



## Determination of Tropical Forage Preferences Using Two Offering Methods in Rabbits

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**ABSTRACT:** Two methods of feed preference trials were compared to evaluate the acceptability of 5 fresh foliages: *Leucaena leucocephala*, *Moringa oleifera*, *Portulaca oleracea*, *Guazuma ulmifolia*, and *Brosimum alicastrum* that was included as control. The evaluation included chemical analyses and forage intake by rabbits. The first method was a cafeteria trial; 12 California growing rabbits aged 8 wk, allocated in individual cages, were offered the five forage plants at the same time inside the cage, while in the second trial 60 California growing rabbits aged 8 wk, allocated individually, were randomly distributed into 5 experimental groups (n = 12/group); for each group just one forage species was offered at a time. The testing period for each method lasted for 7 d, preceded by one week of adaptation. The results showed that *B. alicastrum* and *L. leucocephala* were the most preferred forages while on the contrary *G. ulmifolia* was the least preferred one by rabbits. The results also revealed that the CV% value for the 2nd method (16.32%), which the tested forages were presented separately to rabbits, was lower and methodologically more acceptable than such value for the 1<sup>st</sup> method (34.28%), which all forages were presented together at the same time. It can be concluded that a range of tropical forages were consumed in acceptable quantities by rabbits, suggesting that diets based on such forages with a concentrate supplement could be used successfully for rabbit production. However, growth performance studies are still needed before recommendations could be made on appropriate ration formulations for commercial use. (**Key Words:** Feed Preference, Cafeteria Trial, Tropical Forages, Rabbits)

### INTRODUCTION

Modern animal production faces conflicting demands to produce large volumes of high-quality food at low prices. Nutritional solutions have now become even more important to resolve these demands and this can be achieved by taking full advantage of the alternative feed resources, such as tropical plants, in rabbit diets. Furthermore one of the ways of reducing the cost of animal production in developing countries and therefore making protein available to people at cheaper prices is by the use of

agricultural by-products and tropical plants which are not directly used by humans as food to feed livestock (Asar et al., 2010).

Rabbits can convert locally available plant products such as *Leucaena leucocephala* (Raharjo and Cheeke, 1985) and by-product feeds (Raharjo et al., 1986) into animal protein for human consumption. FAO (1997) reports emphasized that the high rate of growth in meat consumption can be met through the increase in production of short cycle animals, such as rabbits, kept by the small scale farmers.

Rabbits are very selective in their feeding behavior and in the wild will nibble and select specific plant parts. They generally select leaves rather than stems, young plant materials rather than old and green rather than dry materials, resulting in a diet that is higher in protein and digestible energy and lower in fiber than the available total plant material. They are much more sensitive to slight changes in the feed than other livestock. Sometimes they will refuse to

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Submitted Mar. 20, 2013; Accepted Oct. 22, 2013; Revised Jan. 7, 2014

accept a new diet and will starve for several days rather than even taste the new feed (McNitt et al., 1996). When an unusual diet was presented to rabbits, it was clearly rejected in a free-choice test, but it was consumed in a long-term single food test (De Blas and Wiseman, 2010).

Investigating the possible utilization of variety of forages as feedstuffs in rabbit diets is common and of particular importance in tropical countries. Little work has been conducted to evaluate the nutritive value of such plants, and most attempts have been focused on single or double forage evaluation.

This experiment consisted of comparing two different methods of cafeteria trial which were conducted to measure feed preferences of rabbits when they were fed different fresh forages either in a separate form or given them together.

## MATERIALS AND METHODS

### Study site

The study consisted of two trials which were carried out at the rabbit facility of the Faculty of Veterinary Medicine and Animal Science (FMVZ), University of Yucatan (UADY), Merida, Yucatan, Mexico. The climate is sub-humid, with an average annual rainfall (highly variable) of 960 mm, and 6 to 7 months of dry period; the annual average temperature is 26°C. The daily average temperature is 23°C (max 32°C, min 15°C); while from March to September it is 30°C (max 37°C, min 23°C) as reported by Abou-Elezz et al. (2011).

### Animals and housing

In the first trial, 12 unsexed growing California rabbits (8 wk of age and 1,036±30 g initial live weight on average) were allocated in individual cages (40×60×50 cm). By the same way, 60 unsexed growing California rabbits, aged 8 wk and weighted on average 1,079±50 g were used in the second trial and were randomly divided into 5 groups each of 12 rabbits which were allocated in individual smaller cages (40×40×50 cm) as just one forage was presented to the rabbits.

### Forage plants

Five tropical forages were used in this experiment, the forage species were *Leucaena leucocephala*, *Moringa oleifera*, *Portulaca oleracea*, *Guazuma ulmifolia* and *Brosimum alicastrum*, this last one was included as control forage, due to previous feeding experience and chemical composition of this plant. Whole plants (stems and leaves) of *P. oleracea* were harvested at 16-true leaf stage, while fresh leaves of the other forages were harvested from trees (2 to 4-year-old, last harvest was 4 months before) growing at the FMVZ farm. The forages were fed fresh to the rabbits.

The chemical analysis of the forages is shown in Table 2. Subsamples of each batch of forage material were taken, and oven-dried at 60°C until constant weight was attained to determine their dry matter contents.

### The first trial

The first trial lasted for 14 d; 7 d as an adaptation period and 7 d as a testing period (Somers et al., 2008). All the animals were fed on a commercial diet (the chemical composition of the commercial diet is presented in Table 1). Feed was restricted by 40 g concentrated feed, as digestible energy maintenance requirement, to force the rabbits to consume the rationed quantity of the forage feed and they were given free access to 5 species of green forage that were presented as a suspended band of every forage at the same time inside the cage two times a day (08:00 and 16:00 h). The locations of forages inside the cage were distributed in the same proportion. Initially 50 g of each species of forage was offered daily, and the feeding level of individual forage was increased by 10 g, when more than 85% of the forage consumed. Daily feed intake (feed added – refused) and forage dry matter intake (DM added – DM refused) were determined.

### The second trial

The second trial was also carried out for 14 d (7 d as an adaptation period and 7 d as a testing period). Rabbits were randomly divided into 5 equal groups; each group was included just one species of the forages as a suspended band inside the cage. Animals were fed on restricted commercial diet (40 g) and fresh forage was presented *ad libitum* two times a day. The DMI was determined and refusals were recorded daily.

### Chemical composition

Proximate analysis of forage samples were carried out to determine the DM, CP, crude fiber (CF), ether extract (EE) and ash content according to AOAC (1995). NDF and

**Table 1.** Chemical composition of the concentrated commercial diet (% on DM basis)

Measurement	Concentrated diet
DM (% as fed)	88.5
CP	17.0
Crude fiber	14.4
Ether extract	2.2
Ash	7.5
Calcium	1.06
Available phosphorus	0.63
Methionine	0.42
Lysine	0.9
DE (kcal/kg)	2,580
DE:CP	151.76

**Table 2.** Chemical composition of the studied forages (DM basis)

Forage	DM (% as fed)	As g/100 g DM						
		CP	CF	NDF	ADF	EE	Ash	Condensed tannin
<i>B. alicastrum</i>	42.50	14.07	14.65	36.00	28.80	3.24	11.75	0.96
<i>L. leucocephala</i>	37.23	20.26	16.31	34.24	25.90	4.61	7.96	2.74
<i>M. oleifera</i>	23.94	21.04	15.28	31.32	26.88	6.25	8.89	3.09
<i>P. oleracea</i>	12.72	17.28	13.54	35.84	20.17	2.00	25.67	0.15
<i>G. ulmifolia</i>	32.44	17.70	14.48	37.61	22.72	2.21	10.03	6.50

CF = Crude fibre. EE = Ether extract.

ADF were determined following the method of Van Soest et al. (1991). Tannin content was determined according to Makkar et al. (1995).

### Statistical analysis

A completely randomized design was used. Data were analyzed using ANOVA, with PROC MIXED of SAS 9.2 Software (SAS Institute, Cary, North Carolina, USA). The application of the least significant ranges among different treatment means was done according to Duncan (1955). Treatment effects were considered significant at  $p \leq 0.05$ .

## RESULTS

Chemical analysis on a DM basis of forages is listed in Table 2. The highest protein content was observed with *M. oleifera* and *L. leucocephala*, while *B. alicastrum* has the lowest value; however that value provides the appropriate level to meet protein requirements for growing rabbits. Crude fiber content was also the highest for *L. leucocephala* and *M. oleifera* but it was the lowest in *P. oleracea*, although it is worthy to note that values of the fiber fractions (CF, NDF, ADF) for the studied forages are kept in limited range, which reduces possibility of causing differences in preference or acceptability due to the dietary fiber. In regard to condensed tannin content of the tested forages, it is clear that *P. oleracea* and *B. alicastrum* have the lowest condensed tannin content followed by *L. leucocephala* and *M. oleifera* while *G. ulmifolia* has the

highest value.

### First trial

Values regarding daily DMI of the different forages that offered at the same time are presented in Table 3. The data revealed that *L. leucocephala* was significantly ( $p = 0.001$ ) the highest forage consumed (25.66% of the total feed intake which consisted of forage and concentrated feed) followed by such *B. alicastrum*, *P. oleracea*, and *M. oleifera* (7.91%, 7.26%, and 6.83% of the total feed intake, respectively), however *G. ulmifolia* had the lowest consumption (2.13% of the total feed intake). The same trend was observed when the data expressed as g DM per kg metabolic BW. Although a slight difference appears when the data are expressed as relative intake of every forage to the total forage intake, that the highest consumption ( $p = 0.001$ ) was for *L. leucocephala* followed by *B. alicastrum* and *P. oleracea* then *M. oleifera* in the same significant level with *P. oleracea*, while *G. ulmifolia* was significantly the lowest forage consumed.

### Second trial

Data presented in Table 4 shows significant ( $p = 0.001$ ) differences among all treatment groups. In general, rabbits fed *B. alicastrum* have the highest forage intake (50.54% of the total feed intake) followed by such those fed *L. leucocephala* and *P. oleracea* (45.91% and 42.44% of the total feed intake, respectively) then came *M. oleifera* in the same significant level with *P. oleracea* (39.11% of the total

**Table 3.** DMI of the five forages when offered at the same time (n = 12 rabbits for each mean)

Forages	<i>B. alicastrum</i>	<i>L. leucocephala</i>	<i>M. oleifera</i>	<i>P. oleracea</i>	<i>G. ulmifolia</i>	SEM	p-value
g DM/d	6.30 <sup>b</sup>	20.44 <sup>a</sup>	5.44 <sup>b</sup>	5.78 <sup>b</sup>	1.7 <sup>c</sup>	0.41	0.001
g/kg <sup>0.75</sup> /d	5.11 <sup>b</sup>	16.57 <sup>a</sup>	4.42 <sup>b</sup>	4.68 <sup>b</sup>	1.38 <sup>c</sup>	0.34	0.001
% DM/d	16.32 <sup>b</sup>	49.95 <sup>a</sup>	14.37 <sup>c</sup>	15.14 <sup>bc</sup>	4.23 <sup>d</sup>	0.64	0.001

<sup>a,b,c</sup> Letters in the same row with different superscripts are significantly different ( $p < 0.05$ ).

**Table 4.** DMI of the five forages offered separately (n = 12 rabbits for each mean)

Forages	<i>B. alicastrum</i>	<i>L. leucocephala</i>	<i>M. oleifera</i>	<i>P. oleracea</i>	<i>G. ulmifolia</i>	SEM	p-value
g DM/d	40.87 <sup>a</sup>	33.95 <sup>b</sup>	25.69 <sup>c</sup>	29.49 <sup>bc</sup>	19.69 <sup>d</sup>	2.11	0.001
g/kg <sup>0.75</sup> /d	33.74 <sup>a</sup>	27.73 <sup>b</sup>	21.31 <sup>c</sup>	23.61 <sup>bc</sup>	16.79 <sup>d</sup>	1.77	0.001
% DM/d	27.27 <sup>a</sup>	22.71 <sup>b</sup>	17.13 <sup>c</sup>	19.74 <sup>bc</sup>	13.15 <sup>d</sup>	1.42	0.001

<sup>a,b,c</sup> Letters in the same row with different superscripts are significantly different ( $p < 0.05$ ).

feed intake), while the lowest forage intake value was obtained with rabbits fed *G. ulmifolia* (32.90% of the total feed intake). The same trend was obtained when the data expressed either as g DM per kg metabolic BW or as relative intake of every forage to the total forage intake.

Summarized in Table 5 the overall values of forage intake and the CV for both trials, show relatively higher CV values for the 1st trial than the 2nd trial; ranged from 25.55% to 51.30% with an average of 34.28% for this trial, when compared with the CV values of the 2nd trial which ranged from 15.34% to 17.26% with an average of 16.32%.

## DISCUSSION

It is worthy to note that chemical composition of forages may vary according to various factors such as climatic condition under which forage plants were grown, plant age as well as both soil type and fertility (Atawodi et al., 2008; Ayssiwe et al., 2010).

Results of chemical analysis of *B. alicastrum* and *G. ulmifolia* were nearly similar to findings of Lizarraga-Sánchez (2000) being 41.8% and 32.4% for DM, 16.9% and 15.5% for CP, 28.8% and 25.9% for ADF, 11.6% and 10.9% for Ash, respectively. Also, results of chemical analysis of *L. leucocephala* and *M. oleifera* were globally similar to those of Abou-Elezz et al. (2011) being 23.61% and 19.76% for CP, 40.38% and 44.42% for NDF, 25.69% and 27.11% for ADF, 8.27% and 9.61% for Ash, respectively. However, the value of CP for *P. oleracea* was observed to be lower than that published by Abaza et al. (2010) being 30.41%, although it was nearly the same value for CF being 12.81% as found by the same authors. Values of condensed tannin for *L. leucocephala*, *M. oleifera*, and *B. alicastrum* are nearly similar to findings of Mutayoba et al. (2011) and Lizarraga-Sánchez (2000) being 2.35%, 2.83%, and 0.7%, respectively although the value of *G. ulmifolia* was higher than that published by Lizarraga-Sánchez (2000) being 1.8%.

Concerning the forage preference, it is observed that the results obtained from the two trials are almost similar where *B. alicastrum* and *L. leucocephala* were the forage plants

most preferred by rabbits, and then *P. oleracea* and *M. oleifera* had a moderate preference level, meanwhile; *G. ulmifolia* was the least preferred one. In accordance with the present results, Nieves et al. (2004) found that diets containing 30% or 40% *Leucaena leucocephala* leaf meal were more palatable than diets containing the same levels of *Arachis pintoi* meal.

The high water content in *P. oleracea* and *M. oleifera* probably affected intake negatively. Arias et al. (2003) reported that the greatest disadvantage of foliages used as feeds is the low DM content, resulting in low DMI. The DM content can be improved by drying the foliages before feeding. On the other hand, the low preference of *G. ulmifolia* by rabbits was probably due to the high amount of anti-nutritional factors, such as condensed tannins in this plant (6.5%), since the higher tannin content in a plant the less is its dry matter intake. The negative effects of tannins on intake and digestion are attributed to reduce palatability/intake, digestibility, nutrient availability, and weight gain (Silanikove et al., 1996; Rogosic et al., 2008). Tannins tend to decrease diet digestibility through their ability to bind with proteins and other materials, resulting in decreased diet intake (Chang et al., 1998; Al-Mamary et al., 2001). In this regard Mashamaite et al. (2009) reported that 4% is the acceptable level of tannins in rabbit feeds without negative effects on intake and digestibility.

The amounts of total protein intake were measured for both trials as g protein consumed of forage/s plus g protein consumed of concentrated feed/rabbit/d. The value of total protein intake for the 1st trial was relatively high (14.27 g/rabbit) compared to the amounts of total protein intake for the 2nd trial; that were 13.68, 12.55, 12.21, 11.90 and 10.27 g/rabbit for *L. leucocephala*, *B. alicastrum*, *M. oleifera*, *P. oleracea*, and *G. ulmifolia*, respectively. Current results of protein intake confirmed the findings of Thu and Dong (2008) who found that the total crude protein intake for growing rabbits fed on various levels of fresh *Spophocarpus scandén* with concentrated feed ranged from 10.9 to 15.0 g/d.

Regarding the total fiber intake (g CF consumed of forage/s+g CF consumed of concentrated feed/rabbit/d), it was found that rabbits of the 1st trial recorded slightly high value of total fiber intake which was 11.87 as compared to the total fiber intake of the 2nd trial which were 11.75, 11.30, 9.69, 9.75, and 8.6 for *B. alicastrum*, *L. leucocephala*, *M. oleifera*, *P. oleracea*, and *G. ulmifolia*, respectively. These results of fiber intake were consistent of that reported by Supharoek et al. (2007) which was 11.5 g/d for growing rabbits fed different forages together with concentrated feed.

In the 1st trial, the forage DMI varied much (5.44 to 20.44 g/d) as a result of this strategy, when all of the five forages were presented to the animals at the same time, consequently the consumption of one forage species will

**Table 5.** Forage DMI (g/d) and CV% for each trial (n = 12 rabbits for each trial)

Forages	Trial 1	CV (%)	Trial 2	CV (%)
<i>B. alicastrum</i>	6.30 <sup>b</sup>	27.32	40.87 <sup>a</sup>	15.34
<i>L. leucocephala</i>	20.44 <sup>a</sup>	38.46	33.95 <sup>b</sup>	16.09
<i>M. oleifera</i>	5.44 <sup>b</sup>	28.77	25.69 <sup>c</sup>	17.26
<i>P. oleracea</i>	5.78 <sup>b</sup>	25.55	29.49 <sup>bc</sup>	16.24
<i>G. ulmifolia</i>	1.70 <sup>c</sup>	51.30	19.69 <sup>d</sup>	16.67
Average		34.28		16.32

<sup>a,b,c</sup> Letters in the same column with different superscripts are significantly different (p<0.05).

affect the quantity consumed of the other forages, since the capacity of the stomach is constant. While on the contrary that did not happen in the 2nd trial, when just one forage was presented to every group of rabbits, due to the lack of forage competition on the gastrointestinal tract capacity. A similar result was observed by Dong and Thu (2012) who indicated that daily intake of forages was significantly higher and with low variance in a separate feeding method than in a mixed feeding method, the explanation was that the rabbits have high feed selection characteristics thus feeds offered separately stimulated them to consume more feed.

The recommendations deal with feeding/nutrition experiments in rabbits ranged the CV values for feed intake between 11% and 22% as reported by Fernández-Carmona et al. (2005). The CV value of the 2nd trial (16.32%) agreed with that finding, however the value of the 1st trial (34.28%) was observed to be higher than the range reported above, although the latter reflects the additive biological interactions among the forage plants consumed by rabbits in the course of this trial. This theory was reported by Ross and Max Shelton (1994) that some forage plants contain anti-nutritive factors which adversely affect nutritive value, but the combination between two or more plants could be inhibit the adverse effect of each others.

## CONCLUSION

This study has shown that the findings of both trials were almost similar; however the method of presenting the forages separately to rabbits is methodologically more accurate than presenting them all together, although the latter is one of the more realistic methods to indicate voluntary feed preference. It can be also concluded that a range of tropical forages were eaten in acceptable quantities by rabbits, suggesting that diets based on such forages with a concentrate supplement could be used successfully for rabbit production. Nevertheless, this study was conducted over short period and longer-term studies, which examine growth performance as well, are needed before recommendations could be made on appropriate ration formulations for commercial use.

## ACKNOWLEDGEMENT

This research work was partially funded by the scholarship awarded to the first author by the government of Mexico through the Ministry of Foreign Affairs (SRE).

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