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Palatability and *In vivo* Digestibility of Mulberry Leaves (*Morus latifolia* CV. Kokusou 21) in Sheep Feeding

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Abstract: Mulberry (*Morus latifolia* L.) leaves and green tops were utilised to study the palatability and the digestibility in two sheep feeding trials. In trial 1 mulberry palatability was determined by cafeteria test, that studies the animal preferences in a short period of time without the interference of post-ingestive factors. Mulberry leaves were tested in respect to vetch hay and oat concentrate; results showed that mulberry leaves were significantly preferred to other feeds. In trial 2 an *in vivo* digestibility was carried out on 4 rams equipped with the bags for the faeces collection, housed in individual box and fed ad libitum. Results showed that mulberry leaves and green tops were more digestible (OM: 78.19%; CP: 79.19%: NDF: 77.77%; Cellulose: 88.32%) and with high nutrient value (NE_L: 1.61 Mcal kg^{-1} DM, INRA method; NE_{L3m}: 1.73 Mcal kg^{-1} DM, NRC method).

Key words: Palatability, *in vivo* digestibility, mulberry leaves, sheep feeding

INTRODUCTION

Mulberry is a shrub or a tree traditionally used for feeding the silkworm in various countries. It belongs to the Order Urticales, Moraceae Family and genus *Morus*. The better known species, *Morus alba L.* and *Morus nigra* L., seem to have their origin in the Himalayas' foothills (Soo-Ho *et al*., 1990). The literature gives the following climatic ranges for mulberry cultivation: temperature between 18 to 30°C; rainfall between 600 to 2500 mm; photoperiod between 9 to 13 hd^{-1} and relative humidity between 65 to 80% (Ting-Zing *et al*., 1988).

Mulberry is an important component of combined pastoral system oriented towards the regularisation of the seasonal forage availability and the diversification of the pastoral resources (Talamucci *et al*., 2000) 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. The interest of this tree species is due particularly to its plasticity of use, good palatability, chemical composition and productivity. 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 (Angeloni, 2000). The only suggestion of utilizing mulberry for direct grazing came from Talamucci and Pardini (1993) and from Talamucci *et al*. (2000) who proposed a complementary association with clover (*Trifolium subterraneum*) for sheep and cattle grazing in Tuscany, Italy. Mulberry benefits from the N fixation by the clover and contributes with high-quality forage during the summer. The association produces more forage over a longer period than the individual pure stands. This type of forage play an important role in semi-arid environments in many areas of the world, where they can be utilized as main or secondary sources of feed in periods when the availability of conventional forages is low.

The nutrient value of mulberry is one of the highest found in products of vegetable origin, far superior to traditional forages like alfalfa. Mulberry biomass is remarkable due to one characteristics which is found in very few plants; high levels of CP and high levels of digestible energy. It also notable for good mineral content and above all, its low fiber content (Benavides, 2000). 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 and in particular environments as Sicily.

In order to provide a further contribution to knowledge about the nutritional characteristics of the mulberry leaves as sheep feeding, a palatability and *in vivo* digestibility trials were carried out.

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MATERIALS AND METHODS

Feeds and sampling: In experimental field of the Istituto Sperimentale Zootecnico of Sicily in Palermo, *Morus latifolia* (cv. Kokusou 21) shrubs, taken from the germplasm collection of Padova Sericulture Section (Cappellozza, 2000) were utilised. Mulberry leaves and green tops were hand-stripped in order to simulate the effects of sheep browsing. Both the trials were carried out in September in the experimental farm of the Istituto Sperimentale Zootecnico of Sicily. In all trials, before the experimental period, rams were fed for 15 days with *ad libitum* mulberry foliage. Analyses for Dry Matter (DM), ash, Crude Protein (CP), Ether Extract (EE), ash (AOAC, 1990) and the structural carbohydrates: NDF (Goering and Van Soest, 1970), ADF and ADL (Van Soest and Robertson, 1980) on mulberry leaves and green top were carried out.

Palatability: Palatability is defined as plant characteristics or conditions which stimulate a selective response by animals. The palatability of *Morus alba* leaves was evaluated by cafeteria test (Morand-Fehr, 2003). This test study the palatability of feeds or animal preferences in a short period of time without the interference of post-ingestive factors. The mulberry leaves were tested in respect to vetch hay and oat concentrate; all feed pairs possible to test were presented to 15 young rams in successive tests in a Latine square design. Each ram was placed in a 2 m^2 box with a manger containing four small plastic bowls. A feed A was put in two of the bowls and a feed B in the other two bowls. Feed quantities depended on the kinds of feed (200 g for oat, 200 g for vetch hay and 400 g for mulberry leaves) and were calculated so that rams could not be short of either of the two feeds at the end of the test. Each test session was generally composed of four 30 sec manger openings separated by 15 sec manger shutting during which the positioning of the bowls in the manger was changed, so that rams had ample opportunity to make eating choices. Just before a test, rams were moderately hungry. During a sequence of tests, each ram participated in one test per day and only 3 tests per week; altogether two sequence were carried out and repeatability, as inter feed correlation, was calculated. The acceptability of feeds (palatability) was calculated as the mean quantity ingested by all the rams in all the tests (Morand-Fehr *et al*., 1987).

Digestibility: The forage digestibility was determined *in vivo* using 4 three years old rams of the Comisana breed, with a body weight equal to 76.88±8.51 kg. Rams were equipped with the bags for the faeces collection, they were housed in a 2 m^2 individual box and fed *ad libitum* with mulberry leaves and green tops. During the 7-day digestibility phase, forage supplied and refused were recorded daily. Individual faeces were collected daily, weighed, sampled (20%), oven dried at 60°C, ground and stored for later analysis. Forage supplied and refused and faeces were analysed for dry matter, ash, crude protein, ether extract, ash (AOAC, 1990) and the fibrous components: NDF (Goering and Van Soest, 1970), ADF and ADL (Van Soest and Robertson, 1980). The estimation of digestible and metabolizable energy of forage was based on equations of Giger-Reverdin *et al.* (1994).

RESULTS AND DISCUSSION

Feed analysis: Table 1 report the chemical composition of mulberry leaves and green tops in both the experimental: palatability and digestibility trials. Dry matter was higher when compared to traditional grasses used in animal feeding; it varies from 28.41% for the palatability trial, carried out at the begin of September, to 30.40% for the digestibility trial, carried out from the middle to the end of September. Crude protein content was medially around 18%, within the range reported by Sanchez (1999) for several cultivar of *Morus alba*, but it was lower than values reported for mulberry leaves and green tops produced in central Italy (Sarti *et al*., 1982; Casoli *et al*., 1986): In general crude protein values can be considered similar to most legume forages. Ether extract content was medially high, around 9%, probably for its high content of waxes, steroids, phospholipids, pigments, lipid soluble vitamins an so on. Fiber fractions are lightly better than values reported in literature with higher NDF and lower ADL contents (Sanchez, 1999). A striking feature of mulberry leaves is the mineral content, the average value of ash was to 13.40%, but higher values were report in literature (Sanchez, 1999).

Table 1: Chemical composition of *Morus alba* leaves and green tops (% of dry matter)

	Palatability trial	Digestibility trial
Dry matter	28.41±0.70	30.40±0.75
Organic matter	87.07±0.71	86.15±0.72
Ether extract	09.07±0.30	08.38±0.49
Crude protein	18.69±0.75	17.87±0.77
NDF	26.70±2.75	23.82±3.25
ADF	20.38±0.95	18.45±1.00
ADL	03.69±1.30	03.16±1.42
Cellulose	13.25±0.65	13.74±0.50
Ash	12.93±0.70	13.85±0.72

Palatability: Table 2 shows the repeatability of results that was generally good and consistent with other studies(Morand-Fehr, 2003). Rams preferred the mulberry leaves in both the sequences and the differences with other feeds were statistically significant. Mulberry leaves were preferred to oat and to vetch hay in both sequences, while oat was statistically preferred to vetch hay only in the second sequence. The high value of repeatability (r = 0.92) is also a good indicator to show whether rams are sufficiently well adapted to the experimental conditions (Morand-Fehr, 2003). This result is in accordance with the recent literature (Sanchez, 1999) that confirmed that the main feature of mulberry leaves is its high palatability.

Digestibility: The voluntary DM intake medially resulted 1.71±0.44 kg^{-1} day corresponding to 2% of the body weight (Table 3); DM (63.02±13.32 g kg^{-1} $BW^{0.75}$) and DOM (43.98±10.92 g kg^{-1} $BW^{0.75}$) intake resulted higher than maintenance requirements. Table 4 shows the digestibility of mulberry. DM and DOM digestibility coefficients were 74.38% and 80.64%, respectively these coefficients were higher than those reported in analogous studies on sheep (Casoli *et al*., 1986; Doran *et al*., 2006) and lower than those reported for goat specie (Dorigan *et al*., 2004; Jegou *et al*., 1994). In accordance with the afore mentioned literature, crude protein and fiber fractions were more digestible, with coefficients higher than 70%. Ether extract presented the lowest digestibility coefficient in accordance to other studies (Casoli *et al*., 1986). This fact is probably due to the presence of waxes, steroids, phospholipids, pigments, lipid soluble vitamins an so on, together to the lipid fractions extracted by ethylic ether; moreover the ether extract of the faeces could contain metabolic products of bile and intestine origin (Casoli *et al*., 1986).

The energetic value of mulberry leaves was appreciable. Digestible and metabolizable energy was lightly higher than values reported by other authors (Casoli *et al*., 1986; Dorigan *et al*., 2004; Doran *et al*., 2006) probably for higher digestibility coefficients found in this study. The net energy calculated with INRA and NRC methods were similar and comparable with high quality forages.

Table 2: Repeatability of cafeteria tests in rams

	Average quantities ingested in tests (gd^{-1})		
r = 0.92	Mulberry leaves	Oat	Vetch hay
Sequence 1	61.89 A	32.89 B	17.22 B
Sequence 2	90.78 A	46.44 B	5.89 C

On the row, different capital letter(s) are significant at $p \leq 0.01$

Table 3: Body weight and intake of rams

	Mean	Standard deviation
Body weight (kg)	76.88	±8.51
DM intake (kg^{-1} day)	1.71	±0.44
DM intake (g^{-1} day per kg of BW)	20.99	±4.11
DM intake (g^{-1} day per kg of $BW^{0.75}$)	63.02	±13.32
DOM intake (g^{-1} day per kg of $BW^{0.75}$)	43.98	±10.92

Table 4: Digestibility coefficients (% x±sd) and nutrient value (Mcal kg^{-1} DM)

Item	Mean	Standard deviation
Dry Matter (DM)	74.38	±3.53
Organic Matter (OM)	80.64	±2.65
Crude protein	81.28	±3.24
Ether extract	30.75	±8.92
NDF	78.79	±2.68
ADF	70.86	±3.95
Cellulose	89.62	±1.07
Ash	35.24	±9.27
Digestible energy	3.29	±0.22
Metabolizable energy	2.73	±0.20
Milk NE (INRA)	1.68	±0.15
NE_{L3m} (NRC)	1.80	±0.16

CONCLUSION

Overall, mulberry foliage appears to be an excellent forage with many qualities. Both trials clearly showed that mulberry leaves are more palatability by sheep and could be used as sources of high quality forage or protein when feed is scarce or when natural forages are of very low quality. If the mulberry trees or mulberry shrubs have access to deep water, they could remain green and productive in critical periods, as summer, when herbaceous forages are not available. These results concur to demonstrate the potential for mulberry as strategic forage in Mediterranean area.

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