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Mulberry in Livestock Feeding Systems in Cuba: Forage Quality and Goat Growth

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Introduction

Agroforestry, and more specifically the promotion of silvopastoral systems, has received a marked attention in the development of tropical livestock production systems during the last decade. Cuba has not been exempt from this, and, in both the efforts devoted to applied research and in extension directly linked to production, programs have been promoted in which taking advantage of the ecological and nutritional benefits of trees appears as an alternative to consider in livestock recovery programs. Mulberry (*Morus alba*) with excellent results in biomass yield, adaptation to tropical conditions, intake and nutrient digestibility, has shown very favourable characteristics for animal feeding and production.

Taking maximum advantage of the productive potential of the shrub and tree species represents an unresolved challenge for researchers and producers. The "Indio Hatuey" Grass and Forage Experimental Station (EPPF), together with other Cuban institutions, are conducting a series of research projects to validate technologies developed in Costa Rica on the use of mulberry as high quality forage.

Mulberry is a forage tree perfectly adapted to tropical conditions which has shown numerous possibilities of use in ruminant diets. Its is a forage that arouses every time more interest among specialists and producers in charge of promoting ways of

sustainable production and exploitation, as independent as possible from imported inputs but with the solutions to the growing demand of basic products of the family basket.

Not being a legume and having high nutrient requirements, fertilisation is more than necessary, practically indispensable. It has been shown that it is possible to supply these needs with organic fertilisers or with a combination of organic and inorganic fertilisers. Fertilisation considerably stimulates biomass production. It is also possible to plant leguminous trees with mulberry to use their foliage as green manure.

Mulberry foliage is characterised by high digestibility and excellent level of protein (20-24%), which makes it comparable to commercial concentrates for dairy cattle. Variations in chemical composition are due to age, leaf position within the branch and fertilisation level (Benavides, 1995).

With dairy goats, Rojas *et al.* (1994) found milk increases of 2.0 to 2.5kg/d when mulberry supplementation went from 1.0 to 2.6% of live weight on a dry matter (DM) basis, with slight increments in milk fat, protein and total solids.

Few results, however, have explained the effects of the microbial population on the various nutrients present in its foliage, its degradation rate, digestion of cellular wall, nitrogenous compounds and by-pass protein.

In this article, data on forage quality, rumen degradation and goat growth rates are presented.

Methodology

Quality and rumen degradation

Under rainfed and zero fertiliser conditions mulberry foliage of the varieties "Tigreada", "Indonesia", "Criolla" and

"Acorazonada" was harvested at 90d after planting at 0.5m of height, with the purpose of determining chemical composition and rumen digestion characteristics. This latter was only done with the variety "Acorazonada" since there were no differences in chemical composition among varieties.

The nylon bag technique for determining *in situ* degradation as described by Orskov *et al.* (1980) was used with 2 Hostein-Frisian bulls (5 years of age and mean weight of 550kg) fed a standard diet made of chopped fresh King grass *ad libitum* and a soybean-based protein supplement, so as to obtain the levels of rumen metabolism adequate for forage digestion.

Nylon bags with a pore size of 50 μm , with 5g of ground forage sample, were incubated in the rumen in triplicates for each period and animal. Samples were removed at 0, 2, 4, 6, 8, 12, 24, 48 and 72h, they were washed during 5 minutes with tap water and dried to constant weight in an oven with force ventilation at 60°C. Determinations of DM, organic matter (OM), crude protein (CP) and neutral detergent fibre (NDF) were made in the residues and expressed as percentage of the original material.

The various parameters characterising the extent and the rate of rumen degradation, such as: soluble fraction (a), slowly degradable fraction (b) and degradation rate constant of b (c), were calculated according with Orskov *et al.* Effective degradation was estimated from McDonald (1981). Passage rate was assumed to be 0.04/h based on mean retention for these kinds of diets.

Growing goats

Although more preliminary, different evaluations have been carried out to study the effect of mulberry as supplement and various levels of inclusion in ruminant diets (dairy goats and

cows, calves and sheep) both in the EEPF premises and in farms like the Livestock Breeding Enterprise “Los Naranjos”, Habana Province and Jagüey Grande Integrated Farm in Matanzas Province, supervised by EEPF specialists.

In an experiment to evaluate various levels of mulberry forage in the diet of weaned goat kids, 20 F₁ (Criollo x Saanen, Criollo x Nubia , Criollo x Alpina) animals, with mean live weight of 10.2kg and 3 months of age, were kept in confinement Jagüey Grande Farm. They were randomly distributed into 4 groups and assigned to treatments as follows:

- **Treatment A:** Control: Guinea grass (Panicum maximum)+ Dry citrus pulp
- **Treatment B:** Guinea grass + Mulberry at 0.5 % of live weight (on DM basis).
- **Treatment C:** Guinea grass + Mulberry at 1.5 % of live weight
- **Treatment D:** Guinea grass + Mulberry at 2.5 % live weight.

Work started on 01/07/1999. There was an adaptation period of 7d and 29d for data collection. Animals were weighed every 7d. Feed intake was determined daily from feed offered and refused. Feed conversion was calculated from intakes and gains.

The results of a trial with Saanen dairy goats comparing to grazing system and concentrates are presented here. An additional paper will provide details of the agroforestry module with Criollo goats.

Results and Discussion

Rumen degradation.

Chemical composition of the four varieties is presented in Table 1. Mean CP content was 26.1% similar to tropical legumes like *Leucaena*, *Sesbania*, *Calliandra*, etc. (Kamatalit et al., 1992; Cáceres and González, 1998). CF was 15% on average, within the acceptable range for woody forages. Organic matter and minerals were as expected.

Table 1. Chemical composition (%) of mulberry varieties in the optimum harvest time.

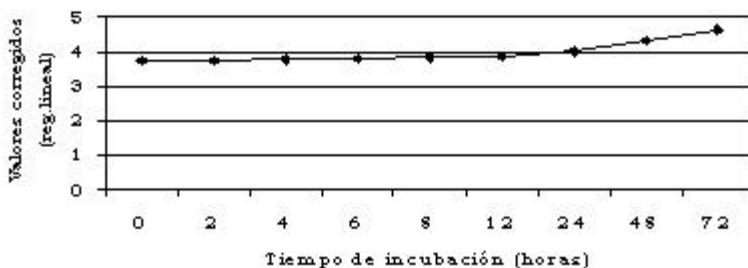
Variety	OM	CP	CF	Ash	Ca	P
Tigreada	89.6	27.6	13.2	10.4	0.14	0.20
Indonesia	88.8	24.3	15.3	11.2	0.17	0.19
Criolla	88.2	27.1	16.9	11.8	0.18	0.26
Acorazonada	86.6	25.2	14.1	13.4	0.20	0.15
Average	88.3	26.1	14.9	11.7	0.17	0.20

OM degradation characteristics are presented in Table 2. Mulberry had a higher effective degradation than *Leucaena* (Kamatalit *et al.*, 1992), due to a higher degradable fraction.

Table 2. OM degradation characteristics of mulberry compared with *Leucaena*.

Parameter	Mulberry	Leucaena
a (%)	27.8	30.7
b (%)	49.0	45.4
a + b (%)	76.8	76.1
c (per hour)	0.03	0.03
P (%) k= 0.04	48.8	47.2

Fig.1. Cinética de degradación de la materia seca de la Morera a nivel ruminal



The degradation kinetics was corrected with linear regression equations calculated with the incubation time. These equations were $y=3.723+0.0125x$ for DM (Figure 1) and $y=3.61+0.0251x$ for NDF (Figure 2).

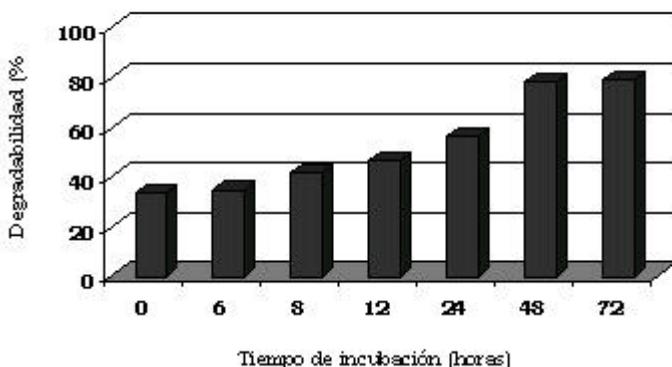
There is a substantial increment in forage digestion velocity from 24h, stabilising between 48-72h of incubation.

Figure 3 reflects in percentage the evolution of DM degradability and Figure 4 for NDF. Total degradation depends on NDF degradation. Once cell wall is digested, other fractions ferment much faster.

Mulberry showed a high degradation potential (approximately 90%) which coincides with the report of other authors (Benavides, 1995; Rojas et al., 1994).

The results also demonstrate that when this forage is harvested in the optimum point, lignocellulose fractions do not interfere with microbial digestion. Despite being a woody plant, there is a perfect degradation of the cell wall and its sugars, like glucose, xylose and arabinose (Sijtsma and Tan, 1993; Flachowsky et al., 1994).

Fig.4 Degradabilidad de la fibra neutral detergente (FND) de la Morera a nivel ruminal



Growing goats.

Intakes of DM, CP and ME per diet component are shown in Table 3. As mulberry increased nutrient intake rose up to the mulberry level of 1.5% when maximum intakes of DM (545g), CP (54.5g) and ME (1.17mcal) were obtained. These values are similar to the ones obtained by Velásquez *et al.* (1994) where voluntary intake increased with higher mulberry supplementation to steers eating sorghum silage.

There was a small decrease on the total intake at the highest level of mulberry (2.5%) in the diet. It is assumed that this level of mulberry would fulfil the nutritional requirements, from the chemostatic point of view, so this may explain the reduction of grass intake. As a consequence, mean digesta retention time was also decreased due to lower fibre consumption. This treatment produced soft faeces.

These results do not agree with those published by Rojas and Benavides (1994). They found a substitution effect of mulberry on grass intake, for every kg of mulberry intake, there was an

increase of 0.5kg in total intake with a reduction of grass consumption. In Table 3, greater mulberry intakes were followed by greater grass intakes up to a point.

Table 3: Goats nutrient intake with increasing mulberry levels.

Treatment	Total	Mulberry	Guinea grass
Dry matter intake (g/animal/day)			
Control	392.6	-	314.0
0.5 % Mulberry	456.0	73.9	382.1
1.5 % Mulberry	544.7	97.0	447.7
2.5 % Mulberry	380.3	125.6	255.0
Crude protein intake (g/animal/day)			
Control	23.2	-	23.2
0.5 % Mulberry	44.6	16.3	28.3
1.5 % Mulberry	54.5	21.3	33.1
2.5 % Mulberry	47.1	27.8	18.9
metabolisable Energy intake (Mcal/animal/day)			
Control	0.65	-	0.65
0.5 % Mulberry	0.98	0.18	0.80
1.5 % Mulberry	1.17	0.24	0.94
2.5 % Mulberry	0.84	0.30	0.54

In Table 4, intakes are expressed per animal, per kg live and metabolic weights. In all cases, except in treatment d (2.5%) intakes levels are within acceptable ranges for growing goats, but greater than those obtained by Xandé and García-Trujillo (1985) with *Leucaena leucocephala* (60g DM/Kg PV^{0.75}) and lower than those reported by Jegou et al. (1994) with mulberry in lactating goats (101g DM/kg PV^{0.75}). Eswara Prasad and Raj Reddy (1991) obtained intakes in goats similar to this study (56.3g DM/kg PV^{0.75}) and smaller to sheep intakes (85.4 g DM/kg PV^{0.75}).

Table 4: Dry matter intakes, per kg live weight (LW) and metabolic weights (MW).

	Total intake (g/d)	Mean live weight (kg)	DM intake per LW (g/kg)	Metabolic weight (LW^{0.75})	DM intake per MW (g/kg LW^{0.75})
Control	392	10.4	37.6	5.8	67.7
0.5% Mulberry	456	11.2	40.9	6.1	74.8
1.5 % Mulberry	545	11.6	47.0	6.3	86.5
2.5 % Mulberry	380	15.1	25.2	7.7	49.7

Initial and final weight and daily and total gain are presented in Table 5. Maximum weight gains were achieved with the highest mulberry level.

Table 5: Initial and final live weights and gains of goats fed mulberry.

Treatment	Initial weight (kg)	Final weight (kg)	Daily gain (g/d)	Total gain (kg)
Control	9.3	11.6	38.0 ^b	2.3
0.5% Mulberry	9.8	12.5	44.8 ^b	2.7
1.5% Mulberry	9.3	13.9	76.2 ^a	4.6
2.5% Mulberry	12.5	17.7	86.2 ^a	5.2

Although, mean daily gains in this treatment was not significantly higher (86.2 vs. 76.2 in treatment C) only half of the DM and CP were needed, compared with treatment B (0.5%) to obtain a gram of weight, 4.4 vs.10.2 and 0.546 vs. 0.995, respectively. Much less energy was required (0.0097 vs.0.0219).

Similar results obtained Benavides (1991) on his work with growing lambs. As mulberry forage increased so did daily gains,

from 60 to 101 g/d. Jiménez et al. (1998) also found high maximum intakes and live weight gains with Jersey heifers fed mulberry.

Conclusions

The quality of the mulberry produced under rainfed conditions in Cuba is comparable to the literature values from Central America and to other tree forages used in tropical livestock husbandry.

Dry matter degradation was 87.8% at 72h of incubation and neutral detergent fibre degradation reached 78.6% in that period.

Further research will be needed to predict what happens with rumen undegradable fraction, the specific degradation of nitrogenous compounds and the bypass protein potential of fresh and conserved mulberry.

Maximum goat gains were obtained with 2.5% mulberry in the diet (86.2g/d). Grass intakes increased up to 1.5% of mulberry supplementation. The efficiency of nutrient improved with increasing levels of mulberry.

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