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Sheep and goat preferences for Mediterranean fodder shrubs. Relationship with the nutritive characteristics

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SUMMARY – Palatability of six Mediterranean fodder shrubs was measured on stall-fed sheep and goats. The ratio I_7/D_7 (average amount of shrub consumed over the 7-day period to average amount of shrub distributed over the 7-day period) was used as a palatability index. Goat consumed more shrubs than sheep. Sheep and goat preferences for shrubs were different. Shrub intake (I_7) by sheep was not related to their chemical composition. In contrast, palatability was significantly correlated to dry matter (I_7/D_7 = –0.76 DM + 67.1, r = 0.70, P < 0.01), ash (I_7/D_7 = 1.92 Ash + 16.1, r = 0.75, P < 0.001), phosphor (I_7/D_7 = 52.2 P + 22.8, r = 0.54, P < 0.05) and sodium (I_7/D_7 = 5.3 Na + 26.3, r = 0.67, P < 0.01) contents. Goat preferred less fibrous (I_7/D_7 = 2.8 ADL + 76.6, r = –0.59, P < 0.05) and sodium rich shrubs (I_7/D_7 = 15.0 Na + 19.1, r = 0.62, P < 0.01). Sheep and goat preferences were not dependent upon condensed tannin content of shrubs. Shrub intake by sheep and goats (I_7) was not related to biological parameters (DM *in vitro* digestibility and *in sacco* degradability, and gas production). These parameters seem to have no effect on goat preferences. In contrast, sheep preferences for shrubs was correlated to DM *in vitro* digestibility (I_7/D_7 = 0.6 dDM_{vitro} + 11.6, r = 0.52, P < 0.05).

Key words: Preferences, sheep, goat, shrub, nutritive value.

RESUME – *"Appétibilité des arbustes fourragers chez le mouton et la chèvre. Relation avec leur valeur alimentaire". L'appétibilité de six arbustes fourragers a été mesurée sur des ovins et des caprins. Le rapport quantité moyenne de matière sèche ingérée pendant 7 jours/quantité moyenne de MS distribuée pendant 7 jours a été utilisé comme index d'appétibilité. La chèvre a consommé plus d'arbustes que le mouton. Les préférences alimentaires de ces deux espèces sont différentes. L'appétibilité des arbustes chez le mouton dépend de leurs teneurs en MS (I_7/D_7 = –0,76 MS + 67,1, r = –0,70, P < 0,01), cendres (I_7/D_7 = 1,92 Cendres + 16,1, r = 0,75, P < 0,001), phosphore (I_7/D_7 = 52,2 P + 22,8, r = 0,54, P < 0,05) et en sodium (I_7/D_7 = 5,3 Na + 26,3, r = 0,67, P < 0,01). La chèvre préfère les arbustes pauvres en lignine (I_7/D_7 = –2,8 ADL + 76,6, r = –0,59, P < 0,05) et riches en sodium (I_7/D_7 = 15,0 Na + 19,1, r = 0,62, P < 0,01). Les préférences alimentaires chez la chèvre et le mouton ne sont pas affectées par la richesse des arbustes en phénols totaux et tannins condensés. Les caractéristiques biologiques (dégradation* in sacco*, digestibilité* in vitro *de la MS et production de gaz) n'ont pas affecté l'appétibilité des arbustes par la chèvre. Dans le cas du mouton, seule la digestibilité* in vitro *de la MS des arbustes affecte leur appétibilité (I_7/D_7 = 0,6 dMS_{vitro} + 11,6, r = 0,52, P < 0,05).*

Mots-clés : *Appétibilité, mouton, chèvre, arbuste, valeur alimentaire.*

Introduction

In addition to common criteria (*i.e.*, chemical composition, intake and digestibility), knowledge of plant species commonly selected by grazing and browsing herbivores at different time of the year is fundamental to render rangeland rehabilitation and grazing management more effective. The relationship between shrub palatability and their nutritive value has been reported in a few studies (Ben Salem *et al.*, 1994; Nefzaoui *et al.*, 1995) and contrasting opinions concerning the effect of the nutritive characteristics of shrub species on their palatability by sheep and goat are reported in the literature (Genin, 1991; Nefzaoui *et al.*, 1995; Nolan and Nastis, 1997). Moreover, to our knowledge comparative studies on sheep and goat preferences for fodder shrubs are scarce. In the present study the palatability and its relationship with the nutritive characteristics of six Mediterranean shrubs were studied on sheep and goats.

Material and methods

Plant material and animals

The "Cafeteria technique" was used to determine the palatability of six fodder shrubs (*Acacia*

cyanophylla Lindl., *Artemisia campestris*, *Artemisia herba alba*, *Atriplex nummularia*, *Ceratonia siliqua* and *Pistacia lentiscus*). Nine Barbarine rams (52±7.5 kg) or nine Local x Alpine kids (36±3.8 kg) were allotted into three homogenous groups (number and initial liveweight). Shrub palatability was measured on sheep and goats on three seven-days experimental periods. Each animal received daily at morning the six freshly cut shrub species *ad libitum* (20% refusal).

The amounts of a shrub species offered and refused by each animal were weighed daily and analysed for dry matter (DM) content (105°C in a forced-air oven). The amount of shrub consumed in the first day (I_1) of each experimental period and the average of DM intake (I_7) of a shrub species corresponding to an experimental period (7 days) were calculated. I_1 and I_7 were expressed as gram DM per day or corrected for animal metabolic weight. Furthermore, the ratio between I_1 and the amount of shrub offered the first day of each experimental period (I_1/D_1) and the ratio between I_7 and the average of the amount of shrub distributed over the 7-day experimental period (I_7/D_7) were calculated. The latter ratio (I_7/D_7) was used as a palatability index for shrub ranking.

Shrub samples were bulked by period and air-dried then ground to pass through a 1 or 3 mm screen and stored until needed for further analysis.

Laboratory analysis

Samples of shrub (leaves and twigs) offered and ground at 1 mm screen were analysed for DM, crude protein (CP), crude fibre (CF) and mineral profile (Ca, P and Na) according to AOAC (1984) and neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) contents using the procedure of Goering and Van Soest (1970). The shrubs were also analysed for total extractable phenols (Julkunen-Tiitto, 1985) and condensed tannins (Broadhurst and Jones, 1978) contents.

Three ruminally fistulated sheep receiving a standard diet (CP 16%) served as rumen liquor donors and for ruminal degradation of shrub species:

(i) The nylon bag technique (Ørskov *et al*., 1980) was used to measure DM disappearance in the rumen of the six shrub species (ground at 3 mm) and thus to estimate DM degradation parameters in the rumen. The incubation times were: 4, 8, 16, 24, 48, 72 and 96 h.

(ii) The shrub samples (200 mg) ground at 1 mm were incubated in duplicate in 100 ml glass according to the method of Menke and Steingass (1988). Gas production was recorded for the following incubation times: 2, 4, 6, 8, 10, 12, 24, 48, 72 and 96 h.

(iii) *In vitro* DM digestibility (dDM_{vitro}) of shrubs was determined according to the procedures of Tilley and Terry (1963).

Data for *in sacco* DM degradation or gas production were fitted to the exponential equation of McDonald (1981): $p = a + b\ (1-e^{-ct})$, where: (i) p is % DM degradation or gas production at time t; (ii) (a+b) is the potential DM degradation or gas production; and (iii) c is the rate of DM degradation or gas production.

Results and discussion

Chemical composition

There was a wide variation in the chemical composition of the shrubs (Tables 1 and 2). The shrub species may be classified into two groups: a tannin-rich group including *P. lentiscus*, *A. cyanophylla* and *C. siliqua*, and a low tannin-group containing the other three species.

Dry matter *in vitro* digestibility and *in sacco* degradation

The *in vitro* DM digestibility and *in sacco* degradation parameters of the shrub species are given in Table 3. The DM *in vitro* digestibility covers a large range; from 23.9 to 52.8%. *A. nummularia* exhibited the highest digestibility value. However, *A. herba alba* had the lowest digestibility coefficient.

Table 1. Chemical composition of fodder shrubs (% DM)

Species	DM (%)	OM	CP	CF	NDF	ADF	ADL
Acacia cyanophylla	38.5	92.6	13.7	21.9	52.3	30.8	13.5
Artemisia campestris	56.1	94.7	7.9	36.9	60.8	43.2	16.2
Artemisia herba alta	62.6	94.7	7.7	38.9	59.4	44.8	17.9
Atriplex nummularia	25.0	79.8	13.8	20.2	46.9	26.0	14.4
Ceratonia siliqua	51.2	94.8	8.1	15.9	49.1	24.5	11.0
Pistacia lentiscus	49.1	93.5	9.3	15.7	44.7	27.2	13.8

Table 2. Mineral total phenol and condensed tannin contents in shrubs (% DM)

Species	Ca	P	Na	TPh†	CT††
Acacia cyanophylla	1.6	0.1	0.2	6.9	4.2
Artemisia campestris	0.7	0.1	0.2	6.3	0.4
Artemisia herba alta	0.6	0.2	0.3	2.6	0.5
Atriplex nummularia	1.8	0.5	4.9	0.8	0.4
Ceratonia siliqua	1.3	0.1	0.1	11.8	3.1
Pistacia lentiscus	0.8	0.1	0.4	16.6	7.7

†TPh = total phenols expressed as g equivalent tannic acid/100 g DM.
††CT = condensed tannins expressed as g equivalent catechin/100 g DM.

Table 3. DM *in vitro* digestibility (dDM_{vitro}) and *in sacco* degradation parameters of shrubs

Species	dDM_{vitro} (%)	a (%)	a (%)	(a+b) (%)	C (/h)
Acacia cyanophylla	26.3	24.7	25.5	50.3	0.033
Artemisia campestris	35.1	15.7	41.0	56.8	0.090
Artemisia herba alta	23.9	13.5	31.2	44.6	0.080
Atriplex nummularia	52.8	35.1	39.2	74.4	0.065
Ceratonia siliqua	34.7	25.3	46.0	71.3	0.025
Pistacia lentiscus	33.0	33.6	33.7	72.4	0.011

There were large variations in the degradation characteristics of the shrubs. The solubility (a) and potential degradability of DM (a+b) ranged from 13.5 to 35.1% and 44.6 to 74.4%, respectively. The major part of the DM loss from the nylon bags occurred between 4 and 24 h for all shrub species.

Gas production

There were large differences in gas production among the shrub species, with *P. lentiscus* followed by *A. cyanophylla* giving less gas (Table 4). Highest gas volume was recorded with *A. campestris* and did not differ consistently with *A. herba alba* and *C. siliqua*. The rate constant for gas production was highest for *A. campestris* and quite similar among the other shrub species (from 0.03 to 0.05 per h).

Shrub intake and palatability by sheep and goats

Overall, goats consumed more shrubs than sheep (Table 5). Total DM intake averaged 102.1 and 67.9 g/kg $W^{0.75}$, respectively. Goats have been described traditionally as browsers (Wilson *et al.*,

1975) and animals that readily consume both grass and browse (Malechek and Leinweber, 1972). Sheep and goat preferences for shrubs were different. *A. nummularia* was the most preferred shrub species by sheep, while for goat *C. siliqua* had the highest palatability.

Table 4. *In vitro* gas production parameters

Species	a (%)	b (%)	(a+b) (%)	c (/h)
Acacia cyanophylla	2.8	24.5	27.2	0.045
Artemisia campestris	–1.4	38.9	37.5	0.080
Artemisia herba alba	–0.3	38.9	38.6	0.054
Atriplex nummularia	–2.5	29.5	28.5	0.048
Ceratonia siliqua	3.4	34.3	37.7	0.038
Pistacia lentiscus	1.7	22.9	24.6	0.041

Table 5. Shrub intake and palatability measured on sheep and goat

	DM intake		I_7/D_7	
	g/day	g/kg $W^{0.75}$	%	Rank
Acacia cyanophylla				
Sheep	310 ± 89	16.2 ± 3.7	39 ± 5	(2)
Goat	328 ± 42	22.8 ± 3.5	44 ± 7	(3)
Artemisia campestris				
Sheep	411 ± 99	21.4 ± 2.2	28.± 3	(4)
Goat	426 ± 57	28.9 ± 2.9	28 ± 2	(4)
Artemisia herba alta				
Sheep	80 ± 30	4.2 ± 1.0	21 ± 3	(5)
Goat	73 ± 19	5.1 ± 1.6	19 ± 8	(6)
Atriplex nummularia				
Sheep	273 ± 48	10.8 ± 3.4	55 ± 3	(1)
Goat	229 ± 65	12.7 ± 9.3	50 ± 3	(2)
Ceratonia siliqua				
Sheep	228 ± 75	11.8 ± 4.2	31 ± 9	(3)
Goat	390 ± 86	26.8 ± 4.0	52 ± 5	(1)
Pistacia lentiscus				
Sheep	66 ± 23	3.5 ± 1.2	20 ± 6	(6)
Goat	84 ± 12	5.8 ± 0.5	24 ± 5	(5)

Relationship between shrub palatability and their nutritive value

Sheep preferences were strongly correlated to DM (I_7/D_7 = –0.76 DM + 67.1, r = –0.70, P < 0.01),

ash (I_7/D_7 = 1.92 Ash + 16.1, r = 0.75, P < 0.001), phosphorus (I_7/D_7 = 52.2 P + 22.8, r = 0.54, P < 0.05) and sodium (I_7/D_7 = 5.3 Na + 26.3, r = 0.67, P < 0.01) contents of shrubs. Goats seem to prefer shrubs low in fibre and lignin (I_7/D_7 = –2.8 ADL + 76.6, r = –0.59, P < 0.05). The negative correlation between goat preferences and ADL content of shrubs was reported by Barroso *et al.* (1995) on free browsing goats. Additionally and similarly to sheep, goat preferred shrubs high in sodium (I_7/D_7 = 15.0 Na + 19.1, r = 0.62, P < 0.01). Total extractable phenols and condensed tannins had no effect on sheep and goat preferences. Few studies have looked to the effect of the so-called "secondary compounds" (e.g., tannins, saponins, etc.) on plant's palatability and conflicting findings were reported in the literature. Genin (1991) pointed out that condensed tannins did not explain diet selection by goats. In contrast, Nolan and Nastis (1997) concluded that secondary compounds, such as tannins, significantly affect palatability. In the current study, *P. lentiscus* a tannin-rich shrub and *A. herba alba* a shrub poor in these substances were the species with the lowest palatability indexes for sheep and goats. Such divergence seems to suggest that animal preferences may be controlled by a combination of several secondary compounds rather than a single compound.

Goat preferences were not related to biological characteristics of shrubs. In contrast, sheep preferences were highly related to *in vitro* DM digestibility of shrubs (I_7/D_7 = 0.6 dDM_{vitro} + 11.6, r = 0.52, P < 0.05). Palatability measured on both animal species was not affected with *in sacco* DM degradation characteristics of fodder shrubs. Ben Salem *et al*. (1994) failed to establish any relationship between sheep and dromedaries preferences and the *in sacco* digestibility of eleven fodder shrubs.

Sheep and goats seem to have different preferences for shrubs. Some nutrients may affect these preferences. It is worthwhile to test these conclusions on free browsing animals.

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