Abstract

Some legumes present in semi-arid regions are important because they can be used as forage in grasslands and have been studied as a food resource for ruminants. This study aimed to evaluate the nutritional quality of kidneywood in a semi-dry climate in Zacatecas, Mexico. Between 2021 and 2022, 20 random samplings were carried out in a 100 ha rangeland. The variables measured were ash (A), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and *in vitro* degradability of dry matter (*iv*DDM). The highest amount of CP ($p< 0.05$) occurred in spring with 25.8%. The highest level of neutral detergent fiber was observed in the autumn and summer (59.17 and 56.26%) and the lowest in spring and winter (43.25 and 39.77%). The highest acid detergent fiber was obtained in summer (36.67%) and the lowest in winter (24.68%). In the and *in vitro* degradability of dry matter, no significant differences were found ($p> 0.05$), averaging 45.06%. The shrub provides the highest levels of protein in spring and adequate levels of fiber for use in ruminants.

Keywords:

Eysenhardtia polystachya, detergent fiber, digestibility, protein.

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Grasslands and shrublands are natural resources in the arid and semi-arid regions of central and northern Mexico, covering approximately 25% of the country (SEMARNAT 2016). The municipality of Cuauhtémoc, Zacatecas, is part of the geographical provinces of the Sierra Madre Occidental (76.19%) and Mesa del Centro (23.81%). Rainfall occurs in summer, so the area becomes colorful from August and during the autumn months (INEGI, 2010; Enríquez *et al*., 2014).

Some legumes present in semi-arid and arid areas are important because that they can be used as forage species in grasslands (Sánchez *et al*., 2023). One of the problems faced by the livestock industry is the variation in the quantity and quality of feed during the year, which negatively affects the production and reproduction parameters of livestock; however, different trees and shrubs have great nutritional potential as high-quality food; that is, they have a high protein content compared to their grass counterparts and high biomass yields (Pérez-Olivera *et al*., 2022a).

Among the most widely used forage species, legumes stand out and within this family, *E. polystachya* is one of the most important plants due to its frequency and diversity of use (Lorenzo-Barrera *et al*., 2023). The most common names (in Spanish) are: varadulce, varaduz, palo dulce, palo cuate, and rosilla (Lorenzo-Barrera *et al*., 2023). It is consumed as forage by goats and sheep; nevertheless, production data are limited or not available (Beltrán-Rodríguez *et al*., 2020).

In addition, *E. polystachya* is the best-adapted forage legume in silvopastoral systems (Pérez-Oliveira *et al*., 2022b). Therefore, this study aimed to evaluate the nutritional quality of *E. polystachya* in four seasons of the year in a semi-dry climate of Cuauhtémoc, Zacatecas, Mexico. In this way, it is hypothesized that the nutritional quality of the forage shrub *E. polystachya* varies in the different seasons of the year.

The experimental design was completely randomized with 20 replications during four seasons of the year within a rangeland of 100 ha located in the municipality of Cuauhtémoc, Zacatecas (22° 29’ 58” north latitude, 102° 23’ 23” west longitude), where the climate is temperate semi-dry with rainfall in summer, temperatures between 14 and 18 °C with precipitation ranging from 400 to 700 mm (INEGI, 2010).

E. polystachya samples were randomly collected, where approximately 300 g of foliage (leaves and stems) was cut from the aerial part of the branches accessible at a height of 1 to 1.5 m from 20 plants at random, during the four seasons of the year, which correspond to spring (June 2021), autumn (October 2021), winter (February 2022), and summer (August 2022).

The variables to be evaluated were ash (A), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and *in vitro* degradability of dry matter (*iv*DDM). The samples were dehydrated at 60 °C for 48 h. Subsequently, they were ground in a Wiley mill with a 1 mm sieve. The amount of ash was determined by incinerating the samples at 550 °C for 10 h, and organic matter was obtained by difference between dry matter and ash. Crude protein was obtained by determination of total nitrogen by the Dumas combustion analysis (Leco PF-528, Leco Corporation, St. Joseph, MI).

Neutral detergent fiber and acid detergent fiber were determined sequentially by the Van Soest analysis using the Ankom200 fiber analyzer (Ankom Technology). The determination of the *in vitro* degradability of dry matter was carried out by using the Ankom Daisy D200 incubator (Ankom Technology).

Data analysis was performed using the PROC GLM procedure of the SAS statistical package (2021). The effect of the season of the year (spring, summer, autumn and winter) was evaluated as the main factor on the bromatological variables analyzed (ash, organic matter, crude protein, detergent fibers and *in vitro* degradability of dry matter).

The means between seasons of the year were compared with Tukey’s comparison of means test ($p< 0.05$) since it is suitable for data analyzed by Anova. In addition, the correlations between the bromatological variables were calculated using the PROC CORR procedure of SAS. This approach allowed us to identify significant relationships between the different variables analyzed.

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In ash, the highest value occurred in summer compared to spring and winter, but it was equal to that in autumn. On average, it was 1.13% lower than the concentrations of 7.47% obtained by Pérez-Olivera *et al*. (2022a) and 3.43% lower than the 9.67% of López-Hernández *et al*. (2023), as can be seen in the Table 1.

Table 1. Proximate chemical analysis of *E. polystachya* foliage during four seasons of the year in a semi-dry climate of Cuauhtémoc, Zacatecas, Mexico.

Variables (%)	Spring	Autumn	Winter	Summer
Ash	5.88^{a}	6.49^{ab}	5.95^{a}	7.07^{b}
Organic matter	94.12^{a}	93.51^{ab}	94.05^{a}	92.93^{b}
Crude protein	25.8^{a}	17.63^{b}	15.05^{c}	16.41^{bc}
Neutral detergent fiber	43.25^{a}	59.17^{b}	39.77^{a}	56.26^{b}
Acid detergent fiber	29.47^{a}	32.37^{ab}	24.68^{c}	36.67^{b}
In vitro degradability of dry matter	46.68	43.27	48.08	42.22

$^{a\ bc}$= different letters within the same row are statistically different (Tukey, $p \leq 0.05$).

There were statistical differences ($p < 0.05$) in crude protein, with the highest concentration in spring (25.8%), followed by autumn (17.63%) and summer (16.41%), and the lowest in winter (15.05%), exceeding 15% in the four seasons, levels suitable to be used in grazing livestock supplementation programs. In the semi-arid northeast of Mexico, Foroughbakhch *et al*. (2013) reported protein concentrations of 18% for *E. polystachya*, which, on average, are similar to those found in the present study, and which are also similar to the 19.28% found in Michoacán, Mexico, by López-Hernández *et al*. (2023).

Likewise, Pérez-Olivera *et al*. (2022a) reported protein values of 15.75%. On the other hand, Ramírez-Lozano (2006) found values of 20, 20, 22, and 20% in most of the legume species browsed in northeastern Mexico in winter, spring, summer and autumn, respectively, 2.27% higher than what was obtained in this study. In addition, it is important to note that, according to Norton (1994), woody trees or shrubs with values of less than 8% of CP are considered deficient since they do not provide the minimum levels of ammonium required by ruminants.

In the case of the NDF (Table 1), it increased in autumn and summer (averaging 57.7%), compared to spring and winter (41.5% on average). López-Hernández *et al*. (2023) reported concentrations of 43.81%. For the ADF, concentrations increased in the summer, followed by autumn and spring, and the lowest concentrations were observed in winter. The values reported by other authors are 43.81% of ADF (López-Hernández *et al*., 2023).

In the *iv*DDM, no statistical difference was observed ($p > 0.05$), averaging 45% during the four stations, 14% lower than the findings by Camacho and Morfín (2010), who reported 59% of *iv*DDM in *E. polystachya*. Ramírez-Lozano (2006) obtained values of 63% in *iv*DDM in *E. polystachya*, which, on average, was 18% higher than that found in the present study (Table 1) and he indicates that legumes had average degradability of 52, 51, 48, 49% in winter, spring, summer and autumn, respectively, which, on average, is lower than that reported by Beltrán López *et al*. (2009), who found average degradability in other shrubs, such as *A. canescens* (75.47%), *P. incanum* (57.41%), and *D. bicolor* (65%).

The results of the Pearson correlations between season (S) ash (A), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF),and *in vitro* degradability of dry matter (*iv*DDM) are shown in Table 2, observing that the most outstanding correlation occurs between the season and crude protein, showing that the more the season advances, the lower the concentration of protein. Casanova-Lugo *et al*. (2014) reported that there are other factors that can influence the forage production parameters of tree legumes in their association with other forage species in the same ecosystem. Nonetheless, the protein content in legumes was constant in all seasons of the year (Ramírez-Lozano, 2006).

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Table 2. Pearson correlation coefficients of *E. polystachya* variables.

	S	A	OM	CP	NDF	ADF	*iv*DDM
S		0.2778*	-0.2778*	-0.6769***	0.2201*	0.2205*	-0.108
A			-1***	-0.128	0.2761*	0.1699	-0.0692
OM				0.128	-0.2761*	-0.1699	0.0692
CP					-0.1661	0.0005	0.0516
NDF						0.7923***	-0.1513
ADF							-0.1227
*iv*DDM							

* = correlation less than 0.05; ** = correlation less than 0.01; *** = correlation less than 0.001.

Conclusions

The nutritional quality of the shrub *E. polystachya* is convenient; the forage provides protein for grazing livestock with higher concentrations in spring and sufficient amounts of protein in winter, making it a nutritional alternative for the dry season in the semi-arid regions of Zacatecas, Mexico.

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