Abanico Veterinario. January-December 2019; 9:1-12. http://dx.doi.org/10.21929/abavet2019.923
Original article. **Received: 02/01/2019. Accepted: 25/09/2019. Published: 05/11/2019.**

Proximal chemical analysis of *Krameria erecta* from the Sonora State

Análisis químico proximal de *Krameria erecta* del Estado de Sonora

Diana Mc-Caughey-Espinoza*[1], Álvaro Reyes-Olivas[1], Gloria Ayala-Astorga[2], Gabriel Lugo-García[1], Andrés Ochoa-Meza[3], Antonio Pacheco-Olvera[4]

[1]College of Agricultural Sciences, Higher School of Agriculture of the Valle del Fuerte, Autonomous University of Sinaloa. Mexico. [2]Department of Scientific and Technological Research of the University of Sonora. Sonora Mexico. [3]Department of Agriculture and Livestock of the University of Sonora. Sonora Mexico. [4]Faculty of Agronomy of the Autonomous University of Sinaloa. Mexico. *Responsible and correspondent author: Mc Caughey-Espinoza, Diana Miriam. College of Agricultural Sciences, Higher School of Agriculture of the Valle del Fuerte, Autonomous University of Sinaloa. Calle 16 Av. Japaraqui S/N. 81110, Juan José Ríos, Ahome, Sinaloa. Mexico. diana.mccaughey@unison.mx, alreo.uas@gmail.com, gloria.ayala@unison.mx, gabriel_lugo9010@hotmail.com, andres.ochoa@unison.mx, apontoniopo345@gmail.com.

ABSTRACT

The southern cósahui (*Krameria erecta*) is a perennial shrub that is found in arid and semi-arid areas of the states of Sonora, Sinaloa, Chihuahua and Baja California Norte. As it is a plant that is appealing to domestic and wild animals, the nutritional value of *Krameria erecta* was determined, located in a type of tree-growing scrubland of the State of Sonora, evaluating the collection of four seasons of the year, in four sites of 2,500 m^2 each one. The results show that there are significant differences between collection times in the crude protein content (7.46 to 13.42 %). The contents of ethereal extract were different between the collection sites and time ($p < 0.05$) on the other hand they also presented significant differences between collection time and sites ($p < 0.05$) in dry matter with 71.2 to 87.3%, except in winter and spring, in the same way there were significant differences in humidity (12.7 to 28.8%), in ashes there were significant differences in the collection time ($p < 0.05$) from 7.41 to 13.3%, in terms of raw fiber differences were shown significant at the time of collection but not between sites with 23.78 to 32.82%, in calcium there was no significant difference between in the summer, autumn and winter harvest with values of 0.05 to 1.33% and phosphorus also showed significant differences between the time of collection ($p < 0.05$) but not between sites with 0.06 to 0.09%.

Keywords: cattle, native plants, nutritional content.

RESUMEN

El cósahui del sur (*Krameria erecta*) es un arbusto perenne que se encuentra en las zonas áridas y semi–áridas, de los estados de Sonora, Sinaloa, Chihuahua y Baja California Norte. Por ser una planta apetecible por los animales domésticos y silvestres, se determinó el valor nutricional de *Krameria erecta,* ubicada en un tipo de matorral arbosufrutescente del Estado de Sonora, evaluándose la colecta de cuatro épocas del año, en cuatro sitios de 2,500 m^2 cada uno. Los resultados demuestran que existen diferencias significativas entre las épocas de colecta en el contenido de proteína cruda (7.46 a 13.42%). Los contenidos de extracto etéreo fueron diferentes entre los sitios de colecta y época ($p<0.05$) por otra parte también presentaron diferencias significativas entre época de colecta y sitios ($p<0.05$) en materia seca con 71.2 a 87.3%, excepto en invierno y primavera, de igual manera se presentaron diferencias significativas en humedad (12.7 a 28.8%), en cenizas se presentaron diferencias significativas en la época de colecta ($p<0.05$) de 7.41 a 13.3%, en lo que respecta a fibra cruda se mostró diferencias significativas en la época de colecta pero no entre los sitios con 23.78 a 32.82%, en calcio no se mostró diferencias significativas entre en la poca de colecta de verano, otoño e invierno con valores de 0.05 a 1.33% y fósforo también presento diferencias significativas entre la época de colecta ($p<0.05$) pero no entre los sitios con 0.06 a 0.09%.

Palabras Clave: ganado, plantas nativas, contenido nutricional.

INTRODUCTION

In the last 30 years the summer pastures dedicated to livestock production in the State of Sonora, Mexico, has a great floristic diversity of non-timber and timber plants. Between 30% to 70% of the native and high forage species that currently have a strong decrease in their populations, are palo fierro (*Olneya tesota* A. Gray), zámota (*Coursetia glandulosa* A. Gray), cósahui (*Krameria erecta* Willd), among others, because they have had a notable consumption by herbivores; coupled with the massive clearings and the change in land use, it has not allowed them to spread naturally; so they are in serious problems that could lead them to disappear from their own ecosystems (Mc Caughey-Espinoza *et al*., 2017). Shrubs constitute a good percentage of the diet of bovine animals, so it is important to conserve native plants in natural habitats. The nutritional value of food is given by its chemical composition and the efficiency with which animals extract their nutrients during digestion (Sanon *et al*., 2008).

Forage plants form the basis of cattle feeding, provide the fundamental nutrients to meet the physiological requirements of animals. Native plants provide a diet rich in protein, phosphorus and calcium, at different seasons of the year. It is of the utmost importance to investigate the forage resources of the environment, to incorporate them into livestock production systems and provide sustainable alternatives that allow improving the agro-ecosystems and living conditions of the communities (Francis and Lowe, 2000; Muñoz *et al.,* 2011; Apráez *et al*., 2017).

Trees and associated shrubs provide multiple benefits to livestock (Ruiz et al., 2006). Native drought-tolerant fodder plants are options to improve the nutritional deficiencies of grazing cattle (Insuasty *et al*., 2013), due to their great versatility and various benefits; they are very important in agroforestry and silvopastoral systems (Portillo *et al*., 2009). It has also been attributed medicinal benefits, showing effects against liver damage, antioxidant, anti-inflammatory and anti-cancer (Carini *et al*., 2002; Torres-González *et al*., 2011; Jiménez-Estrada *et al*., 2013; Morán-Palacio *et al*., 2014).

At present, livestock activity merits a new productive approach that revalues tree and shrub resources, as fundamental elements for the design of efficient and sustainable production systems. Therefore, in this investigation, a chemical analysis of the southern cósahui (*Krameria erecta*) was proposed, due to the forage potential that this species represents for the summer pastures of the state of Sonora, Mexico.

MATERIAL AND METHODS

Location of the study area

The present work was carried out in the ranch "Las Cruces" located in the eastern part of Hermosillo, Sonora; located at 29° 03’21.30” from North Latitude and 110° 45'12022" from West Longitude, at an altitude of 277 meters above sea level, with an average annual rainfall of 330 mm and an average temperature of 24 °C, with vegetation called arbosufrutescent scrubland, and regosol soil. Occasionally frosts and hailstorms occur in the winter.

Species in study and material used

The species under study is the cósahui (*Krameria erecta* Willd), being a plant in the Sonoran desert. Clipper scissors, paper bags, markers and pelouze digital scale, model SP5, were used.

Sampling

For sampling, four study sites were selected, (50 m x 50 m. With an area of 2,500 m2 per quadrant) of summer pastures under grazing conditions (active). The collection of plant material was carried out at random, the phenological stage was not considered because there was a variation between the same times of evaluation; a considerable amount of plant matter (leaf, stems and flowers) was collected; they were mixed and divided into three samples. This same procedure was performed for each of the sites under study.

Dates of Collection

According to the weather conditions present in the state of Sonora, it was considered to carry out the proximal chemical analysis of the four seasons of the year (spring, summer, autumn and winter). The collection of plant material was carried out on the dates shown in table 1.

Chemical analysis

The nutritional content of *Krameria erecta* was carried out in the animal nutrition laboratory of the Department of Agriculture and Livestock of the University of Sonora, using the methods established by the AOAC (1995), which includes the moisture content (method 930.04), crude protein using the Kjeldah method (method 955.04), ashes (by calcination at 550 °C) (method 930.05), ether extract (method 962.09) and crude fiber (method 920.39). As regards the dry material, it was ground in a Willey mill with a mesh size of 1 mm; it was then dried at 55 °C for 48 hours to obtain the dry weight.

Table 1. Dates of plant material collections

# of collection	Season	Date
1rst	Summer	July 16, 2018
2nd	Autumn	November 3, 2018
3rd	Winter	January 31, 2109
4th	Spring	April 27, 2019

Statistical Analysis

The data obtained were analyzed with a completely randomized design, the quadrants and four seasons of the year (spring, summer, autumn and winter) were evaluated. With the data obtained, an analysis of variance was performed. For the comparison of means, the Tukey-Kramer mean test was used, with an alpha of 0.05%. These analyzes were carried out using the statistical package JMP 5.0.1 (JMP, 2002).

RESULTS AND DISCUSSION

When evaluating the nutritional content of *Krameria erecta*, it was shown that there are significant differences with respect to the sampling time and between the sites in the percentage of ethereal extract, % of dry matter, % of humidity, % of ashes, % of phosphorus and % of calcium.

Regarding the percentage of protein, it is observed that they presented significant differences in the four seasons of the year and it was also shown; while in the rest of the sites evaluated no significant differences were shown, presenting crude protein values on average from 7.46 to 13.42 % throughout the year. The highest percentages of crude protein were in the summer season, this may be due to the fact that the protein increases its concentration when the plant is in water stress for prolonged times (Table 2). Due to their considerable protein levels, multipurpose nature, wide margin of adaptation and production capacity, the biomass of trees and shrubs can contribute to improving the quality of the animals' diet (García *et al*., 2009).

Marshal *et al*. (2005), evaluated the raw protein of *Krameria grayi* Rose and Pintor, at four times of the year, showing for winter 10.97%, spring 10.83%, summer 8.55% and autumn 10.62%. These results differ in the four evaluation periods with those obtained in this study, since *Krameria erecta* presented higher values in the four periods evaluated.

They also differ with the results obtained by Toyes-Vargas *et al*. (2013), who analyzed the raw protein content of 5 native forage species: huizache (*Acacia farnesiana*), mesquite (*Propsopis glandulosa*), palo fierro (Olneya tesota), palo verde (*Cercidium floridum*) and Vinorama (*Acacia brandegeana*); presented values of 14.68 to 22.74% crude protein. This difference between the results could be attributed to the fact that the species analyzed by Toyes-Vargas *et al*. (2013), are fabaceae.

In the case of ethereal extract, statistically there are significant differences with (P <0.05). Between the sites and time of collection, the collection dates presented values of 1.8 to 2.4% of ethereal extract; see table 2. The percentage of dry matter presented significant differences between the sites and the time of collection, showing values from 71.2 to 87.3%. It is possible to mention that these results are related to protein content; in summer, the plants have a higher dry matter content and therefore less moisture (Table 2). The presence of rains presents important changes in the content of protein and dry matter, causing the decrease of these variables and increasing the % of humidity, as clearly shown in this study when obtaining values from 12.7 to 28.8% (Table 2).

Table 2. Chemical composition of southern cósahui *Krameria erecta*

Sites/season	%PC*	%EE*	%MS*	%H*
S1 Summer	13.41±0.040415a	2.2±0.100000bcd	87.3±0.360555a	12.7±0.152753f
S2 Summer	13.220.010000±a	1.9±0.100000de	84.9±0.400000b	15.1±0.264575e
S3 Summer	13.31±0.020817a	2±0.100000cde	85.1±0.152753b	14.9±0.115470e
S4 Summer	13.42±0.015275a	1.8±0.100000e	87.2±0.057735a	12.8±0.058595f
S1 Autumn	10.3±0.251661cd	2.7±0.152753a	72.1±0.611583e	27.9±0.200000b
S2 Autumn	10.5±0.200000c	2.2±0.173205bcd	73.4±0.100000d	26.6±0.100000c
S3 Autumn	10.1±0.100000d	2.4±0.100000ab	71.2±0.173205f	28.8±0.115470a
S4 Autumn	10.5±0.100000c	2.2±0.100000bcd	72.3±0.152753e	27.7±0.529150b
SI Winter	7.46±0.055678e	2.3±0.100000bc	73.5±0.100000d	26.5±0.173205c
S2 Winter	7.68±0.030000e	2.1±0.100000bcde	73.3±0.100000d	26.7±0.100000c
S3 Winter	7.61±0.010000e	2.3±0.200000bc	73.6±0.100000d	26.4±0.100000c
S4 Winter	7.67±0.020000e	2.3±0.173205bc	73.4±0.100000d	26.6±0.264575c
SI Spring	11.09±0.020000b	2.2±0.100000bcd	76.3±0.173205c	23.7±0.264575d
S2 Spring	11.03±0.010000b	2±0.100000cde	76.7±0.173205c	23.3±0.100000d
S3 Spring	11.1±0.100000b	2.1±0.100000bcde	76.6±0.200000c	23.4±0.100000d
S4 Spring	11.03±0.010000b	2±0.100000dce	76.4±0.100000c	23.6±0.100000d

*a, b, c, d, e, f Different literals, between lines indicate significant differences (P<0.05). %PC= % of crude protein % EE= % of ethereal extract; %MS= % of dry mass; %H= % of humidity.

It is worth mentioning that the results obtained regarding the percentage of dry matter in this study, differ from those of Toyes-Vargas *et al*. (2013), who evaluated some species of native Huizache (*Acacia farnesiana*), mesquite (*Propsopis* glandulosa), palo fierro (*Olneya tesota*), palo verde (*Cercidium floridum*) and Vinorama (*Acacia brandegeana*); obtaining results from 92.53 to 96.38%.

Therefore, it can be mentioned that, due to lower water availability in the soil, the edaphic evapotranspiration of the plants was greater and had an impact on the humidity variations in the analyzed plant tissue Ojeda *et al*. (2012). The chemical composition of the plant may vary, mainly depending on the environmental conditions (Gallego *et al*., 2014).

The tree and shrub component involved in these systems have broad effects on the nutritional framework of herbivores (Carmona, 2007); due to its considerable protein levels, multipurpose nature, wide margin of adaptation. Trees and shrubs can contribute improving the quality of the animals' diet. It is necessary to evaluate the chemical and nutritional composition of the most promising species in livestock ecosystems, in order to establish the main advantages and limitations in the use of each one for animal feed (García and Medina, 2006; García *et al*., 2009).

Due to the chemical composition and nutritional value of its foliage, flower and fruits, and of high acceptability by animals; woody plants can be considered to have forage potential (Pizzani *et al*., 2006; Pinto-Ruiz *et al*., 2010), and constitutes an important forage with different nutritional values, depending on the part of consumption and the time in that the natural protein bank is found during the year (Orskov, 2005; Hernández *et al*., 2008).

It is worth mentioning that the percentage of ashes present in Krameria erecta, showed significant differences at the time of collection, but not between sites; except in the winter time. On site two they were different from the rest, from that same era. The ash values present were from 7.41 to 13.33%. In the ash content the results differ with those of Toyes-Vargas *et al*., (2013), with Krameria erecta values being higher, with respect to huizache (*Acacia farnesiana*), mesquite (*Propsopis glandulosa*), palo fierro (*Olneya tesota*), palo verde (*Cercidium floridum*) and Vinorama (*Acacia brandegeana*).

In relation to the percentage of crude fiber (% FC), there were significant differences at the time of collection, showing averages of 23.78 to 32.82%; but there is no significant difference between the sites evaluated (table 3). The metabolic processes of plants are not related to the raw fiber content, as they do not intervene in them. Kurdish fiber is necessary to carry out the digestive processes, so the southern cósahui shows considerable values of raw fiber at the different times evaluated. On the other hand, when comparing these results with those of Toyes-Vargas *et al*., (2013), they are similar in terms of the percentage of crude fiber, with respect to the huizache (*Acacia farnesiana*), mesquite (*Propsopis glandulosa*) and Vinorama (*Acacia brandegeana*) and the percentage of raw protein of *Krameria erecta* differs with those of palo fierro (*Olneya tesota*) and palo verde (*Cercidium floridum*), presenting higher values *Krameria erecta*.

Calcium presented significant differences in spring time sites. The seasons of summer, autumn and winter did not show significant differences, except at site three of the winter season, with respect to the rest of the sites of that time. Therefore, this element does show variation in the analyzes in the spring season, this being a stationary element in the soil (table 3); but the variation of this one in the plants, can be due to the fact that calcium can vary its presence in soils that present erosion problems; and considering the latter, it is possible to attribute this variation to the lack of vegetation in the study sites.

With respect to the percentage of phosphorus present in *Krameria erecta*, it is observed that there is a significant difference (P> 0.05), between the times of collection (summer, autumn, winter and spring); showing no significant differences (P> 0.05), between the winter-spring collection seasons and their respective collection sites; when values of 0.05 to 0.09% are presented (table 3). These values can be attributed that the phosphorus is not very mobile in the soil, but it is movable in the plant.

Table 3. Chemical composition of southern cósahui *Krameria erecta*

Sites/season	%Ce*	%FC*	%Ca*	%P*
S1 Summer	13.33±0.026458a	24.11±0.200000d	1.21±0.010000de	0.07±0.017321b
S2 Summer	13.21±0.011547a	23.78±0.023094d	1.18±0.005774de	0.06±0.015275b
S3 Summer	13.28±0.023094a	23.98±0.010000d	1.19±0.010000de	0.07±0.010000b
S4 Summer	13.3±0.100000a	23.99±0.010000d	1.18±0.010000de	0.07±0.010000b
S1 Autumn	10.3±0.100000c	29.21±0.852369b	1.32±0.020000d	0.09±0.036056a
S2 Autumn	10.1±0.200000c	29.54±0.210713b	1.31±0.010000de	0.06±0.010000a
S3 Autumn	10.2±0.100000c	29.39±0.036056b	1.33±0.010000de	0.08±0.010000a
S4 Autumn	10.3±0.173205c	29.5±0.100000b	1.31±0.010000de	0.07±0.017321a
SI Winter	7.41±0.010000e	32.82±0.010000a	0.06±0.000000de	0.05±0.010000c
S2 Winter	7.7±0.100000d	32.17±0.017321a	0.06±0.010000de	0.06±0.010000c
S3 Winter	7.66±0.010000de	32.41±0.010000a	0.05±0.010000e	0.06±0.010000c
S4 Winter	7.62±0.010000de	32.58±0.026458a	0.06±0.010000de	0.06±0.010000c
SI Spring	11.12±0.020000b	26.74±0.017321c	0.87±0.017321c	0.09±0.010000c
S2 Spring	11.01±0.100000b	26.59±0.010000c	0.99±0.010000a	0.08±0.010000c
S3 Spring	11.04±0.017321b	26.64±0.026458c	0.89±0.010000c	0.08±0.010000c
S4 Spring	11.07±0.010000b	26.52±0.026458c	0.93±0.017321b	0.07±0.010000c

a, b, c, d, e Different literals, between lines indicate significant differences (P<0.05). %Ce= % of ashes; %FC= % of crude fiber; %Ca= % of calcium; %P= % of phosphorus.

Despite the drastic changes that occur in this region during the four seasons (seasons) of the year, *Krameria erecta* shows good nutritional potential, as it does not have such strong variations in its bromatological composition in terms of raw fiber, calcium, ethereal extract dry matter and phosphorus. For this reason, it is important to know the food content and nutritional value of the native individual species (Guerrero *et al*., 2010). The use of natural resources in a rational and sustainable manner is a viable option to obtain benefits in agricultural activities (Quansah and Makkar, 2012).

Fodder trees and shrubs are species adapted to the soil conditions and climate of the region, which ensures their survival, persistence and growth from moderate to relatively rapid with high probability; It improves the diet of the animal and reduces the use of concentrates in livestock farms, providing favorable conditions for the increase of the productive response of the animals (De Andrade *et al*., 2008; Rodríguez and Roncallo, 2013; Sosa *et al*., 2004; García and Medina, 2006; Petit *et al*., 2009). Therefore, the integration of trees in the pastures presents an option to improve the productivity and sustainability of livestock (Ortega, 2013).

It is important to note that to discuss the results obtained. Little information is available on the nutritional content of other species in the Krameracea family. More research should be done to continue evaluating the nutritional content of other species not yet studied, which are of great importance to animals; since they cover a large part of their nutritional needs. The above is indispensable for the establishment of strategies for sustainable management of silvopastoral systems; however, livestock activity is carried out under production systems that are not friendly to the environment. Production must be sustainable in biological and economic terms for agricultural production (Korbut *et al*., 2009; Oliva *et al*., 2015; Oliva *et al*., 2018).

CONCLUSIONS

The chemical composition of southern cósahui (*Krameria erecta*) showed a higher nutrient content in summer, except in ethereal extract. The content of the crude protein percentage is almost double in summer than in winter. The statistical analysis between seasons of the year (time) of sampling, indicates that there are significant differences. In the autumn season *Krameria erecta* provides more percent fat and carbohydrates, as energizers for herbivores.

ACKNOWLEDGMENT

A sincere thanks to C. Agustín Hurtado Aguayo and Ing. Tomás López Coronel, for the attentions provided, for the realization of this work at Las Cruces Ranch, in Hermosillo Sonora, Mexico.

CITED LITERATURE

AOAC.1995. (Association of Official Analytical Chemists). Official methods of analysis. 17th ed., William Horwitz editor, Washington D.C., USA.

APRÁEZ GE, Gálvez CAL, Navia EJF. 2017. Evaluación nutricional de arbóreas y arbustivas de bosque muy seco tropical (bms- T) en producción bovina. *Rev. Cienc. Agr.* [online]. 34(1):98-107. ISSN 0120-0135. http://dx.doi.org/10.22267/rcia.173401.66.

CARMONA Agudelo JC. 2007. Effect of use of tree and shrub forage on digestive dynamics in bovines. *Revista Lasallista de Investigación*. *4*(1):40-50. https://www.researchgate.net/publication/262459449_Effect_of_use_of_tree_and_shrub_forage_on_digestive_dynamics_in_bovines. ISSN:1794-4449

CARINI M, G. Aldini M, Orioli, Facino RM. 2002. Antioxidant and photoprotective activity of a lipophilic extract containing neolignans from Krameria triandra roots. *Planta Med.* 68(3):193-7. https://doi.org/10.1055/s-2002-23167

SOARES de Andrade CM, Ferreira Valentim J, da Costa Carneiro J, Alexandre Vaz F. 2004. Crescimento de gramíneas e leguminosas forrageiras tropicais sob sombreamento. *Pesquisa Agropecuária Brasileira.* 39(3): 263-270. https://dx.doi.org/10.1590/S0100-204X2004000300009

QUANSAH ES, Makkar HPS. 2012. Use of lesser-known plants and plant parts as animal feed resources in tropical regions. By Animal Production and Health Working Paper. No. 8. FAO. Rome. https://www.feedipedia.org/content/fao-2012-emmanuel-s-quansah-harinder-ps-makkar-animal-production-and-health-working-paper-no

FRANCIS John K, Lowe Carol A. 2000. *Guazuma ulmifolia* Lam. Guácima. Bioecología de Árboles Nativos y Exóticos de Puerto Rico y las Indias Occidentales. New Orleans. LA: U.S. 255p. https://data.fs.usda.gov/research/pubs/iitf/Bioecologia_gtr15.pdf

GALLEGO-CASTRO LA, Mahecha-Ledesma L, Angulo-Arizala J. 2014. Potencial Forrajero de *Tithonia diversifolia* Hemsl. A Gray en la Producción de Vacas Lechera. *Agron. Mesoam*. 25(2):393-403. ISSN:2215-3608.

GARCÍA Danny E, Medina MG. 2006. Composición química, metabolitos secundarios, valor nutritivo y aceptabilidad relativa de diez árboles forrajeros. *Rev. Zootecnia Trop*. 24(3):233-250. Disponible en: <http://www.scielo.org.ve/scielo.php?script=sci_arttext&pid=S0798-72692006000300004&lng=es&nrm=iso>. ISSN 0798-7269.

GARCÍA DE, Medina M. G, Moratinos P, Cova LJ. Torres A, Santos O, Perdomo D. 2009. Caracterización químico-nutricional de forrajes leguminosos y de otras familias botánicas empleando análisis descriptivo y multivariado. *Avances en Investigación Agropecuaria*. 13(2): 25-39. ISSN:0188789-0.

GUERRERO M, Juárez AS, Ramírez RG, Montoya R, Murillo M, Lao O, Cerrillo MA. 2010. Composición química y degradabilidad de la proteína de forrajes nativos de la región semiárida del norte de México. *Rev. Cub. Cien. Agrí*. 44(2): 147-154. ISSN:0034-7485. https://www.redalyc.org/html/1930/193015662009/

HERNÁNDEZ JE, Franco GFJ, Villarreal EBO, Aguilar L, Sorcia MG. 2008. Identificación y preferencia de especies arbóreo-arbustivas y sus partes consumidas por el ganado caprino en la Mixteca Poblana, Tehuaxtla y Maninalcingo, México. *Zootecnia Tropical.* 26(3): 379-382. ISSN:0798-7269
http://www.avpa.ula.ve/congresos/v_congreso_agroforesteria/pdf/revistazootenia/Hernandez1.pdf

INSUASTY E, Apráez E, Gálvez A. 2013. Caracterización botánica, nutricional y fenológica de especies arbóreas y arbustivas de bosque muy seco tropical. *Rev. Ciencia Animal*. 6:109:124. ISSN:2011-513X. https://www.academia.edu/28584817/Caracterizaci%C3%B3n_bot%C3%A1nica_nutricional_y_fenol%C3%B3gica_de_especies_arb%C3%B3reas_y_arbustivas_de_bosque_muy_seco_tropical_Botanical_Nutritional_and_Phenological_Characterization_of_Tree_and_Shrub_Species_from_a_Very_Dry_Tropical_Forest

JIMÉNEZ-ESTRADA M, Velázquez-Contreras C, Garibay-Escobar A, Sierras-Canchola D, Lapizco-Vázquez R, Ortiz-Sandoval C, Burgos-Hernández A, Robles-Zepeda RE. 2013. In vitro antioxidant and antiproliferative activities of plants of the ethnopharmacopeia from northwest of Mexico. *BMC Complementary and Alternative Medicine.* 13: 329. DOI: 10.1186/1472-6882-13-12

JMP. 2002. The Statistical Discovery Software. SAS institute Inc.Ver. 5.0.1

KORBUT N, Ojeda A, Muñoz D. 2009. Evaluación del perfil bromatológico y de algunos parámetros físicos del follaje de plantas leñosas consumidas por vacunos en silvopastoreo en un bosque seco tropical semideciduo. *Zootecnia Trop*. 27(1):65-72. ISSN:0798-7269. http://www.bioline.org.br/request?zt09008

MARSHAL Jason P, Krausman Paul R, Bleich CV. 2005. Vernon C Rainfall, temperature, and forage dynamics affect nutritional quality of desert mule deer forage. *Rangeland Ecology and Management*. 58, (4):360–365. https://doi.org/10.2111/1551-5028(2005)058[0360:RTAFDA]2.0.CO;2

Mc CAUGHEY-ESPINOZA DM, Ayala Astorga GI, Velázquez-Caudillo J, Anaya-Islas J, Canseco-Vilchis E. 2017. Creación de un jardín botánico y de árbol madre de arbustivas forrajeras nativas del estado de Sonora. *Idesia (Arica), 35*(4):35-45. https://dx.doi.org/10.4067/S0718-34292017000400035

MORÁN-PALACIO EF, Zamora-Álvarez LA, Stephens-Camacho NA, Yáñez-Farías GA, Virgen-Ortiz A, Martínez-Cruz O, Rosas-Rodríguez JA. 2014. Antioxidant capacity, radical scavenging kinetics and phenolic profile of methanol extracts of wild plants of Southern Sonora, Mexico. *Tropical Journal of Pharmaceutical Research.* 13: 1487-1493. htt://dx.doi.org/10.4314/tjpr.v13i9.15

MUÑOZ E, Pupiales S, Navia J. 2011. Evaluación del estado actual del nitrógeno en el arreglo silvopastoril (*Alnus jorullensis* H b &K) kikuyo (*Pennisetum clandestinum* Hochst ex *Pennisetum clandestinum* Hochst ex Chiov.). *Revista de Ciencias Agrícolas*. 28(1):161–175 ISSN: 256-2273 http://revistas.udenar.edu.co/index.php/rfacia/article/view/39

OJEDA A, Obispo N, Canelones C, Muñoz D. 2012. Selección de especies leñosas por vacunos en silvo-pastoreo de un bosque semicaducifolio en Venezuela. *Archivos de Zootecnia.* 61(235):355 - 365. http://dx.doi.org/10.4321/S0004-05922012000300004

OLIVA M, Rojas D, Morales A, Oliva C, Oliva M. 2015. Contenido nutricional, digestibilidad y rendimiento de biomasa de pastos nativos que predominan en las cuencas ganaderas de Molino-pampa, Pomacochas y Leymebamba, Amazonas, Perú. *Scientia Agropecuaria.* 6(3): 211-215. ISSN 1885-4494.

DOI: http://dx.doi.org/10.17268/sci.agropecu.2015.03.07

OLIVA M, Valqui L, Meléndrez J, Milla M, Leiva S, Collazos R, Maicelo J. 2018. Influencia de especies arbóreas nativas en el sistema silvopastoriles sobre el rendimiento y valor nutricional de *Lilium multiplorum* y *Trifolium repens*. *Rev. Scientia Agropecuaria.* 9(4):579-583. DOI:10.17268/sci.agropec.2018.04.14

ORTEGA Jorge Aguirre. 2013. Características nutricionales de algunas leñosas forrajeras. *Abanico Veterinario.* 3(3):42-51. ISSN 2007-4204 https://www.medigraphic.com/pdfs/abanico/av-2013/av133f.pdf

ORSKOV ER. 2005. Silvopastoral systems: technical, enviromental and socio-economic challenges. *Rev. Est. Experiment. Pas. Forr*. 28 (1): 5-9. ISSN: 0864-0394. http://www.redalyc.org/articulo.oa?id=269121628001

PETIT Aldana J, Casanova Lugoy F, Solorio Sánchez FJ. 2009. Fodder tree species in association to improve productivity and nutrients cycling. *Rev. Scielo Agricultura Técnica en México*. 35(1). ISSN 0568-2517. https://www.researchgate.net/publication/317479128_Fodder_tree_species_in_association_to_improve_productivity_and_nutrients_cycling

PINTO-RUIZ R, Hernández D, Gómez H, Cobos MA, Quiroga R, Pezo D. 2010. Árboles forrajeros de tres regiones ganaderas de Chiapas, México: Usos y características nutricionales. *Uni-ciencia*. 26(1):19-31. ISSN 0188789-0 Recuperado en 09 de mayo de 2019, de http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0186-29792010000100002&lng=es&tlng=es.

PIZZANI Pablo, Matute Irana, Martino Giovanna, Arias Adelis, Godoy Susmira, Pereira Luis, Palma José, Rengifo Mercedes. 2006. Composición Fitoquímica y Nutricional de Algunos Frutos de Árboles de Interés Forrajero de Los Llanos Centrales de Venezuela. *Revista de la Facultad de Ciencias Veterinarias*, *47*(2), 105-113. Recuperado en 10 de julio de 2019, de http://ve.scielo.org/scielo.php?script=sci_arttext&pid=S0258-65762006000200005&lng=es&tlng=es

PORTILLO B, Razz-García RC, Marin M, Araujo-Febres O. 2009. Dinámica de crecimiento en plantas de añil dulce (*Indigofera hirsuta* L.). *Archivos latinoamericanos de Produccion Animal.* 17(3-4): 91-96. ISSN 1022-1301 http://www.bioline.org.br/pdf?la09013

RODRÍGUEZ FG, Roncallo FB. 2013. Producción de forraje y respuesta de cabras en crecimiento en arreglos silvopastoriles basados en *Guazuma ulmifolia*, *Leucaena leucocephala* y *Crescentia cujete*. *Rev. Alimentación y nutrición animal*. 14(1):77-89. ISSN 0122-8706 http://www.scielo.org.co/scielo.php?pid=S0122-87062013000100009&script=sci_abstract&tlng=es

RUIZ TE, Castillo E, Alonso J, Febles G. 2006. Factores del manejo para estabilizar la producción de biomasa con leguminosas en el trópico. *Avances en investigaciones agropecuarias.* 10(1):3-20. ISSN: 0188-7890 http://ww.ucol.mx/revaia/portal/pdf/2006/enero/1.pdf

SANON HO, Kabore-Zoungrana C, Ledin I. 2008. Nutritive value and voluntary feed intake by goats of three browse fodder species in the Sahelian zone of West Africa. *Animal Feed Science and Technology.* 144:1–2 https://doi.org/10.1016/j.anifeedsci.2007.10.004

SOSA Rubio EE, Pérez Rodríguez D, Ortega Reyes L, Zapata Buenfil G. 2004. Evaluación del potencial forrajero de árboles y arbustos tropicales para la alimentación de ovinos. *Técnica Pecuaria en México*. 42(2):129-144 ISSN: 0040-1889 https://www.redalyc.org/html/613/61342201/

TORRES-GONZÁLEZ L, Muñoz-Espinosa LE, Rivas-Estilla AM, Trujillo-Murillo K, Salazar-Aranda R, Waksman de Torres N, Cordero-Pérez P. 2011. Protective effect of four Mexican plants against CCl4-induced damage on the Huh7 human hepatoma cell line. *Annals of Hepatology*. 10: 73-79. https://doi.org/10.1016/S1665-2681(19)31590-X

TOYES-VARGAS EA, Murillo-Amador B, Espinoza-Villavicencio JL, Carreón-Palau L, Palacios-Espinosa A. 2013. Composición química y precursores de ácidos vaccénico y uménico en especies forrajeras en Baja California Sur, México. *Revista mexicana de ciencias pecuarias*, *4*(3), 373-386. Recuperado en 27 de junio de 2019, de http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S2007-11242013000300008&lng=es&tlng=es.