Factors influencing mulberry leaf yield

Zhiyi Ye
College of Animal Sciences
Zhejiang University
Hangzhou, Zhejiang, China

NUMBER AND LENGTH OF BRANCHES AND SHOOTS

Investigations have shown that in Zhejiang and Jiangsu Provinces, when the number of branches and shoots is below 75 000/ha, the annual leaf yield is about 15 tonnes; between 90 000 and 150 000, the yield is 22.5-37.5 tonnes; but above 150 000, the yield will decrease. The ideal number is between 100 000 and 120 000.

High-yield mulberry plantations have a good colonial structure starting with a planting density of 12 000-15 000 plants/ha, the number of crowns at 37 500-45 000; the number of branches and shoots at 105 000-120 000 and the total length of the branches at 150 000-180 000 m per ha (the average length of a branch or shoot is about 1.4 m). Some high-yield plantations have a density at 22 500-30 000 trees/ha with four branches and shoots per tree, for a total of branches/shoots.

Apart from their numbers, the length and diameter of branches and shoots are also directly related to leaf yield.

VARIETIES

When a new mulberry field is established, high-yield and superior quality varieties, adaptable to the local environment, should be used. Among the Husang varieties, Heyebai is a high-yield variety widely cultivated in Zhejiang and Jiangsu Provinces.

FERTILIZERS

There is a direct positive relationship between fertilizer dosage and quantity and quality of mulberry leaves. However, there is a reduction in the incremental response to fertilizer application as the dose increases.

High-yield mulberry plantations require a plentiful supply of fertilizers (N 1 100 kg; P_2O_5, 345-450 kg; K_2O, 375-525 kg/ha/year) and water. Timing and application method should be adequate to obtain maximum response.

PLANT SHAPE AND AGE

Under similar conditions, low-trunk trees can be formed in a short period, and their leaf yields are higher than and medium-trunk trees, which take longer to develop. Harvest index and leaf yield of trees are low because of the high proportion of the non-assimilating organs. Since the 1970s, many high-yield plantations with low-trunk or trunkless mulberry trees have been established in China. The varieties planted have good characteristics, such as fast growth and high harvest index, but the highly productive life is shorter compared with high and medium-trunk trees.

Compared with mature trees, both young and old trees have a lower leaf yield. Young trees need to form structural organs, and old trees have lost physiological capacity. Therefore, attempts should be made to develop plants quickly and to lengthen the high-yield period as much as possible.

Apart from the above factors, mulberry leaf yield is also related to methods and frequency of harvesting, as well as to crop management.

The high-trunk mulberry system in tropical climates

José Eduardo de Almeida
Estação Experimental de Zootecnia
Gália, São Paulo, Brasil
Tamara Canto Fonseca
Instituto de Zootecnia
Nova Odessa, São Paulo, Brasil

INTRODUCTION

Mulberry (*Morus* sp.) has made new advances worldwide as a forage plant because of its high protein content and high digestibility (Baffi, 1992; Basaglia, 1993; Hara, 1993; Sugohara *et al*., 1994a,b; Takahashi *et al*., 1994; FAO, 1999; Schmidek, 1999). However, its management is not yet defined, and there are various alternatives when is it destined to be used for domestic farm animals.

In Brazil, mulberry is known as feed for the silkworm (*Bombyx mori*) and it is cultivated at approximate spacing of 1 m^2/plant, with cuts close to the ground at 91 days-intervals (13 weeks).

Management of mulberry as a shrub or tree has been encouraged by some experienced veterans, such as Giuseppe Briani, Marino Serpa and Mário Hashimoto, who are familiar with the practices utilized in Europe and Japan. These experts defend the advantages of the system: greater production and quality, better exploitation of soil, longevity and possibility of associated crops, in the limits of roads or property boundaries. Briani states that trees older than 200 years in Assisi (Italy) produce about 15 kg of leaves per tree/year.

This article is a contribution towards the knowledge of high-trunk mulberry.

MATERIALS AND METHODS

An experiment was carried out at the Livestock Experimental Station of the Instituto de Zootecnia (IZ) in Gália (western São Paulo state, latitude 22°17’S, longitude 49°33’W), in a sandy and acid low fertile soil. Stakes (length, 30 cm; diameter, 1.5 cm) were planted at 2 x 2 m in 1996. Each plot consisted of two lines (subplots) of five plants each. Production was measured in the 1997/98 and 1998/99 seasons.

TABLE 1

Characteristics and annual production of mulberry clones under the stump system

Clone	Sex	Origin	Annual Production (tonnes/ha)
IZ	Male	Fernão Dias x Catânia	-

1/16		Paulista	
IZ 3/2	Female	Contadini x Catânia Paulista	-
IZ 6/7	Female	Lopes Lins x Catânia Paulista	-
IZ 10/1	Male	Lopes Lins x Catânia Paulista	-
IZ 10/4	Male	Lopes Lins x Catânia Paulista	17.8
IZ 10/8	Male	Lopes Lins x Catânia Paulista	19.3
IZ 11/9	Female	Formosa x Kokuso 27	10.1
IZ 13/6	Male	Fernão Dias x Kokuso 27	26.2
IZ 56/4	Female	Formosa x Catânia Paulista	32.0
IZ 57/2	Female	Formosa x Kokuso 27	24.5
IZ 40	Female	Open pollination	25.7
Korin	Female	Mutation of Miura variety	-

Source: Fonseca et al., 1987c.

The experimental plot was a split-plot design, with 12 treatments, 11 IZ clones (Fonseca, Almeida and Okamoto, 1994) and a commercial clone as control (Table 1), two subplots (harvests at nine and 13 weeks) and four random blocks.

Annual production data were utilized for comparing management within harvest, among harvests, clone within management and within harvests and through non-parametric tests: sing test, Wilcoxon's sign-rank test and Friedman's cc2 test (Campos, 1983; Dagnelie, 1988; Hollander and Wolfe, 1973).

RESULTS AND DISCUSSION

Table 2 presents annual production of clones harvested every nine weeks (four cuts per year) or 13 weeks (three cuts per year). Production data are similar to the stump system (Table 1). The yield of IZ 11/9, the lowest, was 10.1 tonnes/ha/year in the stump system and 9.8 at nine-week harvesting and 13.5 tonnes/ha/year at 13-week harvesting with high trunks (Table 2).

These results demonstrate the adaptation of clones to the new system, despite their young age (two years old) and the interaction with harvest frequency. This indicates an inadequate selection procedure based on only a few harvests (Fonseca *et al*., 1981). The year effect was highlighted by the sign Test. With the average results of the two managements a B = 3 was obtained, accepting H0, with a level of significance of aa = 0.0193. The year effect with management was also significant, with reduction in production for four cuts per year (B = 2) and increases for three cuts per year (B = 1).

TABLE 2

Annual production, per plant and per hectare, of 12 clones (2 500 plants/ha) subjected to cuts every nine or 13 weeks

Clones	Cutting frequency					
	9 weeks (4 cuts)			13 weeks (3 cuts)		
	1997/98	1998/99	Annual mean	1997/98	1998/99	Annual mean
	(kg/plant)	(kg/plant)	(tonne/ha)	(kg/plant)	(kg/plant)	(tonne/ha)
IZ 1/16	7.19	6.67	17.3	6.44	9.06	19.4
IZ 3/2	5.58	3.91	11.9	5.33	7.45	16.0
IZ 6/7	5.15	5.55	13.4	4.32	6.05	13.0
IZ 10/1	5.49	4.73	12.8	5.98	9.20	19.0
IZ 10/4	5.97	5.03	13.8	7.01	8.61	19.5
IZ 10/8	6.46	5.72	15.2	5.55	9.32	18.6

IZ 11/9	4.59	3.26	9.8	5.90	4.92	13.5
IZ 13/6	6.48	6.42	16.1	6.59	9.03	19.5
IZ 56/4	7.01	4.73	14.7	4.72	8.00	15.9
IZ 57/2	5.54	3.57	11.4	6.03	6.67	15.9
IZ 40	6.62	7.26	17.4	6.80	9.33	20.2
Korin	6.81	5.36	15.2	6.62	9.43	20.1

These results suggest that cuts every nine weeks are detrimental to the performance of the clones, whereas cuts every 13 weeks allow the plants to show gradual production increases. This is understandable since the clones were selected within a cutting system of every 13 weeks (Fonseca, Fonseca and Schammas, 1986; 1987a; Fonseca *et al*., 1987b; 1987c).

In order to confirm this assumption, the same test was applied for the two managements in the first year of production (1997/98) obtaining B = 6, therefore accepting H_0. In the second year, B = 0 was obtained, rejecting H_0. This indicates that during the first year, production per plant was the same for the two cutting frequencies. In the second year, the residual effect caused a reduction in yield in the nine-week frequency and an increase in the 13-week treatment (Table 2).

A similar result was obtained when Wilcoxon's sign-rank test was applied. For the first year W = 0.404 (accepting H_0) and for the second year W = 3.002 (rejecting H_0).

Since one of the objectives of this experiment was to indicate an appropriate clone for the proposed management system, the Kruskal-Wallis test [H = 12.7887 (ns) for nine weeks and H = 12.1449 (ns) for 13 weeks] and the Friedman's cc2 were applied to the performance data. It was shown that the clones performed similarly, without significant differences at aa=0.05 in both cutting frequencies.

CONCLUSION

The clones responded well to the high-trunk system with yields comparable to the stump method. It was not possible in two years to select a superior clone among the 12 clones studie, as had been the intention.

BIBLIOGRAPHY

Baffi, M. H. 1992. *Utilização da amoreira* (Morus alba L.), *cultivar Yamada para caprinos: curva de crescimento e digestibilidade* in vitro. Tesis UNESP, Campus de Jaboticabal, SP, Brazil. 35 pp.

Basaglia, R. 1993. *Eficiência da utilização da proteína da amoreira* (*Morus alba L.*), *para caprinos*. Tesis UNESP, Campus de Jaboticabal, SP, Brazil. 45

pp.

Campos, H. 1983. *Estatística Experimental Não Paramétrica*. 4ª ed., FEALQ, ESALQ/USP, Piracicaba, SP, Brasil.

Dagnelie, P. 1988. *Théorie et Méthodes statistiques*. Vol. 2. Les Presse Agronomiques of Belgium, Gembloux.

FAO. 1999. Mulberry: a high forage available almost worldwide*. World Animal Review*. 93(2): 36-46.

Fonseca, A.S., Fonseca, T.C. & Schammass, E.A. 1981. Estimação de parâmetros visando à seleção de híbridos artificiais de amoreira. *Indústr. animal*, Nova Odessa, SP, Brasil, 38(1): 85-108.

Fonseca, T. C., Almeida, J. E. & Okamoto, F. 1994. Le programme d'amélioration du mûrier dans l'état de São Paulo au Brasil. *Sericologia*, 34(4): 727-733.

Fonseca, A.S.**, Fonseca, T.C. & Schammas, E.A.** 1986. Competiçao de híbridos artificiais de amoreira (1) *B. Indústr.anim*., 44(2): 315-322. Nova Odessa.

Fonseca, A.S., Fonseca, T.C. and Schammass, E.A. 1987a. Competição de híbridos naturais e artificiais de amoreira (2). *B. Indústr. anim.,* 43(2): 367-373. Nova Odessa.

Fonseca, A.S., Fonseca, T.C. & Schammas, E.A. 1987b. Competição de híbridos naturais e artificiais de amoreira. (3) *B. Indústr. anim.,* 44(2): 323-328. Nova Odessa.

Fonseca, A.S., Fonseca, T.C., Cunha, E.A. & Schammas, E.A. 1987c. *Competição de híbridos naturais e artificiais de amoreira*. (4) B. Indústr. anim., 44(2): 329-334. Nova Odessa.

Hara, C.H. 1993. *Produçao e digestibilidade in vitro da matéria seca e proteína de cultivares de amoreira* (Morus alba L.). Trabalho apresentado a Faculdade de Ciências Agrárias e Veterinárias, UNESP, Jaboticabal, SP, Brazil. 40 pp.

Hollander, M. & Wolfe, D. A. 1973. *Nonparametrical statistical methods*. New York, John Wiley & Sons.

Schmidek, A. 1999. *Composição bromatológica e degradabilidade em caprinos, de cultivares de amoreira* (Morus alba L.). Tesis UNESP, Campus de Jaboticabal, SP, Brasil. 63p.

Silva, D.J. 1981. *Análise de alimentos*. Viçosa. Imprensa Universitária. 166

pp.

Sugoraha, A., Resende, K.T., Takahashi, R., Magiario, K., & Reis, R.A. 1994a. *Composição bromatológica da amoreira* (Morus alba *L.*)*, cultivar Yamada, em diferentes idades de crescimento*. Anais da XXXI Reunião Anual da SBZ, Maringá, PR, Brasil.

Sugohara, A., Resende, K. T., Takahashi, R., Guideli, C., Reis, R.A., & Vasconcelos, V.R. 1994b. *Composição bromatológica de cultivares de amoreira* (Morus alba L.). 3 - Estação de verão. Anais da XXXI Reunião Anual da SBZ, Maringá, PR, Brasil.

Takahashi, R., Sugoraha, A., Resende, K.T., Reis, R.A., & Vasconcelos, V.R. 1994. *Produção e digestibilidade de cultivares de amoreira* (Morus alba *L.*). *1 - Estação da primavera*. Anais da XXXI Reunião Anual da SBZ, Maringá, PR, Brasil.

The potential of mulberry as feed for ruminants in central Tanzania

C.M. Shayo
Zonal Research and Development Centre
Livestock Production Research Institute
Mpwapwa, United Republic of Tanzania

INTRODUCTION

Ruminant livestock in most areas of the United Republic of Tanzania are managed under semipastoral and agro-pastoral systems, feeding mostly on natural pasture and crop residues.

The amount of high-quality pasture is usually sufficient during the rainy season but, as maturity advances, the nutritive value decreases (Shayo and Msangi, 1989). Therefore, available feed resources during the dry season are usually unable to provide sufficient nutrients for reasonable livestock productivity, and livestock generally lose weight, become susceptible to diseases and have reduced breeding performance.

Although supplementation using commercial feeds or by-products such as maize bran and oilseed cakes is widely used to improve growth rates and milk yields, these supplements are expensive and not easily available in remote villages. Similarly, improvement of low-quality roughage by physical and chemical treatment is expensive, difficult to apply in rural areas and may result in environmental pollution.

In recent years there has been a growing interest in many tropical regions to identify potentially important feed sources among shrubs and trees for inclusion in ruminant diets. The increased importance of trees and shrubs as a non-conventional feed resource has been recognized as one of the most effective means of improving forage supply in smallholder livestock production (Blair, 1989). Emphasis on the use of trees in farming systems is based on their high-quality leaves and pods and the overall role they play in the natural ecosystems and human and animal welfare improvement (Shayo, 1998).

There are a number of introduced and native trees that are important sources of nutrients for livestock in Tanzania. However, some of the introduced trees have had difficulties adapting to the local environment (e.g. *Leucaena leucocephala*). More over, most native deciduous browse species shed their leaves during the dry season, and during this period most evergreen species are known to contain some physical structures or chemical compounds that defend them against herbivores (Coley, Bryant and Chapin, 1985).

Efforts to explore the potential use of mulberry (*M. alba*) trees as livestock feeds in the semi-arid areas of central Tanzania were initiated by Shayo (1997). There are positive indications that the tree could be an alternative for improving farm animal diets and reducing feed costs in many production systems. This has prompted more studies on the effect of mulberry leaves on growth and milk production in farm animals (e.g. goats), currently being carried out at the Livestock Production Research Institute in central Tanzania and at the Sokoine University of Agriculture.

This paper presents the initial findings of the potential of mulberry for livestock production in the semi-arid areas of central Tanzania.

DISTRIBUTION AND USE OF MULBERRY

According to FAO (1988), mulberry is both a temperate and a subtropical plant grown in many regions of the world, predominantly in eastern, southern and southeastern Asia, southern Europe, southern North America, northwestern South America and parts of Africa. In Africa, it has been reported to occur in humid, subhumid and semi-arid areas at an altitude up to more than 1 000 m above sea level (Le Houerou, 1980). It is not well known when mulberry was introduced in Tanzania but it appears to have been in the country for many decades. In the humid areas of the northern highlands mulberry trees are incorporated into the intensive farming systems and are widely used to feed sheep and goats in a cut-and-carry system. In some situations mulberry is used as live fence. However, there have been reports (unpublished) that some missionaries have established mulberry trees for wine making, using the fruit.

Apart from the highlands of the north, mulberry is also present in the semi-arid areas of central Tanzania, in the coastal belt and in the southern highlands. So far, there have been no formal studies on the distribution and use of mulberry in the country. However, survey studies (Shayo, 1997; Omar, 1998) in some villages in two districts of the semi-arid areas of central Tanzania (Mpwapwa and Kondoa districts) showed that mulberry trees were found in 5 percent of homesteads. The trees were grown close to the dwellings and the number of trees per household did not exceed five (the average was 2). Some trees were found away from the homesteads, where they were left by farmers who previously occupied the land. The trees were used for a range of purposes: for fruit, shade, vegetables (to a lesser extent), medicinal purposes and as fuel wood. The leaves were rarely used for livestock feeding, since most farmers were not aware of this use.

PRODUCTIVITY

There are several natural and management factors affecting the productivity of mulberry, such as soil and climatic conditions, mode of propagation and harvesting techniques. In general, longer intervals between defoliation have increased total yield; however, the proportion of inedible wood may also increase, leading to a decline in forage quality (Ivory, 1990; Shelton and Brewbaker, 1994). On the other hand, as plant spacing is reduced, yield per plant decreases owing to competition, but total forage yield per unit area increases, as does the leaf:wood ratio (Ella *et al*., 1989). This was confirmed by Shayo (1997) in a trial to study biomass production at different spacing and harvesting intervals in the semi-arid areas of central Tanzania (Table 1).

Although yield per season increased with harvesting interval, the amounts and nutritive value of edible components decreased considerably due to senescence and drop of leaves. Tikader *et al*. (1993) found that maximum mulberry leaf yields could be obtained by harvesting three times per year. The results in Table 1 show that mulberry harvested twice, at the end of rainy season and in the middle of the dry season, gave considerably higher amounts of fodder.

It is interesting to note that mulberry harvested during the peak of the dry season developed considerable numbers of shoots. As reported by Walker (1980), regeneration of new shoots after pruning is independent of rainfall. The advantage with the new shoots is that they are more tender and nutritious than ordinary branches and grow more rapidly. This is also reflected by higher proportion of leaf:stem in younger plants and regrowths than older plants (Table 2).

NUTRITIVE VALUE

Mulberry leaves are highly digestible and contain high concentrations of crude protein (CP) and minerals, and low cell wall contents (Table 3). This suggests that mulberry could be used to minimize nutrient deficiencies faced by grazing animals in the semi-arid areas of central Tanzania. Furthermore, the bark is reasonably digestible, with CP concentrations higher than in dry season pastures and crop residues. Older leaves contain lower concentrations of CP than young leaves (Table 3). Young leaves and bark are more degradable than old leaves and bark (Shayo, 1997).

TABLE 1

Mean yield of mulberry, by fractions, under different spacings at various periods of the year

Harvest (years)	Spacing[1]	Yield/plant (kg DM)				Yield/ha (tonnes/DM)			
		Leaf	Stem	Bark	Total	Leaf	Stem	Bark	Total
1 st-2[3]	S1	0.59^{ab2}	0.97^{a}	0.18^{a}	1.74^{a}	16.9^{a}	28.2^{a}	5.3^{a}	50.4^{ab}
	S2	0.65^{a}	1.37^{c}	0.28^{b}	2.30^{b}	3.4^{b}	7.1^{b}	1.4^{b}	11.8^{c}
	S3	0.63^{a}	1.12^{ab}	0.22^{ab}	1.97^{ab}	8.5^{c}	15.1^{c}	3.0^{c}	26.6^{d}
1st-2	S1	0.08^{c}	1.65^{bd}	0.46^{c}	2.19^{ab}	2.3^{b}	47.8^{d}	13.2^{d}	63.3^{b}
+ 190 days[4]	S2	0.31^{bc}	2.14^{d}	0.54^{c}	2.98^{b}	1.6^{b}	11.0^{bc}	2.8^{bc}	15.4^{cd}
	S3	0.14^{c}	2.00^{cd}	0.49^{c}	2.64^{ab}	2.0^{b}	27.1^{a}	6.6^{a}	35.7^{ad}
2nd-120	S1	0.14^{a}	0.12	0.05^{a}	0.31	4.0^{a}	3.5^{a}	1.4^{a}	9.00^{a}

days[5]	S2	0.13^{a}	0.14	0.06^{a}	0.33	0.7^{bc}	0.7^{b}	0.3^{bc}	1.7^{b}
	S3	0.11^{a}	0.14	0.06^{a}	0.30	1.5^{b}	1.9^{bc}	0.8^{d}	4.1^{c}
2nd-190 days[6]	S1	0.05^{b}	0.16	0.02^{b}	0.22	1.3^{b}	4.5^{d}	0.6^{cd}	6.4^{d}
	S2	0.06^{b}	0.17	0.02^{b}	0.25	0.3^{c}	0.9^{b}	0.1^{b}	1.3^{b}
	S3	0.05^{b}	0.17	0.02^{b}	0.23	0.6^{c}	2.3^{c}	0.3^{b}	3.1^{bc}

[1]Plant spacing: S1 = 0.5 x 0.7 m; S2 = 1 x 2 m; S3 = Double row (1 x 1 x 0.5 m).

[2]Means within harvest type in same column with different letters are significantly different ($P < 0.05$)

[3]Harvested two years after establishment (first cutting, end of the rainy season)

[4]Harvested for the first time at the peak of the dry season (190 days after the first cutting)

[5]Regrowth harvested 120 days after the first cutting (mid-dry season).

[6]Regrowth harvested 190 days after the first cutting (peak of the dry season)

The rate of in sacco degradation of leaves was high, 70-80 percent at 24 hours of incubation. The study also showed that degradability of the old bark was maximal (about 70 percent of the DM) after 72 hours. Another advantage of mulberry leaves is that they contain considerably lower levels of total phenolics compared with leaves and pods of most native browse trees and shrubs in central Tanzania, such as Faidherbia albida, Acacia tortilis, Acacia nilotica, Delonix elata and Dichrostachys cinerea (Shayo and Udén, 1999). Phenolic compounds have a capacity to bind to carbohydrates, plant proteins, salivary mucoprotein and gastrointestinal enzymes (Lowry *et al*., 1996), thereby reducing protein and cell wall digestion (Zucker, 1983). Makkar *et al*. (1989) classified mulberry as low tannin fodder tree.

TABLE 2

Proportion of mulberry fractions as affected by spacings and harvest time

Type	**Treatment**[1]	**Part of the plant (%)**		
		Leaf	**Stem**	**Bark**
First harvest at 2 y	S1	33.6	55.9	10.5
	S2	28.3	59.6	12.2
	S3	31.8	56.8	11.4
	Mean	31.2^{a2}	57.4^{a}	11.4^{a}

	Mean	31.2^{a2}	57.4^{a}	11.4^{a}
First harvest at 2 y + 190 days	S1	3.6	75.5	20.9
	S2	10.2	71.7	18.1
	S3	5.5	75.9	18.6
	Mean	6.4^{b}	74.4^{b}	19.2^{b}
Regrowth at 120 days	S1	44.7	39.4	15.9
	S2	39.3	42.5	18.2
	S3	36.1	45.4	18.4
	Mean	40.0	42.4^{c}	17.5^{b}
Regrowth at 190 days	S1	20.5	70.1	9.3
	S2	23.7	66.8	9.5
	S3	20.3	71.9	8.0
	Mean	21.5^{d}	69.6^{b}	8.9^{a}

[1]Plant spacing: S1 = 0.5 x 0.7 m; S2 = 1 x 2 m; S3 = Double row (1 x 1 x 0.5 m).

[2]Means in the same column with different letters are significantly different ($P < 0.05$).

Source: Shayo, 1997.

CONCLUSION

The results have shown that mulberry can survive in the semi-arid areas of central Tanzania and possibly in other areas of the world with a similar climate. Mulberry produces large quantities of highly digestible forage, high in protein. It is encouraging to note that biomass production of edible forage from mulberry is comparable to that of other introduced browse species. The multi-purpose nature of the mulberry makes it suitable for incorporating in the agro-forestry systems of central Tanzania. However, since mulberry is not a nitrogen fixing plant and since the leaves will be harvested for livestock feeding, recycling of the nitrogen and other nutrients removed from the soil will be necessary. Studies to determine distribution and use of mulberry in the whole country are encouraged. Also, studies to determine production and reproduction performance of different types and classes of livestock fed mulberry fodder are necessary.

TABLE 3

Chemical composition and digestibility of mulberry leaves and bark in central Tanzania

Parameter (% DM)	Part of the plant			
	Leaf	Bark	Leaf	Bark
Ash	14.3	6.1	13.3	6.3

Crude protein	18.6	7.8	14	8.7
Neutral detergent fibre	24.6	46.8	27.6	44.5
Acid detergent fibre	20.8	36.9	25.1	38.3
Hemicellulose	3.8	9.9	2.5	6.2
Acid detergent lignin	8.1	7.1	-	-
Cellulose	12.6	29.7	-	-
Acid detergent insoluble ash	2.5	1.1	-	-
In vitro DM digestibility	82	60	-	-
In vitro organic matter digestibility	-	-	89	85
Reference	Shayo (1997)		Omar, Shayo and Udén (1998)	

BIBLIOGRAPHY

Blair, G.J. 1989. The diversity of potential value of shrubs and tree fodders. In: C. Devendra, ed., *Shrubs and tree Fodders for Farm Animals*. p. 2-9. Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989.

Coley, P.D., Bryant, J.P. & Chapin, F.S. 1985. Resource availability and plant anti-herbivore defense. *Science*. 230**,** 895-899.

Ella, A., Jacobsen, C., Stür, W.W. & Blair, G.L. 1989. Effect of plant density and cutting frequency on the productivity of four tree legumes. *Tropical Grasslands,* 23, 28-34.

FAO. 1998. *Mulberry cultivation*. FAO Agricultural Services Bulletin. No 73/1. Rome. 127 pp.

Ivory, D.A 1990. Major characteristics, agronomic features and nutritional value of shrubs and tree fodders. In: C. Devendra ed., *Shrubs and Tree Fodders for Farm Animals.* Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989, pp 22-38.

Le Houerou, H.N. 1980. The role of browse in management of natural grazing lands. In: Le Houerou, H.N. (ed.), *Browse in Africa. The current state of knowledge*: Addis Ababa, Ethiopia, ILCA. pp. 355.

Lowry, B.J., McSweeney, C.S. & Palmer, B. 1996. Changing perceptions on the effect of plant phenolics on nutrient supply in the ruminant. *Australian Journal of Agricultural Research,* 47, 829-842.

Makkar, H.P.S., Singh, B. & Negi, S.S. 1989. Relationship of rumen degradability with some microbial colonization, cell wall constituents and tannin level in some tree leaves. *British Society of Animal Production,* 49: 299-303.

Omar, S.S. 1998. A survey on usage, distribution, utilisation and cultivation of mulberry (Morus alba) tree and other trees and shrubs as fodder for smallholders in three villages in Kondoa District, Tanzania. In: *The potential of mulberry* (Morus alba) *as fodder tree for goats in semi-arid Tanzania.* Swedish University of Agricultural Sciences. (thesis)

Omar, S.S., Shayo, C.M. & Udén, P. 1998. Voluntary intake and digestibility of mulberry (Morus alba) diets by goats. In: *The potential of mulberry* (Morus alba) *as fodder tree for goats in semi-arid Tanzania*. M.Sc. Thesis. Swedish University of Agricultural Sciences.

Shelton, H.M. and Brewbaker, J.L. 1994. Leucaena leucocephala - the most widely used forage tree legume. In: R.C Gutteridge, and H.M. Shelton eds., *Forage Legumes in Tropical Agriculture.* p. 15-29. CAB International

Shayo, C.M. and Msangi, R.B.R 1989. Performance and nutritive value of local and introduced pastures. In: *Development and Utilisation of forages for Livestock Feeding in Tanzania*. p. 9-22. Proceedings of TALIRO/SAREC conference held at the livestock Production Research Institute, Mpwapwa, Tanzania, 14-15 March 1989.

Shayo, C.M. 1998. Browse leaves and pods as ruminant feed in central Tanzania. Ph.D. Thesis. Swedish University of Agricultural Sciences*. Agraria* 120

Shayo, C.M. 1997. Uses, yield and nutritive value of mulberry (*Morus alba*) trees for ruminants in the semi-arid areas of central Tanzania. *Tropical Grasslands,* **31,** 599-604.

Shayo, C.M. & Udén, P. 1999. Nutritional uniformity of neutral detergent solubles in some tropical browse leaf and pod diets. *Animal feed science and Technology*, 82, 141-151.

Tikader, A., Roychoudhury, S., Mishra, A.K. & Das, C. 1993. Foliage yield of different varieties of mulberry (*Morus* species) grown at two spacings at hills of West Bengal. *Indian Journal of agricultural Sciences,* 63**,** 36-37.

Walker, B.H. 1980. A review of browse and its role in livestock production in southern Africa. In: H.N. Le Houerou ed., *Browse in Africa. The current state of knowledge.* p. 7-24. Addis Ababa, Ethiopia, ILCA.

Zheng, T.Z., Tan, Y.F., Ma, B., Chen, D.Y., Zhou, Q.H.M., Hong, G. & Chen, Z.P. 1988. *Mulberry cultivation.* FAO Agricultural Services Bulletin, N° 73/1, FAO, ROME.

Zucker, W.V. 1983. Tannins: does structure determine function? An ecological perspective. *American Naturalist,* 121**,** 335-365.

The potential of mulberry foliage as a feed supplement in India

B. Singh
Indian Veterinary Research Institute
Regional Station
Palampur, Himachal Pradesh
India
and
Harinder P. S. Makkar
Animal Production and Health Section
Joint FAO/IAEA Division
Vienna, Austria

INTRODUCTION

A major constraint to animal production in developing countries is the scarcity and fluctuating quantity and quality of the year-round feed supply. These countries experience serious shortages in animal feeds of the conventional type. Grains are required almost exclusively for human consumption. By the year 2020, world population is expected to reach eight billion and most of the population growth will occur in developing countries. With increasing demand for livestock products as a result of rapid growth in the world economies and shrinking land area, future hopes of feeding the millions and safeguarding their food security will depend on better utilization of unconventional feed resources that do not compete with food for human beings. In addition, over-exploitation of soil resources has resulted in wide scale land degradation. This calls not only for better utilization of already known unconventional feed resources but also for the identification and introduction of new and lesser known plants capable of growing in marginal soils. The propagation of such plants can play a vital role in the control of soil erosion, bring economic benefits to farmers, create jobs and bridge the wide gap between supply and demand for animal feeds. These factors would also lead to diversification in traditional agriculture and conservation of biodiversity through sustainable utilization of natural resources.

The rearing of livestock is an integral part of the economy of most of the developing countries. The economy of the Indian farmer is based to a large extent on animal production. However, production is quite low as the animal is undernourished for a significant part of the year. The low productivity is exacerbated by long calving intervals and a late age of puberty. Crop residues and low quality forages are the major feed resources. The primary constraint to ruminant production on such feeds is the low efficiency of feed utilization.

Livestock development over the past three decades has been mainly directed towards satisfying the rapidly increasing demand for milk and meat in the urban centres. The resource-poor small farmers produce a major part of this milk and meat. Appropriate technologies to improve the performance of locally available animal and feed resources within the rural system are lacking. Animal productivity can be increased by the introduction of low cost technologies that improve the current systems of husbandry. Acceptable and successful feeding systems are those that are simple, practical, consistently reproducible and within the limits of the farmer's capacity and available resources.

Fodder, the mainstay for livestock rearing, is cultivated on only four percent of the total cultivable land in India and this figure has remained more or less static for the last three decades. Because of the increase in human population, demand for food grains and other cash crops is increasing, resulting in a smaller area for fodder cultivation. The denuded grasslands, pastures, forest openings and the forests are the major source of herbage for livestock. The 1993 draft report of the Policy Advisory Group on Integrated Grazing Policy, Ministry of Environment and Forests, Government of India indicated the deficit was 584 and 745 million tonnes of dry and green fodder respectively. The present level of availability of animal feeds indicates a deficiency of about 19 percent DM, 55 percent DCP and 28 percent TDN for feeding the existing livestock population. The increasing human population, limited land holdings and the growing requirements of food grains for the human population have a direct impact on livestock production.

Recent nutritional research has demonstrated the possibility of a large increase in animal production that can be achieved by alterations to the feed base (FAO, 1997). Production can be increased by up to fivefold by providing the critical catalytic nutrients that are deficient in the diet and by balancing the availability of nutrients closer to requirements. In the rangelands, particularly in the semi-arid areas, tree forages, seeds and pods represent by far the greatest potential source of protein meals.

In more recent times, trees and shrubs have been introduced into cropping and grazing systems to provide green fodder that is high in protein to supplement the available low protein forage. These are grown in banks or hedges, between crops (alley farming) or as a component of pastures and as shade trees. Multipurpose trees can make a significant contribution to agricultural systems by improving soil fertility and providing a variety of useful products, including valuable forage and wood. The feeding value of low-quality roughages and grasses can be greatly improved by the foliage from trees, which can be integrated directly with pastures and in fences. In some cases, pure stands of forage shrubs and trees can be the best option to intensify animal production replacing traditional low performing grass-based systems. The potential roles of tree foliage in ruminant nutrition are a) a high quality and high digestibility biomass resource, available in and around the farm; b) a supplement to provide nutrients deficient in the diet resulting in enhancement of microbial growth and digestion of cellulosic biomass in the rumen; c) a source of undegradable protein; d) a source of vitamins and minerals to complement deficiencies in the basal fed resource, and e) a reduction in the requirements for purchased concentrates and as a result the decrease in a cost of feeding.

Tree forages form an integral part of ruminant feeds in the high altitudes of the Himachal Pradesh, Jammu and Kashmir and Uttar Pradesh states of India. The use of tree forages as components of diets is a widespread practice in many tropical countries. Considerable diversity exists in the type of forage supplements of value, particularly to ruminants. Recognition of the potential of tree foliage to produce considerable amounts of high protein biomass has led to the development of animal farming systems that integrate the use of tree foliages with local bulky feed resources. In order to determine the suitability of trees/shrubs as components of ruminant fibrous diets, knowledge is required in many areas, including:

- the capacity and ability of the tree to regenerate foliage when grazed or harvested;
- the feeding behaviour of animals when confronted with tree forages;
- the voluntary intake of tree foliage under different environmental conditions;
- the adaptation of trees to the local conditions and their potential to become weeds;
- the growth pattern of trees/shrubs in relation to crops or pasture;
- the required soil pH characteristics and nutrient status;
- the nutritive value of the foliage and its change with harvesting, grazing or

cultivation.

The mulberry plant in the tropical belt is grown as a low bush while it is grown as a high bush in temperate regions. In tropical conditions, individual leaf and branch harvest yields 10 to 30 tonnes/ha/year, while shoot harvesting in temperate regions has a leaf yield of 25 to 30 tonnes/ha/year. The percentage of moisture, protein and carbohydrates is higher in temperate regions when compared to the tropics. Mulberry is a monoecious, occasionally dioecious shrub or moderate-sized tree with a fairly cylindrical straight bole, up to 3.0 m high and 1.8 m in girth. Leaves are very variable, ovate or broadly ovate, serrate or crenate-serrate, and often deeply lobed. The plant is frost hardy but liable to wind damage. It regenerates itself naturally from seeds that are dispersed by birds and to a limited extent by jackals and human beings. It can be propagated artificially by seeds or cuttings. It grows rapidly in the early stages and reaches maturity at an early age; the growth rate falls off rapidly after approximately ten years. Mulberry coppices vigorously and pollards well. When grown close in plantations, the tree develops a long clean bole.

At present in many other parts of the world, mulberry leaves are predominantly used for silk production, and therefore it will be pertinent to mention the status of silk production from mulberry in India. This might encourage workers to develop strategies to integrate silk and livestock production at the village level, resulting in higher incomes for farmers.

SILK PRODUCTION

Numerous types of mulberry are under cultivation in various silk-producing countries of the world; the types differ in their adaptability to various soils and climates, resistance to diseases, food value of the leaf crop for the silkworm and suitability for use as stock or scion in grafting. In Japan, the world's major silk-producing country, approximately 700 types of mulberry are known to exist, of which 21 have been selected for extensive cultivation. Some of these types are adaptable to a wide range of climatic conditions.

The most important type of mulberry grown in India for rearing silkworms is *Morus alba* var. *multicaulis* Loud, which is a native of China or the Philippines. It is fast-growing and adapted for cultivation as a field crop producing large, tender and thick leaves. *M alba* var. *atropurpurea* (Shahtut), also a native of China, is cultivated widely as a tree crop for its large, cylindrical, dark purple, succulent fruits. It is also fast-growing and yields large thick leaves, which are at the same time smooth, tender and succulent fruit. *Atropurpurea* is recommended for cultivation along the borders of bush plantations in Bengal.

Mulberry is grown on an extensive scale in various parts of India, particularly in Mysore, West Bengal and Jammu and Kashmir for its leaf, which constitutes food for the silkworm. Its cultivation is an integral part of the sericultural industry. In some areas, it has run wild and spread. It is also grown as a roadside and avenue tree. In the Himalayas, it reaches a height of about 1 200

m. In the hills, it is mostly confined to stream beds or places where sufficient moisture is available. It does not grow on dry slopes or shallow soils where moisture is a limiting factor. The old leaves are shed in November to December and the trees are leafless during the winter season. The new leaves appear in March to April depending upon the climate of the locality. Mulberry tolerates shade and it can with advantage be grown as an understory with other light-demanding species.

In Mysore and West Bengal, mulberry is grown as a field crop and the leaves are harvested several times a year to feed the multivoltine races of silkworm. In Jammu and Kashmir, it is grown as a tree and the leaves are lopped only in one season for rearing the univoltine races of the worm. A system of growing dwarf grafted trees or "high bushes" has recently been tried in West Bengal. Mulberry is also grown to a small extent in the Punjab, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Bihar, Orissa, Assam, Manipur and Andhra Pradesh states of India, where small quantities of silk are produced. The largest area is in Mysore, which accounts for more than 75 percent of the total mulberry raw silk production in the country.

Young leaves that have attained full size are best suited for feeding silkworm larvae. The composition of the leaves varies according to the type, degree of maturity and the soil in which the plants are grown. The content of protein and soluble sugars in leaves decreases with the maturity of leaves whereas fibre, fat and ash constituents increase. Young leaves are more acidic than older ones. An analysis of leaves collected from different silk-producing localities in India gave the following ranges of values (percentage in DM): CP 16-39, soluble sugars 7.6-26 and ash 8-17.

India has the advantage of producing of all the four known commercial silk varieties in the world, i.e. mulberry, tusser, eri and muga. Mulberry silk is domesticated while the rest are wild. India produces currently about 14 050 tonnes of silk of which mulberry alone accounts for more than 90 percent of the total silk production, practised in over 60 000 villages in the country. Mulberry sericulture is well suited for marginal, small and landless farmers since it has several advantages over other crops in the rural sector. It is estimated that one hectare of irrigated mulberry will generate employment for about 13 people starting from mulberry cultivation to trading throughout the year and that, in value addition, 48.3 percent goes to the farmer; 21.6 percent to traders and the rest to weavers, reelers, twisters and dyers (Lakshmanan and Devi Geetha, 2000).

Year	Area under mulberry (Million ha)
1950-51	0.05673
1960-61	0.08295
1970-71	0.09424
1980-81	0.17000
1990-91	0.31310

1995-96	0.35000

In Himachal Pradesh, mulberry is grown as a shade tree on wastelands, roadsides, borders of fields and around farmers' houses. Himachal Pradesh is predominantly a univoltine/bivoltine silk-producing state. Mulberry leaves for silkworm rearing are collected from trees grown on the border of the fields, around the houses and on the wastelands under rainfed conditions. Family labour is employed in sericulture; women play a major role. Sericulture is adopted mainly by small and marginal farmers and landless labourers as a subsidiary occupation.

The preferential food value of mulberry leaf for silkworm larvae is attributed to the presence of three stimulant factors in it, i.e. an attractant, a biting factor and a swallowing factor. The substances that attract the larvae to the leaves have been identified as citral, linalyl acetate, linalol, terpinyl acetate and hexenol. Sitosterol (approximately 0.2 percent in leaves), together with some sterols and a water-soluble substance, is the main factor that stimulates the biting action.

ANIMAL FEEDING

The leaf fodder of mulberry is reported to be of good quality and can be profitably utilized as a supplement to poor quality roughages. Leaf yield varies according to the fertility of the soil, irrigation and frequency of plucking of the leaves. In West Bengal, one hectare of well manured and irrigated plantation can yield about 19 to 28 tonnes of leaves in five pluckings. On a DM basis, the leaves contained 15.0-27.6 percent CP, 2.3-8.0 percent ether extract (EE), 9.1-15.3 percent crude fibre (CF), 48.0-49.7 percent nitrogen free extract (NFE), 63.3 percent total carbohydrates, 14.3-22.9 percent ash, 2.42-4.71 percent Ca, 0.23-0.97 percent P, 0.196 percent S, 1.66-3.25 percent K, 350-840 ppm Fe (Jayal and Kehar, 1962; Singh, Goel and Negi, 1984; Singh, Makkar and Negi, 1989; Makkar, Singh and Negi, 1989). The cell wall constituents were: NDF 33-46 percent, ADF 28-35 percent, hemicellulose 5-10 percent, cellulose 19-25 percent, and lignin approximately 11 percent (Lohan *et al*., 1979; Makka, Singh and Negi, 1989). The content of total phenols was very low (1.8 percent as tannic acid equivalent), and tannins by the protein precipitation capacity method were not detectable (Makkar, Singh and Negi, 1989; Makkar and Becker, 1998).

A prolamine has been separated from the alcoholic (alkaline) extracts of mulberry leaves and it forms the principal protein of the leaves. The nitrogen (N) distribution in a preparation containing 12.6 percent N was as follows: HCl-insoluble N 0.50; humin N 0.45; amide N 0.96; diamino acid N (arginine N 0.89, histidine N 0.49, lysine N 0.35, cystine N 0.01) 1.74; and monoamino acid N 7.89 percent. Protein preparations from young mulberry leaves form an excellent supplement to protein-deficient diets.

Non-protein nitrogen accounts for approximately 22 percent of the total N in young leaves and approximately 14 percent in mature leaves. The amino acids identified in the free form are: phenylalanine, leucine, valine, tyearosine, proline, alanine, glutamic acid, glycine, serine, arginine, aspartic acid, cystine, threonine, pipecolic acid and 5-hydroxy pipecolic acid.

The mulberry leaves are thus rich in CP, EE, calcium and ascorbic acid (200-300 mg/100 g; 90 percent of which are present in the reduced form) and low in CF. They also contain carotene, vitamin B1, folic acid, folinic acid and vitamin D. The presence of glutathione in leaves has been reported. Copper, zinc, boron and manganese occur in traces. Phytate phosphorus accounts for 18 percent of the total. Sulphur is required together with nitrogen for microbial protein synthesis in the rumen. Concentrations of sulphur greater than 1.5 g/kg DM or nitrogen: sulphur ratios less than 15:1 are considered adequate. Both these requirements are met in mulberry leaves. Similarly the levels of potassium and iron in mulberry leaves are also higher than their recommended levels (Fe 30-50 ppm, K 0.5-1.0 percent) in diets (McDowell, 1997). Higher Ca content in mulberry leaves (2.4 -4.7 percent) than the required level in diet (0.19-0.82 percent; McDowell, 1997) could be useful for high yielding ruminants during the early stages of lactation. Ca is closely associated with phosphorus metabolism. A high ratio of Ca:P in mulberry leaves could create some problem with calcium, phosphorus and vitamin D metabolism at a high level of supplementation of leaves in diets. It has been suggested that high Ca:P is associated with infertility in cattle. It should be noted that mulberry leaves would usually be used only as a part of livestock diets.

Feeding experiments with sheep showed that the leaves are highly palatable. The digestibility coefficients for CP, EE, CF, NFE and total carbohydrates were found to be 71, 4, 54, 84 and 76 percent respectively (Jayal and Kehar, 1962). The digestible nutrients per 100 kg of leaves on a DM basis were 10.7 kg CP, 0.27 kg EE, 8.3 kg CF, 40.2 kg NFE and 59.6 kg total nutrients.

Mulberry leaves are also useful as cattle fodder - they are nutritious and palatable, and are stated to improve milk yield when fed to dairy animals. The feeding value of mulberry leaves is rated high by livestock owners. Feeding experiments have shown that up to 6 kg of leaves per day can be fed to milch cows without adversely affecting the health of animals or the yield and butter content of milk.

Mulberry leaf stalks, left after feeding silkworms, can also be used for feeding cattle without any adverse effect on their health and performance. The chemical composition of leaf stalks (percent in DM basis) was: 11.5 CP, 7.0 true protein, 2.7 EE, 34.0 CF, 42.5 NFE, 76.5 total carbohydrates, 9.3 total ash, 1.56 Ca, 0.20 P (Subba Rao, Amrith Kumar, 1971). Digestibility coefficients of organic matter (OM), CP, EE, CF, NFE and total carbohydrate were 58, 69, 73, 49, 60 and 56 percent respectively. The balances of N, Ca and P were positive and the adult bullocks gained body weight during the experimental period.

Mulberry leaves can also be used in poultry rations. Incorporation of shade-dried mulberry leaves in layers' mash to the extent of 6 percent showed an increase in egg production with desirable yolk colour without any adverse effect on body weight and egg quality (Narayana and Setty, 1977). Mulberry leaves, owing to their high carotene content, can form a valuable source of vitamin A for the health of poultry birds and increased egg production.

The effect of supplementing mulberry leaves ad libitum to concentrate diets of Angora rabbits on wool production has been studied by Singh, Goel and Negi (1984). The average intake of mulberry leaves was 10.4 g/day/kg W 0.75 while the total DM intake was 29.5 g/day/kg W 0.75. The digestibility coefficients for DM, CP, CF and NFE were 69, 66, 72 and 78 percent respectively. The nutritive value of mulberry leaves (percent in DM) calculated by difference was digestible CP 9.8 and total digestible nutrients 64. The results indicated that mulberry leaves can be advantageously incorporated in the diets of Angora rabbits for wool production. Mulberry leaves may be supplemented up to a level of 40 percent of the DM with impunity.

Studies have recently conducted at the Regional Station of the Indian Veterinary Research Institute on the characterization of mulberry leaves for digestion kinetics parameters and comparison of these values with other tree foliages (Devarajan, 1999). Degradation kinetic parameters as studied by the *in vitro* gas production technique (Menke *et al*., 1979) showed that the potential gas production in young leaves was 60.6 ml/200 mg while the rate of degradation was 0.0703. The corresponding values for the mature leaves were 35.4 ml and 0.0624 respectively, indicating the fall in fermentability with maturity. The potential gas production for the young leaves was highest among the forages studied and the rate of gas production lower compared with only *Moringa oleifera* (Table 1), suggesting high nutritive value of the young leaves. The fermentability of the mature leaves was also high and comparable with *Leucaena* leaves. The high rate of gas production for mulberry indicates high intake potential of this forage.

The rate, potential extent and effective degradability (at passage rate of 0.05/hours) of DM using the *in sacco* method of Orskov and McDonald (1979) were 0.0672, 85 percent and 52 percent respectively. These values for CP were 0.0467, 95 percent and 57 percent and for NDF 0.0368, 82 percent and 43 percent respectively. The effective DM degradability of various *Leucaena* species has been reported to be 46-51 percent (Tolera, Seygoum and Sundstol, 1998) and the value obtained in India was 51 percent (Table 3). For mulberry leaves, the kinetic parameters for CP were also comparable to those for other good quality tree fodders (Table 4).

In sacco 48-hour degradability (percentage) values for DM, CP, NDF and NDF-linked N were 76, 87, 70 and 79 respectively. It is clear from these values that nitrogen linked to NDF is degraded in the rumen to a considerable extent but depending on the rate of passage could well serve as source of undegradable nitrogen. The leaves of *Artocarpus* and *Ficus* are regarded as the most valuable fodder by farmers in the hilly areas of Nepal and India. The degradability values for mulberry are similar to those for *Leucaena leucocephala*, *Artocarpus lakoocha* and *Ficus roxburghii* (Table 5). The contents of NDIN and ADIN in mulberry leaves were 56.5 and 20.4 percent of the total nitrogen respectively. The solubility of nitrogen (as percent of total nitrogen) in borate phosphate buffer was 17.3 percent and in phosphate buffer 15.7 percent. These values are of order similar to those for *Leucaena, Artocarpus, Dendrocalamus* and *Ficus* (Table 6). It was interesting that all the soluble N in mulberry was in the NPN form.

TABLE 2

Potential and rate of gas production from some tree forages

Forage	**Gas production**	
	Potential (ml/200 mg)	**Rate**
Acacia catechu	24.4	0.0456
Albizzia stipulata	17.4	0.0586
Artocarpus lakoocha	51.1	0.0379
Bauhinia variegata	23.1	0.0308
Dendrocalamus hamiltonii	33.8	0.0256
Ficus roxburghii	42.6	0.0462

Leucaena leucocephala	37.2	0.0578
Morus alba (young)	60.6	0.0703
Morus alba (mature)	35.4	0.0624
Moringa oleifera[1]	49.5	0.0852

Source: Makkar and Becker, 1996.

TABLE 3

Rate and potential extent of dry matter degradation (PD) and effective degradability (ED) of dry matter (passage rate of 0.05/hours)

Forage	**Rate**	**PD**	**ED**
Acacia catechu	0.0390	55	33
Albizzia stipulata	0.0348	32	24
Artocarpus lakoocha	0.0953	85	57
Bauhinia variegata	0.0489	42	27
Dendrocalamus hamiltonii	0.0347	56	26
Ficus roxburghii	0.0647	93	56
Leucaena leucocephala	0.0693	75	51
Morus alba (mature)	0.0467	85	52

TABLE 4

Rate and potential extent of crude protein degradation (PD) and effective degradability (ED) of crude protein (passage rate 0.05/hours)

Forage	Rate	PD	ED
Acacia catechu	0.0295	42	14
Albizzia stipulata	1.0907	22	21
Artocarpus lakoocha	0.0693	93	64
Bauhinia variegata	1.2233	53	51
Dendrocalamus hamiltonii	0.0283	75	35
Ficus roxburghii	0.0540	95	60
Leucaena leucocephala	0.0426	78	43
Morus alba (mature)	0.0672	95	57

TABLE 5

***In sacco* degradability (48 hours) of dry matter (DM), crude protein (CP), neutral detergent fibre (NDF) and neutral detergent fibre bound nitrogen (NDF-N)**

Forage	DM	CP	NDF	NDF-N
Acacia catechu	47	34	28	11
Albizzia stipulata	30	25	2	0
Artocarpus lakoocha	85	92	75	90
Bauhinia variegata	42	64	20	27
Dendrocalamus hamiltonii	45	57	39	51
Ficus roxburghii	88	86	84	87
Leucaena leucocephala	72	71	58	56
Morus alba (mature)	76	87	70	79

TABLE 6

Solubility of nitrogen (N) for some tree leaves

Forage	**(% of total N)**	
	Borate phosphate buffer (pH 8.1)	**Phosphate buffer (pH 6.8)**
Acacia catechu	21.5	13.0
Albizzia stipulata	21.6	12.2

Artocarpus lakoocha	16.9	14.6
Bauhinia variegata	42.0	23.5
Dendrocalamus hamiltonii	14.5	12.3
Ficus roxburghii	14.4	14.8
Leucaena leucocephala	19.1	13.3
Morus alba (mature)	17.3	15.7

From the *in sacco* data, the values for rumen degradable nitrogen (RDN), rumen undegradable nitrogen (UDN) and rumen undegradable but available post ruminally (DUN) calculated are shown in Table 7, and the values for digestible organic matter, metabolizable energy and intake potential calculated from the gas production data in Table 8.

It is evident from the data presented in these tables that the nutritive value of mulberry is as high as some well-known good quality fodders. In addition, tannins at high levels are present in the leaves of most trees (Makkar and Becker, 1998), whereas mulberry leaves are free of tannins. Mulberry leaves have the potential to be used as a supplementary feed for increasing livestock productivity in crop residue-based livestock systems.

It has been a popular misconception that the low productivity of ruminants in developing countries is mainly the result of the low energy density (low digestibility) of available forages.

TABLE 7

Rumen degradable nitrogen (RDN), rumen undegradable nitrogen (UDN) and rumen undegradable but available post ruminally (DUN) of some tree forages calculated at a passage rate of 0.05/hours (values are g/kg DM)

Forage	**RDN**	**UDN**	**DUN**
Acacia catechu	4.8	28.7	16.0
Albizzia stipulata	7.3	28.4	11.6
Artocarpus lakoocha	19.7	11.4	4.6
Bauhinia variegata	16.9	16.1	9.45
Dendrocalamus hamiltonii	11.1	20.6	11.2
Ficus roxburghii	13.2	8.9	2.6
Leucaena leucocephala	14.6	19.1	5.8
Morus alba (mature)	16.3	12.2	5.8

TABLE 8

Digestible organic matter (DOM), metabolisable energy (ME) and intake potential calculated from the gas data production data

Forage	DOM (%)	ME (MJ/kg)	Intake potential (g/kg W0.75)
Acacia catechu	45	10.5	58.2
Albizzia stipulata	44	6.8	65.8
Artocarpus lakoocha	63	9.1	58.8
Bauhinia variegata	42	7.6	47.7
Dendrocalamus hamiltonii	40	6.7	46.5
Ficus roxburghii	54.9	9.2	62.0
Leucaena leucocephala	59.1	13.1	69.6
Morus alba (mature)	64	11.3	61-72
Moringa oleifera[1]	74	9.5	-

[1]**Source**: Makkar and Becker (1996).

There is now abundant evidence that low productivity stems from an inefficient utilization of the feed resources because of deficiencies of nutrients (mainly nitrogen, sulphur and minerals) in the diet. Maximum fermentation rates are attained when all factors required by the ruminal micro-organisms are available - a source of energy (sugar, cellulose, hemicellulose), nitrogen, sulphur and minerals, and also when the nitrogen release and the energy availability are synchronized. Ruminants fed low-quality forages require supplementation with the critically deficient nutrients to optimize productivity. Since mulberry leaves are rich in nitrogen, sulphur and minerals their supplementation could increase the efficiency of utilization of crop residues by increasing the efficiency of microbial protein synthesis in the rumen, leading to higher microbial protein supply to the intestine. Recent concepts of diet formulation are based on the manipulation of the diet in order to achieve high microbial efficiency and high production of microbial protein in the rumen by creating an efficient rumen ecosystem. An associated advantage of achieving high efficiency of microbial protein synthesis in the rumen is the lower emission of environmental polluting gases - methane and carbon dioxide, from feeds. The combination of trees and grassland would obviously be both a desirable development and synergistic for cattle production. Strategic supplementation is justified because of regular feed shortages that occur and the fact that ruminants subsist for most of their life on fibrous crop residues on small farms. For high producing animals the feeding strategy should also be aimed at supplementation with bypass protein of dietary origin in addition to creating an efficient ecosystem. The genetic potential of superior livestock will only be realized if feeding systems are developed to ensure that the supply of essential dietary nutrients matches the requirements for higher levels of production.

The use of high protein mulberry tree fodder should be encouraged to provide supplementation of crop residues and natural pastures, thereby increasing productivity and the overall use of available on-farm biomass. Mulberry tree forage is well accepted by ruminants, pigs, poultry and rabbits. There is a need for systematic research on the optimization of the use of this tree forage and for developing strategies for its optimum supplementation under different feeding situations. The promotion of mulberry should be viewed in context of a holistic farming systems approach with the aim to increasing farmers' incomes, generating employment and conserving the environment. An attractive option to achieve an integration of silk production and livestock rearing. Acceptance of these strategies could reduce the need for land clearing and pasture establishment in the fragile areas of the world that are prone to erosion following clearing.

According to one estimate, a total of approximately 1.2 billion hectares of land in the world is degraded, barren or marginal and this proportion is increasing every year. Mulberry is an ideal tree species for economic management of unutilized wasteland (under rainfed conditions) for the following reasons:

- it is tap rooted with minimum superficial roots;
- it has good coppicing power and is tolerant to lopping and pruning;
- pruning and training of mulberry enhances the size and quality of its

leaves;

- it has easy generation capacity through seeds and vegetative means;
- it is a multipurpose tree that yields fodder, fibre, fruit, wood, etc. The leaves are highly palatable and nutritious for livestock, yet they are used extensively for silk production;
- many varieties of mulberry are available that can grow in varied agroclimatic conditions in both temperate and tropical areas.

Mulberry has the potential to play a valuable role in world agriculture. It is an extremely versatile plant that can fulfil a number of roles in smallholder agricultural production. Its value is multifaceted and the potential for increasing and diversifying its use is enormous. However, its value and benefits as a high-quality supplement to low-quality roughages in ruminant feeding systems have not been widely known nor fully exploited. There is a wide genetic diversity in this species which has wide-ranging soil and climatic adaptation - a large number of provenances are available that grow under different soil and climatic conditions. Systematic studies are warranted to evaluate these provenances in order to know the superior genotypes, collect and maintain germplasm, and conduct agronomy and management studies. Such studies include: environmental adaptation; establishment and propagation; defoliation management of trees; planting density, cutting intervals and cutting heights in intensive forage production systems; seed production in different agroforestry systems (e.g. agrosilviculture, agrosilvi-horticulture, silvipasture, energy plantation, boundary plantation, alley cropping and perennial cropping). This will improve biomass production with high nutrients for livestock feeding and extend the ecological range of the plant. The future role and value of mulberry will depend on the outcome of these programmes.

BIBLIOGRAPHY

Devarajan, S. 1999. *Effect of tannins on the ruminal degradation kinetics of locally available tree forages*. Izatnagar, India I. RI Deemed University,.

FAO. 1997. *Tree foliage in animal nutrition*. FAO Animal Health and Production Paper No. 139, FAO, Rome.

Jayal, M.M. & Kehar, N.D. 1962. A study on the nutritive value of mulberry (*Morus alba*) tree leaves. *Indian J. of Dairy Science*, 15: 21-27.

Lakshmanan, S. & Devi Geetha, R.G. 2000 Mulberry sericulture: an emerging industry. *Yojna* 44: 42-44.

Lohan, O.P., Lall, D., Pal, R.N. & Negi, S.S. 1979. *Studies on tannins in fodder trees*. Fifteenth Dairy Industry Conference, Hyderabad, India.

Makkar, H.P.S. & Becker, K. 1996. Nutritional value and antinutritional components of whole and ethanol extracted *Moringa oleifera* leaves. *Animal Feed Science and Technology*, 63: 211-228.

Makkar, H.P.S. & Becker, K. 1998. Do tannins in leaves of trees and shrubs from African and Himalayan regions differ in level and activity? *Agroforestry Systems*, 40: 59-68.

Makkar, H.P.S., Singh, B. & Negi, S.S. 1989. Relationship of rumen degradability with microbial colonization, cell wall constituents and tannin levels in some tree leaves. *Animal Production* 49: 299-303.

Menke, K. H., Raab, L., Salewski, A., Steingass, H., Fritz, D. & Schneider, W. 1979. The estimation of the digestibility and metabolizable energy content of ruminant feedstuffs from the gas production when they are incubated with rumen liquor *in vitro. J. Agric. Sci.* (Camb.), 92: 217-222.

McDowell, L.R. 1997. *Minerals for grazing ruminants in tropical regions*. University of Florida, Institute for Food and Agricultural Science, USA.

Narayana, H. & Setty, S.V.S. 1977. Studies on the incorporation of mulberry (Morus indica) leaves in layers mash on health, production and egg quality. *Indian J. of Animal Sci.* 47: 212-215.

Orskov, E.R. & McDonald, I. 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *J. of Agric. Sci.* (Camb.), 92: 499-503.

Singh, B., Goel, G.C. & Negi, S.S. 1984 Effect of supplementing mulberry (Morus alba) leaves *ad libitum* to concentrate diets of Angora rabbits on wool production. *J. Applied Rabbit Research*, 7: 156-160.

Singh, B., Makkar, H.P.S. & Negi, S.S. 1989. Rate and extent of digestion and potentially digestible DM and cell walls of various tree leaves. *J. Dairy Sci.* 72: 3233-3239.

Tolera, A., Seyoum, M. & Sundstol, F. 1998. Nutritive evaluation of *Leucaena leucocephala*, *L. diversifolia* and *L. pallida* in Awassa, Southern Ethiopia. In: H.M. Shelton, R.C. Gutteridge, B.F. Mullen and R.A. Bray, eds. *Leucaena - adaptation, quality and farming systems* (eds. Shelton, H.M., Gutteridge, R.C., Mullen, B.F. and Bray, R.A.) ACIAR Proceedings No. 86.

Subba Rao, A., Amrith Kumar, M.N. & Sampath, S.R., 1971. Studies on mulberry (*Morus indica*) leaf stalk palatability, chemical composition and nutritive value. *Indian Vet. J.,* 48: 853-857.

The forage potential for some mulberry clones in Brazil

José Eduardo de Almeida
Estação Experimental de Zootecnia
Gália, São Paulo
Brazil
and
Tamara Canto Fonseca
Instituto de Zootecnia
Nova Odessa, São Paulo
Brazil

INTRODUCTION

It should be clarified that mulberry is not yet cultivated as forage in Brazil. However, animal scientists have increasingly focused on the potential of mulberry for animal feeding, especially in the Department of Agriculture and Veterinary Sciences at Jaboticabal, São Paulo state (altitude of 614 m, latitude -21°14'4,9'' and longitude -48°17'9,3''). The climate in this region is humid subtropical, with dry winters and rainy summers, and an average annual temperature of 20°C. Annual rainfall is 1 400 mm. The soil is classified as dark red latosol, with average texture, and classified by the seventh American approximation as typic haphorthox.

Determinations of growth curve, dry material production, crude protein (CP) content, ratio leaf:stem, have been carried out for some clones (Brazão, *et al*. 1992; Takahashi *et al*., 1992; Resende *et al*., 1992; Guideli *et al*., 1993). Scrutinizing 5 clones (Korin, Calabresa, FM 86, FM SM and Miura) in four different cutting frequencies (45, 60, 75 and 90 days), Brazão (1992) found that the best clone was FM SM at 60 days, with a higher percentage of CP. Other authors, studying the seasonal effect along the year (winter, autumn and summer), observed that the FM SM clone was also the best, with higher yield related to total DM, stem and leef DM, but presented lower ratio leaf/stem (Takahashi *et al*., 1992; Resende *et al*., 1992; Guideli *et al*., 1993).

Also the bromatological composition has been determined for different ages and parts of the plant by Sugohara *et al*. (1994a,b) and by Resende *et al*. (1994a,b).

Another characteristic of mulberry that has caught attention from researchers and specialists is the dry material digestibility. Experiences were conducted in vitro, by Resende *et al*.(1994c); Takahashi *et al*.(1994) and Sugohara *et al*.

(1994c) (reporting on Hara, 1993) and Baffi, 1992, and in situ, conducted by Vasconcelos *et al*.(1994) and Schmidek (1999), and in feces and urine, conducted by Basaglia (1993). The main results of the published papers are summarized in the following section.

EXPERIMENTAL RESULTS

TABLE 1

Bromatological composition in leaf and stem of lamada clones for different cutting frequencies (in days)

	Leaf fraction				**Stem fraction**			
Days	**45**	**60**	**75**	**90**	**45**	**60**	**75**	**90**
DM	20.1a	22.0a	26.0a	23.8a	18.2d	22.7c	27.6b	32.6a
Crude protein	25.6a	24.6ab	23.7ab	22.9b	8.8a	7.2b	6.4bc	5.5c
Ether extract	3.8b	6.0a	5.5a	5.2a	2.5b	2.2b	2.1b	2.9a
Ash	5.9a	8.1a	7.9a	9.5a	6.3a	4.4b	3.2bc	2.6c
NDF	34.5a	26.1b	7.7b	37.3a	71.7c	75.5b	77.3b	81.1a
ADF	22.2a	19.4a	22.4a	22.4a	56.0a	55.8a	56.2a	57.6a
Cellulose	5.9a	8.1a	7.9a	9.5a	35.8b	39.9a	38.6ab	41.9a
Lignin	9.0a	6.9a	8.4a	8.0a	16.3a	14.7ab	15.0ab	14.2b

Lignine	9.0a	6.9a	8.4a	8.9a	16.3a	14.7ab	15.9ab	14.2b

Note: values in rows with the same letter were not different in Tukey Test, at 5 percent level.
Source: Sugohara *et al*., 1994a.

TABLE 2

Bromatological composition in leaf and stem of some mulberry clones (four years of age) in the winter[1], summer[2] and in the spring[3]

Parameter (%)	Winter (range)		Spring		Summer	
	Leaf	Stem	Leaf	Stem	Leaf	Stem
DM	22-24	25-30	22.2	22.4		
Crude Protein	28-30	8-9	30.7	10.3	21.8 (FM SM) 23.7 (Miura)	5.9 (FMSM) 6.7 (Miura)
Ash	10-12	4-5	4.6	2.3		
Ether extract	4-5	2-3	10.2	5.0		
NDF	27-34	79-82	29.1	80.6	29.7	
ADF	16-20	49-55	18.0	51.1	11.6	
Lignin	6-7	13-14	5.7	11.8		

Cellulose	7-8	36-40	-	-		

Source: [1] Resende *et al*., 1994a; [2] Sugonara *et al*., 1994; [3] Resende *et al*., 1994b.

The design was completely randomized 5 x 4 factorial (clones x growth age) with two repetitions. Spacing was 3 m between lines and 0.6 m between plants. After the evaluation of experimental data, the authors concluded that the lamada clone had a high forage potential.

During the winter, there were no marked changes in the leaf and stem fractions with cutting. In the spring, there was a significant decrease in CP and an increase in fibre fraction ($P < 0.05$) with cutting age. In the summer, cell composition changed with cutting age, with an increase in cell wall and a decrease in cell contents. The authors came to the conclusion that mulberry had a high forage potential, suitable for animal feeding, especially for caprines.

TABLE 3

I*n vitro* digestibility (Tilley and Terry, 1963) of some mulberry clones in experiments conducted in two seasons (in days)

Clone	Stem DMr		Leaf DMr		Leaf protein	
	April-	**August-**	**April-**	**August-**	**April-**	**August-**

	June	October	June	October	June	October
Korin	45.3	48.6	66.5	68.3	56.4	66.6
Calabresa	50.0	42.6	64.7	70.0	54.6	66.6
FM 86	49.8	46.8	70.2	71.4	57.2	65.0
FM SM	48.4	49.3	69.6	71.3	56.8	65.9
Miura	50.9	47.6	66.8	69.1	56.7	65.6
Average	48.9	47.0	67.6	70.0	56.3	65.9

Source: Tilley and Terry, 1993; Hara, 1993.

TABLE 4

Production of dry matter and crude protein of five mulberry clones in two seasons (in days)

Cutting	Stem DMr		Leaf DMr		Leaf CP		Leaf DCP	
Frequency	Apr-Jun	Aug-Oct	Apr-Jun	Aug-Oct	Apr-Jun	Aug-Oct	Apr-Jun	Aug-Oct
45	9.4	1.9	6.3	1.2	2.9	0.6	5.5	1.2
60	8.6	4.4	5.9	3.5	2.6	1.5	5.1	3.5
75	7.0	6.9	4.7	4.9	1.8	2.2	3.7	4.7

90	11.1	10.7	7.5	7.2	3.0	2.8	6.2	6.0

Spacing was 3 m x 0.6 m. The experiment had a completely randomized factorial design 5 x 4 (clones x cutting age).

Source: Hara, 1993.

Hara (1993) observed that at 90 days, mulberry gave the largest DM and leaf protein production. Research conducted by Resende et al. (1994c) indicated that in the winter mean DM digestibility for Korin, Calabresa, FM 86, FM SM and Miura was 67.6 percent for leaf, 48.8 percent for stem, and the average digestibility of protein was 56.3 percent. In spring, those figures ranged from 67 to 74 percent and from 37 to 55 percent, for DM to CP, respectively (Takahashi *et al*., 1994). In both experiments, FM SM showed the largest digestible DM production in winter (75 days) and in spring (90 days). In summer (Sugohara *et al*. 1994) observed that FM SM had digestibilities of 53 percent for leaf DM and 44 percent for stem DM.

TABLE 5

***In vitro* digestibility[1] of lamada clones (nine years of age), with different cutting frequencies.**

	In vitro digestibility

Cutting frequency	In vitro digestibility			
	Dry matter		Crude protein	
	Stem	Leaf	Stem	Leaf
45	52.8	82.7	92.3	88.3
60	47.6	83.4	92.9	90.4
75	45.3	80.0	97.9	87.8
90	39.3	78.9	90.5	86.0

Source: Baffi, 1992; Tilley and Terry, 1993. [1] Tilley and Terry (1963). Spacing was 3m by 0.6m.

TABLE 6

Rumen degradation characteristics of some mulberry clones in caprines

	Vasconcelos et al., 1994		Schmidek, 1991	
	DM	CP	DM	CP
Soluble fraction	31.2	21.5	31.4	17.7
Degradable fraction	60.6	74.4	61.8	79.3
Non-degradable fraction	7.9	4.1	6.8	3.2
Potential degradation	92.1	95.9	92.4	90.7

Source: Schmidek, 1999.

The data showed a high potential degradation of DM and CP in mulberry, which makes it an adequate option for feeding caprines.

TABLE 7

Nutritive value of two six year-old mulberry clones[1] (Basaglia, 1993).

Clone/cutting	Digestibility		Metabolizable protein (%)	Biological value (%)	Nitrogen balance (g)
	DM	CP			
FM86	74.8	76.7	76.6	99.9	14.7
FMSM	73.8	78.0	77.9	99.9	14.9
45 days	77.5a	81.1a	81.0a	99.9a	16.6a
90 days	71.1b	73.6b	73.4b	99.8b	12.9b

[1]The experiment had a completely randomized factorial design 2 x 2 (mulberry clones x growth ages) with two cutting frequencies. Spacing was 3 x 0.6 m.

Source: Basaglia, 1993.

No significant differences were observed among clones, but the cutting frequency influenced the efficiency of mulberry as a feeding source for caprines. A better result was obtained at 45 days.

BIBLIOGRAPHY

Baffi, M.H. 1992. *Utilização da amoreira* (Morus alba L.) *cultivar Yamada para caprinos: Curva de crescimento e digestibilidade* in vitro. Trabalho apresentado a Faculdade de Ciências Agrárias e Veterinárias, UNESP, Campus de Jaboticabal, para graduação em Zootecnia. FCAV. UNESO, Jaboticabal, São Paulo, Brazil.

Basaglia, R. 1993. *Eficiência de utilização da proteína da amoreira* (*Morus alba*) *pelos caprinos e digestibilidade* in vitro. Trabalho apresentado a Faculdade de Ciências Agrárias e Veterinárias, UNESP, Campus de Jaboticabal, para graduação em Zootecnia. FCAV. UNESO, Jaboticabal, Sao Paulo, Brazil. 1993

Brazão, C.S., Takahashi, R., Sugohara, A. & Resende, K. T. 1992. *Curva de crescimento e composição bromatológica da amoreira* (Morus alba L.) IV Congresso de Iniciação Científica da UNESP, Araçatuba, Sao Paulo, Brazil - 27 a 29 de agosto de 1992

Guideli, C., Resende, K. T., Takahashi, R., Sugohara, A. & Reis, R. A.

1993. *Produção de cultivares de amoreira* (*Morus alba* L.) *em diferentes idades de crescimento, durante o verão*. V Congresso de Iniciação Científica da UNESP. Depto de Zootecnia, FCAV, Jaboticabal, Sao Paulo, Brazil.

Hara, C. H. 1993. *Produção e digestibilidade* in vitro *da matéria seca e proteína de cultivares de amoreira* (*Morus alba* L.) - Trabalho apresentado a Faculdade de Ciências Agrárias e Veterinárias, UNESP, Campus de Jaboticabal, para graduação em Zootecnia. FCAV - UNESO, Jaboticabal, Sao Paulo, Brazil.

Resende, K. T.; Sugohara, A.; Takahashi, R; Reis, R. A. & Brazão, Claudia S. 1992. *Produção de matéria seca de cultivares de amoreira* (Morus alba L.) *no outono, visando sua utilização na alimentação de ruminantes*. Anais da XXIX Reunião Anual da SBZ - Lavras, MG, Brazil.

Resende, K. T.; Takahashi, R.; Sugohara, A.; Brazão, Claudia S.; Reis, R. A. & Vasconcelos, V. R. 1994a. *Composição bromatológica de cultivares de amoreira* (*Morus alba* L.). 1 - Estação de inverno. Anais da XXXI Reunião Anual da SBZ, Maringá, PR, Brazil.

Resende, K. T.; Takahashi, R.; Sugohara, A.; Brazão, Claudia.; Reis, R. A. & Vasconcelos, V. R. 1994b. *Composição bromatológica de cultivares de amoreira* (*Morus alba* L.). 2 - Estação da primavera. Anais da XXXI Reunião Anual da SBZ, Maringá, PR, Brazil.

Resende, K. T.; Takahashi, R.; Sugohara, A.; Reis, R. A., Hara, C. & Vasconcelos, V. R. 1994c. *Produção e digestibilidade de cultivares de amoreira* (*Morus alba* L.). 1 - Estação de inverno. Anais da XXXI Reunião Anual da SBZ, Maringá, PR, Brazil.

Schmidek, A. 1999. *Composição bromatológica e degradabilidade em caprinos, de cultivares de amoreira* (Morus alba L.) Trabalho apresentado a Faculdade de Ciências Agrárias e Veterinárias, UNESP, Campus de Jaboticabal, para graduação em Zootecnia. FCAV - UNESO, Jaboticabal, SP, Brazil.

Sugohara, A., Resende, K. T., Takahashi, R., Magario, K. e Reis, R. A. 1994a. *Composição bromatológica da amoreira* (Morus alba L.), *cultivar Yamada, em diferentes idades de crescimento*. Anais da XXXI Reunião Anual da SBZ, Maringá, PR, Brazil.

Sugohara, A., Resende, K. T., Takahashi, R., Guideli, C., Reis, R. A. & Vasconcelos, Vânia R. 1994b. *Composição bromatológica de cultivares de amoreira* (Morus alba L.). 3 - Estação de verão. Anais da XXXI Reunião Anual da SBZ, Maringá, PR, Brazil.

Sugohara, A., Resende, K. T., Takahashi, R., Guideli, C., Reis, R.A. & Vasconcelos, Vânia R. 1994c. *Produção e digestibilidade de cultivares de amoreira* (Morus alba L.). 3 - Estação de verão. Anais da XXXI Reunião Anual da SBZ, Maringá, PR, Brazil.

Takahashi, R., Sugohara, A., Resende, K. T., Reis, R. A. & Brazão, C. S. 1992. *Produção de matéria seca de cultivares de amoreira* (Morus alba L.) *no inverno, visando sua utilização na alimentação de ruminantes*. Anais da XXIX Reunião Anual da SBZ - Lavras, MG, Brazil.

Takahashi, R., Sugohara, A., Resende, K. T., Reis, R. A. & Vasconcelos, V. R. 1994. *Produção e digestibilidade de cultivares de amoreira* (Morus alba L.). 1 - *Estação da primavera*. Anais da XXXI Reunião Anual da SBZ, Maringá, PR, Brazil.

Tilley, J. M. & Terry, R. A. 1993. A two stage for the in vitro digestion of forage crops*. J.Br.Grassland Soc*. 18: 104-111.

Vasconcelos, V. R., Resende, K. T., Sugohara, A., Costa, R. G. & Takahashi, R. 1994. *Características de degradação da matéria seca e proteína bruta da amoreira* (Morus alba L.) *por caprinos*. Anais da XXXI Reunião Anual da SBZ, Maringá, PR, Brazil.

Supplementation of grazing dairy cattle with mulberry in Costa Rica

J. Benavídes, I. Hernández, J. Ésquivel, J. Vasconcelos, J. González
and
E. Espinosa
Tropical Agriculture Research and Higher Education Centre
(CATIE)
Turrialba
Costa Rica

INTRODUCTION

In Costa Rica and other tropical countries, because of many species of trees and shrubs have good forage characteristics because of the high nutrient of their forage and their capacity for producing large amounts of biomass per unit area (Benavides, 1991; Reed, 1991). The use of this forage helps to reduce dependency on imported inputs for feeding livestock (Romero *et al*., 1991).

Among woody forages, mulberry (*Morus* sp.) is exceptional, since its leaves have more than 20 percent CP and *in vitro* DM digestibility (IVDMD) between 70-80 percent (Benavides, 1994). Jegou *et al*. (1991) reported *in vivo* digestibility of 79 percent for DM and 89 percent for CP. Under humid tropical conditions, with 4 harvests per year, 30 tonnes of DM per year, with 60 percent edible material, have been obtained (Benavides, Lachaux and Fuentes, 1994). Oviedo (1995) stated that in association with poró (*Erythrina poeppigiana*), mulberry can produce up to 7.2 tonnes of edible DM/ha by applying poró foliage as green manure.

Supplementing with mulberry only the milk yield of grazing dairy cows in the humid tropics did not differ significantly from that obtained with commercial concentrate supplementation (Oviedo, 1995). The objective of this experiment was to test the effect of different levels of concentrate substitution by mulberry on milk production with genetically superior cows.

MATERIALS AND METHODS

The trial was conducted in a dairy farm at Coronado (San José, Costa Rica) at 1 471 m above sea level, with an annual mean temperature of 16.7°C and rainfall of 2 892mm (Chinchilla, 1987). Six Holstein cows with two or more calvings, an initial production of 18 kg of milk per day and 485 kg of body weight were used. On a DM basis, the supplementation treatments were: commercial concentrate (T1); 35 percent mulberry and 65 percent concentrate (T2); and 65 percent mulberry and 35 percent concentrate (T3).

A Latin-square, simple changeover, 3 x 3 design (Lucas, 1957) with two repetitions, was utilized. Each period lasted 21 days (16 for adaptation and five for measurements). Supplementation was at the level of 1.3 percent of body weight on a DM basis at the beginning of each period.

The experimental animals grazed with the rest of the cows on Kikuyo grass (*Pennisetum clandestinum*) which had patches of African star grass (*Cynodon nlemfuensis*). Supplements offered and refused were measured individually and sampled for DM CP and *in vitro* DM digestibility determinations. Chromic oxide was used as a marker for grazing intake estimations (Lascano, 1990). In addition to milk yield, intakes of DM and CP were measured and digestible energy (DE) calculated. Milk samples were analysed for fat, protein and total solids.

RESULTS AND DISCUSSION

Mulberry used in this experiment had less CP compared to previous reports (Benavides, Lachaux and Fuentes, 1994), who reported values over 20 percent. IVDMD and DE were high and comparable to reports from the same authors, 85.0 percent y 3,75 Mcal/kg MS, respectively (Table 1).

TABLE 1

Dry Matter, crude protein, digestible energy and *in vitro* dry matter digestibility of feeds utilized for dairy cows

Feed	DM (%)	CP (%)	IVDMD (%)	DE[1] (Mcal/kg DM)
Kikuyo grass	23.0	8.0	65.0	2.9
Mulberry	25.4	16.1	80.0	3.5
Concentrate	91.5	17.7	85.0	3.7

[1] DE = (IVDMD x 4 409)/100.

The nutritional value of mulberry was better than Kikuyo grass and slightly better than the concentrate. It was also superior to other supplements traditionally used in dairies, such as sugar cane (4.9 percent CP, 2.9 Mcal DE/kg DM), bananas (4.8 percent CP, 3.1 Mcal DE/kg DM) and poultry manure (19.2 percent CP, 1.4 Mcal DE/kg DM) (Vargas, 1984).

Intakes of DM were adequate for animal type and production level. Although there were no significant differences among treatments, total intake decreased with increasing levels of mulberry (Table 2), possibly due to the greater rumen fill of the bulky fresh mulberry. The intake was smaller than that reported by Oviedo (1995), of 3.8 percent of liveweight on a DM basis when supplementing dairy cows under humid tropical conditions. Similar intakes of CP (1.9; 1.8 and 1.7 kg/day, for each level) and DE (50.6; 48.0 and 44.3 Mcal/day) were observed.

TABLE 2

Effect of mulberry supplementation on DM intake of grazing dairy cows

Feed	**Ratio concentrate/mulberry**		
	100/0	**60/40**	**25/75**
	DM, kg/animal/day		
Concentrate	6.4	4.2	1.9
Mulberry	0	2.8	5.5
Kikuyo grass	9.3^{a}	7.8^{ab}	6.2^{b}
Total	15.7	14.8	13.6
	DM, % body weight		
Concentrate	1.3	0.8	0.4
Mulberry	0	0.5	1.1
Kikuyo grass	1.7^{a}	1.6^{ab}	1.2^{b}
Total	3.0	2.9	2.7

Despite a slight decrease in intake, there were no significant differences ($P < 0.05$) in milk quality and yield due to supplement substitution (Table 3). Oviedo (1995) did not find significant differences in milk production and in composition when concentrate was replaced by mulberry (1.03 percent body weight on DM basis) in dairy cows in the humid tropics.

TABLE 3

Milk yield and quality of dairy cows with different proportions of concentrate and mulberry

Parameter	Ratio concentrate/mulberry		
	100/0	63/35	35/65
Milk, kg/animal/day	14.2	13.2	13.8
Milk protein, %	3.0	3.0	2.9
Milk fat, %	3.6	3.6	3.5
Total solids, %	12.7	12.6	12.5

Partial analysis of income and costs, considering only feed costs, indicated a higher net income and better benefit:cost ratio per animal when mulberry replaced concentrates (Table 4).

TABLE 4

Partial benefit:cost ratio per animal when supplementing with

concentrate and/or mulberry on grazing dairy cows (in colones[2]**).**

Item	Ratio concentrate/mulberry[1]	
	100/0	35/65
Concentrate	135 983	40 561
Cut & carry mulberry		54 626
Manure spreading		6 400
Depreciatión[3]		6 010
Total costs	135 983	107 560
Total income	307 343	298 694
Net income	171 361	191 096
Profitability, percent	56	64

[1] Considering only feed costs. [2] December 1995. [3] Depreciation in ten years the establishment cost for mulberry
Source: Ramos, 1996

CONCLUSIONS AND RECOMMENDATIONS

Substituting mulberry for concentrates in supplements for grazing dairy cows did not affect milk yield or quality. Mulberry use can decrease feeding costs and the need for concentrates. It is advisable to carry out longer-term studies to establish the real potential for mulberry in complete lactations and to evaluate its effect on reproductive parameters.

BIBLIOGRAPHY

Benavides, J. E. 1991. Integración de árboles y arbustos en sistemas de alimentación para cabras en América Central: un enfoque agroforestal. *El Chasqui* (*C.R.*), No. 25: 6-36.

Benavides, J. E., Lachaux, M. & Fuentes, M. 1994. Efecto de la aplicación de estiércol de cabra en el suelo sobre la calidad y producción de biomasa de Morera (Morus sp.) In: *Arboles y arbustos forrajeros en América Central*, p. 495-514. Technical Report No. 236. Vol. 2. Turrialba, Costa Rica, CATIE.

Chinchilla, E. 1987. *Atlas Cantonal de Costa Rica*. Vol.1. San José C P IFAM. 396 p.

Jegou, 0., Nicolas J., Waelput, J.J. & Brunschwig, G. 1991. Consumo, digestibilidad y ciclo del nitrógeno del follaje de Morera (Morus sp.) y Amapola (*Malvaviscus arboreus*) con cabras lactantes. In: *Seminario Internacional de Investigación en cabras* (1., 1991, El Zamorano, Hond.). Memorias. SRN. p. irr.

Lucas, H.L. 1957. Extra-period Latin-square change over designs. *J. Dairy Sci*. 40: 225-239.

Mora, J.A. 1996. *Indicadores de impacto ambiental: Plan de mejoramiento ambiental de la Cuenca del río Virilla, Costa Rica*. Tesis Mag. Sc., Turrialba, Costa Rica, CATIE. 173 p. (thesis)

Oviedo, F. 1995. *Morera* (Morus *sp.*) *en asocio con poró* (Erythrinna poeppigiana) y *como suplemento para vacas lecheras en pastoreo*. Turrialba Costa Rica, CATIE. 87pp. (thesis)

Oviedo, F.J., Benavides, J.E. & Vallejo, M. 1994. Evaluación bioeconómica de un módulo agroforestal con cabras en el trópico húmedo. In: *Arboles y arbustos forrajeros en América Central*. p. 495-514. Technical Report No. 236. Vol. 2. Turrialba, Costa Rica, CATIE.

Ramos, J.A. 1996. *Indicadores de impacto ambiental. Plan de mejoramiento ambiental de la Cuenca del río Virrilla, Costa Rica.* Turrialba, CR, CATIE 176p.

Reed, J. 1991. Características de las plantas tropicales que determinan el valor nutritivo. In: Ganadería y recursos naturales en América Central: estrategias para la sostenibilidad. (1991, San José, C.R.). 1994. [Memorias]. Homan, E.J. (ed). CATIE, Turrialba. p. 195-206.

Romero, F.; Benavides J.; Kass, M. y Pezo, M. 1991. Utilización de Arboles *y* arbustos en sistemas de producción de rumiantes. In: *Ganadería y recursos naturales en América Central: estrategias para la sostenibilidad*. Turrialba, CATIE. p. 207-220.

Vargas, L. 1984. *Tabla de composición de alimentos para animales de Costa Rica.* San José, Costa Rica, Editorial 90 pp.

Nutritional quality of mulberry cultivated for ruminant feeding

Carlos F. Boschini
Experimental Station Alfredo Volio Mata
University of Costa Rica, Tres Ríos, Costa Rica

INTRODUCTION

Dairy husbandry phases the challenge of improving production and feeding systems. It is hoped that future models have as their basis a sustainable focus and a rational use of natural resources (Castro and Benavides, 1994). Mulberry, although originally from Asia, has adapted excellently to the tropics of Central America (Benavides, Lachaux and Fuentes, 1994; Rodriguez, Arias and Quiñones, 1994; Boschini, Dormond and Castro, 1998) and gives very high yields. For forage production, mulberry has shown excellent characteristics of palatability and, consequently, high intakes by cattle (Benavides, Lachaux and Fuentes, 1994; Ortiz, 1992; Castro, 1989). The literature reports that the whole plant contains between 14-22 percent crude protein on DM basis (Piccioni, 1970) and *in vitro* digestibility between 70 to 80 percent (Ortiz, 1992). The mulberry samples analysed by the UFAG Laboratories in Switzerland, from the high zone of Cartago in the Central Plateau of Costa Rica, gave on a DM basis, 22 percent of crude protein (CP), 19 percent of crude fibre (CF), 2.3 percent of ether extract, 50 percent of by-pass protein and an estimated 1.48 Mcal/kg of net energy for lactation. Eswara and Reddy (1992) when evaluating the nutritive value of mulberry leaves, reported DM intakes of 2.74 and 3.55 percent of liveweight in goats and sheep, respectively, with 12 percent CP and 71 percent TDN.

The nutritional value of mulberry is in its leaves. However, being a shrub, biomass supply is considered an important aspect when used in animal feeding. Boschini, Dormond and Castro (1998) reported leaf:stem ratios above 1, before 100 days of growth. Leaf:stem proportion varies with cultivation and management conditions, plant density and cutting frequency. The whole mulberry plant, once chopped, is offered to cattle. This represents a mixture of leaf and stem which the animal selects during consumption. For this reason it is necessary to know precisely chemical composition of leaves and stems. The results of the influence of plant density, cutting height and frequency on the chemical composition throughout the year in a high tropical environment are presented here.

ENVIRONMENTAL CONDITIONS, MANAGEMENT AND HARVEST

Research was conducted at the Dairy Cattle Experimental Station "Alfredo Volio Mata" at the University of Costa Rica. The station is located at 1 542 m above sea level, and has a mean rainfall of 2 050 mm, distributed during the months of May to November. From December to mid-May, there is no rainfall. Mean temperature is 19.5ºC and relative humidity 84 percent. The soil is volcanic, classified as Typic Distrandepts (Vásquez, 1982). It is characterized by its medium depth, good natural drainage and medium fertility (7.7 of Ca, 3.0 of Mg, 1.54 cmol/l of K, 10.0 of P, 28.8 of Cu, 234 of Fe, 6.3 of Mn and 2.6 mg/l of Zn). The pH is 5.9. Ecologically, the zone typifies as low mountain humid forest (Tosi, 1970, cited by Vásquez, 1982).

Agricultural practices, seeding conditions and management were described by Boschini, Dormond and Castro (1998). The plantation was left to grow for one year, during which weeding was practised and fertilization with ammonium nitrate was applied at the rate of 150 kg of N/ha/year in two equal doses (July and October). The following year in May, the three plots received a standardization cut, with scissors, half of the plot at 30 cm and half at 60 cm from the ground. From that date, cuts were given every 56 days (6 cuts), 84 days (4 cuts) or 112 days (3 cuts), during the experimental period of 336 days. After each cut, the plots were weeded, leaving the needs between rows. When the shoots reached 3-5 cm (approximately two weeks after harvest) they were fertilized with ammonium nitrate at a dose equivalent to 150 kg of N/ha/year.

Mulberry samples were collected at each spacing, cutting height and frequency. The branches were weighed fresh in the field, and then the leaves and stems were separated and weighed. Each sample was dried in the oven at 60 ^{o}C for 48 hours until weight was constant. The samples were then milled and subjected to DM (at 105ºC), crude protein (Kjeldall) and total ash (AOAC, 1980) determinations. NDF), ADF and lignin were analysed by the method described by Goering and Van Soest (1970). Hemicellulose and cellulose values were obtained by difference. DM and chemical fractions were analysed with PROC GLM of the statistical package SAS (1985). Variation sources with statistical significance were subjected to the Duncan test to differentiate the significance among means.

BROMATOLOGICAL COMPOSITION OF HARVESTED FORAGE

The chemical composition of leaves and stem as affected by planting density, cutting height and frequency are presented in Table 1. DM percentage in the fresh forage was very constant (P >0.05) in leaves for the different planting densities. Cutting height and frequency did not influence DM percentage (P >0.05). However, the difference in DM content between 30 and 60 cm in cutting height was less than 1 percent. There were no differences in DM percentage between 56 and 84 days, and only 2.3-3 percent between them and 112 days. Crude protein content showed very little differences (P <0.05) between spacings and cutting heights. These variations were accentuated (P <0.01) between cutting frequencies, decreasing two to three percent for every 28 days from eight weeks growth. Planting densities did not influence (P >0.05) cell walls, ADF, hemicellulose, cellulose, lignin and total ash. Cell wall and total ash showed very small differences between cutting heights. Hemicellulose, ADF, cellulose and lignin showed not significant differences (P >0.05) between cutting heights. Cutting height influenced cell wall and total ash (P <0.01), ADF and cellulose (P <0.05). Changes in hemicellulose and lignin were not significant (P>0.05) with height.

The interaction planting density and cutting frequency was significant (P <0.01) for leaf DM content and its content of protein and minerals. The structural fractions were not affected (P <0.01) by the group effect (Table 2). In Table 3, the chemical composition of leaves and stems planted at different spacing and harvested at different heights are presented. DM, CP, cell walls, hemicellulose and total ash all had an interaction effect (P <0.05) due to these variables. ADF and its components were not affected. The associated effects of cutting height and frequency (Table 4) on chemical composition were significant for CP, cell wall (P <0.01) and total ash (P <0.01). Contents of DM, NDF components and hemicellulose did not show important variations.

Table 5 presents the values of leaf chemical components detailed by cutting number within each frequency. The effect was highly significant (P<0.01) for all chemical fractions studied. The highest level interaction, density by cutting height, influenced DM, CP and total ash (P <0.01). None of the structural carbohydrates showed important variations.

TABLE 1

Leaf and stem chemical composition (% DM) of mulberry at three spacings, two cutting heights and three frequencies

Factor	DM	CP	NDF	Hem.	ADF	Cel.	Lignin	Ash
				Leaf				
Spacing								
60 cm	24.5	23.7[a]	33.5[a]	9.2[a]	24.4[a]	18.5[a]	5.8[a]	16.7[a]
90 cm	24.5	23.5[a]	32.4[a]	8.3[a]	24.1[a]	19.1[a]	5.1[a]	24.5[a]
120 cm	24.8	23.2[b]	32.6[a]	8.6[a]	24.1[a]	18.7[a]	5.4[a]	24.8[a]
Height								

30 cm	24.1	23.8^{a}	33.5^{a}	9.4^{a}	24.1^{a}	18.9^{a}	5.3^{a}	17.0^{a}
60 cm	25.1	23.1^{b}	32.1^{b}	7.9^{b}	24.2^{a}	18.7^{a}	5.6^{a}	16.5^{b}
Frequency								
56 days	24.1	25.6^{a}	34.3^{a}	9.1^{a}	25.2^{a}	19.5^{a}	5.7^{a}	16.1^{a}
84 days	23.7	22.2^{b}	32.3^{b}	8.8^{a}	23.5^{b}	18.6^{a}	4.9^{a}	16.9^{b}
112 days	26.8	20.8^{c}	30.7^{c}	7.6^{a}	23.1^{b}	17.4^{b}	5.7^{a}	18.1^{c}
				Stem				
Spacing								
60 cm	23.2^{a}	8.7^{a}	63.2^{a}	14.5^{a}	48.7^{a}	40.0^{a}	8.7^{a}	8.2^{a}
90 cm	23.4^{a}	8.8^{a}	63.2^{a}	14.5^{a}	48.8^{a}	40.5^{a}	8.3^{a}	8.3^{a}
120 cm	24.9^{b}	8.8^{a}	64.4^{a}	16.3^{b}	48.1^{a}	39.6^{a}	8.5^{a}	7.7^{b}
Height								
30 cm	23.4^{a}	8.8^{a}	63.6^{b}	14.8^{a}	48.8^{a}	40.2^{a}	8.6^{a}	8.0^{a}
60 cm	24.2^{b}	8.8^{a}	63.6^{a}	15.4^{a}	48.2^{a}	39.8^{a}	8.4^{a}	8.1^{a}
Frequency								
56 days	20.9^{a}	10.7^{a}	59.0^{a}	15.7^{a}	36.6^{a}	43.3^{a}	6.7^{a}	10.0^{a}

84 days	23.6^{b}	7.8^{b}	65.9^{b}	12.7^{b}	43.2^{a}	53.2^{b}	10.0^{b}	7.1^{b}
112 days	30.0^{c}	6.3^{c}	69.8^{c}	17.0^{c}	42.7^{b}	52.7^{b}	10.1^{b}	5.5^{c}

[1] On a DM basis; a,b,c = significant differences (P <0.05)

DM in stems did not show important variations (P >0.05) between planting densities. Between cutting height there was a difference (P <0.05) of less than 1 percent and between cutting frequencies there were significant variations (P <0.01). CP content was very constant (P >0.05) between densities and cutting heights. Cutting frequency influenced (P <0.01) CP very clearly. Cell wall, ADF and its components cellulose and lignin, did not show important variations (P <0.05) between planting densities, but hemicellulose and total ash were affected slightly (P<0.05). Cutting height did not influence stem structural carbohydrates or total ash. Cutting frequency had a marked effect (P <0.01) on cell wall and its components, and on total ash.

TABLE 2

Leaf and stem chemical composition (% dry matter) of mulberry cultivated at three planting distances and harvested at three cutting frequencies.

Spacing	Frequency	DM	CP	NDF	Hem.	ADF	Cel.	Lignin	Ash

(cm)	(days)								
					Leaf				
60	56	24.4	25.9	35.0	10.1	24.8	19.3	5.5	16.3
60	84	23.2	22.5	33.5	9.6	23.9	18.4	5.4	16.6
60	112	26.3	20.9	30.6	6.5	24.1	16.8	7.2	17.6
90	56	24.8	25.8	33.4	8.6	24.9	19.3	5.5	16.1
90	84	23.2	22.0	31.3	7.3	24.1	18.6	4.4	17.0
90	112	25.6	21.0	31.6	8.9	22.6	17.7	4.9	18.0
120	56	23.1	25.1	34.5	8.6	25.9	19.9	6.0	15.9
120	84	24.6	22.3	31.9	9.5	22.5	17.8	4.8	16.9
120	112	28.5	20.6	29.8	7.3	22.5	17.6	4.9	18.6
					Stem				
60	56	21.4	10.6	58.5	15.7	42.8	36.4	6.4	9.9
60	84	21.2	7.8	64.9	11.4	53.4	42.9	10.5	7.6
60	122	29.6	6.3	70.3	16.1	54.3	43.4	10.9	5.5
90	56	21.2	10.7	58.6	14.9	43.7	37.1	6.7	10.2
90	84	23.0	7.8	66.1	12.3	53.8	44.3	9.4	7.2
90	112	28.2	6.3	68.7	16.6	52.1	42.2	9.9	5.7
120	56	20.1	10.8	59.8	16.5	43.3	36.2	7.1	9.7

120	84	26.6	7.6	66.7	14.4	52.4	42.4	10.0	6.5
120	112	32.1	6.3	70.2	18.3	51.9	42.4	9.5	5.3

TABLE 3

Leaf and stem chemical composition (percent of DM) of mulberry cultivated at three planting distances and harvested at two cutting heights

Spacing (cm)	Height (cm)	DM	CP	NDF	Hem.	ADF	Cel.	Lignin	Ash
					Leaf				
60	30	24.6	33.9	33.9	9.6	24.2	18.8	5.4	17.3
60	60	24.4	23.4	33.2	8.6	24.5	18.3	6.3	16.1
90	30	23.5	23.7	32.0	8.2	23.8	18.7	5.1	17.2
90	60	25.6	23.3	32.8	8.3	24.4	19.4	5.0	16.4
120	30	24.3	23.5	34.8	10.4	24.4	19.1	5.4	16.5
120	60	25.3	22.9	30.5	6.8	23.7	18.3	5.4	17.2
					Stem				
60	30	23.0	8.8	62.7	13.7	49.0	40.3	8.7	8.3
60	60	23.5	8.7	63.7	15.2	48.4	39.8	8.6	8.0
90	30	23.3	9.0	63.2	15.2	48.0	39.6	8.4	8.2

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
90	60	23.5	8.7	63.3	13.8	49.5	41.3	8.1	8.3
120	30	24.0	8.7	64.9	15.5	49.4	40.7	8.6	7.5
120	60	25.8	8.9	63.8	17.1	46.8	38.4	8.4	7.9

TABLE 4

Leaf and stem chemical composition (percent of DM) of mulberry harvested at two cutting heights and three cutting frequencies

Height (cm)	Freq. (days)	DM	CP	NDF	Hem.	ADF	Cel.	Lignin	Ash
					Stem				
30	56	23.6	25.8	35.0	10.0	25.0	19.7	5.4	16.5
30	84	23.0	22.8	34.0	10.2	23.8	18.5	5.4	17.0
30	112	26.8	21.0	29.9	7.2	22.8	17.7	5.2	18.1
60	56	24.6	25.4	33.6	8.3	25.4	19.3	6.0	15.7
60	84	24.4	21.7	30.5	7.4	23.1	18.7	4.4	16.7
60	112	26.9	20.6	31.4	8.0	23.4	17.2	6.2	18.0
					Stem				
30	56	21.5	10.7	58.9	15.2	43.7	37.0	6.7	9.9
30	84	22.0	7.9	66.0	12.3	53.7	43.4	10.2	7.2

30	112	29.2	6.2	69.7	17.2	52.6	42.4	10.2	5.4
60	56	20.3	10.7	59.1	16.2	42.9	36.2	6.7	10.0
60	84	25.2	7.6	65.8	13.1	52.7	43.0	9.7	7.0
60	112	30.7	6.4	69.8	16.9	52.9	42.9	10.0	5.6

The interaction between density and cutting frequency (Table 2) was significant (P <0.01) for stem DM but CP, ash and structural carbohydrates were not. Table 3 shows the chemical composition of the stem of plants at different densities and cutting heights. Hemicellulose, ADF and cellulose were affected by the associated action of these factors significantly (P <0.01). Other components were not affected. When analysing the interaction of cutting height and frequency on stem chemical composition (Table 4), only DM was affected (P <0.01). Table 5 presents stem chemical composition by harvest number at each cutting frequency. The analysis showed that harvest numbers within each frequency had a significant effect (P<0.01) on all chemical components studied. The interaction between density and cutting frequency only affected stem DM content (P <0.05).

The general chemical composition (mean and standard deviation) of the experiment was: DM 24.6 percent (±2.24); CP 23.5 percent (±0.59); NDF 32.8 percent (±3.87); hemicellulose 8.7 percent (±3.85); ADF 24.2 percent (±2.76); cellulose 18.8 percent (±2.46); lignin 5.4 percent (±2.21) and total ash 16.8 percent (±0.75) in leaves and DM 23.8 percent (±2.01); CP 8.8 percent

(±0.66); NDF 63.6 percent (±2.8); hemicellulose 15.1 percent (±2.8); ADF 48.5 percent (±2.99); cellulose 40.0 percent (±2.78); lignin 8.5 percent (±1.13) and total ash 8.0 percent (±0.88) in the stems.

TABLE 5

Leaf and stem chemical composition (percent of DM) of mulberry harvested at three cutting frequencies by cut number

Freq. (days)	Cut #	DM	CP	NDF	Hem.	ADF	Cel.	Lignin	Ash
					Leaf				
56	1	22.0	27.9	37.4	15.3	22.0	17.8	4.2	15.4
56	2	22.0	27.6	46.0	10.2	35.8	28.6	7.2	16.7
56	3	26.6	23.9	33.9	9.8	24.1	17.9	6.3	16.0
56	4	25.6	24.5	27.8	5.4	22.4	16.5	5.9	16.6
56	5	24.0	24.1	30.6	7.4	23.2	17.5	5.6	16.8
56	6	24.4	25.7	30.2	6.5	23.6	18.7	4.9	15.0
84	1	15.8	24.7	34.5	10.4	24.1	18.7	5.4	15.8
84	2	25.0	21.1	35.7	12.7	23.0	18.1	5.1	17.9
84	3	26.2	22.1	26.9	4.1	22.9	18.5	4.4	17.3
84	4	27.8	21.0	31.8	8.0	23.8	19.2	4.6	16.5
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

112	1	26.3	22.1	32.8	8.9	23.9	16.9	7.0	17.3
112	2	26.9	20.6	28.3	6.3	22.0	16.7	5.4	19.6
112	3	27.2	19.8	30.9	7.6	23.3	18.7	4.6	17.4
					Stem				
56	1	17.3	13.4	63.2	18.1	45.2	38.3	6.9	9.7
56	2	17.1	11.3	60.1	35.1	25.1	19.4	5.7	10.1
56	3	21.1	10.3	57.6	11.5	46.1	38.5	7.6	10.3
56	4	23.6	9.8	57.9	10.5	47.4	41.0	6.4	10.5
56	5	22.4	9.44	58.5	9.3	49.2	42.5	6.7	9.7
56	6	24.0	10.0	56.7	9.8	46.9	39.8	7.1	9.4
84	1	13.8	8.9	68.9	14.5	54.3	44.2	10.1	6.9
84	2	22.3	8.6	62.7	12.0	50.7	41.5	9.2	8.2
84	3	25.7	7.0	65.6	11.0	54.6	43.7	10.9	6.8
84	4	32.6	6.5	66.4	13.3	53.2	43.5	9.7	6.6
112	1	27.3	6.9	70.4	19.3	51.1	41.9	9.2	5.2
112	2	28.2	6.9	69.2	14.9	54.3	43.7	10.6	6.0
112	3	33.9	5.2	69.6	16.8	52.8	42.4	10.4	5.2

EXPECTED QUALITY VARIATIONS AND OTHER FORAGE COMPARISONS

The chemical composition of leaf and stem and their variations have been indicated previously. Planting density produced significant variations on leaf CP and stem DM, hemicellulose and total ash. However, differences were slight from the biological point of view. The rest of the components showed very narrow variation from the mean. In general, spacing did not influence the nutrients present in leaf and stem. Cutting height statistically also affected leaf DM, CP, cell wall, ADF and total ash, but only stem DM. These differences were less than 1 percent, which are not biologically important to favour a certain cutting height. Contrary to what had been found for planting density and cutting height, cutting frequency had a significant effect on nutrient accumulation, except for leaf hemicellulose and lignin. At frequent cuttings, leaf and stem CP and leaf cell wall were high. At longer cutting, stem NDF and all cell wall components increased. Total ash in leaves increased with cutting interval, whereas the opposite occurred with the stem.

Chemical composition was very different between leaf and stem, except for the percentage of DM. Leaf CP was three times that of the stem, and leaf cell wall and ADF were half. Cellulose was 75 percent of ADF in leaf and 80 percent in stem. Lignin was 25 percent of ADF in the leaf and 20 percent in the stem. Mulberry had two to three times more ash in leaves than in stem. Piccioni (1970) reports, on DM basis, mulberry leaf CP of 16 percent, ether extract 4.1 percent, cellulose 6.9 percent and ash 11 percent. Rodríguez, Arias and Quiñones (1994) found CP concentrations of 21 percent without fertilizer and 24 percent with 80 kg of N/ha after each 6-week harvest.

Increasing cutting frequency to 12 weeks, leaf CP decreased to 18 percent without fertiliser and to 16 percent with fertiliser. Eswara and Reddy (1992) reported DM and CP values of 30 percent and 14.5 percent respectively.

When comparing mulberry with tropical and subtropical grasses, CP is higher than in alfalfa (17 percent), young Orchard grass (15 percent), Pangola grass (1 percent) and Elephant grass (9 percent). Mulberry leaf has 33 percent NDF and the stem 64 percent, whereas alfalfa has 40 percent, Orchard grass 55 percent, Pangola grass 70 percent and Elephant grass 72 percent (Van Soest, 1992), Mulberry stem at 112 days has a cell wall equal to or smaller than any tropical grass. Lignin in subtropical grasses varies between 4-8 percent and in tropical grasses between 7 and 8 percent, whereas mulberry has 5.5 percent in the leaves and 8 percent in the stem. It can be deducted that mulberry leaf is superior to any subtropical forage and that mulberry stem compares to tropical grasses. Considering that net energy for lactation in cattle (Weiss, 1998; Traxler *et al*., 1998) is calculated from TDN from lignin content in NDF or ADF, the high digestibility of mulberry is confirmed (Rojas and Benavides, 1994; Eswara and Reddy, 1992). Table 6 presents hemicellulose, cellulose and NDF for leaf and stem. Lignin represents between 15 and 18 percent of leaf cell wall and between 11 and 15 percent of stem cell wall, which is used to estimate the high digestibility of both fractions.

The main limitation of the use of mulberry stem as feed is not related to chemical quality per se but to the physical form in which it is offered to animals for their use. Many tropical feeds, rspecially in dry periods, are inferior to mulberry stem in terms of quality. Mulberry leaf, properly dried and ground, is of excellent quality and its characteristics make it most suitable for inclusion in compounded feed for highly producing dairy cattle.

TABLE 6

Hemicellulose, cellulose and lignin in the neutral detergent fibre (NDF) or cell wall of mulberry leaf and stem

Factor	NDF (% DM)	Hemi. (% of NDF)	Cellulose (% of NDF)	Lignin (% of NDF)	Hem. Cellulose
Spacing (cm)					
60	33.5	27.3	55.2	17.5	0.50
90	32.4	25.5	58.9	15.6	0.43
120	32.6	26.3	57.4	16.5	0.46
Height (cm)					
30	33.5	28.0	56.2	15.9	0.50
60	32.1	24.6	58.0	17.3	0.42
Frequency					

Frequency (d)					
56	34.3	26.6	56.9	16.6	0.47
84	32.3	27.2	57.8	15.2	0.47
112	30.7	24.8	56.7	18,5	0.44
Spacing (cm)					
60	63.2	22.9	63.3	13.7	0.36
90	63.2	22.9	64.0	13.1	0.36
120	64.4	25.3	61.5	13.3	0.41
Height (cm)					
30	63.6	3.2	63.2	13.5	0.37
60	63.6	24.2	62.6	13.2	0.39
Frequency (d)					
56	59.0	26.6	73.4	11.4	0.36
84	65.9	19.3	80.7	15.1	0.24
112	69.8	24.4	75.6	14.5	0.32

IMPLICATIONS AND RECOMMENDATIONS

Leaf CP and cell wall contents, together with structural carbohydrates and ash, indicate that mulberry is an excellent feed for high yielding animals, and can be offered fresh or dried in compounded feeds. Stem composition is very similar to tropical grasses. Experimental factors influenced DM chemical composition. Planting density and cutting height produced small variations in leaf and stem composition. Although cutting frequency produced greater variation, the differences in DM, CP, structural carbohydrates and total ash were less than 3 percent between the smallest and the longest interval. In the stem, the largest change was of 9 percent and occurred in DM, cell wall and in structural carbohydrates, such as cellulose. The number of cuts within the yearly cycle produced a variation in chemical composition, which should be considered when feeding mulberry. Under tropical conditions, industrial mulberry production for compounded feeds needs further study.

BIBLIOGRAPHY

AOAC. 1980. *Methods of analysis*. Ed. 13. Washington DC, Association of Official Analytical Chemists.

Benavides, J., Lachaux, M. & Fuentes, M. 1994. Efecto de la aplicación de estiércol de cabra en el suelo sobre la calidad y producción de biomasa de Morera (*Morus sp.*). *Arboles y arbustos forrajeros en América Central,* p. 495-514. Technical Report No. 236. Vol. 2. Turrialba, Costa Rica, CATIE.

Boschini, C., Dormond, H. & Castro, A. 1998. Producción de biomasa de morera (*Morus alba*) en la Meseta Central de Costa Rica, establecida y cosechada a diferentes distancias de siembra, alturas y frecuencias de poda. *Agronomía Mesoamericana,* 9(2): 28-39.

Castro, A. 1989. *Producción de leche de cabras alimentadas con King grass* (*Pennisetum purpureum* x *P. typloides*), suplementales con diferentes niveles de follaje de Poró (*E. poeppigrama*) y de fruto de plátamo va de (*Musa sp*. var. Pelipita). Turrialba, Costa Rica, University of Costa Rica/CATIE. 58 pp. (thesis).

Castro, A. & Benavides, J. 1994. Evolución de los sistemas de alimentación en explotaciones caprinas de Costa Rica. *Arboles y arbustos forrajeros en América Central*, p. 245-250. Technical Report No. 236. Vol. 2. Turrialba, Costa Rica, CATIE.

Eswara, P. & Reddy M.R. 1992. Nutritive value of Muberry (*Morus alba*) leaves in goats and sheep. *Indian J. Anim. Sci.,* 8(4): 295-296.

Goering, H.K. & Van Soest, P.J. 1970. *Forage fiber analysis* (*apparatus, reagents, procedures and some applications*). Agricultural Handbook No. 379. Washington, DC, ARS-USDA.

Ortiz, G. 1992. *Efecto de la alimentación con pasto King grass* (Pennisetum purpureum x P. typhoides), *suplementado con diferentes niveles de follaje de morera* (Morus alba) *y de banano verde* (Musa sp.) *sobre la producción de leche de cabra*. Escuela de Zootecnia. University of Costa Rica. 45pp.

Piccioni, M. 1970, *Diccionario de alimentación animal,* p. 492-494. Saragossa, Editorial Acribia.

Rodríguez, C. Arias, R. & Quiñones J. 1994. Efecto de la frecuencia de poda y el nivel de fertilización nitrogenada, sobre el rendimiento y calidad de la biomasa de Morera (Morus sp.) en el trópico seco de Guatemala. *Árboles y arbustos forrajeros en América Central, p. 515-528*. Technical Report No. 236. Vol. 2. Turrialba, Costa Rica, CATIE

Rojas, H. & Benavides, J. 1994. Producción de leche de cabras alimentadas con pasto y suplementadas con altos niveles de morera (Morus sp). *Arboles y arbustos forrajeros en América Central,* p. 305-319/Technical Report No. 236. Vol. 1. Turrialba, Costa Rica, CATIE.

SAS Cary, NC 1985. SAS User´s Guide: Statistics (Version 5 Ed.) SAS Institute Inc. Cary, NC. Statistical Analysis System.

Traxler, M.J., Fox, D.G., Van Soest, P.J., Pell, A.N., Lascano, C.E., Lanna, D.P.D., Moor, J.E., Lana, R.P., Velez, M. & Flores, A. 1998. Predicting forage indigestible NFD from lignin concentration. *J. Anim.Sci*. 76

(5): 1469-1480.

Van Soest, P.J. 1982. *Nutritional ecology of the ruminant*. Dortland, USA, Durham and Downey, Inc.

Vásquez, A. 1982. *Estudio detallado de los suelos de la Estación Experimental de Ganado Lechero El Alto*. Escuela de Fitotécnia, Facultad de Agronomía, Universidad de Costa Rica. 36 pp.

Weiss, W.P. 1998. Estimating the available energy content of feeds for dairy cattle. *J. Dairy Sci.,* 81(3): 830-839.

Utilization of mulberry as animal fodder in India

R.K. Datta, A. Sarkar, P. Rama Mohan Rao and N.R. Singhvi
Central Sericultural Research and Training Institute,
Central Silk Board, Sriramapura,
Mysore, India

INTRODUCTION

Production of green fodder on cultivated land is not very common in India, because of its low economic return. Furthermore, the lack of sufficient arable land with irrigation facilities also restricts fodder production. Such a situation is more acute in the hilly areas of the country. The huge cattle population in areas depends only on the leaves of certain tree species. Trees have the advantage that they can be planted on hills, on wasteland and at the edges of ponds, and canals, etc. Trees can also be grown on boundaries where regular crops cannot be grown. They have the potential to produce as much green fodder per unit area as agricultural fodder crops. Trees do not need to be watered since they can extract water through their deep and extensive root system. The abilities of trees to extract water from deep underground layers and to withstand drought are outstanding advantages over agricultural fodder crops. Trees also do not need such heavy inputs in the form of fertilizers, pesticides, fungicides and labour, as are needed for growing agricultural crops.

Of all the tree species used as fodder, mulberry (*Morus* sp.) occupies a significant place as it grows anywhere, either in the form of have tree or shrub. Mulberry is believed to have originated in the foothills of the Himalayas and has been exploited for rearing silkworm in China since at least 3 500 BC. Sericulture then spread to India and to other countries. Although mulberry is the only food for the silkworm, its casual use as animal feed has also been known for a long time.

DISTRIBUTION OF MULBERRY

Mulberry is distributed throughout the world as it has enough plasticity to survive under disruptive environmental conditions. At least 30 countries are now producing raw silk with mulberry and silkworms. In some of these countries, the use of mulberry leaf as fodder has also been adopted. Mulberry can be grown successfully in all conditions, even in tropical, subtropical and temperate climates. It can survive with rainfall ranging from 400-4 500 mm per annum. Although the optimum temperature for growth is between 18 and 30°C, mulberry can survive even when the temperature goes beyond 48°C or below 0°C.

Mulberry can therefore be considered a universal plant, which can grow anywhere under varied climatic conditions. Although this does not guarantee successful silkworm rearing, the plant’s wide adaptability can be exploited in plantations, fully or partly, for animal feed.

MULBERRY AS ANIMAL FEED

The important role of green leaves in supplementing animal feed is unquestionable. In the developing countries, cereal straws and grasses are fed to animals, but they cannot support full performance because of their poor nutritive value. In most places where concentrates are also provided, the diet is not balanced. Mulberry leaf supplementation can improve the efficiency of the whole diet.

In addition, because of increasing pressure from the human population and to higher incomes earned from cereal and cash crops rather than from forage crops, more agricultural land cannot be set aside for fodder production. Another consequent advantage of mulberry is that it can be grown either as a tree or a shrub and harvested several times a year.

In countries such as India, where mulberry is primarily grown for sericulture, excess leaves and leftovers are fed to cattle, sheep and goats. In hilly areas, where mulberry trees are abundant, their leaves are fed to animals. Of the different species available, *Morus alba* and other species that are suitable for silkworm rearing are cultivated in the plains and on hilly ground.

Morus serrata, Morus laevigata and *Morus australis* are grown in the hills. Because of their deep root system, the leaves remain green for most of the year, except in winter when the leaves fall.

As a result of the above advantages, mulberry can be considered as a perennial source of feed for most of the year.

Mulberry fodder is considered to be of good quality (Majumdar, Momin and

Kehar, 1967a, b). Leaf yield varies with nutrient supply and irrigation. In general, under irrigation with the recommended dose of fertilizer, mulberry yields nearly 35-45 tonnes of fresh leaf/ha/year. On a dry matter basis, leaves contain an average of 20-23 percent CP, 8-10 percent, total sugar, and 12-18 percent minerals. The leaves contain nearly 70 percent moisture. The cell wall constituents are neutral detergent fibre 45.6 percent, cell contents 54.4 percent, acid detergent fibre 35.0 percent, hemicellulose 10-40 percent, lignin 10 percent, cellulose 21.8 percent and silica 2.7 percent (Lohan, 1980). The contents of minerals are as follows: magnesium, 0.52-1.25 percent; chlorine, 0.02-0.29 percent; sulphur, 0.18-0.76 percent; potassium 0.93-3.19 percent and sodium 0.13-0.23 percent (Majumdar *et al*., 1967*a*, b). Tannin accounts for 0.85 percent in leaf DM. The chemical composition of the leaves varies from season to season. In hilly areas where the plants are not pruned repeatedly the protein content gradually decreases from February onwards, and minimum values are found in December when leaf fall starts. Like nitrogen, phosphorus also shows the same trend, its maximum content being in February.

Mulberry leaf stalks and leftovers, after silkworm feeding, are generally fed to cattle. Their composition on a DM basis is 11.5 percent CP, 34.0 percent CF, 76.5 percent total carbohydrate, 9.3 percent total ash, 1.6 percent Ca and 0.2 percent P. The calculated values were 70.8 percent for digestible CP, 48.4 percent for total digestible nutrients and 35.6 percent for starch equivalent on a dry basis. The balance of N, Ca and P were positive and animals also gained weight (Subba Rao, Amrith Kumar and Sampath, 1971).

A trial feeding of mulberry leaves to sheep was conducted by Jayal and Kehar (1962). The digestible nutrients of leaves on a DM basis were 10.7 percent for CP, 8.3 percent for CF and 39.6 percent for total digestible nutrients.

Narayana and Setty (1977) indicated that incorporation of 6 percent shade-dried mulberry leaves with poultry feed increased egg production.

MULBERRY AS CATTLE FEED

To ascertain the effect of feeding leftover mulberry leaves with stalks, a study was conducted by the authors during 1999-2000 at Kolar, the traditional sericultural area of Karnataka (India) with hybrid milk cows (local x Jersey) at the farmer level. Twenty farmers, who regularly feed mulberry leftover leaves and stalks after silkworm feeding, were selected. In general, only one feeding of mulberry leaves at noon was carried out. There was a control group of ten cows. On average, 15-20 kg of either full mulberry leaves (if there were any in excess after rearing) or leftover leaves with stalks were fed to the cows.

In the case of the control group, the same feeding schedule was followed except at noon, when mulberry leaves were replaced by cereal straw. The amount of feed supplied at different times is shown in Table 1.

TABLE 1

Schedule of feeding and quantity of feed given to milk cows.

Feeding time	Control feed		Mulberry feed	
		kg		kg
06:00h	Fodder grass	15	Fodder grass	15
11:00h	Finger millet grass	20	Finger millet grass	20
13:00h	Rice straw	15	Mulberry	15
22:00h	Concentrate	10	Concentrate	10

Farmers provided mulberry leaves (either leftovers or full) only once a day. It was found that animals did not have any reluctance in accepting mulberry as feed. Records were kept on milk yield, fat percentage and time required for next pregnancy for both the groups. The data collected were subjected to statistical analysis (T test) to study the significance of feeding mulberry leaves. The total quantity of feed was constant for both groups (Table 1). Animal performance data are presented in Table 2.

The study clearly shows that mulberry improved feed quality significantly. Nearly 34 percent higher milk yield was recorded when mulberry was provided once a day. Milk yield was found to increase both morning and evening, although the improvement was found to be more pronounced evening milking. Fat content was higher in cows fed mulberry (3.50 against 2.94 percent).

Interestingly, cows fed mulberry conceived 24 days. However, 25 percent of farmers believe that continuous feeding with mulberry can cause termination of pregnancy in some cases for unknown reasons. Experiments are required to study this theory.

TABLE 2

Comparison of normal feeds vis-à-vis partial mulberry feeds with respect to economic characters in hybrid cows (local x Jersey)

Group	Milk yield (litres)			Fat %	Days to conception
	Morning	Evening	Total		
Control (n = 10)	8.4	6.7	15.1	2.94	100
Mulberry (n = 20)	11.0	9.2	20.2	3.50	77
"t" value	9.203	9.366	9.747	21.43	19.56
Significance	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01

CONCLUSION

Production of green fodder on cultivated land is constrained by difficulties in setting aside sufficient cultivable area for fodder production, lack of irrigation facilities and other inputs; and low economic returns compared to cash crops. Mulberry trees that can be grown under varied climatic condition, including fallow and wastelands not fit for agriculture can be used, totally or partly, for producing nutritious green fodder. The study conducted by this Institute directly with farmers proved that feeding mulberry as part of the daily ration of cows, improved the quality and quantity of milk and reduced calving intervals.

BIBLIOGRAPHY

Jayal, M.M. & Kehar, N.D. 1962. A study on the nutritive value of mulberry (*Morus indica*) tree leaves. *Indian J. Dairy Sci*., 15(1): 21-27.

Lohan, O.P. 1980. Cell wall constituents and in vitro DM digestibility of some fodder trees in Himachal Pradesh. *Forage Res.,* 6: 21-27.

Majumdar, B.N., Momin, S.A. & Kehar, N.D. 1967a. Studies on tree leaves as cattle fodder. 1. Chemical composition as affected by the stage of growth. *Indian J. Vet. Sci.,* 37(b): 217-223.

Majumdar, B.N., Momin, S.A. & Kehar, N.D. 1967b. Studies on tree leaves as cattle fodder. 2. Chemical composition as affected by the locality. *Indian J. Vet. Sci*., 37(4): 217-223.

Narayana, H. & Setty, S.V.S. 1977. Studies on the incorporation of mulberry leaves (*Morus indica*) in layers' mash. *Indian Vet. J.,* 56(9): 778-787.

Subba Rao, A., Amrith Kumar, M.N. & Sampath, S.R. 1971. Studies on mulberry (*Morus alba*) leaf stalk palatability, chemical composition and nutritive value. *Indian J. Vet. Sci*., 48: 853-857.

Mulberry leaf supplement for sheep fed ammoniated rice straw

Liu, J.X., Jun Yao, Yan, B. J., Z.Q.Shi and X.Q.Wang
College of Animal Sciences
Zhejiang University
Hangzhou, Zhejiang, China
and
J.Q. Yu
Animal Production and Health Station
Tongxiang, Zhejiang, China

INTRODUCTION

The use of crop residues as basal diets for fattening cattle and lambs has been promoted in China during the last decade with much success (FAO, 1995a; FAO, 1998b). Farmers generally supplement with high levels of concentrates, including cereal grains and oilseed meals. It is important to find alternative supplements (FAO, 1995b). With growing lambs, Liu *et al.* (1998) observed that the growth rate was dramatically increased when the ammonia bicarbonate rice straw (ABRS) diet was supplemented with small amounts of rapeseed meal (RSM), and that the benefits of ammoniation were least when a high level of RSM was used.

Sericulture, based on mulberry (*M. alba*) leaves, is an important farming activity in China, with over 106 ha planted in China and 105 ha in Zhejiang Province. Yield of fresh leaves is in the order of 15 to 22 tonnes/ha/year. Silk production is not always profitable, since it depends on price and world trade. Alternative ways of using mulberry foliage would be welcomed by farmers when income from sericulture is low. Mulberry leaves are relished by sheep and goats and have a high nutritive value with a protein content of about 20 percent of DM (FAO, 1998). Roothaert (1999) observed that dairy heifers had higher voluntary intake, and thus higher potential of milk production, when consuming mulberry fodder rather than the cassava tree (*Manihot glaziovii*) and Leucaena (Le*ucaena diversifolia*). Mulberry leaves could be considered an appropriate supplement for sheep fed a basal diet of ammoniated straw, replacing partially or totally the oilseed meals, which could then be used in monogastric diets. However, there is little information on this subject.

The objectives of the present study were: to evaluate the nutritional value of mulberry leaves collected from clones at different stages of maturity (Experiment 1); and to determine the effect of mulberry leaves as a supplement, substituting RSM, for growing lambs fed ABRS (Experiment 2). The results of Experiment 1 have already been published (Yao *et al.*, 2000).

MATERIALS AND METHODS

Experiment 1. Evaluation of the nutritional value of mulberry leaves

Sampling of mulberry leaves

Clones used were Tuantou Heyebai (TH), Husang No. 9 (HS), Tongxiangqing (TX) and Nongsang No. 8 (NS). Leaves were sampled six times in 1998, three in the spring (28 April, 14 and 29 May); and three in autumn (28 August, 30 September and 30 October). Samples were taken in the morning, weighed immediately and ovendried at 65ºC. Subsamples were milled to pass a 2 mm - sieve for further nutritional evaluation.

Nutritional evaluation

All samples were analysed for CP and true protein (TP) following AOAC (1990); for NDF (Van Soest, Robertson & Lowis, 1992). Amino acid (AA) contents were determined using an AA analyser (Knauer, Germany). The nutritional value of mulberry leaves was evaluated with *in vitro* gas production (GP) of Menke and Steingass (1988) with calibrated glass syringes (Model Fortuna, Häberle Labortechnik, Lonsee-Ettlenschieb, Germany). Samples for GP determination were ground with a hammer mill to pass a 1-mm-screen. About 200 mg (DM) samples were introduced into syringes with rumen liquor collected from two rumen fistulated Huzhou sheep, fed an ammoniated rice straw diet (75 percent ABRS, 5 percent RSM and 25 percent concentrate mixture). The GP data were then fitted to the equation GP=a+b(1-exp(-ct)) (FAO, 1985), where a, b and c are constants and GP is the gas production from the substrate at time t.

Statistical analysis

Results for each season were analysed according to a 3 x 4 factorial design. The difference of means was tested using Duncan's new multiple range test (Steel and Torrie, 1980).

Experiment 2. Effect of mulberry leaves replacing rapeseed meal on the performance of growing sheep fed ammoniated rice straw

Experimental feeds

The ABRS was prepared by the "stack method". Fertilizer grade ammonium bicarbonate (17% N) was used and the weight proportion of straw:bicarbonate:water was 100:10:30 (Liu *et al*., 1991). The straw was treated under ambient temperature (15-20^{o}C) for 30 days. The treated straw was then exposed to the air for a maximum of 24 hours before feeding to allow free ammonia to escape.

Mulberry leaves were collected at Tongxiang Silkwork Breeding Farm. All leaves were harvested in autumn (late October) and airdried before storage.

Animals and design

Forty-five growing Huzhou lambs (a local prolific breed) with an initial weight of 16-18 kg, were divided into five equal groups, according to sex and weight, and randomly allocated the following treatments:

A: 100 g RSM
B: 75 g RSM + 60 g mulberry leaves
C: 50 g RSM + 120 g mulberry leaves
D: 25 g RSM + 180 g mulberry leaves
E: 240 g mulberry leaves

Supplementation with RSM at 100 g/day was based on the result in a previous study (Liu *et al*., 1998). All five supplementary treatments were calculated to have similar CP content. All animals had ABRS, mineralized salt block and water ad libitum and 100 g/head/day of ground maize.

Feeding trial

The experimental period lasted 75 days (15 days for adaptation). The lambs were weighed, before the morning feeding, every 15 days. Feed intake was recorded daily. Feed samples were periodically taken for CP and NDF analysis. The ruminal degradation of DM and CP for RSM and mulberry leaves was measured using the nylon bag technique of Ørskov (FAO, 1985) as by Liu *et al*. (1997). Data of disappearance rate were fitted to the model of Ørskov (FAO, 1985): $p=a+b(1-\exp(-ct))$, where p is the disappearance rate at time t (hour), a is the rapidly digestible fraction in the rumen, and b is the fraction slowly digested at rate c ($c>0$).

In vitro gas production test

GP, as described above, was measured to compare the nutritional value of different diets. In order to analyse the associate effect on GP parameters, only the mixtures of RSM and mulberry leaves at different ratios were also incubated. The proportions of both supplements for different combinations (PA, PB, PC, PD and PE) were based on their ratios in the corresponding diets (A, B, C, D and E) in feeding trials.

Statistical analysis

The results were analysed by one-way analysis of variance. The difference of means for the five treatments was tested by using Duncan's new multiple range test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Composition of mulberry leaves

The chemical composition of mulberry leaves is shown in Table 1. There were no significant differences (P >0.05) among mulberry clones in DM, CP, TP and NDF (for spring leaves). Only the clone Tuantou Heyebai had lower NDF (P <0.05) in the autumn. Sampling time (maturation stage) had a great effect on chemical compositions. For spring leaves, contents of CP and TP were slightly higher at mid stage than at early or late stage, whereas the CP content of autumn leaves decreased significantly (P <0.05) with maturation. The NDF content increased with maturation (P <0.05) in both seasons.

Little seasonal differences were found in the contents of CP and TP of mulberry leaves. Average CP contents were 21.1 and 20.9 percent of DM, and the TP accounted for 88.2 and 85.8 percent of CP in spring and autumn, respectively. However, the NDF content was lower for mulberry leaves in spring (38.8 percentDM) than for those in autumn (41.4 percent). Except for a few amino acids (AA), no significant difference (P >0.05) was observed in individual AA content among clones (data not included). There were little differences in total, essential or non-essential AA among clones. AA content tended to increase with the time, but the differences showed no statistical significance.

TABLE 1

Chemical composition of mulberry leaves in spring and autumn

Sample	Dry matter (%)	Crude protein (% DM)	True protein (% CP)	NDF (% DM)
Spring leaves				
Date				
28 April 98	25.1	21.1[ab]	87.5	34.6[Bc]
14 May 98	25.2	21.9[a]	90.4	38.9[Aa]
29 May 98	26.6	20.0[b]	86.3	42.9[Aa]
Clone				
Tuantou Heyebai	24.4	21.6	86.7	39.5
Husang No. 9	24.1	20.9	89.6	37.5
Tongxiangqing	23.7	20.9	88.3	39.7

Nongsang No. 8	23.6	20.8	88.5	38.5
SE	0.10	0.17	1.16	0.59
Autumn leaves				
Date				
28 August 98	25.9^{C}	22.3^{A}	86.9	36.7^{Bc}
30 September 98	29.9^{B}	21.4^{A}	85.7	40.4^{Bb}
30 October 98	33.8	18.9^{B}	84.7	47.2^{Aa}
Clone				
Tuantou Heyebai	30.4	21.9	84.4	38.9^{b}
Husang No. 9	29.7	20.3	86.4	40.8^{ab}
Tongxiangqing	29.6	19.6	87.5	42.6a
Nongsang No. 8	29.8	21.7	84.9	43.4a
SE	0.42	0.23	0.57	0.46

A,B,C Means with different superscripts within mulberry trains or sampling times differed ($P < 0.01$).

a,b,c Means with different superscripts within mulberry trains or sampling times differed ($P < 0.05$).

Nutritional value of mulberry leaves

The nutritional value of mulberry leaves based on the GP test is presented in Table 2. In spring, clone Nongsang No 8 had higher nutritive value ($P < 0.05$). There was little difference between clones in the GP24 and potential GP for autumn leaves, though rate of GP was slightly higher for clones Nongsang and Tongxiangqing. The estimated organic matter digestibility (OMD) (Menke and Steingass, 1988) showed a similar tendency to GP parameters (Table 2). Similar to CP content (Table 1), mid-spring samples tended to have a higher GP ($P < 0.05$) than early or late sampling, while for autumn leaves the GP in late season was lower ($P < 0.05$), with little difference between those at early and middle season.

In general, the nutritional value of spring leaves was much higher than autumn leaves. The spring mulberry leaves with OMD of 65.6-71.3 percent are comparable with some leguminous hays such as alfalfa and vetch (FAO, 1998). According to farmers' practice, the twigs of mulberry trees must be cut and modified in late May or early June in order assure to ensure leaves for the silkworm. These twigs and leaves may be dried and stored for winter use.

TABLE 2

In vitro gas production (GP) parameters and estimated organic matter digestibility (OMD) of mulberry leaves

Sample	GP at 24 hours(ml)	Potential GP (ml)	Rate of GP (% h-1)	OMD (%)
Spring leaves				
Date				
28 April 98	43.7[ab]	47.8[ab]	9.70	69.2[ab]
14 May 98	46.9[a]	52.2[a]	8.79	71.3[a]
29 May 98	38.5[b]	43.3[b]	9.25[ab]	65.6[b]
Clone				
Tuantou Heyebai	41.9[ab]	45.7[ab]	7.26	69.1[ab]
Husang No. 9	43.1[ab]	47.4[ab]	9.02	68.8[ab]
Tongxiangqing	39.6[b]	43.9[b]	8.90	65.9[b]
Nongsang No. 8	47.6[a]	52.7[a]	9.50	71.9[a]
SE	0.94	1.04	0.11	0.74

Autumn leaves				
Date				
28 August 98	32.5^{a}	38.7	7.15^{A}	61.4^{Aa}
30 September 98	31.7^{ab}	38.3	6.69^{AB}	60.3^{ABa}
30 October 98	28.7^{b}	35.4	6.18^{B}	56.3^{Bb}
Clone				
Tuantou Heyebai	31.0	37.8	6.57^{ab}	60.0
Husang No. 9	30.8	38.0	6.16^{b}	58.8
Tongxiangqing	30.8	36.7	7.01^{a}	58.4
Nongsang No. 8	31.3	37.4	6.95^{a}	60.1
SE	0.55	0.60	0.11	0.47

^{A,B,C} Means with different superscripts within mulberry trains or sampling times differed ($P < 0.01$).

^{a,b,c} Means with different superscripts within mulberry trains or sampling times differed ($P < 0.05$).

Dry Matter intake

CP and NDF contents for mulberry leaves used in feeding trials were 23.0 and 43.7 percent DM, and the corresponding values for RSM were 42.3 and 51.1 percent DM, and for ABRS, 13.3 and 63.9 percent DM, respectively. The rumen degradation results are shown in Table 3. The rates of disappearance of DM were higher for mulberry leaves than for RSM, but those of CP were lower. CP fractions degrading rapidly (a) or slowly (b) were much lower for mulberry leaves than for RSM. Rumen escape protein was higher in mulberry leaves than in RSM.

TABLE 3

Constants of DM and crude protein of the equation $p=a+b(1-\exp(-ct))$ together with 48 hour rumen degradability (D_{48}) of rapeseed meal and mulberry leaves

	Rapeseed meal		**Mulberry leaves**	
	DM	**CP**	**DM**	**CP**
a (%)	19.2	32.6	20.5	19.5
b (%)	47.9	67.4	53.9	50.2
c (%/hour)	2.70	2.07	3.10	2.57

se	2.07	2.50	0.65	0.84
a+*b* (%)	67.1	86.5	74.4	69.7
ED[a] with passage rate at				
2.00 percent/hour	46.7	66.9	53.3	47.7
4.00 %/hour	38.5	55.6	44.0	39.1
D_{48} (%)	54.5	76.2	62.1	54.9

[a] ED = effective degradability.

Animals consumed all rapeseed meal, ground maize and mulberry leaves offered. The intake of ABRS was slightly increased when supplementing with the mulberry leaves, and hence the total intake increased with the increase in mulberry leaves (Table 4). Total DM intakes were 451, 455, 495, 540 and 590 g/day for lambs on diets A, B, C, D and E, respectively. Basal ammoniated straw accounted for more than 50 percent of total diets in all treatments, and intake from forage exceeded 85 percent of total diets when the RSM was fully substituted by mulberry leaves (diet E). Intake of the basal diet is usually decreased because of a substitution effect when a straw-based diet is supplemented with forage. Tharmaraj *et al*. (1989) observed a decline in the DM intake of both ammoniated and untreated RS when supplemented with *Gliricidia*, a leguminous tree. Liu *et al*. (1997) found that inclusion of milk vetch silage at a level higher than 23 percent of diets reduced the intake of ammoniated rice straw by growing heifers. In the present study the mulberry leaves accounted for 11, 21, 29 and 35 percent of dietary DM intake in diets B, C, D and E, but the ABRS intake was even slightly increased with the rising amounts of mulberry leaves.

TABLE 4

Dry matter intake and growth performance of lambs.

Parameter	**Diets (g Mulberry: g RSM)**				
	0:100	**60:75**	**120:50**	**180:25**	**240:0**
N^{o} of animals	9	9	9	9	9
Feed intake (g DM/day)					
Rapeseed meal	88	66	44	22	0
Mulberry leaves	0	52.30	104.50	156.60	209.00
Ground corn	86	86	86	86	86
Ammoniated rice straw	277.10	250.50	260.60	275.80	295.60
Total intake	451.10	454.80	495.10	540.40	590.60
Initial weight (kg)	18.00	17.70	17.80	16.20	18.40
Growth rate (g/day)	58±4 ^{a}	47±8 ^{b}	40±6 ^{c}	46±5 ^{b}	55±3 ^{a}

Feed efficiency (kg/kg)					
Total intake/gain	7.78	9.67	12.37	11.75	10.74
Concentrate/gain	3.00	3.23	3.25	2.35	1.56
Feed cost/kg gain	4.56	5.39	6.25	5.38	4.47

[1] Price (yuan/kg): ammoniated rice straw 0.20; RSM 1.20; maize 1.20; mulberry leaves 0.40. US$1 = 8.25 Yuan.

[a,b,c] Means with different superscripts differ (P <0.05).

Lamb performance

Lamb growth rates are shown in Table 4. The growth rate in diets with only RSM was comparable to that obtained in a previous trial (63 g/day) by Liu *et al*. (1998), who supplemented ABRS diet with 100g RSM and 100g rice bran. The animals supplemented with mulberry leaves grew the same as those with RSM, but the growth rates were lower (P <0.05) when both supplements were given together. There was no difference among sex and groupings (Figure 1). In the limited literature on mulberry leaves as animal feeds, Leng (1997) mentioned that dairy cows achieved up to 18 litres of milk/day on forage supplemented with fresh mulberry foliage. In his perspective, the production rate on high intakes of tree foliages such as mulberry may be as good as those of cattle on ammoniated straw and supplemented with 1-1.5 kg/day of cottonseed meal.

Figure 1. Growth rate of lambs offered ammoniated rice straw diets supplemented with different combinations of rapeseed meal and mulberry leaves

While feed efficiency was higher when receiving only RSM, concentrate consumption per kg of weight gain was lower when a higher level of mulberry leaves was supplemented. Compared with other treatments, feed cost per kg gain was lower in the diets with only RSM or mulberry, the lowest in the latter. When mulberry leaves were used as the supplement to substitute for RSM, there was a benefit of 0.09 yuan/day (US$1=8.25 yuan), equivalent to yuan 9.00 for the usual fattening period of 100 days.

Relationship between lamb performance and gas production

The results of *in vitro* GP tests for different diets are summarized in Table 5. The GP for diets with low levels of mulberry (B and C) was lower than for other diets. The potential GP (a+b) was significantly higher in diet with only RSM ($P < 0.05$). The GP48 value showed a similar trend to the potential GP, although the difference between diets was not statistically significant. These results suggest a negative associative effect between rapeseed and mulberry leaves.

TABLE 5

Parameters of in vitro gas production (GP) for different experimental diets

Parameters	Diets (g Mulberry: g RSM)					SE
	0:100	**60:75**	**120:50**	**180:25**	**240:0**	
a (ml)	2.5	3.0	2.0	1.7	2.9	0.3
b (ml)	36.4	33.3	32.9	33.6	34.4	3.6
a+*b* (ml)	38.9 ^{a}	36.3 ^{bc}	34.5 ^{c}	35.6 ^{bc}	37.7 ^{ab}	1.4
Rate of GP,%/hour	3.56	4.01	4.38	5.33	4.43	0.07
GP_{48} (ml)	31.2	30.0	29.4	31.5	31.5	4.5

^{a,b,c} Means with different superscripts differ (P<0.05).

Table 6 presents the result of GP tests when only mixtures of mulberry leaves and RSM were incubated. The potential GP and rate of GP for mulberry leaves (PE) were higher than for RSM (PA), but the GP parameters were not improved proportionally when mulberry leaves were increased (PB and PC). There was apparently a negative associative effect between mulberry leaves and RSM (Figure 2) where the estimated GP values were much lower than the measured ones. This may partially account for the growth rate of lambs offered different diets (Table 4). There may be some secondary plant compounds in mulberry leaves that exert a detrimental effect on ruminal microbes or reduce the utilization of the dietary nutrients (Leng, 1997). Further study is needed to clarify these aspects.

TABLE 6

Parameters of *in vitro* gas production of mixtures of mulberry leaves and rapeseed meal

Treatment	**PA**	**PB**	**PC**	**PD**	**PE**
Mulberry:RSM	**0:100**	**41:59**	**68:32**	**86:14**	**100:0**
GP parameters					
a (ml)	3.3	2.9	2.7	1.1	-0.2
b (ml)	29.1	29.5	32.4	38.0	41.7
a+b (ml)	32.4	32.4	35.1	40.1	41.5
c (%/hour)	4.22	4.41	5.92	6.15	6.10
GP_{48} (ml)	27.7	28.3	32.7	37.3	39.2

IMPLICATIONS

Mulberry leaves have a high nutritional content, which is higher in spring than in autumn. When used as a supplement for an ammoniated rice straw diet, the mulberry berry may fully substitute for rapeseed meal, but attention should be paid to the negative associative effect between rapeseed meal and mulberry leaves when supplemented together. The benefits resulting from supplementation with mulberry leaves included an increased intake of basal diet, less consumption of concentrate and an increased income. However, the growth rate of lambs on the ammoniated straw diets in the present study were not very high, regardless of the supplement. One of the reasons may be that straw intakes were not high. Further study is needed to investigate the response to the increasing percentage of mulberry leaves in diets for lambs.

Figure 2. Comparison of measured gas production (potential GP) with the estimated value at different proportions of rapeseed meal and mulberry leaves

ACKNOWLEDGEMENTS

This work was funded by the International Foundation for Science (Grant Agreement No B/2720-1). The authors express their sincere gratitude to T.R. Preston and René Sansoucy for their kind advice, to Dr C.F. Lou for his permission to sample the mulberry leaves from his experimental trees, and to Ms. Jinmei Zhou for her assistance in mulberry leaves sampling. Thanks are also given to the staff at the Shimen Silkworm Breeding Farm and the Tongxiang Station of Animal Production and Health for their assistance in

feeding trials.

BIBLIOGRAPHY

AOAC, 1990. *Official Methods of Analysis*, 15th ed. Vol 1. AOAC. Washington,DC, 69-90 Association of Official Analytical Chemists,

FAO. 1985. Evaluation of crop residues and agro-industrial by productgs using the nylon bag method, by E.R. Ørskov. In *Better utilization of crop residues and by-productgs in animal feeding: research guidelines. 1. State of knowledge, p. 153-162.* FAO Animal Production and Health Paper No. 50/1. Rome.

FAO. 1995a. Treated straw for beef production in China. *World Animal Review,* 82:101.

FAO. 1995b. *Tropical Animal feeding - a manual for research workers*. FAO Animal Production and Health Paper No. 126. Rome. *http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/FRG/AHPP126/ahpp126.htm*

FAO. 1997. *Tree foliage in ruminant nutrition*. Animal Production and Health Paper 139. FAO, Rome *http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/FRG/Aph139/aph139.htm*

FAO, 1998a. Animal Feed Resources Information System from the original book named Tropical Feeds by Bo Göhl - database by Andrew Speedy and Nick Waltham. 8th Edition. FAO, Rome. *http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/FRG/TFEED8/index.htm*

FAO. 1998b. New developments in livestock system based on crop residues in China. In: The 2rd FAO Electronic Conference on Tropical Feeds - Livestock Feed Resources within the Integrated Farming Systems, 09 September 1997-18 February 1998. *http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/FRG/conf96.htm/guo.htm*

Liu, J.X., Chen, Z.M., Yu, J.Q., Fei, B.R., Wang, W.D. &, Zhang, J.F. 1998. Effect of ammonium bicarbonate treatment and rapeseed meal supplementation on growth rate of Huzhou lambs receiving rice straw, *Livestock Research for Rural Development*, 10(2). http://www.cipav.org.co/lrrd/lrrd10/2/liu102.htm

Liu, J.X., Xu, N.Y., Wu, Y.M., Dai, X.M. & Han, Y.G. 1991. Ammonia bicarbonate as a source of ammonia for improving the nutritive value of rice straw. *China Feed* (*Suppl.*), 87-92. (in Chinese)

Liu, J.X., Ye, J.A., Ye & H.W. 1997. The effects of supplementary Chinese milk vetch silage on growth rate of cattle and their intake of ammoniated rice straw. *Anim. Feed Sci. Technol*., 65: 79-86.

Menke, K.H. & Steingass, H., 1988. Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen liquid. *Animal Research and Development*, 28: 7-55.

Roothaert, R. L.. 1999. Feed intake and selection of tree fodder by dairy heifers. *Anim. Feed Sci. Technol*., 79(1-2): 1-13.

Steel, R.D.G. & Torrie, J.H. 1980. *Principles and procedures of statistics*. New York, McGraw-Hill. p. 137- 191, 236-372.

Tharmaraj, J., Vander, H.R., Sewalt, V.J.H. & Schiere, J.B., 1989. Overcoming the nutritional limitation of rice straw for ruminants. 4. Urea treatment and supplementation with Gliricidia for growing Sahiwal bulls. *Aust.J.Agric.Res*., 2(2): 85-90.

Van Soest, P.J., Robertson, J.B. & Lowis, B.A., 1992. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *J.Dairy Sci.,* 74: 3583-3597.

Yao, J., Yan, B., Wang, X.Q. & Liu, J.X. 2000. Nutritional evaluation of mulberry leaves as feeds for ruminants. *Livestock Research for Rural Development*, Vol.12 http://www.cipav.org.co/lrrd/

Mulberry for rearing dairy heifers

F. Uribe Trujillo
Médico Veterinario Zootecnista
Hacienda Lucerna Ltda.
Bugalagrande, Valle, Colombia

INTRODUCTION

Mulberry (*Morus* sp.) foliage, characterized by its high digestibility and good protein content, has great possibilities for use in animal feeding, both for ruminants and for monogastrics.

Manuel Vicente de la Roche introduced mulberry to Colombia in 1868, but its propagation only started in 1970 when the Colombian Coffee Growers Federation decided, as part of its diversification programmes, to destine resources for the study and adaptation of mulberry in the coffee regions of Caldas, Risaralda and Cauca. Kanva 2 (*M. indica*) is the most widespread variety in the country (Federación Nacional de Cafeteros de Colombia, 1984).

CULTIVATION

The ideal soil for mulberry should have medium texture, with 60 cm in depth, phreatic level of at least 1 m, good drainage, pH 6-7 and good organic matter. Mulberry does not tolerate flooding.

Mulberry is reproduced asexually. Stakes should be 15-20 cm in length and 18-20mm in diameter. It is important to use matured stems (more than three months of age), with stakes chosen from the middle part.

Direct planting is not recommended because of high failure, high weeding cost and low resistance to the dry period. Rooting is done on 1.20 m x 0.10 m beds, where stakes are planted with a spacing of 10 x 20 cm, burying two-thirds of the stake. Beds are covered with a plastic sheet to control humidity and weeds. After 45 days, the plastic is cut to allow aeration. The operation should last two to three months. Transplanting is carried out by pulling the plants from the bed, removing the leaves and once planted, by pruning to 10-15 cm.

Recommended density lies between 25 and 32 000/ha (e.g. 80 x 40 cm; 80 x 50 cm; 90 x 40 cm). It is advisable to apply 50 kg of calcium phosphate and 400 g of organic matter per plant at transplanting.

Strict weed control is required during establishment since weeds are one of the mayor problems of the forage crop.

Three prunings are recommended: formation pruning (to 20 cm) after two or three months of transplanting, to shape the plant (productive crown) and to encourage shooting; regular harvests at 20-40 cm, 1 cm higher than the previous cut, every 75-90 days; and rejuvenating pruning (to 10-20 cm) after the plant has formed a multiple-shoot high crown called "deer's antlers" which has low productivity.

Forage production increases up to the third year (Cifuentes and Han, 1992), when yield reaches 30-50 tonnes of fresh leaves per year. At Hacienda Lucerna, the average production is 50t/ha/year of fresh leaves with 90 days cuts. In 1993, an evaluation was initiated with the combination of mulberry with Gliricidia sepium, mixed planted at a spacing of 40-60 cm between plants in double lines 1 m apart. The objective was to profit from the N fixation by Gliricidia. With this system annual yields of fresh foliage of 60t/ha of mulberry and 30t/ha of Gliricidia, have been obtained.

NUTRITIVE VALUE

Digestibilities between 80 and 93 percent have been reported for mulberry leaves and 50 percent for stems (Benavides, 1995). Velázquez (1992) found 205 ppm of Ca, 55 ppm of P, 6.0 ppm of Fe and 0.4 ppm of Zn.

Mulberry leaves (Kanva 2) from Hacienda Lucerna had 20.0 percent DM, 15.8

percent CP, 11.5 percent CF, 4.6 percent EE, 50.9 percent N-free extract and 17.3 percent ash, with a calculated net energy value of 2.4 Mcal/kg (González and Mejía, 1994).

ANIMAL RESPONSE

The work by Benavides (1995) with goats is a good example of the positive impacts achieved with woody plants, such as mulberry, during the last decade in Costa Rica. The use of larger quantities of mulberry is reflected in bigger flocks and better production.

In Guatemala, when feeding increasing levels of mulberry to young bulls on a base diet of sorghum silage, total intake and weight gains improved while consumption of salt and mineral decreased (Velázquez, 1992).

At Hacienda Lucerna a study was conducted in order to evaluate mulberry as partial replacement of concentrate in the rearing of diary heifers (Gonzalez and Mejía, 1994). The work consisted in the technical and economic evaluation with replacement heifers of tree levels (100, 75 and 50 percent) of commercial concentrate (with 16 percent protein), substituting 25 and 50 percent with fresh mulberry leaves. Thirty Lucerna (a criollo breed) heifers from five days old and 30 kg of weight were reared with the restricted suckling method for 112 days. Average weight gains were 0.406, 0.437 and 0.406 kg/day for the 0, 25 and 50 percent replacement, respectively.

From this experiment, the following conclusions were drawn:

- It is possible to replace 50 percent of commercial concentrate with mulberry without affecting heifer performance from zero to four months reared with restricted suckling.
- Offering mulberry leaves ad libitum, total DM intake is improved (see Table).
- The Mulberry leaves replace commercial concentrate, 25 percent of feeding costs are saved.
- These results show the importance of providing high-quality forage to induce rapid rumen development in heifers.

TABLE 1

Daily intake (kg) of heifers supplemented with fresh mulberry leaves

	Treatments (concentrate: mulberry)		
	100: 0	75: 25	50: 50
Total DM intake	0.372	0.514	0.415
Mulberry intake	0	0.307	0.299

Source: Gonzales and Mejía, 1994.

BIBLIOGRAPHY

Benavides. J.E. 1995. Arboles y arbustos forrajeros para las montañas americanas. In: *Sistemas pecuarios sostenibles para las montañas tropicales,*. p.103-123., Cali, Colombia, CIPAV.

Cifuentes, C.A. & Han, K.M. 1992. *Manual de sericultura. Plan Nacional de Rehabilitación.* Ed. Imprimiendo Ltda., Pereira, Colombia.

Federación Nacional de Cafeteros de Colombia. 1986. *Programa de desarrollo y diversificación de zonas cafeteras. Proyecto sericultura*. Santafé de Bogotá, Colombia.

Gómez, M.E., Rodríguez, L., Murgueitio, E., Ríos, C.I., Molina, C.H., Molina, E. & Molina, J.P. 1995. *Arboles y arbustos forrajeros utilizados en alimentación animal como fuente de proteína*. p.1-11. CIPAV, Cali, Colombia.

González, S.E. & Mejía, I. 1994. *Utilización de la morera* (Morus indica) *como reemplazo parcial del concentrado en la crianza de terneras*. Facultad de Zootecnia, Universidad Nacional de Colombia, Palmira, Colombia. (thesis).

Velázquez, C.M. 1992. *La morera como fuente de proteína en dietas a base* *de ensilado de sorgo para novillos en Cuyuta*. Facultad de Zootecnia, Instituto de Ciencia y Tecnología Agrícola, Guatemala. (thesis).

Bromatological composition and degradation rate of mulberry in goats

Anita Schmidek & R. Takahashi
Faculty of Agrarian and Veterinary Sciences
São Paulo State University, Jaboticabal Campus
São Paulo, Brazil
A. Nuñes de Medeiros
Depto. Agropecuária-CFT- UFPB-Campus IV
Bananeiras-PB, Brazil
K.T. de Resende
Faculty of Agrarian and Veterinary Sciences
São Paulo State University, Jaboticabal Campus
São Paulo, Brazil

INTRODUCTION

Mulberry, traditionally used as feed for silkworm, has been the subject of research at the Faculty of Agrarian and Veterinary Sciences, São Paulo State University (FCAV-UNESP), with the objective of feeding goats. Its favourable characteristics for a high intake by goats include: high protein content (similar to alfalfa), and good green biomass production (5-8 tonnes/ha/cut) throughout the year, including the dry season.

The *in situ* technique enables the degradation curve to be drawn and provides information for balancing diets, considering that, independently of the degradation potential of a feed, its efficiency of utilization by the animals is highly influenced by the matching or not of the degradation rates of protein and energy (Russel *et al*., 1991, cited by Sampaio *et al*., 1998).

The objective of this work was to analyse the nutritional value of mulberry clones by means of their bromatological composition and degradation rate in the goat rumen.

MATERIALS AND METHODS

The research was conducted in the Caprine Section using mulberry cultivated in the Sericulture Section at FCAV-UNESP, Jaboticabal Campus.

The bromatological composition of leaves of Miura, FM Shima-Miura and FM

86 clontes at 90 days of regrowth and of the incubation residue was determined following the recommendations by Silva (1981).

For the incubation, five Saanen male goats, of two years of age, were utilized with a ruminal cannula. Their diet was Tifton hay and mulberry hay ad libitum and 300 g of concentrate with 21 percent protein. After an adaptation period of 21 days, the incubations lasted 6, 12, 24, 48 and 96 hours.

The estimates of the degradation rate of DM, crude protein and neutral detergent fibre were obtained from disappearance percentage in the incubation periods.

The experimental design was randomized blocks, with split plots (mulberry clones) with five repetitions (animals) and five plots (incubation times). The different parameters studies were compared by the Tukey test at 5 percent probability.

RESULTS AND DISCUSSION

The bromatological composition of the five clones is presented in Table 1. The Miura clone showed the best values ($P < 0.05$) in organic matter (OM), total digestible nutrients (TDN), digestible energy (DE), NDF, hemicellulose and ash and lower contents of acid detergent fibre. Brazão (1992), studying the same cultivars and the same cutting frequency, obtained similar values for DM and CP, and an even lower NDF. The high contents of CP (2.7 percent), TDN

(80.1 percent) and DE (3.53 Mcal/kg DM) found in mulberry, indicate its high nutritive value. There are few forage plants comparable to mulberry, among them alfalfa with 22 percent CP. However, the estimated DE values indicate an energy: protein relation of 63.8 g of CP: 1 Mal of DE, which is higher than the NRC (1981) recommendation for goats, 32 g of CP: 1 Mcal of DE, suggest the need to conduct performance trials with mulberry in pure diets and/or like protein supplement in balanced diets.

From the degradation results, it can be observed that the maximum degradation potential was reached at 48 hours of incubation. There were no statistical differences ($P > 0.05$) in DM degradation among the clones (Table 2). All of them showed high degradation rates, which indicates the great potential of mulberry with a higher degradation rate within the first hours (6-12h), followed by a stabilizing phase, reaching, after 48 hours, a degradation of 93 percent. There were no differences either ($P > 0.05$) in CP degradation among clones, reaching a mean degradation of 96.8 percent after 48 hours. Only in NDF degradation there were statistical differences ($P < 0.05$) among clones, the clone Miura being superior which contains less NDF, inversely related to feed digestibility.

TABLE 1

Bromatological composition of clones on a dry matter (DM) basis

Parameters	**Clones**

Parameters	Clones		
	Miura	FM Shima Miura	FM 86
DM	24.6[a]	25.3[a]	24.5[a]
Organic matter	90.9[a]	89.8[b]	90.0[b]
Crude Protein (CP)	23.6[a]	22.7[a]	21.7[a]
Ether Extract	2.1[a]	2.1[a]	2.1[a]
Total Digestible Nutrients[1]	82.9[a]	77.8[b]	79.5[b]
Digestible Energy[2]	3.6[a]	3.5[b]	3.5[b]
Neutral Detergent Fibre (NDF)	39.3[b]	36.6[b]	30.2[a]
Acid Detergent Fibre	17.2[a]	21.7[b]	20.2[b]
Hemicellulose	22.0[a]	14.9[b]	11.0[c]
NDF-nitrogen (percentCP)	18.8[a]	19.6[a]	17.7[b]
ADF-nitrogen (percentPB)	5.8[a]	5.1[a]	4.6[a]
Ash	9.1[b]	10.2[a]	10.0[a]

Values in lines with the same letter do not differ by the Tukey test (P

<0.05).

[1]Calculated from TDN = 102.56 - (ADF percentage x 1.40), proposed by Raffler (1975), cited by NRC (1989)

[2](Mcal/kg DM); calculated from 1 kg TDN = 4.409 percent Mcal DE.

The superior qualities of the Miura clone for the studied parameters does not mean that is the best clone. Other variables should be compared such as biomass yield per unit area.

TABLE 2

Degradation rates of DM, crude protein and neutral detergent fibre (NDF) of the clones

Parameter	Clone	Incubation times (hour)				
		6	12	24	48	96
Dry Matter	Miura	52.2	81.7	91.8	93.3	91.0
	FM Shima Miura	54.8	78.8	89.1	93.2	92.1
	FM 86	56.7	80.3	91.5	93.0	91.4
Crude protein	Miura	50.7	84.1	94.9	97.3	96.8
	FM Shima Miura	49.8	80.0	90.0	97.0	96.0

	FM Shima Miura	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	FM 86	50.9	83.1	94.7	96.2	96.3
FDN	Miura	34.2	71.4	83.8	86.8	85.2
	FM Shima Miura	27.0	61.6	76.8	84.9	82.6
	FM 86	27.7	63.3	79.7	83.4	76.9

CONCLUSIONS

The mulberry clones studied showed a satisfactory bromatological composition and high degradation rate in the rumen of goats. The values for CP (22.7 percent), TDN (80.1 percent) and NDF (37.7 percent, of which 44.8 percent is hemicellulose) stand out. After an incubation of 48 hours, the material reached the maximum degradation. Other studies should be conducted to determine the best way of utilizing mulberry.

BIBLIOGRAPHY

Brazão, C. S. 1992. *Estudo da curva de crescimento e composição bromatológica da amoreira* (*Morus alba* L.). Jaboticabal. 42 pp. Trabalho apresentado à Faculdade de Ciências Agrárias e Veterinárias, UNESP, Campus de Jaboticabal, para graduação em Zootecnia. (thesis).

NRC (National Research Council). 1981. *Nutrient requirement of goats*. No.. 15. Washington, DC. National Academy of Sciences, 91pp.

Sampaio, A. M. S., Rossi Júnior, P. Brito, R. M. *et al*. 1998. Efeito de diferentes volumosos sobre a degradabilidade *in situ* de nutrientes e variáveis da fermentação ruminal, mediantea aplicação da somatotropina bovina. *R. Bras. Zootec.,* 27(6): 1234-1240.

Silva, D. J. 1981. *Análise de alimentos*. Viçosa, Brazil, Imprensa Universitária, 166pp.

Potential and effective degradation of mulberry clones in goats

Anita Schmidek & R. Takahashi
Faculty of Agrarian and Veterinary Sciences
São Paulo State University, Jaboticabal Campus
São Paulo, Brazil

A. Nuñes de Medeiros
Depto. Agropecuária-CFT- UFPB-Campus IV
Bananeiras-PB, Brazil
K.T. de Resende
Faculty of Agrarian and Veterinary Sciences
São Paulo State University, Jaboticabal Campus
São Paulo, Brazil

INTRODUCTION

Mulberry has been shown to have a considerable potential for feeding goats, both from the biological and economic points of view, since it is well accepted by these animals, has high contents of CP and TDN and a good green biomass production per unit area with a deep root system, which allows good production throughout the year including the dry period (Takahashi, 1998).

Currently the *in situ* degradation technique has been extensively used to determine the rate and dynamics of feed degradation in the rumen, enabling the soluble, microbial degradable and undegradable fractions to be identified as well as the time required for this to happen. From these data, potential degradability (PD) and effective degradability (ED) can be estimated.

Feed degradation rate can be used to predict nutritional value since it is related to voluntary feed intake (Aguiar *et al*., 1997). Feeds with higher degradation remain less time in the rumen allowing a greater intake.

The objective of this study was to analyse the potential and effective degradation and the fractions of the equation by Ørskov (1979) of three mulberry clones.

MATERIALS AND METHODS

Research was conducted in the Goat Husbandry Section of the Faculty of Agrarian and Veterinary Sciences, Jaboticabal Campus of São Paulo State University (Brasil), using mulberry cultivated by the Sericulture Section. Leaves with 90 days of regrowth from the clones Miura, FM Shima Miura and FM 86 were used.

For the incubation five two-year old Saanen wethers with a rumen cannula kept in a group pen were used. Their diet consisted of Tifton hay, mulberry hay and 300 g of a concentrate with 21 percent CP. After an adaptation period of 21 days, the ground leaves were incubated for 0, 6, 12, 24, 48 and 96 hours.

Analysis of DM, CP and TDN were made on the material to be incubated and on the residue (Silva, 1981). The estimation of fractions "A", "B" and "C" were based on the recommendation by Ørskov (1988) and were used to calculate degradation by means of the equations PD =A + B (1 - ect) and ED = A + (B * c)/(c + kp).

The experimental design was random blocks with split plots (mulberry clones) with five repetitions (animals) and five plots (incubation times). The various parameters were subjected to the Tukey test at 5 percent.

RESULTS AND DISCUSSION

Table 1 presents the values of the fractions studied. Compared to the commonly used forages for goats, mulberry clones showed a large soluble fraction (A) with a mean value of 31.4 percent and a large potential degradable fraction (B) with a mean value of 61.8 percent. There was only a small undegradable fraction (U) of 6.8 percent and a high degradation rate (c) of 15.0 percent/h. For the protein, mulberry leaves presented a smaller A fraction (17.7 percent) in relation to fraction B (79.3 percent), with a small undegradable fraction (U) of 3.2 percent, which indicates the importance of microbes in the degradation of the CP. In relation to the NDF, a large B fraction was observed (85.0 percent) with a reasonable fraction U (15.0 percent/hour) and a high fraction c (14.0 percent/h), indicating the large utilization potential of mulberry fibre.

For the estimation of the degradation potential of DM, CP and NDF, the results of the incubation for 48 hours were utilized, since the maximum degradation had been obtained by this time.

TABLE 1

Soluble (A), potentially degradable (B) and undegradable (U) and degradation rate (c) of dry matter (DM), crude protein (CP) and neutral detergent fibre (NDF) of the mulberry clones

Parameter	Clone	Fractions			
		A (%)	B (%)	U (%)	c (%/h)
	Miura	34.0	59.4	6.8	0.16
DM	FM Shima Miura	29.3	64.0	6.8	0.13
	FM 86	31.0	62.0	7.0	0.16
	Miura	24.3	73.3	2.7	0.18
CP	FM Shima Miura	11.3	85.7	3.0	0.14
	FM 86	17.4	78.9	3.8	0.16
	Miura	0.0	86.8	13.2	0.17
NDF	FM Shima Miura	0.0	84.9	15.1	0.12
	FM 86	0.0	83.4	16.7	0.14

There were no differences (P >0.05) for PD and ED of the DM at the passage rates (kp) considered, but they were all high (Table 2). This can be explained by the fact that only leaves were used. There were no differences either among clones on CP (P >0.05). The values observed in this study were a little smaller than those found by Vasconcelos (1994), which obtained a value for PD of 96.7 percent and ED of 71.1 percent of DM for kp 4.4 percent, which could be explained by the lower "c" value found by this author. At the same time when the values of PD for DM and CP are compared with the published *in vivo* and the *in vitro* digestibility coefficients, it is clear that there is an overestimation of the *in situ* method. The PD values for NDF in this study are close to the ones found by Hara (1993) and Basaglia (1993).

TABLE 2

Potential (PD) and effective degradation (ED) of DM (DM), crude protein (CP) and neutral detergent fibre (NDF) of mulberry clones

Parameter	Clone	PD	ED		
			kp 0.02	kp 0.05	kp 0.08
	Miura	93.3	86.4	85.8	85.4
DM	FM Shima Miura	97.2	84.0	77.6	76.9
	FM 86	86.7	85.8	71.6	70.8

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Miura	92.7	89.3	80.2	72.7
CP	FM Shima Miura	95.8	84.3	71.7	63.0
	FM 86	83.5	87.5	77.5	70.1
	Miura	93.0	76.8	65.7	57.5
NDF	FM Shima Miura	96.2	71.3	58.1	49.2
	FM 86	83.2	72.6	61.0	52.67

The NDF was not different (P >0.05) among clones, neither in PD and ED, values considered acceptable for the fibre fraction. This parameter did not have an A fraction, since it does not dissolve in water and depends exclusively on the microbes for its disappearance from the bags.

CONCLUSIONS

Considering the high values of the soluble and potentially degradable fractions, as well as the potential and effective degradation of leaves of the mulberry clones studied, it is confirmed that this feed shows a high nutritive value with large potential for feeding goats.

BIBLIOGRAPHY

Aguiar, R. S., Maldonado, H., Da Silva, J. F. C. *et al*. 1997. *Degradabilidade* in situ *da matéria seca, da proteína bruta e da fibra em detergente neutro do capim-furachão* (Panicum repens L.) *em diferentes idades de corte*. In Reunião Anual DA SBZ, 34, 1997, 67 pp. Juiz de Fora. Anais.

Basaglia, R. 1993. *Eficiência de utilização da proteína da amoreira* (Morus alba)*.* Jaboticabal. Trabalho de Graduação (Graduação em Zootecnia) FCAV-UNESP. 45 p.

Orskov, E. R. 1988. In: *Nutrición proteica de los ruminantes*. Saragossa, Acribia.

Hara, C. H. 1993. *Produção e digestibilidade* in vitro da *matéria seca e proteína bruta em cultivares de amoreira* (Morus alba L.*).* Jaboticabal. 1993. Trabalho de Graduação (Graduação em Zootecnia). FCAV-UNESP. 43 pp.

Silva, D.J. 1981. *Análise de alimentos*. Viçosa, Imprensa Universitária, 166 pp.

Takahashi, R. 1998. Sericicultura: Amoreira (*Morus alba L.*) Bicho da Seda (*Bombyx mori L.*)*.* Jaboticabal: FCAV UNESP, 135 p. (Apostila).

Vasconcelos, V. R. 1994. *Degradação ruminal da amoreira* (*Morus alba* L.) *em caprinos.* Jaboticabal. Dissertação (Mestrado em Zootecnia) - FCAV-UNESP. 86pp.

Evolution of research on mulberry as cattle and sheep feed in central Italy

A. Angeloni
Ph.D. student
University of Udine, Italy

Studies on the use of shrubs to overcome the summer gap of forage availability in central Italy started in the middle of the 1980s with comparisons among different species in artificial plantations. In trials carried out at different sites, 14 shrub species were compared. These species were some of those commonly used in traditional animal rearing (*Acer campestre, Almus cordata, Corylus avellana, Fraxinus ornus, Morus alba, Ostrya carpinifolia, Robinia* *pseudoacacia, Ulmus carpinifolia, Vitis rupestris, Medicago arborea, Coronilla emerus*) and new introductions (*Acer negundo, Amorpha fruticosa*). The local *M. alba* was included in all the trials (Pardini, 1990; Talamucci, Pardini and Piemontese, 1990).

Characteristics considered were rapidity and rate of establishment, growth rate, productivity, effects of cutting heights, chemical composition and palatability. Most of the results were published in specialized journals.

Acer negundo, A. fruticosa, M. alba and *R. pseudoacacia* resulted to be the most productive and had the highest protein contents. *M. alba* was preferred to the first two species because of its better palatability. Work on *R. pseudacacia* was halted because of its excessive amount of thorns, even though the variety tested was a Greek selection with reduced spines.

Promising results encouraged the repetition of some of the trial focusing on a selected cultivar of mulberry. The Japanese variety "Kokuso" was chosen because of its higher productivity (Talamucci and Pardini, 1993; Argenti *et al*., 1999). However, *A. negundo* was also kept for further studies in one of the trials (Pardini, 1991). It was then abandoned because, despite its high productivity, it did not show good palatability and a high proportion of its leaves fell during the last part of the driest summers.

Once mulberry had been chosen as the most promising species for the sites studied, research on its possible integration into various grazing systems started.

No species of shrubs can be considered to be the only feed source for animals. Pastures composed of different species of grasses and legumes have proved to be much more productive. Thus, shrubs are considered "strategic" plants to be used only in critical seasons.

The use of mulberry was considered in different rotations with other resources (Pardini and Rossini, 1997; Talamucci *et al*., 1996; Talamucci and Pardini, 1999).

This stage of the research on the integration of the individual shrub and herbaceous species into organized pastoral systems was coordinated also at an interregional level by the FAO/International Centre for Advanced Medigterranean Agronomic Stuedies (CIHEAM) network on the "Mediterranean pastoral system" with the participation of scientists from Europe, the Near East and North Africa and from the Mediterranean areas of other continents.

This network includes a project on "Forage and grazing systems", that coordinates some of the activities developed at the national level (Argenti *et al*., 1999). The recent trends into Italian research, deriving from studies on the integration of different resources in complex pastoral systems, are now concerned with the diversification of land use and multifunctionality of territory. Due to recent modification in Italian agriculture, more traditional farms are becoming a support to new emerging economic sectors such as ecotourism and tourism in natural reserve areas (Piano and Talamucci, 1996).

Within this new perspective, forage resource productivity has become secondary to extraproductive functions (such as protection of the territory, including landscape beauty and the sustainability of production). These are receiving major attention in large areas of Italy as well as in other southern European countries.

Mulberry, together with other shrubby species, might play an important role in maintaining resource variety and, in turn, contribute to land use diversification.

BIBLIOGRAPHY

Argenti, G., Bianchetto, E., Lombardi, P., Sabatini, S. & Staglianò, N. 1999. *Some examples of Mediterranean pastoral systems*. Florence, University of Florence. DISAT, 62 pp.

Argenti, G., Pardini, A. & Talamucci, P. 1999. Productivity and growing rhythm of forage shrubs. *Georgia Kthnohrofia*, 54-62.

Pardini, A. 1990. Possibilità di utilizzazione di alcune specie arboree e arbustive con il pascolamento bovino durante la stagione estiva. *Agricoltura Toscana*, 6: 33-34.

Pardini, A. 1991. Utilisation combinée de *Acer negundo* L. et trèfle souterrain par les bovins et les ovins en Toscane (Italie du centre). *Herba*, 4: 41-45.

Pardini, A. & Rossini, F. 1997. Sistemi pascolivi nell'Italia centro-meridionale. Relazione inviata al congresso conclusivo del progetto MAF "Foraggicoltura Prativa", Lodi 22-24 May 1996. *Riv. Di Agron.*, 1: 89-100.

Piano, E. & Talamucci, P. 1996. *Annual self-reseeding legumes in Mediterranean areas*. Proc. XVI European Grassland Federation meeting, Grado (I), 1996.

Talamucci, P. & Pardini, A. 1993. *Possibility of combined utilization of* Morus alba *and Trifolium subterraneum in Tuscan Maremma* (*Italy*). REUR Technical Series No. 28. VII meeting FAO Subnetwork on Mediterranean Pastures and Fodder Crops, 21-23 April 1993, Chania, Greece.

Talamucci, P. & Pardini, A. 1999. *Pastoral systems which integrate woody plants.* Invited paper at the Occasional Symposium of the European Grassland Federation, Thessaloniki, Greece, 24-30 May, 1999.

Talamucci, P. Pardini, A. Argenti, G. & Staglianò, N. 1996. Theoretical sylvo-pastoral systems based on seasonal distribution of diversified resources in an Italian Mediterranean environment. FAO Congress on Sylvo-pstoral systems in Avignon (F), 29-30 June 1995. Publiched in *Western European Silvopastoral Systems*, INRA. p. 183-193.

Talamucci, P., Pardini, A. & Piemontese, S. 1990. Primi risultati sul comportamento di alberi ed arbusti da foraggio in Toscana. *Agricoltura Ricerca*, 106: 135-144.

Effects of grazing animals and cutting on the production and intake of a mulberry-subterranean clover association

P. Talamucci, A. Pardini & G. Argenti
Department of Agronomy and Land Management
University of Florence, Italy

Mulberry is native to the temperate areas of Asia, where it was first planted for sericulture, to feed the silkworm. Its uses were however then extended to firewood, timber, windbreaks, live fences, shade for food crops and forage for cattle and sheep in specialized plantations (ICRAF, 1999).

Today, mulberry is cropped as a multipurpose tree in Europe and temperate Asia, as well as in subtropical and tropical climates, including the tropical highlands of Africa, especially the United Republic of Tanzania and Kenya (Mbuya *et al*., 1994; Boschini, 2000).

Mulberry is an important component of combined pastoral systems oriented towards regularization of seasonal forage availability and diversification of pastoral resources (Talamucci, Pardini and Piemontese, 1990; Talamucci *et al*. 1996; Talamucci and Pardini, 1999). Both these aspects are important for the variability of land use and consequently for the conservation of biodiversity, and thus for the sustainability of production. Interest in this tree species is due particularly to its plasticity of use, good palatability, chemical composition and productivity.

Early mulberry introduction in Italy was for silkworm feeding and for tutoring vines. More recently its use has been attempted in some farms with mixed cattle-sheep husbandry where it is planted under the alley cropping system, which has been known in the Mediterranean Basin since the times of the Roman Empire and is associated with grasses or sown pastures of annual legumes (Talamucci and Pardini, 1993; Talamucci, Pardini and Argenti, 1997).

The cattle feed on the upper part of the branches and the sheep graze the sward and the lower leaves of the trees. These systems do not resolve completely the problems of forage availability for both species throughout the year: in winter cattle have difficulty in grazing the pasture because it is too short, and in summer sheep have difficulty in getting leaves from the tallest branches. With this system, both animal species require supplementation in the critical seasons, with hay or silage produced on farm or purchased. Furthermore, livestock numbers are being reduced in Italy due to the European Union policies, and farmers prefer to specialize in sheep. Some have even preferred to change over completely to wildlife for hunting or tourism. Sheep require a pastoral system with green forage easily available in summer. Such a system is largely used elsewhere (Nair, 1993), where leaves are made available by lopping trees weekly throughout the summer.

The aim of this research was to compare traditional and alternative management systems of mulberry (*M. alba*) and their effects on animal diets in Central Italy.

MATERIALS AND METHODS

Twelve hectares of *M. alba* cv. "Kokuso" associated with *Trifolium subterraneum* cv. "Woogenellup" plus *T. brachycalycinum* cv. "Clare" were established in a private farm in central Italy with fertile alluvial soils. Several experiments were conducted on that association and data were recorded for twelve years. The present article refers to data collected in the last trial in a mature plantation, carried out between 1996 and 1999.

Mulberry plants were micropropagated and planted in October (northern autumn) in rows 5 m apart with 3 m within rows. The mixture of subterranean clovers was sown soon after at the rate of 30 kg/ha. Reseeding was carried out every four to five years.

The following treatments were compared in the association:

- *Cutting season*: a) in February (winter) in order to stimulate the production of leaves in spring and to limit the height of the crown, or b) in August (summer) as an immediate supplement of feed for the animals.
- *Grazing animals*: a) only cattle, b) only sheep, c) cattle and sheep.

All interactions were investigated, using fenced sectors in a split-plot design. Animals grazed all through the year, and were supplemented with hay when forage availability was not sufficient to satisfy their estimated needs. The sheep grazed all through the year and the cattle only browsed the upper leaves beyond the reach of sheep in summer. The cattle were kept in different pastures for the rest of the year.

Two rows of mulberry were lopped at the beginning of the week, in the sectors with the summer cutting treatment, for a period of 90 days. There were 20 rows of mulberry per treatment. Non-grazed lines were utilized for measurements.

The cattle were Chianina, a local tall and strong breed, resistant to extreme climates and well adapted for extensive grazing. The sheep were Sarda, a milking type breed very common in the area. The mean annual stocking rate was 1.0 livestock unit (one adult cow of 500 kg or six sheep of the above breed).

Measurements:

- Forage production of subterranean clovers: monthly measurements with exclusion cages.
- Forage production of mulberry: weekly measurements with exclusion cages.
- Forage residuals of subterranean clover and mulberry: weekly measurements out of cages.
- Intake was estimated from the difference between forage availability and residuals.

RESULTS AND DISCUSSION

Dry matter production (Table 1)

Mulberry

On average, sheep and sheep plus cattle allowed higher leaf yields (9.5 and 9.3 tonnes/ha-1 respectively) than cattle alone (8.5). There was probably more than one reason for this. Sheep caused less stress to mulberry shrubs because they are shorter and ingest fewer leaves than cattle. They also competed with cattle and reduced their intake when grazing together. Moreover, sheep consumed more clover than cattle due to their grazing habits. This higher clover intake reduced competition with the shrubs. Spaced rows and good soil fertility suggest that the strongest competition was for water.

Mulberry yields in plots browsed by cattle were significantly higher with the winter cutting than with the summer cutting. This difference was probably due to the complete removal of leaves and branches in the summer. Mulberry shrubs might have mobilised root reserves to overcome this damage to allow regrowth during the autumn. Reserves were then not available for the early growth in the spring.

After the winter cut, root reserves are utilized for early spring growth. They are replenished by the summer and can maintain vegetative activity in autumn. The autumnal vegetation is maintained by using only part of the root reserves and remain available for regrowth after the winter cut.

Sheep had the same positive effect on the mulberry cut in winter. This was probably because the shrub regrows well after the winter cut and sheep are able to consume only the leaves in the lower part; this happens especially in summer when the animals are hungry but most of the leaves are too high. Thus, stress is reduced to winter only and nutrients are stocked again in the roots during the following spring. On the contrary, nutrients are not stocked in the root system if mulberry is cut in summer and the trees have a late and slow regrowth in spring.

Grazing with mixed species does not result in forage production that is significantly different from only sheep grazing. In fact the cattle do not care much for tree leaves while there is abundant and green pasture.

On average, the winter cut gave higher yields of mulberry leaves compared to the summer cut. This was probably due to the longer period left for the plants to form new reserves after the last stress. Summer harvesting can reduce plant survival. The cutting season did not significantly affect clover yield.

The results of the interaction between the two analysed parameters (cutting season and grazing species) given here.

TABLE 1

Mean dry matter production (tonnes/ha) of mulberry and clovers

	Mulberry	Clovers	Total
Cattle Winter cutting	9.5[b]	5.5[c]	15.0[c]
Cattle Summer cutting	7.5[c]	4.5[c]	12.0[d]
Sheep Winter cutting	10.5[a]	7.5[b]	18.0[a]
Sheep Summer cutting	8.5[b]	8.5[a]	17.0[ab]
Cattle+sheep - Winter cutting	10.3[a]	6.3[b]	16.6[b]
Cattle+sheep - Summer cutting	8.2[bc]	7.9[a]	16.1[b]

Values having different letters are significantly different ($P < 0.05$).

Subterranean clover

Clover yields were higher when mulberry shrubs were cut in winter than in summer since the availability of green leaves due to the summer cut reduces the ingestion of clover seed and allows the plant to last longer.

Subterranean clover yields were small when cattle grazed because cattle only graze this plant efficiently when it tall enough. The cattle return to the area already grazed after a minimum period of two weeks, when the clover grown back. This sort of self-controlled rotational grazing causes senescence of the green tissues in the lower layers of the sward canopy and, in turn, reduces photosynthetic efficiency.

Sheep stimulated higher pasture production than cattle; the intensive grazing favoured the young and more efficient plant tissues. Sheep also favoured seed production, crop persistency and productivity in the following years. Clover productivity was higher with the summer cut.

The combination of cattle and sheep allowed yields very similar to those with sheep only. This suggests that the impact of sheep on the shrubs was stronger than that of cattle under the experimental conditions.

Total dry matter production

Total yield was favoured by the presence of sheep that grazed the clover intensely and did not cause stress to the shrubs.

Forage availability (Table 2)

Forage availability in the critical season was differed according to cutting season and plant species. Mulberry availability was zero in winter and maximum in summer. Clover was available in good quantity in winter and a minimum was also present in summer as stalks and seeds. Forage availability of the association was more balanced than the two separately.

Biomass intake (Table 3)

Mulberry

Mulberry intake leaves only was higher with cattle (6 tonnes/ha, average of cutting season) and sheep + cattle (5.5 tonnes/ha) than with sheep only (4.7 tonnes/ha). Animal height made the difference. Differences in mulberry intake were not significant throughout. Only sheep on shrubs cut in winter had lower intakes (2.3 tonnes/ha). Mulberry intake was influenced by cutting season and animal species.

TABLE 2

Forage availability in winter and summer (percentage of total production)

	Mulberry		Clover		Total	
	Winter	**Sum.**	**Winter**	**Sum.**	**Winter**	**Sum.**
Cattle - Winter cutting	0	25	10	4	10	29
Cattle - Summer cutting	0	20	11	3	11	23
Sheep - Winter cutting	0	74	14	2	14	76
Sheep - Summer cutting	0	60	12	1	12	61
Cattle+sheep - Winter cut	0	13	13	1	13	14
Cattle+sheep - Summer cut	0	14	10	1	14	15

The summer cut favoured mulberry intake because tall branches were grounded and were thus also available to shorter animals. Furthermore, clover intake was favoured by summer lopping, probably because green forage encouraged (dried) pasture consumption.

TABLE 3

Total, mulberry and subterranean clover intake (tonnes). Percentage of ingested biomass on total production

	Mulberry	Sub-clovers	Total Intake	% intake
Cattle - Winter cutting	6.5^{a}	2.5^{c}	9^{b}	60^{b}
Cattle - Summer cutting	5.5^{a}	2.2^{c}	7.7^{c}	64^{b}
Sheep - Winter cutting	2.3^{b}	6.5^{b}	8.8^{bc}	49^{c}
Sheep - Summer cutting	7.0^{a}	7.6^{a}	14.6^{a}	86^{a}
Cattle+sheep- Winter cut	4.5^{a}	5.3^{b}	9.8^{b}	59^{b}
Cattle+sheep-Summer cut	6.5^{a}	6.7^{a}	13.2^{a}	82^{a}

Values having different letters are significantly different ($P < 0.05$).

The statistical analysis of values expressed in percentages was preceded by angular transformation according to Bliss.

Subterranean clover

Clover intake was proportional to leaf yields. Intake was influenced by animal species, but not correlated with the mulberry cutting season.

Total intake

Total intake was higher with branches cut in summer with sheep (86 percent) and with cattle + sheep (82.0 percent). Maximum waste of leaf forage was on shrubs cut in winter with sheep (48.9 percent).

CONCLUSIONS

Larger variability of climatic parameters caused by global climate changes will influence the reliability of yields. Increased diversification of resources will become more important, especially in forages, because of their higher sensitivity to climatic variations compared with other crops.

Higher diversification will imply more complex management of pastoral systems. The simplest grazing technique should be defined for each resource in order to simplify management. For the same reason, the number of species reared in each farm should be reduced.

Mulberry might be interesting as a strategic resource for dry summer periods while subterranean clover could be used for the winter. The results of this trial show that simplifications in management can be achieved by summer cutting and, contemporarily, by sheep grazing only.

The cutting season may influence mulberry growth, thus leaf yield and, in turn, subterranean clover yields. The winter cut increased mulberry production and reduced subterranean clover. Cutting season will be less important in farms where both cattle and sheep are kept. Winter cutting should be chosen when plantation survival is of primary importance and summer cutting when higher forage is sought.

Cattle benefit if shrubs are cut in winter. However, sheep have greater intake if shrub branches are lopped in summer. Mixed herds are the best users, but imply a more complicated management.

Further investigations could contribute to resolving questions such as plantation persistence. Since yields were reduced with summer cutting this could suggest higher plant stress and possible reductions in shrub life.

BIBLIOGRAPHY

Boschini, C. 2000. *Establishment and management of mulberry for intensive forage production*. Proceedings of electronic conference.

ICRAF. 1999. *Agroforestree database*. CD-ROM. Nairobi, Kenya.

Mbuya, L.P., Msanga, H.P., Ruffo, C.K., Birnie, A. & Tengnas, B., 1994. *Useful trees and shrubs for Tanzania*. SIDA (Swedish Intern. Develop. Authority), Nairobi, Kenya, 542p.

Nair, P.K.R. 1993. *An introduction to agroforestry*. Kluwer Academic Publ., 499 pp.

Talamucci, P. & Pardini, A., 1993. *Possibility of combined utilization of* Morus alba and *Trifolium subterraneum in the Tuscan Maremma* (Italy), p.206-209. REUR Technical Series No. 28. VII Meeting of FAO Subnetwork on Mediterranean Pastures and Fodder Crops, 21-23 April 1993, Chania, Greece.

Talamucci, P., Pardini, A. & Piemontese, S. 1990. *Primi risultati sul comportamento di alberi e arbusti foraggeri nella Maremma toscana* (*Italia centrale*). Proc. Agrimed meeting held in Sassari I: 207-218.

Talamucci, P. Pardini, A. Argenti, G. & Staglianò, N. 1996. Theoretical sylvo-pastoral systems based on seasonal distribution of diversified resources in an Italian Mediterranean environment. In *Temperate and Mediterranean silvopastoral systems of Western Europe*, p.183-194. Versailles, INRA.

Talamucci, P. Pardini, A. & Argenti, G. 1997. Mediterranean climate - Mediterranean agroforestry. *Agroforestry Today*, 9(3): 28.

Talamucci, P. & Pardini, A. 1999. *Pastoral systems which integrate woody plants.* Invited paper at the Occasional Symposium of the European Grassland Federation, Thessaloniki, Greece, 24-30 May 1999. p. 331-341.