Alimentary and anti-methanogenic potential of four species of tropical fodder legumes in domestic ruminants

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ABSTRACT

Objective: To describe some considerations about the alimentary and anti-methanogenic potential of *Bauhinia divaricata*, *Dalbergia glabra*, *Piscidia piscipula* and *Caesalpinia vesicaria* (Fabaceae) present in Campeche, Mexico, in domestic ruminants.

Design/methodology/approach: The information was obtained from databases and archives in the internet, as well as official websites of national and international organizations.

Results: Although there is vast information about some Fabaceae species, it is still limited for *B. divaricata*, *D. glabra*, *P. piscipula* and *C. vesicaria*, although they are consumed by domestic ruminants. The few studies available report between 11 and 18% of raw protein (RP) and some secondary metabolites; however, there are no studies that allow understanding their anti-methanogenic potential and their effects on productivity.

Limitations on study/implications: This study offers a panorama of the alimentary and anti-methanogenic potential of four tropical species in domestic ruminants.

Findings/conclusions: *B. divaricata*, *D. glabra*, *P. piscipula* and *C. vesicaria* grow in the Yucatan Peninsula, they are found in grazing zones and are consumed by animals; however, there are few reports that determine the nutritional value of their edible components and no reports that evaluate their effect on productivity of domestic ruminants or their capacity to decrease the ruminal production of methane (CH_4).

Keywords: cattle; fodder; secondary metabolites; tropical trees; methane.

Citation: Beytia-Pacheco, E. S., Espinoza-Velasco, B., Crosby-Galván, M. M., Sánchez- Villarreal, A., & Ramírez-Mella, M. (2023). Alimentary and anti-methanogenic potential of four tropical species in domestic ruminants. *Agro Productividad*. https://doi.org/10.32854/agrop.v16i3.2454

Academic Editors: Jorge Cadena Iñiguez and Libia Iris Trejo Téllez

Received: May 10, 2022.
Accepted: March 05, 2023.
Published on-line: May 19, 2023.

Agro Productividad, *16*(3). March. 2023. pp: 167-173.

INTRODUCTION

Livestock production is facing diverse environmental challenges, among which greenhouse gas emissions (GGE) stand out, with the region of Latin America and the Caribbean being one of the zones of highest GGE production in the world, primarily from beef production (FAO, 1997). This is because an important number of domestic ruminants in this region are fed with low-quality fodders, especially during the drought period. During this period, grasses decrease their content of raw protein (RP) and increase the content of neutral detergent fiber (NDF), limiting the ruminal fermentation of dry matter (DM) and the absorption of volatile fatty acids (VFAs), in addition to increasing the retention time

of the feed. As consequence, the production levels of the animals are low but the amount of ruminal methane (CH_4) produced is high (Ku-Vera *et al.*, 2020). This is worsened in tropical regions where grasses of photosynthetic path C4 predominate, since the livestock fed with these grasses produces more CH_4 by kg of DM consumed than the livestock fed with C3 grasses, typical of temperate or cold regions (Thompson and Rowntree, 2020). Therefore, it is essential to decrease the environmental impact of livestock activities in tropical regions, with the diet being a way to achieve it, primarily with the use of local fodder trees.

There is information about the nutritional composition of diverse fodder trees such as *Leucaena leucocephala*, *Guazuma ulmifolia* or *Gliricidia sepium*, as well as their effects on ruminal fermentation and CH_4 production, both in *in vitro* and *in vivo* studies (Piñeiro-Vázquez *et al.*, 2015; Naranjo *et al.*, 2016; Molina-Botero *et al.*, 2019; Galindo *et al.*, 2016; Castrejón-Pineda *et al.*, 2016; Canul-Solis *et al.*, 2020). However, there are several tropical species (Fabaceae) that have been scarcely studied despite being present in the grazing areas and consumed by the livestock. Because of this, the objective was to describe some considerations about the alimentary and anti-methanogenic potential of *Bauhinia divaricata*, *Dalbergia glabra*, *Piscidia piscipula* and *Caesalpinia vesicaria* present in Campeche, Mexico, which are consumed by domestic ruminants.

MATERIALS AND METHODS

The search for information began in August 2020 and ended in March 2021, through databases and data archives available on the internet, among which Google Scholar, Redalyc, SciELO and NCBI stand out, as well as official websites of national and international organizations such as CICY and FAO. Terms in Spanish and English were included, individually or combined, including words like: "ruminants", "domestic ruminants", "bovines", "ruminal methanogenesis", "methane", "greenhouse gases", "legumes", "fodder legumes", "tropical legumes", "*Bauhinia divaricata*", "*Dalbergia glabra*", "*Piscidia piscipula*" and "*Caesalpinia vesicaria*". The information was analyzed and synthesized to extract the key points that allowed fulfilling the objective of this literature review.

Fodder legumes (Fabaceae)

The Fabaceae family is one of the three vascular plant families best represented globally; 737 genera and 19,325 species of cosmopolitan distribution are recognized, primarily in warm and temperate regions. In Mexico, there are 139 genera and 1850 species of this family (Rzedowski *et al.*, 2016). The fodder species of legumes (Fabaceae) in association with grasses (Poaceae) play a relevant role in the nutrition and sustainability of livestock systems, due to their higher content of RP (up to 25% in dry base) and lower content of cell walls than the commonly used grasses in domestic ruminant diets. In addition, they have a higher passage rate because they are highly fermentable and have less retention time in the rumen, decreasing the methanogenesis (Ku-Vera *et al.*, 2020); however, there are other species that have been scarcely used, due to factors such as scarcity of commercial seed or lack of knowledge of their management, so the information regarding their nutritional

potential and their effect on ruminal fermentation is limited (Sosa-Montes *et al.*, 2020). The characteristics of four fodder species found on the roads or paddocks where livestock graze in Campeche, Mexico, are described.

***Bauhinia divaricata* L.** It is a shrub or tree up to 8 m tall (Figure 1a). It is commonly known as tatil bichim (Huasteco), pata de res, pata de vaca, pata de venado, pie de cabra (Rzedowski and Calderón de Rzedowsky, 1997); in Maya as chandzulutok, cocohoof, dsuruktok, ts'ulubtok, turku-tov, xdzuruntok, xpata, vaca-xmaywakax (Torres-Colín *et al.*, 2009). In general, it is found in low deciduous forest, medium sub-deciduous forest, and sub-evergreen forest. It also penetrates derived secondary vegetation. It is distributed in warm and humid to sub-humid lands of nearly all of Mexico, extending to Costa Rica and the Antilles (Rzedowski and Calderón de Rzedowsky, 1997). Among the uses of *B. divaricata*, the use of wood is reported for construction of houses, palapas, chicken coops and other rural constructions; in traditional medicine, it is used against stomach pain, bronchitis, asthma, colitis and snake bites (Torres-Colín *et al.*, 2009). Heike (2010) describes it as a perennial ruderal plant since it grows on the edge of roads and disturbed environments. It can also be found in paddocks and tropical plantations used as fodder; occasionally, it is used as ornamental and considered an important honey-producing species. In Yucatán the interior bark is used to make traps and fences.

There is scarce information regarding its use in livestock feed. In a study carried out by Sosa-Rubio *et al.* (2004), where the fodder potential of tropical trees and shrubs in the state of Quintana Roo was evaluated, the authors reported different uses of *Bauhinia divaricata*, among them as fodder, shade and ornamental. In that study, they report that there is 13.7% of RP, 48.0% of NDF and 34.7% of acid detergent fiber (ADF), as well as 38% of *in vitro* digestibility of DM (IVDDM).

Cab-Jiménez *et al.* (2015), in a study carried out in Campeche about the chemical composition and digestibility of fodder tropical trees, found values of IVDDM at 72 hours of 67.1%, as well as 16.9% content of RP, 60.9% of NDF and 35.4% of ADF during the drought season. On the other hand, there is scarce information about the content of secondary metabolites. In this regard, Albores-Moreno *et al.* (2018) reported 3.8% of condensed tannins, as well as presence of alkaloids and saponins. The RP content and of secondary metabolites, as well as its high IVDDM, make *Bauhinia divaricata* an excellent alternative for the diet of domestic ruminants; however, there are few studies and there are no reports of their use in *in vivo* studies. There are also no reports about its potential to decrease ruminal methanogenesis.

***Dalbergia glabra* (Mill.) Standl.** It is a tree or shrub (Figure 1b) that is distributed in the states of Chiapas, Oaxaca, Tabasco and Veracruz, primarily in high evergreen forest, low deciduous forest, medium sub-evergreen forest, and in secondary vegetation, with interest as a honey-producing and timber-yielding species (CICY, 2010). In Campeche, this species is commonly seen in paddocks and natural vegetation, as well as disturbed areas. The information available regarding its use in livestock feed is practically inexistent. A study carried out by López-Herrera *et al.* (2008) about native fodder plants in Ejido Kantunilkin, in Quintana Roo, Mexico, reported that *D. glabra* is known by producers, hunters and practitioners of traditional medicine with the

common name "verde" and it is a species with fodder potential in this zone. In that same study, the authors reported a content of RP, NDF and ADF of 18.7%, 62.9% and 41.5%, respectively, as well as presence of saponins, phenols and alkaloids. The high content of RP and the presence of various secondary metabolites suggest that D. glabra could have the potential to decrease ruminal production of CH_4; however, there are no studies about it. There are also no studies that assess its effects on ruminal fermentation or on livestock productivity.

***Piscidia piscipula* (L.) Sarrg**. It is known with the common name of jabín, habín or ja'abin (Maya) (CICY, 2010). It is a tree of 15 to 26 m of height and 57 to 62 cm of diameter (Figure 1c) (Vester and Navarro, 2007). It is one of the species with highest density and relative dominance of the plant community in Campeche, Mexico (Zamora-Crescencio *et al.*, 2014). In the Yucatan Peninsula, it is considered a nectar-polliniferous, fodder, medicinal and ornamental plant. In addition, its leaves and wood are used in the elaboration process of Pib, required to prepare Pibil, a specialty of traditional Mayan cuisine (Zamora-Crescencio *et al.*, 2009). Regarding its potential as feed for livestock, there are some studies that show the chemical and nutritional composition of *P. piscipula*. In this regard, Cab-Jiménez *et al.* (2015) reported that it has 18.3% of RP, 52.9% of NDF and 40.7% of ADF, close to 60% of IVDDM and did not show presence of saponins in samples collected during the dry season. Authors like Albores-Moreno *et al.* (2018), in a study carried out in fodder trees of secondary vegetation (Acahual), reported values

Figure 1. Four species of tropical fodder legumes from Campeche: a. *Bauhinia divaricata*; b. *Dalbergia glabra*; c. *Piscidia piscipula*; d. *Caesalpinia vesicaria*.

of 15.5%, 55.3% and 44.8% of RP, NDF and ADF, respectively, as well as 44.2% of IVDDM, 2.6% condensed tannins and abundant presence of saponins and alkaloids. Meanwhile, the study by Sosa-Rubio *et al.* (2004) reported a content of 11.5%, 61% and 47.8% of RP, NDF and ADF, respectively, as well as 51% of IVDDM. Likewise, López-Herrera *et al.* (2008), reported 12.6% of RP, 50% of NDF and 34.6% of ADF, as well as presence of saponins and phenols. The previous results indicate that *P. piscipula* could be a species used in paddocks, not only as live fences or shade for the livestock, but also as feed due to their contribution of RP and adequate digestibility. Likewise, due to its content of secondary metabolites, it could modify ruminal fermentation and decrease the production of CH_4, although it would be necessary to conduct studies about it.

***Caesalpinia vesicaria* L**. It is a species (Figure 1d) known as mareña (Spanish) or ya'ax k'iin che' (Maya) (CICY, 2010). It is a species of the dry forest (0-400 masl), which is distributed from Mexico to Nicaragua. It has various uses such as firewood, carbon, rustic constructions, beams, bridges, fence posts, and ornamental. Pulverized carbon from the bark is a domestic remedy against diarrhea in children (Quezada *et al.*, 2010). It is also used for the construction of rustic houses, in live fences, and for posts because its wood is very hard and resistant. Until now, there are no studies that indicate its nutritional contribution or value; however, it is reported as a species rich in tannins (CICY, 2010). Of the four species reported in this review, *C. vesicaria* is the least studied, so there is an area of opportunity to evaluate its viability in the diet of ruminants in Campeche.

CONCLUSIONS

There is enough evidence that shows that several species of the Fabaceae family have a high nutritional value and the capacity to decrease the production of CH_4 in ruminants because of the contents of secondary metabolites present in the edible parts of the plant. It is possible for other species of this botanical family to have the same alimentary and anti-methanogenic capacity. Presently, the need to apply strategies to decrease CH_4 emissions from ruminal fermentation is urgent, and these fodder species can be an option for domestic ruminants under grazing in tropical regions. The species *Bauhinia divaricata*, *Dalbergia glabra*, *Piscidia piscipula* and *Caesalpinia vesicaria* grow in the Yucatan Peninsula, they are found in grazing zones, and are consumed by livestock; however, the reports that determine the nutritional value of their edible components are scarce and there are no studies that evaluate their effect on the productivity of the animals and on their capacity to decrease the ruminal production of CH_4. Therefore, there is an area of opportunity to carry out research directed at a more sustainable animal diet, primarily for tropical regions of Mexico like Campeche.

ACKNOWLEDGEMENTS

The authors wish to thank Consejo Nacional de Ciencia y Tecnología (CONACyT) in Mexico for the scholarship received by the first and second authors, as well the support given through Project 417 of the Call to Address National Problems 2015. Also, the authors are grateful for the support given by Colegio de Postgraduados Campus Campeche.

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