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Feeding Rabbits with tropical Foliage, Sugar Cane, and Sunflower Seeds

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Abstract

The productive behavior of fattening rabbits was assessed using four feeding variants combining tropical foliage (*Teramnus labiales*, *Hibiscus rosas-sinensis*, *Pyla nodiflora* and *Ipomoea batata*) with sugar cane and sunflower seeds. Sixty Cuban Brown rabbits weaned at 40 days of age were used, weighing an average 679 g, after 80 days of fattening. Three animals were placed in each cage, following a completely random design. Each animal was considered a replica for the following variables: initial live weight, final live weight, and mean daily gain. For feed consumption and feed conversion variables, the means of the animals in every cage were considered. Sugar cane foliage and stems were administered at will. The sunflower seeds were administered at a rate of 25 g/rabbit/day; water was supplied *ad libitum*. Variants *Teramnus labialis*-sugar cane-sunflower, *Ipomoea batata*-sugar cane-sunflower and *Phyla nodiflora*-sugar cane-sunflower had the best y (100 % viability, live weigh gains between 19.28 and 22.78 g/rabbit/day, and cleaned meat production, between 785 and 972 g, at a cost of 11.45, 16.94 and 12.52 CUP) for *Teramnus labialis*-sugar cane-sunflower, *Ipomoea batata*-sugar cane-sunflower and *Phyla nodiflora*-sugar cane-sunflower, respectively. Variant *Hibiscus rosa-sinensis* sugar cane-sunflower was the least efficient.

Key Words: *rabbit fattening, feeding variants, non-conventional feedstuffs*

Introduction

A large number of animal nutrition researchers have focused on conventional feeding alternatives to reduce feeding costs and competition with widely used nutrients for human consumption (Felipe, 2014).

Forage-based diets for rabbits have been studied for years in tropical countries, though little has been defined in terms of maximum inclusion and ideal features of diets based on forages. Rabbit final weight may vary from 1.8 to 5.5 kg, in 72 days (Machado, 2012).

Teramnus labialis is a forage species with a high nutritional value, suitable stem-leaf ratio, and high raw protein content until maturity (Mazorra *et al.*, 2001). A relatively little studied choice is fast-growing, arborescent *Hibiscus rosa-sinensis*, mainly used in gardens (Ruiz *et al.*, 2006). Its foliage contains between 142 g PB/kg of MS and 210 g PB/kg of MS (Benavides, 2000 and Sosa *et al.*, 2004)

Ipomoea batata is a very appealing crop when water is available, due to cultivation easiness and high yields on average, or poorly prepared soils (Jarret, 1991). *Phyla nodiflora* is widely used by rabbit breeders, with protein content of 16.06 %, and relatively low raw fiber content (19.10 %).

Sugar cane is possibly the most efficient tropical crop to make photosynthesis, and active biomass production mechanisms (Fundora, 2006). Just with the sugar cane juice or enriched molasses, 3.8 times more energy is produced than with cereal supplementation (Figueroa and Ly, 1990). Pérez (2002) has reported its use as an energy source for rabbits.

Sunflower is a typically oily plant, which plays an important role in human nutrition, apart from being an excellent source of forages (Padilla, 2006). The seeds are used to feed animals, like fowl, and as nutritional element to make feedstuffs.

The purpose of this paper was to assess the productive behavior of rabbit fattening, using four feeding variants that combine tropical forages (*Teramnus labiales*, *Hibiscus rosas-sinensis*, *Pyla nodiflora* and *Ipomoea batata)* with sugar cane stems and sunflower seeds.

Materials and Methods

The experiment was conducted in experimental areas at the Agroforestry Faculty of the University of Guantánamo. Sixty Cuban Brown rabbits, weaned at 40 days, with mean live weight of 679 g, after 80 days of fattening, were included in the experiment. A feeding system comprising four variants: T1- *Teramnus labialis* + sugar cane stems + sunflower seeds; T2- *Hibiscus rosa-sinensis* + sugar cane stems + sunflower seeds; T3- *Phyla nodiflora* + sugar cane stems + sunflower seeds; and T4- *Ipomoea batata* + sugar cane stems + sunflower seeds, was evaluated. Three animals were placed in each cage, following a completely random design. Each animal was considered a replica for these variables: initial live weight, final live weight, and mean daily gain; and cages, for these variables: feedstuff consumption, and feed conversion.

Foliage and sugar cane were administered at two different times (8:00 and 16:00 h) in sufficient quantities for the animals to have free access 24 h a day. Adjustments were made to forage and sugar cane, depending on the supply-rejection variation. The sunflower seeds were administered in grains (without processing), at a rate of 25/rabbit/day. Water was administered *ad libitum*, and the troughs were washed on a daily basis.

Foliage yields were based on daily and weekly consumption for each group of animals. Fresh and dried yields from every plant species were considered, as well. Foliage harvest was made between days 55 and 65 of plant age. Accordingly, a scale-up planting strategy was designed in five 1 000 m^2 lots; whereas foliage from *Teramnus labialis* and *Phyla nodiflora* were obtained from already-existing plantations, with scale-up cuts inside each forage area. At the beginning of the experiment five samples of each forage type were taken to determine the bromatogical composition.

Dry matter (MS), ashes, organic matter (MO), and raw protein contents were determined, using the methodology described by AOAC (1995). Fiber volume fraction was made according to Van Soest *et al.* (1991), and calcium (Ca) and phosphorous (P) were determined according to Herrera (1980). British Gallemkamp adiabatic calorimeter was used to measure the gross energy. The values are presented in Table 1. Foliage, sugar cane, and sunflower digestible energy were determined from the energy balance of feeds (ingested energy – excreted energy).

A triple beam balance (range of 2 610 g) was used to weigh the live animals and feedstuffs.

Feed consumption was estimated at the supplying times, by the difference between the supplied and rejected quantities. Leaf, stem and whole foliage were estimated, by weighing ration samples before the administration, and determining the leaf-stem ration. Accordingly, the amount of leaves and stems supplied was determined. Rejects were weighed as a whole, and then the leaves were cut from the stems and weighed independently.

The economic balance was made according to the production costs, after adjusting the experiment. Depreciation of facilities, material costs, salaries, vacations, taxes, and animal (17.5 CUP/kg live weight), and feed (foliage of *Termanus labiales*, *Hibiscus rosa-sinensis*, *Phyla nodiflora*, *Ipomoea batata*, sunflower seeds and sugar cane) costs, were included too. Overall income from live rabbit sales ($17.5 CUP/kg), based on the mean live weight and live weight for each feeding variant, were included.

A simple variance analysis was made, and the mean values were compared by Duncan Multiple Comparisons Test (1955).

RESULTS AND DISCUSSION

It can be affirmed that by analyzing total MS consumption in the fattening cycle, and feedstuffs in every feeding variant (Table 2), the behavior observed was more closely related to palatability of the foliage used, leading to the highest MS consumption values of *Teramnus labialis*-sugar cane-sunflower; and the lowest results with *Hibiscus rosa-sinensis*-sugar cane-sunflower. Low *Hibiscus rosa-sinensis* foliage consumption may be attributed to anti-nutritional factors for this kind of forage (Vera, 2005). Although tannins play a key role in decreasing voluntary ingestion, it has not been fully explained. Mitjaxila *et al.* (1977) noted that high levels of tannins in the diet can reduce the levels of voluntary ingestion, because they precipitate salivary proteins and cause an unpleasant astringent taste in the mouth.

Dried sugar cane and sunflower consumption had little variation among the feeding variants, with values ranging between 21.4 and 24.0; and 20.9 and 22.6 g, for sugar cane and sunflower, respectively. The lowest consumption values were found in animals given *Ipomoea batata*-sugar cane-sunflower.

In general terms, high MS consumption was observed, maybe caused by the need to meet the requirements of digestible energy (Santana, 1999), and the particular features of the rabbit´s digestive system, focused on the cecal-cecotrophic fermentation that favored transit speed and ingestion capacity. According to De Blas and Wiseman (1998), this system is the base for high yields made by the species, though it feeds on diet with low nutrient concentration. The previous was corroborated by Gidenne (1992) and Dihigo *et al.* (2002), who found increases in consumption when meal from foliage was included in rabbit diets. It was attributed to increases in non-soluble fibers that stimulate feed consumption due to an increase in feed passage speed and greater cecotrophy.

The results of this experiment are similar to the ones reported by Reynoso *et al.* (2002), who achieved 86.9 g of MS in fattening rabbits fed with common carob, and reports by Naranjo *et al.* (2002), using diets with 30 % dried citrus pulp.

Nutrient consumption in the four feeding variants assessed is shown in Table 3. The highest consumption value of raw protein ($P < 0.05$), with 15.41 g/rabbit/d), and digestible energy (1.07 MJ), was observed in the animals that received *Teramnus labialis*-sugar cane-sunflower, and the lowest values corresponded to *Hibiscus rosa-sinensis*- sugar cane-sunflower.

The nutrient balance for raw protein showed that only *Teramnus labialis*-sugar cane-sunflower had the most appropriate level for this nutrient, according to González (1996) and Lebas (2004), with 98 %, followed by variants *Phyla nodiflora*-sugar cane-sunflower and *Ipomoea batata*- sugar cane-sunflower, with 67 and 72 %, respectively. Meanwhile, *Hibiscus rosas-sinensis*- sugar cane-sunflower only reached 60 % of the protein needs. In all these variants, the inclusion of sunflower seeds as whole diet supplement, favored a better nutrient balance; *Phyla nodiflora*- sugar cane-sunflower was the most favored.

When analyzing the satisfaction level of the 1.07 MJ of digestible energy required for rabbits in this growth stage, variant *Teramnus labialis*-sugar cane-sunflower met those needs 100%. Acceptable balance was observed in variants *Ipomoea batata*- sugar cane-sunflower (89 %) and *Phyla nodiflora*- sugar cane-sunflower (85 %). The lowest levels were observed in *Hibiscus rosas*-sinensis- sugar cane-sunflower (80 %). It is important to note that 100% satisfaction for energy requirements was not achieved in all the variants, the inclusion of sunflower seeds also favored better energy balance in the animals. These results indicate the excellent nutritional value of this oily plant to fatten rabbits.

In general terms, high FDN and FDA consumption was observed, which led to excess nutritional requirement in the animals, accounting for 188, 171, 178, and 163% in variants *Teramnus labialis*- sugar cane-sunflower, *Hibiscus rosa-sinensis*-sugar cane-sunflower, *Phyla nodiflora*- sugar cane-sunflower and *Ipomoea batata*- sugar cane-sunflower, respectively.

A negative balance was observed for Ca and P in the feeding variants studied. However, the highest Ca consumption was observed in variant *Phyla nodiflora*- sugar cane-sunflower, followed by *Teramnus labialis*- sugar cane-sunflower. The lowest levels ($P < 0.05$) were observed in *Hibiscus rosa-sinensis*- sugar cane-sunflower and *Ipomoea batata*- sugar cane-sunflower; whereas, phosphorous consumption was similar in the four variants assessed.

The final weight, mean daily gain and feed conversion values are shown in Table 4. At the end of fattening, the highest live weight values were observed in variant *Teramnus labialis* - sugar cane-sunflower, followed by variants *Phyla nodiflora*-sugar cane-sunflower, and *Ipomoea batata*- sugar cane-sunflower, with no differences between the latter two. Live weight at the end of fattening in these three treatments was above the 2.0 kg set by the National MINAG Management, for sacrifice. However, variant *Hibiscus rosa-sinensis*- sugar cane-sunflower did not produce the adequate live weight for sacrifice.

The treatment with *Teramnus labialis*- sugar cane-sunflower produced the highest daily live weight gains (22.78 g/rabbit/day). No differences were found for this indicator between variants *Phyla nodiflora*- sugar cane-sunflower and *Ipomoea batata*- sugar cane-sunflower, with 20.06 and 19.78 g, respectively, whereas variant *Hibiscus rosa-sinensis*- sugar cane-sunflower produced the poorest gains (15.61 g/day), despite the inclusion of sunflower seeds. Due to low growth speed and breeding duration, variant *Hibiscus rosa-sinensis*- sugar cane-sunflower is not recommended to rabbit producers in Cuba to reach live final weight.

Weight gains using these variants moved around 20 g/rabbit/day, considered as satisfactory by Lukefahr and Cheeke (1991), for tropical or arid climates, similar to reports by Vargas *et al.* (2002), who claimed live weight gains of 20.81 g/animal/day in Red New Zealand Rabbits, on white mulberry (*Morus alba*) and *Ipomoea batata* diets. Moreover, Nieves *et al.* (1997) achieved 18.9 g/animal/d live weight gain in rabbits, using a diet based on 30 % *Arachis pintoi*, compared to 23.8 g/animal/day in the control group. Accordingly, daily live weight gains using the three feeding variants can be considered acceptable.

The conversion rates for MS had differences among the four variants ($P < 0.05$), with the best values for *Phyla nodiflora*- sugar cane-sunflower (4.06), followed by *Teramnus labialis*- sugar cane-sunflower (4.10) and *Ipomoea batata*- sugar cane-sunflower (4.32). The worst conversion rate was for *Hibiscus rosa-sinensis*- sugar cane-sunflower (4.56).

The feeding variant costs in the fattening cycles are shown in table 5. Salaries, facilities, materials, accessories, and other costs were the same for all the variants. Variation of total costs in the variants was determined by the production costs of feeds. The highest numbers of items were found in variant *Ipomoea batata*- sugar cane-sunflower, producing the highest total cost ($ 319.12 CUP) due to the temporary character of the crop.

Regarding income (Table 6), *Teramnus labialis*- sugar cane-sunflower produced the highest income, and *Hibiscus rosa-sinensis*- sugar cane-sunflower, the lowest. These results were related to animal weight gains during the 90 fattening days, which led to final weight differences.

The four feeding variants had a positive relationship in all the items analyzed, with a more positive behavior for *Teramnus labialis*- sugar cane-sunflower, and a more unfavorable behavior for *Ipomoea batata*- sugar cane-sunflower, with the worst balance, because its foliage can only be used for two months in every harvest (Table 7). Nieves *et al.* (2002) suggested forage peanut meal and leucaena, with 40% inclusion, and other non-conventional ingredients, supplemented with fresh nacedero (*Trichanthera gigantea*). Comparison with the behavior of a control group fed with a commercial concentrate, the benefit-cost relation (2.98 and 1.83) showed that it was higher for the non-conventional diets, increasing income per kilogram of meat produced.

CONCLUSIONS

Feeding variants *Phyla nodiflora*- sugar cane-sunflower, *Teramnus labialis*- sugar cane-sunflower, *Ipomoea batata*- sugar cane-sunflower, had the best productive behaviors, in comparison with variant *Hibiscus rosa-sinensis* sugar cane-sunflower.

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Table 1. Chemical composition of feedstuffs

Feedstuffs	Digestible energy and nutrients						
	MS %	PB %	ED MJ/kg de MS	FDN %	FDA %	Ca %	P %
Teramnus labialis	18.54	22.29	9.33	42.98	26.47	0.64	0.16
H. rosa-sinensis	20.38	16.58	8.32	41.63	30.13	0.58	0.21
Phyla nodiflora	12.37	16.18	9.23	45.14	26.03	2.93	0.24
Ipomoea batata	12.40	16.49	8.23	25.95	20.29	0.56	0.23
Stems of *sacharum oficinarum*	23.00	2.02	14.09	64.35	52.18	0.42	0.22
Sunflower seeds	92.5	19.72	13.52	43.06	28.15	0.2	1.2

Table 2. Mean MS consumption (g) of feedstuffs used for fattening Cuban Brown Rabbits

Forage	*T. labialis* sugar cane-sunflower	*H. rosa-sinensis* sugar cane-sunflower	*P. nodiflora* sugar cane-sunflower	*I. batata* sugar cane-sunflower	EE ± Sig.
Leaves	29,1a	18,7d	22,1c	24,9b	0,74**
Stems	20,1a	5,8d	14,3c	16,1b	0,36**
Foliage	49,3a	24,5d	36,4c	41,0b	1,08**
Sugar cane	23,3	24,6	23,7	21,4	1,23
Sunflower	20,9b	22,6a	21,4ab	21,0b	0,54*
Total	93,4a	71,2c	81,5b	83,3b	2,68*

abcd Values with different letters in the same row differ significantly P < 0.05 (Duncan, 1955)
*P < 0.05 **P < 0.01

Table 3. Daily nutrient (g) and digestible energy (MJ) consumption

Nutrients	Feeding variants				*EE ± Sig*
	T. labialis-sugar cane-sunflower	*H. rosa-sinensis*-sugar cane-sunflower	*P. nodiflora*-sugar cane-sunflower	*I. batata*-sugar cane-sunflower	
PB	15.4[a]	9.4[c]	10.6[bc]	11.25[b]	0.32**
FND	43.9[a]	40.0[a]	40.9[a]	33.56[b]	1.38**
FAD	29.6[a]	27.0[ab]	28.1[ab]	25.60[b]	1.00
Ca	0.5[b]	0.3[d]	1.2[a]	0.37[c]	0.02**
P	0.4	0.4	0.4	0.38	0.01
ED	1.1[a]	0.9[c]	1.0[b]	0.9[b]	0.001*

[abc] Valores con letras distintas dentro de la misma fila difieren significativamente a P < 0,05 (Duncan, 1955)
*P < 0,05
**P < 0,01

Table 4. Behavior of fattening Cuban Brown Rabbits fed with tropical foliage, sugar cane stems, and sunflower seeds

Indicators	Feeding variants				.
	T. labilis-sugar cane-sunflower	*H. rosa-sinensis*-sugar cane-sunflower	*P. nodiflora*-sugar cane-sunflower	*I. batata*-sugar cane-sunflower	EE ± Sig
Initial live weight, g	682	677	681	677	5.9
Final live weight, g	2 550 a	1 957 c	2 326 b	2 258 b	31**
Live weight gain, g/day	22.78 a	15.61 c	20.06 b	19.28 b	0.35**
Feed conversion	4.10c	4.56a	4.06d	4.32b	0.001**

abc Values with different letters in the same row differ significantly P < 0.05 (Duncan, 1955)
**P < 0.01

Table 5. Total cost (CUP) of rabbit fattening using feeding variants *Teramnus labisalis*-sugar cane-sunflower, *Ipomoea batata*- sugar cane-sunflower, *Phyla nodiflora*- sugar cane-sunflower and *Hibiscus rosa-sinensis*- sugar cane-sunflower

Item	*T. labialis* sugar cane-sunflower	*H. rosa-sinensis*-sugar cane-sunflower	*P. nodiflora* sugar cane-sunflower	*I. batata* sugar cane-sunflower
Salaries	174.01	174.01	174.01	174.01
Animal purchase	178.24	178.24	178.24	178.24
Facilities	15.65	15.65	15.65	15.65
Materials and accessories	7.14	7.14	7.14	7.14
Feedstuff production	62.12	57.64	60.70	121.38
Other costs	0.94	0.94	0.94	0.94
Total	438.10	433.62	436.68	497.36

Table 6. Analysis of income from fattening using *Teramnus labialis*-sugar cane-sunflower, *Ipomoea batata*-sugar cane-sunflower, *Phyla nodiflora*-sugar cane-sunflower and *H. rosa-sinensis*-sugar cane-sunflower

Items	*T. labialis* sugar cane-sunflower	*H. rosa-sinensis* sugar cane-sunflower	*P. nodiflora*-sugar cane-sunflower	*I. batata* sugar cane-sunflower
Live weight production, kg	38.25	29.36	34.89	33.87
Live weight price, CUP/kg	17.50	17.50	17.50	17.50
Total of income, CUP	669.375	513.8	610.575	592.725

Table 7. Economic assessment of feeding variants *Teramnus labialis*-sugar cane-sunflower, *Ipomoea batata*-sugar cane-sunflower, *Phyla nodiflora*-sugar cane-sunflower and *Hibiscus rosa-sinensis*-sugar cane-sunflower for fattening

Items	*T. labialis* sugar cane-sunflower	*H. rosa-sinensis*-sugar cane-sunflower	*P. nodiflora*-sugar cane-sunflower	*I. batata*-sugar cane-sunflower
Gains, CUP	231.28	80.18	173.90	95.37
Cost/Benefit	65.45	84.39	71.52	83.91
Benefit/cost	1.53	1.18	1.40	1.19
Gain/cost	0.53	0.18	0.40	0.19
Live weight cost, kg , CUP	11.45	12.80	12.52	16.94
Profit margin, CUP/kg	6.05	4.70	4.98	0.56