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Ben Salem H., Nefzaoui A., Abdouli H.

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PALATABILITY OF SHRUBS AND FODDER TREES MEASURED ON SHEEP AND CAMELS.
Methodological approach and preliminary results

H. BEN SALEM, A. NEFZAOUI and H. ABDOULI

INRA of Tunisia, Laboratory of Animal Nutrition
Rue Hédi Karray, 2049 Ariana, Tunisia

ABSTRACT

Experiments were performed to study the effect of measurement duration on palatability of eleven range species and to define thereafter a palatability index.

The range species were randomly distributed in five combinations (C1 to C5) containing each four species. Each combination was tested over a 15-day experimental period on four one-year old sheep and five two-year old one-humped camels (*camelus dromedarius*). Animals received daily at 0800h the four range species *ad libitum* and were supplemented at 1700h with spineless cactus. The barley hay (standard food) was distributed with the range species only during the first five days of each experimental period. Food intakes measured on the first day (I1), average food intakes on the first five-day period (I5), the second five-day period (I10) and the third five-day period (I15) were compared.

A significant correlations ($P<0.05$) were found between I1 and I5 ($r=0.93$), I5 and I10 ($r=0.75$) or I15 ($r=0.61$) and I10 and I15 ($r=0.87$) for sheep. These correlations were higher for camels and intakes may be predicted by the following regression equations: $I5 = 1.09I1+0.07$ ($r=0.96$), $I10 = 1.15I1 + 0.25$ ($r=0.85$), $I15 = 1.41I1 + 0.33$ ($r=0.78$).

As the range species were not distributed in the same amounts, intakes were expressed as a percent of the relative distributed quantities (I1/D1, I5/D5, I10/D10 and I15/D15). The same trend reported above was observed between I1/D1 and I5/D5 or I10/D10 or I15/D15. Such results suggested that one day of measurement may be sufficient for palatability assessment.

As far as all the range species were not distributed in one time, I1/D1 and I5/D5 ratios were reported to hay intake (HI)/hay distributed (HD) ratio. Two indexes were then calculated: R1=(I1/D1)/(HI1/HD1) and R2=(I5/D5)/(HI5/HD5). R1 and R2 were found to be highly correlated for sheep ($r=0.94$) and camels ($r=0.92$). Therefore, R1 was chosed as a palatability index. The range species were ranked using this index and animals preferences were established.

INTRODUCTION

Shrubs and native trees provide valuable fodder ressources in arid and semi-arid regions. However, management and use of range plants into livestock feeding systems require a good knowledge of their palatability and nutritive value. Only a few trials have been carried out to study range species palatability and the meaning of which is not yet well defined. Marten (1969) reported in his review some different definitions of palatability gathered from the litterature. Thus, numerous, methodological problems arise when one desire to determine range species palatability. McInnis et al. (1983) and recently Olson (1991) pointed out that conventional methods commonly used to assess classic forage preferences (oesophageal fistula technic, stomach content analysis and faecal analysis) are not convenient for range species, since they are laborious, costly and complicated. Methodology based on direct feeding observations and measurement of plant species intakes either in pasture or in stall experiments seems to be more suitable for palatability studies. When using the latter method to measure palatability, the choice of trial's length becomes necessary. Several durations have been reported, some are limited to thirty minutes (Canon et al., 1987), others to two hours (Rios et al., 1989; Robledo et al., 1989) or one day (Mill et al., 1990) after offering feed. Trials lasting long terms up to several months or even entire grazing seasons have been also reported (Lusigni et al., 1984).

"Cafeteria-type" trials (brief exposure of several plant species to animal) seem to biase estimates of the relative palatability of any food. Tribe (1950) contended that "the food selection of an animal today may be critically influenced by what it chosed yesterday". Moreover, animal seems to adapt to consume initially-unpalatable feeds in long-term palatability trials.

Palatability rank of browsing species is determined using indexes calculated as the ratio between biomass consumed and biomass offered or simply by reference to the time spent by the animal eating a given range specie as classification criteria.

The lack of comparative trials make the choice of the best duration of palatability measurement hasardeous. Therefore, this research was initiated (i) to study the effect of measurement's duration on range species palatability and (ii) to determine palatability of the most important shrubs and fodder trees which are representative of the tunisian arid zones using sheep and camels.

MATERIAL AND METHODS

Study area

The experiments were performed from february to june 1992 in INRAT experimental station located in Ousseltia in the Central Tunisia at latitude 35°51' north and longitude 9°35'east. This region is characterized by a montainous relief and semi-arid climate with a mean annual rainfall of 390 mm.

The experimental station covered a total area of 1850 ha, 750 ha of which are rangelands dominated by native species (*Artemisia campestris, Artemisia herba alba, Rosmarinus officinalis* and *Stipa tenacissima*) and introduced species (*Acacia cyanophylla, Atriplex halimus* and *Opuntia ficus indica var. inermis*).

Plant material

The investigated species were limited to those available during the experimental period and judged by herdsmen, who have fairly accurate knowledge of plants eaten by their livestock, to be palatable by sheep and camels.

Eleven range species were tested in addition to barley hay and spineless cactus *(Opuntia ficus indica*). The high number of species didn't permit their distribution in one time to animals. They were randomly distributed in five combinations, containing each 4 range species, the barley hay and the cactus (table 1).

Shrubs and fodder trees were daily collected either by stripping or by cutting with hand shears.

Animals, feeds and experimental design

Four one-year old Barbarine wethers (average liveweight, 42 kg) and five two-year old one-humped camels (*Camelus dromedarius*) were housed in individual open-air enclosures equiped each with six separated feeders.

Approximately 10 days, prior to data collection, were spent familiarizing animals with enclosures.

Range species of each combination (C1 to C5) were tested succesively by the two groups of animals over a 15-day experimental periods. From day 1 to day 15 of each period, animals received *ad libitum* freshly-cut range species. The barley hay used as standard, was fed at levels of 0.8 and 4 kg per day, respectively for sheep and camels during the first 5 days (day 1 to day 5) of each experimental period. From day 6 to day 15, the hay was removed. Range species as well as hay were offered once daily at 08.00 hr. In addition, sheep and camels received at the end of the day (17.00 hr), respectively, 3 and 15 kg of fresh cactus pads cut in small pieces as a supplement feed allowing them to meet their requirement (at least maintenance). Cactus is offered separately from the others feeds because it is known to be very palatable and its presence in the morning meal may affect palatability of the other range species.

For each animal, each range specie was placed in a designed feeder. Order of distribution of feeds was randomly changed every day in order to avoid "habit reflex".

Animals were watered once daily.

Measurements and chemical analysis

Offered feeds and refusals corresponding to each plant specie were controlled for each animal. Grab samples were taken and dried at 105 °C for dry matter determination. Subsamples of consumable parts of each shrub were pooled by combination, dried at 50 °C in a forced-air oven, ground through 1 mm screen and stored for subsequent analysis. Organic matter (OM), crude protein (CP) and crude fiber (CF) were determined according to AOAC methodology (1975). Neutral Detergent fiber (NDF) contents of feeds were determined as described by Van Soest (1963).

OM digestibility of the range species was measured by the nylon bag technique (Orskov et al., 1980). Two cows fitted with rumen cannula and fed hay-based diet and 2 kg of concentrate (65 % barley grain, 32 % fava beans and 3 % minerals and vitamins mixture) were used for this purpose. The range species were ground through a 3 mm screen and 3 g sample were placed in duplicate in nylon bags (6.5 x 11 cm, pore size 50 microns) and incubated for 48 hours. After incubation, bags were washed and dried for 24 hr at 105 °C in order to determine the undegraded fraction. Residues were thereafter ashed (550 °C) in order to determine OM contents.

Calculation and statistical analysis

The following parameters were defined:

HI1 : hay intake on day 1
HI5 : average hay intake on the first 5-day period
I1 : shrub intake on day 1
I5 : average shrub intake on the first 5-day period
I10 : average shrub intake on the second 5-day period
I15 : average shrub intake on the third 5-day period
HD1 : amount of hay offered on day 1
HD5 : average amount of hay offered on the first 5-day period
D1 : amount of shrub offered on day 1.

Some ratios were then calculated : I1/D1, I5/D5, I10/D10, I15/D15, (I1/D1)/(HI1/HD1) and (I5/D5)/(HI5/HD5).

The general linear models procedure of SAS (1985) was used for regression analysis of the obtained data and calculation of correlation coefficients.

RESULTS AND DISCUSSION

Nutritive value of feeds

There is a wide variation of chemical composition between range species (table 2). *Atriplex halimus showed* the highest CP content (16 % of DM), whereas lowest concentrations were observed with *Globularia alypum* and cactus (3.7 % DM). *Atriplex halimus* as well as cactus have a considerable amount of ash, averaging 20 % of DM. Crude fiber content of range species varied between 15 % (cactus) and 54 % of DM (*Artemisia herba alba*). However, *Stipa tenacissima* and *Artemisia campestris* were the most fibrous species with respect to NDF contents (81 % and 83 % od DM, respectively).

Close relationship between CF and NDF often reported for conventional forages (i.e. Jarrige, 1979) is not observed in our data. This suggests, like it has been reported by Reed (1986), that NDF does not represent cell wall carbohydrates and lignin in some tannins rich shrubs. In fact, condensed tannins can interfere with fiber analysis by forming insoluble complexes. Thus, NDF may not be an accurate measure of cell wall in browse (Reed, 1986; Barnes et al, 1991).

According to OMD values, the shrubs may be classified in 3 groups. The first group, highly digestible (70 to 80 %) includes *cactus*, *Artemisia campestris*, *Atriplex halimus* and *Globularia alypum*. The second, with moderate digestibility values (50 to 70 %) concernes *Acacia cyanophylla* , *Artemisia campestris, Juniperus phoenicea, Rosmarinus officinalis*. The remainder species (*Stipa tenacissima, Ceratonia siliqua, Cistus libanotus, Pistacia lentiscus*) with digestibility values less than 50 %, represent the third group. It should be emphasized that OMD is not significantly (P>0.05) correlated with CP and CF. The species with high CP contents are not the most digestible and the ones with high CF contents are not less digestible.

These observations are not in agreement with the general trends reported with conventional herbaceous forages. According to many authors (Andrieu and Weiss, 1979; Demarquilly and Jarrige, 1979), OMD is correlated positively to CP contents and negatively to CF contents.

Intake and palatability results

In order to determine the effect of measurements duration on intake, the 15-day experimental period for each combination was divided into 3 subperiods of 5 days.

Regardless to time effect, shrubs comsumption by sheep is less than hay (table 3). The more palatable are *Artemisia campestris, Acacia cyanophylla, Ceratonia siliqua, Artemisia herba alba* and *Juniperus phoenicea.* For all species offered in presence of hay (during the first 5 days), a very close correlation (r = 0.93) was obtained between 1 day and 5 days of measurements (table 5). This suggests that 1 day of measurement is enough. When hay was removed from the combination (day 5 to day 15), sheep increase their level of intake of shrubs, especially for *Atriplex halimus, Globularia alypum, Pistacia lentiscus, Rosmarinus officinalis and Stipa tenacissima*. A significant correlations were found between I5 and I10 (r=0.75) or I15 (r=0.61). A close relationship was also observed between I10 and I15 (r=0.84). It can be concluded from these results that for the case of sheep the 15 days of experiment may be shortened to one day.

The same trend was found with camel (table 5). It is however interesting to note that sheep and camels do not have the same preferences for shrubs and fodder trees. Camels had much greater preferences for Ceratonia siliqua, Atriplex halimus and Pistacia lentiscus than did sheep. Moreover, camels contrary to sheep, have greater intakes of some shrubs than hay.

The effect of measurements duration on intake by camels is clearly observed for *Ceratonia siliqua, Pistacia lentiscus, Acacia cyanophylla, Artemisia campestris and Globularia alypum*. Comparing I1 to I15, range species intake was substantially increased. *Cistus libanotus* is however poorly appreciated by sheep and camels.

The Intake increment during the experimental period for a limited number of species may be explained by an adaptation effect of the animals.

As stated out in the litterature (i.e. Allison, 1985; Marten, 1969), palatability can strongly affect intake of grazing or housed animals and factors controlling palatability and thus intake are numerous and complex. Forage preferences are partly dependant upon olfactory and gustatory sences (Arnold, 1966a, 1966 b). According to Personius et al. (1987), herbivores are able to detect some toxic compounds by smell before eating or immediately after the first bite. Most of species intake concerned with this study didn't decrease during the 15-day experimental period suggesting that effect of inhibitory factors (like glycosides, tannins, volatile oils, etc...) is rather limited.

It should be stressed that palatability of a shrub may change over time and depend on the nature of the associated feeds in the diet (Marten, 1969). Data reported by Migongo-bake and Hansen (1987) corroborate this conclusion.

The correlation between intakes with respect to time was investigated on sheep (table 4) and camels (table 6). It appears that for sheep I1 is significantly correlated to I5 (r=0.93) and to a less extent to I10 (r=0.69). A significant correlations were also found between I5 and I10 or I15 (r=0.79, r=0.61 respectively). Close relationship is also observed between I10 and I15 (r=0.87). It can be concluded according to these results that the 15 days of experiment may be shortened to 1 day.

Correlations between I1 and I5, I10 and I15 obtained on camels trial were highly significant and more important than those found on sheep trial. Such correlations were expressed by the following regression equations:

$$I5 = 1.09\ I1 + 0.07\ (r=0.96)$$
$$I10 = 1.15\ I1 + 0.25\ (r=0.85)$$
$$I15 = 1.41\ I1 + 0.33\ (r=0.78)$$

Consequently, as concluded for sheep, there is no need to measure intake on experimental periods longer than 1 day.

Effect of fodder amount on intake

It is well known that intake is closely related to the amount of food offered. In order to take in account this aspect, intakes of range species were expressed in per cent of relative distributed amounts (table 3 and 5). Results indicate that, whatever the animal species is, I1/D1 is significantly correlated to I5/D5, I10/D10 and I15/D15. Nevertheless, correlation coefficient declined for both animal species with lenght of measurement period. These ratios are closely correlated to the (I1/D1)/(HI1/HD1) and (I5/D5)/(HI5/HD5) ratios. The ratio including the standard food (hay) seems to be a suitable index for palatability ranking of shrubs. The choice of such index may be also justified by the fact that it is impossible to offer to animals in one time (1 combination) all the shrubs. The ratio (I1/D1)/(HI1/HD1) is then retained for ranking range species palatability (table 7).

Using this index, sheep have a better preference in a decreasing order to *Acacia cyanophylla, Artemisia campestris, Ceratonia siliqua, Atriplex halimus, Artemisia herba alba* and *Juniperus pheonicea*. The remaining species are less palatable by sheep.

Camels behave in a different order, where *Atriplex halimus* is the most palatable, followed by *Pistacia lentiscus* and *Ceratonia siliqua*. This result is not surprising since camels prefer salty plants (Peyre de Fabrègues, 1989).

Another surprising result is the high palatability of *Artemisia campestris*, especially with sheep, which is not in agreement with the common opinions reported in litterature (Le Houerou, 1987).

Some species are likely not well eaten by both camel and sheep (*Cistus libanotus, Globularia alypum, Rosmarinus officinalis*). This is may be related, at least for *Rosmarinus officinalis*, to their high content in secondary compounds (volatile oils).

Data reported by Rios et al. (1989) revealed that when palatability is measured on sheep and using the biomass consumed/biomass offered ratio as classification criteria, *Ceratonia siliqua, Pistacia lentiscus* as well as *Atriplex halimus* and *Artemisia herba alba* as well as *Rosmarinus officinalis* were, respectively, highly palatable (90-100 %), very palatable (65-90 %), and fairly palatable (10-45 %). Using the same species and the same index, these results are not in agreement with our findings. Our values are significantly lower. This discrepances can be accounted at least for two factors. First, grinding shrubs before their distribution to animals increases certainly their relative intake allowing consequently high indexes. Second, grouping shrubs of similar characteristics for palatability measurement as did Rios et al. (198) do not really reflects the competitivity and nor the complementarity between range species.

Concerning methodology, the experimental model adopted for this study seems to be more realistic and seems more suitable to palatability assessment. We tried to reproduce grazing conditions with letting the animals in open-air enclosures and offering range species in their natural forms (without any processing). Moreover, ranges species were randomly distributed in order to resolve the problem of the high number of shrubs in comparison to the limited number of feeders and at least to reduce the specie effect.

To compare between range or animal species, the use of standard food (hay) is necessary. Comparison of nutritive values of range species in relation to their palatability ranks suggests that the dietary preferences of sheep and camels have, *a priori*, no nutritional significances. Further investigations on this aspect are needed.

For major species concerned with this study, camels and sheep do not seem to compete for the same shrubs. They can graze together on rangelands of North Africa arid zones, without risk of plant cover degradation.

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Table 1 : Species arrangement in the tested combinations

Specie (family)	Abrev.[1]	C1	C2	C3	C4	C5
Acacia cyanophylla (Leguminosae)	Ac C					*
Artemisia campestris (Compositae)	Ar C		*		*	*
Artemisia herba alba (Compositae)	Ar H		*		*	
Atriplex halimus (Chenopodiaceae)	At H				*	*
Ceratonia siliqua (Leguminosae)	Ce S					*
Cistus libanotus (Cistaceae)	Ci L	*				
Globularia alypum (Globulariaceae)	Gl A	*				
Juniperus phoenicea (Cupressaceae)	Ju P			*		
Pistacia lentiscus (Anacardiaceae)	Pi L			*	*	
Rosmarinus officinalis (Labiatae)	Ro O	*	*	*		
Stipa tenacissima (Graminae)	St T	*	*	*		
Opuntia ficus indica (Cactaceae)	OFI	*	*	*	*	*
Barley hay	H	*	*	*	*	*

[1]Abrev. : abreviated names of species

Table 2 : Chemical composition and organic matter digestibility (OMD) of species[1]

Species[2]	DM, %	Nutrient contents, g/kg DM				OMD, %
		OM	CP	CF	NDF	
Ac C	55.5	900	129	254	469	51.2
Ar C	64.7	939	69	435	828	79.6
Ar H	67.1	930	105	539	760	65.9
At H	46.4	799	161	164	328	79.3
Ce S	60.4	926	82	212	390	41.4
Ci L	50.2	958	43	370	553	46.8
Gl A	56.9	961	37	253	493	74.1
Ju P	65.0	945	64	468	401	52.4
Pi L	68.7	931	74	212	415	47.8
Ro O	54.9	930	62	321	430	57.4
St T	67.6	957	56	357	811	36.0
O.F.I.	10.0	779	38	154	197	82.3
Barley hay	80.8	916	64	350	605	-

[1]Chemical composition and OMD relative to consumable parts (leaves, twigs and small branches)
[2]see table 1 for corresponding specie full name

Table 3 : Intake of range species by sheep

Species[1]	Intake, kg DM/d				Intake, % of distributed				Intake, % of hay intake[2]	
	I1	I5	I10	I15	I1/D1	I5/D5	I10/D10	I15/D15	R1	R2
Ac C	0.34	0.25	0.35	0.41	62	46	46	49	81	75
Ar C	0.35	0.37	0.39	0.45	38	40	41	46	45	52
Ar H	0.28	0.24	0.28	0.24	31	25	29	25	34	30
At H	0.16	0.18	0.27	0.31	28	29	39	43	35	39
Ce S	0.31	0.37	0.34	0.33	32	38	35	35	38	48
Ci L	0.03	0.05	0.10	0.08	7	11	21	16	13	17
Gl A	0.02	0.08	0.20	0.14	4	15	36	26	8	22
Ju P	0.21	0.17	0.18	0.26	22	19	19	28	29	28
Pi L	0.06	0.15	0.29	0.45	11	25	35	49	15	42
Ro O	0.18	0.18	0.37	0.26	21	22	35	33	27	32
St T	0.16	0.12	0.33	0.36	16	12	34	38	23	18
O F I	0.17	0.15	0.17	0.17	53	48	55	57	67	66
Hay	0.51	0.47	-	-	79	73	-	-	100	100

[1] refer to table 1 for species full names

[2] R1=(I1/D1)/(HI1/HD1) and R2=(I5/D5)/(HI5/HD5)

Table 4 : Correlation coefficients between intake parameters for sheep

parameters	1	2	3	4	5	6	7	8	9	10
1. I1	1.00	0.93a	0.69c	0.54	0.85a	0.81a	0.27	0.31	0.82a	0.76a
2. I5		1.00	0.75b	0.61c	0.74b	0.80a	0.26	0.32	0.69b	0.74b
3. I10			1.00	0.87a	0.38	0.42	0.35	0.45	0.34	0.40
4. I15				1.00	0.32	0.39	0.26	0.59	0.30	0.44
5. I1/D1					1.00	0.94a	0.68c	0.64c	0.99a	0.94a
6. I5/D5						1.00	0.77b	0.76b	0.93a	0.98a
7. I10/D10							1.00	0.84a	0.69c	0.78b
8. I15/D15								1.00	0.65c	0.80b
9. (I1/D1)/(HI1/HD1)									1.00	0.94a
10. (I5/D5)/(HI5/HD5)										1.00

* a, b, c : level of significance, respectively for 0.001 , 0.01 and 0.05 probability

Table 5 : Intake of range species by camels

Species[1]	Intake, kg DM/d				Intake, % of distributed				Intake, % of hay intake[2]	
	I1	I5	I10	I15	I1/D1	I5/D5	I10/D10	I15/D15	R1	R2
Ac C	0.84	0.96	1.42	2.60	30	35	51	60	44	90
Ar C	1.10	1.09	1.55	2.15	31	31	39	41	41	48
Ar H	1.08	0.85	0.79	1.06	31	24	26	38	37	30
At H	2.21	2.46	2.07	2.51	61	48	28	28	91	108
Ce S	2.71	2.86	4.00	4.60	42	41	40	32	61	72
Ci L	0.22	0.24	0.19	0.58	12	8	9	13	16	12
Gl A	0.39	0.31	0.80	1.00	14	9	34	21	18	14
Ju P	0.31	0.15	0.16	0.16	9	4	6	8	13	6
Pi L	1.34	1.81	2.40	3.90	50	46	56	57	74	120
Ro O	0.33	0.33	0.73	0.40	13	13	25	16	14	15
St T	0.66	0.91	1.86	1.54	14	22	42	33	18	26
O F I	1.25	1.34	1.41	1.23	80	87	91	77	107	145
Hay	2.44	2.12	-	-	76	66	-	-	100	100

[1] refer to table 1 for species full names
[2] R1=(I1/D1)/(HI1/HD1) and R2=(I5/D5)/(HI5/HD5)

Table 6 : Correlation coefficients between intake parameters for camel

parameters	1	2	3	4	5	6	7	8	9	10
1. I1	1.00	0.96a	0.85b	0.78b	0.70c	0.60	0.20	0.18	0.73	0.56
2. I5		1.00	0.90a	0.85b	0.68c	0.60c	0.29	0.24	0.73c	0.64c
3. I10			1.00	0.92a	0.40	0.40	0.31	0.22	0.45	0.44
4. I15				1.00	0.40	0.37	0.30	0.34	0.47	0.53
5. I1/D1					1.00	0.96a	0.73c	0.69c	0.99a	0.89a
6. I5/D5						1.00	0.88a	0.82b	0.94a	0.91a
7. I10/D10							1.00	0.93a	0.69c	0.79b
8. I15/D15								1.00	0.67c	0.80b
9. (I1/D1)/(HI1/HD1)									1.00	0.92a
10. (I5/D5)/(HI5/HD5)										1.00

* a, b, c : level of significance, respectively for 0.001 , 0.01 and 0.05 probability

Table 7 : Palatability ranks of range species measured on sheep and camels

Species	Palatability rank sheep	camel
Acacia cyanophylla	1	4
Artemisia campestris	2	5
Artemisia herba alba	5	6
Atriplex halimus	4	1
Ceratonia siliqua	3	3
Cistus libanotus	10	8
Globularia alypum	11	7
Juniperus phoenicea	6	10
Pistacia lentiscus	9	2
Rosmarinus officinalis	7	9
Stipa tenacissima	8	7