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The protein and fiber content of tropical forages does not affect its preference by fattening rabbits

Contenido de proteína y fibra en forrajes tropicales no afecta la preferencia en conejos de engorda

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ABSTRACT

The objective of this research was to evaluate the preference for forages commonly used in animal feed in tropical areas of Mexico. Forages of Guasimo (*Guazuma ulmifolia*), Cocohite (*Gliricidia sepium*), Swirl grass or Bahiagrass (*Paspalum notatum*), Egypt grass (*Brachiaria mutica*), and Humidicola grass (*Brachiaria humidicola*) were offered simultaneously to 24 New Zealand rabbits for 14 days. In this investigation it was shown that *Gliricidia sepium* and *Brachiaria mutica* were preferred compared to *Guazuma ulmifolia, Paspalum notatum* and *Brachiaria humidicola* (P <0.05). The consumption of crude protein, acid detergent fiber, and neutral detergent fiber were higher with *Gliricidia sepium and Brachiaria mutica* (P <0.05). In conclusion, fattening rabbits preferred *Gliricidia septum*, and Nutrient content was not related to consumption preference. Forage preference study and its relationship with nutritional content are necessary to include tropical resources in rabbit feeding.
Keywords: *Brachiaria*, *Gliricidia sepium*, *Guazuma ulmifolia,* intake*, Paspalum notatum*

RESUMEN

El objetivo de esta investigación fue evaluar la preferencia de forrajes empleados comúnmente en la alimentación animal en zonas tropicales de México. El forraje de guasimo (*Guazuma ulmifolia)*, cocohite (*Gliricidia sepium)*, pasto remolino (*Paspalum notatum)*, pasto Egipto (*Brachiaria mutica)* y pasto humidicola (*Brachiaria humidicola)* fueron ofrecidos simultáneamente a 24 conejos Nueva Zelanda durante 14 días. En esta investigación se demostró que *Gliricidia sepium* y *Brachiaria mutica* fueron preferidos en comparación con *Guazuma ulmifolia, Paspalum notatum y Brachiaria humidicola* (P<0.05). El consumo de proteína cruda, fibra detergente ácido, y fibra detergente neutro fueron mayores con *Gliricidia sepium* y *Brachiaria mutica* (P<0.05). En conclusión, *Gliricidia sepium* fue preferido por conejos de engorda. El contenido de nutrientes no tuvo relación con la preferencia de consumo. El estudio de la preferencia de forrajes y su relación con su contenido nutricional es necesario para la inclusión de recursos tropicales en la alimentación de conejos.
Palabras clave *Brachiaria*, consumo, *Gliricidia sepium*, *Guazuma ulmifolia, Paspalum notatum.*

INTRODUCTION

The need for animal protein in developing countries has generated growing interest in the study of alternative, cheap and available food sources for animal production (Nieves *et al*, 2011; Malavé *et al,* 2013). In tropical areas around the world, a wide variety of plant species with potential for feeding herbivores, such as rabbits, have been identified, considering their availability, biomass production and chemical composition (Nieves *et al*, 2011; Malavé *et al,* 2013). Different studies conducted in Latin America and the world, show that the inclusion of tropical forages in the feed of fattening rabbits allows obtaining satisfactory productive yields (Nieves *et al*, 2011); however, the information generated on the preference of these resources in rabbits is still scarce (Safwat *et al*, 2014; Hafsa *et al*, 2016). Feed consumption and preference in rabbits have been evaluated under farm and laboratory conditions, demonstrating that it is influenced by multiple factors, including fiber content, digestible energy, fat, amino acid composition, gut fill, and the physical form of the consumed material and environmental conditions (Prebble & Meredith 2014). The simultaneous forage offering method is the closest to reality for determining forage preference in rabbits (Safwat *et al*, 2014). The study of forage preference may favor the development of local resource-based rabbit production in tropical areas (Safwat *et al*, 2014; Ozakwe & Ekwe, 2017).

The objective of the present study was to evaluate the preference of tropical forages in fattening rabbits and the relationship with chemical composition.

MATERIAL AND METHODS

Study area

The study was carried out in the tropical zone of southeastern Mexico (17°58'20" North Latitude and 92°35'20" West Longitude, at an average altitude of 0 meters; mean annual temperature of 27°C and mean annual precipitation of 2550 mm. The experiment was carried out in the facilities of the production area and rabbits studies of the Academic Division of Agricultural Sciences of the Universidad Autónoma Juárez de Tabasco, Mexico.

Animals and experimental procedures

Twenty-four male New Zealand rabbits of eight weeks of age and 1±0.25 kg live weight were used, they were housed individually in cages of 60 x 40 x 80 cm, equipped with an automatic plastic feeder and waterer; an adaptation period of 7 days and an evaluation period of 15 days were carried out according to Somers *et al*, (2008). Forage of guasimo (*Guazuma ulmifolia*), cocohite (*Gliricidia sepium*), bahiagrass (*Paspalum notatum*), Egypt grass (*Brachiaria mutica*) and humidicola grass (*Brachiaria humidicola*) was evaluated. The animals received 40 g of commercial feed daily to cover the digestible energy requirement for maintenance reported by Xiccato and Trocino (2010) (102.77 kcal/kg live

weight$^{0.75}$). The forages evaluated were offered daily and simultaneously, 50 g of each fresh forage, suspended from the cage ceiling by elastic bands; once 85 % of the offered forage was consumed, 10 g were added to ensure availability.

Chemical analysis and variables studied

Proximal chemical analysis was performed on samples of commercial feed and forages (Table 1). For dry matter (DM) determination, the samples were processed in a forced air oven at 50-60 °C for 48 h. An aliquot of these samples was taken from the commercial feed and forages (Table 1). An aliquot of these samples was placed in an oven at 110 °C to determine total moisture, and subsequently crushed to pass a 1 mm sieve using a Wiley mill (Model 4; Arthur H. Thomas Co. Philadelphia, Pa., USA). Crude protein (CP) (method 954.05) was determined by the macro-Kjeldahl procedure (N x 6.25) (AOAC 1990). Acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined according to Van Soest (1963) and Van Soest *et al.* (1991).

The variables studied were fresh consumption, dry matter consumption and consumption of CP, ADF and NDF fractions; in addition, the relative preference index (RPI) was estimated according to Ben Salem *et al,* (1994) using commercial feed as reference material. The parameters were defined as follows: feed intake on day 1 (FI1), average commercial feed intake for the first 5-day period (FI5), average commercial feed intake for the second 5-day period (FI10), average commercial feed intake for the third 5-day period, forage intake on day 1 (I1), average forage intake during the first 5 days (I5), average forage intake for the second 5-day period (I10), average forage intake for the third 5-day period (I15), amount of feed offered on day 1 (OF1), average amount of feed offered in the first 5-day period (OF5), average amount of feed offered in the second 5-day period (OF10), average amount of feed offered in the third 5-day period (OF15), amount of forage offered on day 1 (D1), amount of forage offered in the first 5 days (D5), amount of forage offered in the second 5-day period (D10) and amount of forage offered in the third 5-day period (D15).

Calculation and statistical analysis

The results obtained were analyzed by descriptive statistics and analysis of variance (ANOVA) completely at random; Pearson's correlation was also used to examine the association between chemical composition and total forage consumption using the STATGRAPHICS 5.1 statistical program. The relative preference index was determined from the ratio for day 1, RPI1 = ((I1/D1)/(FI1/OF1)); for the first 5-day period, RPI2= ((I5/D5)/(FI5/OF5)), for the second 5-day period, RPI3 =((I10/D10)/(FI10/OF10)) and for the third 5-day period, RPI4= ((I15/D15)/(FI15/OF/15)).

RESULTS

Table 1 shows that the highest CP content in forages corresponded to *Guazuma ulmifolia* (17.70%), followed by Gliricidia *sepium* (15.84%); the lowest CP content was found in *Brachiaria humidicola* (9.00%). Regarding fibrous content, the genus *Brachiaria* presented the highest values of ADF (40.80-48.55%), *Guazuma ulmifolia* had the lowest value of ADF with 22.72%; also, the FDN content was higher in the genus *Brachiaria* forages (67.7-70.45%); the forages *Guazuma ulmifolia* and *Gliricidia sepium* obtained values of 37.61% and 41.74%, respectively.

Table 1. Proximate chemical analysis of commercial feed and tropical forages offered to fattening rabbits

Variables (%)	Commercial feed	Guasimo *(Guazuma ulmifolia)*	*Cocohite (Gliricidia sepium)*	*Swirl grass (Paspalum notatum)*	*Humidicola grass (Brachiaria humidicola)*	*Egypt grass (Brachiaria mutica)*
Dry matter	87.73	32.44	94.50	24.70	74.00	92.90
Crude protein	20.59	17.70	15.84	14.20	9.00	11.65
Acid detergent fiber	38.95	22.72	32.12	37.00	40.80	48.55
Neutral detergent fiber	21.89	37.61	41.74	66.90	67.70	70.45

Table 2. Consumption of tropical forages, dry matter, crude protein, ADF and NDF in fattening rabbits

Variable	Commercial feed	*Guasimo (Guazuma ulmifolia)*	*Cocohite (Gliricidia sepium)*	*Swirl grass (Paspalum notatum)*	*Humidicola grass (Brachiaria humidicola)*	*Egypt grass (Brachiaria mutica)*
Total consumption Kg (14 days)	12.42^{b}	7.65^{c}	17.09^{a}	7.47^{c}	7.70^{c}	12.06^{b}
Average consumption per animal Kg (14 days)	0.564^{b}	0.34^{c}	0.777a	0.34^{c}	0.350^{c}	0.548^{b}
Average daily consumption g	37^{b}	23^{c}	51^{a}	14^{c}	23^{c}	36^{b}
Total DM consumption Kg	10.89^{b}	2.48^{C}	16.15^{a}	1.84^{C}	5.70^{c}	11.20^{b}
Total CP consumption Kg	2.56^{a}	1.35^{c}	2.70^{a}	1.06^{c}	0.69^{c}	1.40^{b}
Total ADF consumption Kg	4.83^{b}	1.73^{d}	5.49^{a}	2.76^{c}	3.14^{c}	5.85^{a}
Total NDF consumption Kg	2.71^{c}	2.87^{d}	7.13^{a}	4.99^{d}	5.21^{b}	8.49^{a}

[a, b, c] Different letters in the same column P<0.05

Table 2 shows that *Gliricidia sepium* was the species with the highest intake with 51 g (p <0.05) per day, followed by commercial feed (37 g) and *Brachiaria mutica* (36 g); the lowest intake was observed with *Guazuma ulmifolia* and *Paspalum notatum*. Likewise, *Gliricidia sepium* showed a higher total DM intake of 16.5 kg and total crude protein intake of 2.7 kg (p <0.05). *Brachiaria mutica* was the second highest total DM intake 11.20 kg. With respect to NDF and ADF intake, *Brachiaria mutica* showed the highest total intake with 8.49 kg and 5.85 kg, respectively (p <0.05), compared to the other species evaluated.

Table 3 shows that the correlation coefficient between total forage intake and CP, NDF and ADF content is low (P> 0.05); therefore, there is no relationship between the elements.

Table 3. Pearson's correlation coefficient between total intake, I1, I5, I10, I15 and Crude Protein, Neutral Detergent Fiber and Acid Detergent Fiber content of tropical forages fed to fattening rabbits

	Element	Correlation coefficient	r2	P Value
Total consumption	Crude protein	0.12	3.74	0.7552
	Neutral detergent fiber	0.33	10.04	0.6034
	Acid detergent fiber	0.03	0.89	0.8798
Consumption on day 1 (I1)	Crude protein	-0.374	13.99	0.5351
	Neutral detergent fiber	0.4466	21.71	0.4289
	Acid detergent fiber	0.0676	0.4577	0.9139
Consumption of the first 5-day period (I5)	Crude protein	-0.1966	3.868	0.7512
	Neutral detergent fiber	0.2347	5.5108	0.7039
	Acid detergent fiber	-0.1509	2.2796	0.8085
Consumption of the second 5-day period (I10)	Crude protein	0.1052	1.1075	0.8663
	Neutral detergent fiber	-0.1222	1.4947	0.8447
	Acid detergent fiber	-0.4282	18.336	0.4719
Consumption of the third 5-day period (I15)	Crude protein	-0.0164	0.0269	0.9791
	Neutral detergent fiber	0.0464	0.2154	0.9409
	Acid detergent fiber	-0.2979	8.8761	0.6264

With respect to the relative preference index, Table 4 shows that *Gliricidia sepium* had the highest consumption preference (P<0.05), while *Brachiaria mutica*, *Brachiaria humidicola*, *Paspalum notatum* and *Guazuma ulmifolia* forages did not show significant variations (P>0.05) in consumption preference during the experimental period.

Table 4. Relative consumption preference index of *Gliricidia sepium*, *Brachiaria mutica*, *Brachiaria humidicola*, *Paspalum* notatum and *Guazuma Ulmifolia* in fattening rabbits

Forage	Consumption (DM kg day^{-1})				Consumption (% offered)			
	I1	I5	I10	I15	I1/D1	I5/D5	I10/D10	I15/D15
Cocohite (Gliricidia. Sepium)	27.43	29.21	35.11	35.11	0.55^{a}	0.79^{a}	0.95^{a}	0.95^{a}
Egypt grass (Brachiaria Mutica)	23.41	18.23	9.20	13.71	0.47^{b}	0.79^{b}	0.25^{b}	0.37^{b}
Humidcola grass (Brachiaria Humidicola)	20.04	18.53	15.51	16.85	0.40^{b}	0.50^{b}	0.42^{b}	0.46^{b}
Swirl grass (paspalum notatum)	6.23	5.78	5.42	5.77	0.12^{c}	0.16^{c}	0.15^{c}	0.16^{c}
Guasimo (Guazuma Ulmifolia)	7.29	7.97	7.45	6.22	0.15^{c}	0.22^{c}	0.20^{c}	0.17^{c}

Forage	RPI1	Rank	RPI 2	Rank	RPI 3	Rank	RPI 4	Rank
Cocohite (Gliricidia. Sepium)	0.59	1	0.85	1	1.03	1	1.03	1
Egypt grass (Brachiaria Mutica)	0.51	2	0.53	3	0.27	3	0.40	3
Humidcola grass Brachiaria Humidicola.)	0.43	3	0.54	2	0.45	2	0.50	2
Swirl grass (paspalum notatum)	0.13	5	0.17	5	0.16	5	0.17	5
Guasimo (Guazuma Ulmifolia)	0.16	4	0.23	4	0.21	4	0.18	4

RPI1= (I1/D1)/(FI1/OF1).; RPI 2 = ((I5/D5)/(FI5/OF5); RPI 3 = (I10/D10)/(FI10/OF10); RPI4=(I15/D15)/(FI15/OF/15)

[a, b, c] Different letters in the same column P<0.05

DISCUSSION

In the present study, the simultaneous forage offering method and the relative preference index were used to measure consumption preference. *Gliricidia sepium* tree forage had higher consumption and preference compared to *Brachiaria mutica* grass, *Guazuma ulmifolia* tree, and *Paspalum notatum* and *Brachiaria humidicola* grasses (P <0.05). (Kontsiotis *et al*, 2015), as well as (Clauss & Hatt, 2017), mention that the diet composition of wild rabbits is composed of different plants and food types (grasses, shrubs, herbs and leaves), depending largely on the availability and quality of food resources in the environment. According to the results of (DeJaco & Batzli, 2013), cottontail rabbits (*Sylvilagus floridanus*) prefer in their diet herbaceous plants such as: *Trifolium pratense*, *Medicago sativa*, *Persicaria vulgaris*, *Aster ericoides* and *Viola pranticola*; as well as woody plants, which it may preferentially consume depending on their availability. (Ozakwe & Ekwe, 2017) indicate that preference measured through forage consumption

(palatability) in rabbits, is a phenomenon influenced by dietary and environmental factors. However, (Bobadilla *et al,* 2020) points out that the trophic selection of rabbits is positive for grasses, while forages and shrubs are avoided; however in these animals the consumption of more nutritious plants (rich in protein) can be of great importance in ecosystems where the available plants have low nutritional value. In this sense, it has been shown that the consumption of woody species by rabbits increases when the availability of grasses decreases, due to seasonal variations.

Regarding the relationship between consumption and chemical composition of diets, according to (Franz *et al*, 2011) and (Somers *et al*, 2008) rabbits are selective consumers, so they prefer parts with high protein content, since in nature the consumption of protein-rich materials guarantees a higher nutritional value of a low-energy diet. For their part (Crowell *et al*, 2018), points out that in the wild, pygmy rabbits (*Brachylagus idahoensis*) and cottontail rabbits (*Sylvilagus nuttallii*) employ behavioral strategies to consume materials with specific characteristics, such as low or high amount of fiber according to the availability in the meadow, or with higher crude protein content to decrease exposure times to predators and obtain food of higher nutritional quality; or to regulate or decrease the amount of secondary metabolites present in the plants they consume. According to (Wallage Drees & Deinum, 1985), the nutritional composition of the diet of wild rabbits represents crude fiber (CF) levels of 25 to 30% (DM) and neutral detergent fiber (NDF) levels of 50 to 60%. (Ogbuewu *et al*, 2017) (Ozakwe & Ekwe, 2017) indicate that there is a relationship between crude protein content and the preference of rabbits in consumption terms. The authors found that forages with high crude protein content such as *Centrosema pubescence*, *Calopogonium mucunoides* and *Elaeis guinensis* were the most consumed in a cafeteria trial. (Lush *et al*, 2017) report that rabbits prefer short grasses with lower fiber concentration and select forages for higher quality rather than higher quantity to meet their nutritional needs. However (Safwat *et al*, 2014) and (Abubakar *et al*, 2015) reported a large variability in the response of rabbits to forage supplementation; besides, (Kontsiotis *et al*, 2015) and (Lush *et al*, 2017), note that changes in feeding strategies are likely an adaptation to seasonal changes imposed by environmental conditions, which affect both forage availability and quality and that the diet of herbivorous mammals such as rabbits, can be affected by a myriad of factors such as resource availability, forage quality, area available for foraging and the presence of predators. (Lush *et al*, 2017) note that lagomorphs such as rabbits and hares are selective consumers, capable of consuming large amounts of low quality food and adapting to the availability of resources with higher nutritional quality.

In the present study, the content of crude protein, acid detergent fiber and neutral detergent fiber in the forages studied (crude protein, ADF and NDF) did not affect the preference in terms of consumption in any of the consumption periods evaluated (I1, I5, I10, I15) (P> 0. 05); which is contrary to that reported by (Ulappa *et al*, 2014), who point out that the odds of a forage being consumed increase 1.64 times for every 1% increase in crude protein content. According to (Somers *et al*, 2008), the selection of higher nutritional quality diets is a behavioral adaptation by which herbivores maximize their nutrient intake by selecting plants with high crude protein content. (Schmalz *et al*, 2014) reports that pygmy rabbits (*Brachilagus Idahoensis*) prefer to feed on sagebrush (*Artemisa vulgaris*); which has higher crude protein and lower fiber content (ADF-NDF); such preference may be associated more with the energy density it presents, being richer in protein than fiber, which may be especially important during winter when pygmy rabbit diets are 99.1% sagebrush, because energy requirements are especially high for thermoregulation at low temperatures, which could be contrary in tropical areas where temperatures are high. On the other hand (Hernández *et al*, 2017) and (Carpio *et al*, 2017) point out that the differences observed in consumption preference in rabbits, may be related to the presence of secondary metabolites such as saponins, flavonoids, total phenolic compounds and tannins, in cover crops and some fruits, which were not quantified in the foods studied in the present work. (Malavé *et al,* 2013) and (Ogbuewu *et al*, 2017) point out that the study and use of resources with high protein content in tropical areas, represent a viable option for rabbit feeding without relying on commercial feeds.

CONCLUSIONS

The CP, NDF and ADF content of tropical forages did not modify the consumption preference in fattening rabbits. *Gliricidia sepium* forage was preferred by fattening rabbits compared to *Brachiaria mutica*, *Guazuma ulmifolia*, *Paspalum notatum* and *Brachiaria humicola* forages. The study of forage preference in rabbits and its relationship with nutrient content is necessary to improve the use of these resources in tropical areas.

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