Egyptian Journal of Biology, 2007, Vol. 9, pp 47-52
© Printed in Egypt. **Egyptian British Biological Society (EBB Soc)**

Chemical composition, *in vitro* digestibility and palatability of nine plant species for dromedary camels in the province of Semnan, Iran

Towhidi, A[1 *] & Zhandi, M [2]
1. Department of Animal Science, Faculty of Agronomy & Animal Science, University of Tehran, P.O.Box 31587-4111, Karaj, Iran.
2. Department of Animal Science, Faculty of Agriculture, Karaj Islamic Azad University.

Abstract

This work studied the chemical composition of plants, and their digestibility and palatability to camels, selecting plants most eaten by camels from the Iranian desert of the province of Semnan. The results indicated that the order of usefulness, from the most useful, was: *Salsola arbuscula*, *Seidlitzia rosmarinus*, *Suaeda fruticosa*, *Alhagi camelorum*, *Haloxylon ammodendron*, *Halostachys* spp., *Tamarix tetragyna*, *Tamarix stricta* and *Hammada salicornica*. No correlation was detected between the organic matter digestibility in dry matter and chemical composition, and there was no consistent relationship between either of these variables and palatability.

Keywords: herbage

Introduction

To determine the nutritive value of feedstuffs for camels, the first step is to analyse the chemical composition of different species of plants preferred by camels, and then to measure their digestibility and palatability. The chemical composition of many foods has been measured from different ecosystems in the Arab region of Asia and Africa (Wardeh *et al.* 1990). In Iran, Javan (2001) reported the digestibility of some arid-rangeland plants using bovine rumen liquor. The determination of *in vivo* digestibility of wheat straw implied that camels apparently digest poor-quality roughage better than cattle and sheep (Hedi & Khamais 1990; Cianci *et al.* 2004), but we need to measure the *in vitro* digestibility of herbage using camel rumen liquor. Recently we reported the nutritive value of 11 plant species from the province of Yazd, Iran (Towhidi 2007), but in general little information is known about the nutritive value of range herbage consumed by camels in the arid and semi-arid zones of Iran.

The objectives of the current study were to determine the chemical composition and gross energy content of the most-consumed plant species: *Seidlitzia rosmarinus* Boiss., *Tamarix tetragyna* Ehrenb., *Tamarix stricta* Boiss., *Halostachys* spp, *Suaeda fruticosa* Forssk., *Alhagi camelorum* (Fisch.), *Haloxylon ammodendron* (Meyer) Bunge, *Salsola arbuscula* Pallas and *Hammada salicornica* (Moq.) Illjin; to measure the *in vitro* digestibility of these plants using camel rumen liquor; and look at the possible relationship between palatability (preference) and digestibility or chemical composition of plant food for the dromedary camel.

Materials & Methods

Plant samples were collected in autumn 2002 using stratified random sampling from the rangelands of Semnan province in Iran. 30 samples of the parts typically browsed were prepared, pooled, dried at room temperature and milled. The chemical composition was analyzed in the Animal Science Research Institute (Karaj) by standard methods (AOAC 1990; Wiseman & Cole 1990; Undersander *et al.* 19930 for dry matter (DM), crude protein (CP), crude fiber (CF), neutral detergent fiber (NDF), acid detergent fiber (ADF), ether extract (EE), total ash (TA), macro-elements (Ca, P, Mg, K), micro-elements (Fe, Mn, Cu, Zn) and gross energy (GE).

To determine the digestibility of the plants, four mature male camels were each fitted with a fistula in the rumen under anesthesia. The *in vitro* digestibility was measured in

* Address For Correspondence

duplicate by camel rumen liquor and pepsin, using the method of Tilley & Terry (1963). The percentage of dry matter digestibility (DMD %), organic matter digestibility (OMD %), and organic matter digestibility in dry matter (DOMD %) were calculated.

The palatability of plants was determined by recording three mature camels in cafeteria trials. The camels were placed in individual pens and offered a simultaneous choice of the browsable parts of 9 fresh plant species collected from the rangelands. No apparent stress or anxiety was observed from individual penning of the camels. Camels were fed each morning for one hour during six consecutive days. Each feed was weighed and offered in three separate containers in sufficient quantities so that it would not be depleted. Food left over after a feeding session was weighed to determine the amount consumed, and the containers refilled. The location of the containers in the pen was randomized at each feeding time. To compare the preferred rating based on a defined standard, a sample of each of the collected samples was dried at room temperature for one month.

Data from food preference trials were analyzed by GLM using SAS software (1996). The means were compared within the GLM by Duncan's multiple-range test.

Results & Discussion

Table 1 shows the chemical composition, and Tables 2 and 3 show the *in vitro* digestibility and palatability of the plants, respectively. The highest crude protein content was *Alhagi camelorum*, and the lowest fibre content (NDF, ADF) were from *Haloxylon ammodendron*. The lowest crude protein was from *Hammada salicornica*, and the highest fibre (NDF, ADF) were from *Halostachys* spp.

Table 1: Chemical composition, gross energy of different plant species based on dry matter in Semnan province. (a) gross composition

Plant	DM (%)	CP (%)	CF (%)	NDF (%)	ADF (%)	TA (%)	EE (%)	GE (g/cal)
Seidlitzia rosmarinus	93.6	7.9	33.2	60.5	38.3	24.5	0.5	3511
Tamarix tetragyna	94.7	6.8	32.6	51.2	36.2	9.6	1.7	4011.6
Tamarix stricta	95.4	8	35.6	56.8	39	8	1.7	4160.7
Halostachys spp.	95.5	7.7	41.6	69.4	46.2	9.1	1.5	3977.6
Suaeda fruticosa	93.9	7.9	38.2	67.4	40	9.9	1.0	4261.1
Alhagi camelorum	95.1	10.7	35.0	47.2	35.8	11.2	0.3	4019
Haloxylon ammodendron	94.3	8.6	22.4	38.6	24.6	28.7	1.4	3130
Salsola arbuscula	94.5	6.8	29.6	48.4	30.8	22	1.4	3448
Hammada salicornica	95.3	5.5	44.2	61.6	45.0	19.1	1.4	3920

DM=dry matter, CP=crude protein, CF=crude fiber, NDF=neutral detergent fiber, ADF=acid detergent fiber, TA=total ash, GE=gross energy

Table 1: (b) elemental composition

Plant	Ca (%)	P (%)	Mg (%)	K (%)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg /kg)	Na (%)
Seidlitzia rosmarinus	1.38	0.15	18.7	0.4	13	125	210	1.2
Tamarix tetragyna	1.3	0.18	20	0.4	8.5	125	250	1.1
Tamarix stricta	1.2	0.13	21.5	0.39	8.7	145	320	1.19
Halostachys spp.	1.02	0.2	16	0.24	6.7	95	500	0.99
Suaeda fruticosa	1.2	0.19	35	0.35	6.3	150	452	1.03
Alhagi camelorum	0.93	0.17	60	0.25	8.3	50	1440	1.35
Haloxylon ammodendron	0.93	0.07	77.5	0.19	7.9	66	890	1.38
Salsola arbuscula	1.25	0.06	132	0.23	15.5	95	750	1.04
Hammada salicornica	1.05	0.02	81	0.26	8.3	53.5	740	0.77

Little information is known about the digestibility of fodder in camel except for some measurements for the digestibility of CP and CF of tree leaves and green lucerne fodder (Bhagwat *et al*. 2001), and *in situ* DM and fiber degradation in camel and in vitro gas production of four grasses irrigated with sea water (Alhadrami *et al*. 1998; Abdel-Gawad & Alhadrami 1998).

Table 2: *in vitro* digestibility of different plant species

Scientific name of plants	DMD%	OMD%	DOMD%
Seidlitzia rosmarinus	45.16	36.90	29.81
Tamarix tetragyna	37.75	32.55	29.13
Tamarix stricta	42.81	38.28	34.41
Halostachys spp.	26.92	23.19	21.61
Suaeda fruticosa	23.63	19.71	18.53
Alhagi camelorum	43.57	39.03	34.66
Haloxylon ammodendron	71.57	63.61	45.36
Salsola arbuscula	63.79	54.98	42.88
Hammada salicornica	37.37	25.66	20.76

Table 3: Mean ± SD intake of different plant species as air-dried or fresh weight

Scientific name of plants	Air-dried	Fresh
Salsola arbuscula	5.92 ± 0.64a	13.28 ± 0.43a
Seidlitzia rosmarinus	5.45 ± 0.51a	12.12 ± 0.65a
Suaeda fruticosa	3.30 ± 0.35b	10.32 ± 0.33b
Alhagi camelorum	2.78 ± 0.11c	8.43 ± 0.25c
Haloxylon ammodendron	1.25 ± 0.20d	2.27 ± 0.35d
Halostachys spp.	0.53 ± 0.08de	0.88 ± 0.12d
Tamarix tetragyna	0.46 ± 0.35de	0.90 ± 0.07d
Tamarix stricta	0.39 ± 0.09e	0.67 ± 0.08de
Hammada salicornica	0.27 ± 0.06e	0.42 ± 0.13e

* The values which do not have a common letter(s) are significantly different ($p<0.05$)

Our data is the first report about the *in vitro* digestibility of Iranian herbage. The highest and the lowest DOMD % were from *Haloxylon ammodendron* and *Suaeda fruticosa*, respectively. From these DOMD % values we can calculate the metabolizable energy of the plants (= 0.15 DOMD %: Orskov, 1984). The DOMD % of *Haloxylon ammodendron* (57.9%), *Seidlitzia rosmarinus* (20.6), and *Hammada salicornica* (48.7) have previously been measured with the bovine rumen liquor technique (Javan 2001). The different results may be caused by

the kind of animal liquor or the stage of the plants. In province of Yazd, we reported that the DOMD% of *Seidlitzia rosmarinus*, *Suaeda fruticosa*, *Haloxylon ammodendron* and *Hammada salicornica* were 32%, 34%, 45% and 42%, respectively. In the present study these values are lower (Table 3. The highest DOMD% was from *Haloxylon ammodendron* in both provinces. The different values of DOMD% of same plant species from the two provinces may be caused by the different plant collecting areas and climates.

The results indicated that species of plants had a significant effect ($p<0.01$) on intake. The mean intake of *Salsola arbuscula* and *Seidlitzia rosmarinus* were significantly ($p<0.05$) greater than the other plant species based on air-dried or fresh weight. Relative intake was greater ($p<0.01$) for fresh *Salsola arbuscula* and fresh *Seidlitzia rosmarinus* and air-dried or fresh *Suaeda fruticosa* than for the other plant species (Table 3).

Considering the data, we can divide these plants into three groups: 1) the most palatable, including *Salsola arbuscula* and *Seidlitzia rosmarinus*; 2) the somewhat palatable, including *Suaeda fruticosa* and *Alhagi camelorum*; and 3) the less palatable or undesirable, including *Hammada salicornica*, *Tamarix stricta*, *Halostachys* spp, *Tamarix tetragyna* and *Haloxylon ammodendron*.

In our previous study in Yazd province, the mean intake of *Atriplex lentiformis* (Torrey) Watson was significantly ($p<0.05$) greater than that of other plant species, based on air-dried weight. In that study we found that the most palatable species were *Atriplex lentiformis* and *Alhagi persarum* Boiss. & Buhse; the somewhat palatable were *Seidlitzia rosmarinus*, *Suaeda fruticosa*, *Haloxylon ammodendron* and *Salsola tomentosa* (Moq.) Spach; and the less palatable or undesirable plants were *Hammada salicornica*, *Tamarix kotschyi* Bunge, *Salsola yazdiana* Assadi, *Tamarix aphylla* (L.) Karst and *Artemisia sieberi* Besser. Comparison of the differences between these assessments show the importance of the different plant collecting areas and climate.

Lower fiber (NDF and ADF) is associated with higher digestibility and higher dry matter intake in sheep (Lascano *et al*. 2003). There was no correlation between these variables in our data for the dromedary camel, neither here nor in our previous study from Yazd province (Towhidi 2007). Previous studies have shown that NDF indigestibility increases non-linearly as the lignin concentration of the NDF increases (Jung *et al*. 1997; Traxler *et al*. 1998). Unfortunately we did not measure lignin concentration or indigestible NDF in this experiment.

There is little information about herbage preferences and grazing behavior in camels. In one study by Wardeh (1990), no relationship was reported between palatability and chemical composition or digestibility. In cattle, increased NDF indigestibility results in higher energy values, and perhaps more importantly, increased forage intake. Relatively small improvements in fiber digestibility can significantly increase dry-matter intake (Bagg 2003). In sheep, palatability is associated with lower NDF, a greater nitrogen content, and generally a greater concentration of minerals (K, Ca, Mg, S, and Fe) (Reid *et al.* 1992; Lascano *et al*. 2003). It has been suggested that sheep can select a diet meeting their protein requirements, and avoid at least to a certain extent excess protein intake (Reid *et al*. 1966; Kyrizakis & Oldham 1993).

A herbivore needs to be aware of nutritional differences between foods which differ in taste, color or some other factor discriminable by the sense. Social interactions between animals can also influence food selection (Forbes & Kyriazakis 1995). The presence of toxins in one food can markedly reduce an animal's preference for that food; for example, Ralphs *et al*. (1990) showed that the presence of the toxic alkaloid swainsonine in locoweed caused ewes not to select it if other foods were offered. However, we did not measure toxins in the plants.

Diet selection theory is extremely complex and has been reviewed for grazing and browsing livestock, for example, by Malechek & Balph (1987) and Milne (1991). In our study, specific points of interest were whether palatability or preference ratings were related to chemical composition and (or) nutritional characteristics of the herbage.

Forbes & Kyriazakis (1995) have suggested that preferred foods, or the preferred ratio of two or more foods, are tuned to provide a diet which promotes maximum metabolic comfort. Hence, it is reasonable to presume that camels select a combination of foods/plants which provide their metabolic requirements rather than being based on chemical composition.

In conclusion, we studied the *in vitro* digestibility (by camel rumen liquor) and the palatability of some herbage plants from Semnan province in Iran. There were no consistent patterns between palatability and plant chemical composition or digestibility. For further study, we suggest investigating the relationship between palatability and other components of plants such as lignin and toxins.

***Acknowledgements*:** We are grateful to the Animal Science Research Institute, Karaj for providing necessary research facilities.

References

Abdel-Gawad MH & Alhadrami GA (1998) In-situ DM and fiber degradation in camel and in vitro gas production of two grasses irrigated with sea water. 2. *Spartina* grass (*Spartina alterniflora*). *Proceedings of the Third Annual Meeting for Animal Production Under Arid Conditions U.A.E*. Abstract 35.

Alhadrami GA, Abdel-Gawad MH & Jumma A (1998) In-situ DM and fiber degradation in camel and in vitro gas production of two grasses irrigated with sea water. 1. *Sporobolus* grass (*Sporobolus virginicus*). *Proceedings of the Third Annual Meeting for Animal Production Under Arid Conditions U.A.E*. Abstract 5.

AOAC: Association of Official Analytical Chemists (1990) Official methods of analysis. 15th edition U.S.A. pp. 1289.

Bagg J (2003) Fiber Digestibility. *Proceedings of Forage Focus Conference. Canada*. Abstract 9.

Bhagwat SR, Pande MB & Dongre D (2001) Nutritive value of different tree leaves and green lucerne fodder for camels in north semi-arid zone of Gujarat. *Proceedings of the Sixth Annual Conference for Animal Production under Arid Conditions. U.A.E*. Abstract 50 .

Cianci D, Goio L, Hashi AM, Pastorelli S, Kamoun M, Liponi GB & Orlandi M (2004) Feed intake and digestibility in camels fed wheat straw and meadow hay. *Journal of Camel Science* 1: 52-56 .

Forbes JM & Kyriazakis I (1995) Food preference in farm animals: why don't they always choose wisely? *Proceedings of the Nutrition Society* 54: 429-440.

Hedi A & Khemais K (1990) Intake, digestion and feeding behaviour of the one-humped camel stall-fed straw-based diets. *Livestock Research for Rural Development* 2:1-5.

Javan AA (2001) *Chemical composition and digestibility of five plants consumed by dromedary camel*. The final report of research project. Research Center of Natural Resources and Animal Sciences of Sistan and Balouchestan.

Jung HG, Mertens DR & Payne AJ (1997) Correlation of acid detergent lignin and Klason lignin with digestibility of forage dry matter and neutral detergent fiber. *Journal of Dairy Science* 80: 1622-1628.

Kyriazakis I & Oldham JD (1993) Diet selection in sheep: the ability of growing lambs to select a diet that meets their crude protein (nitrogen * 6.25) requirements. *British Journal of Nutrition* 69: 617-629.

Lascano C, Avila P & Stewart J (2003) Intake, digestibility and nitrogen utilisation by sheep fed provenances of *Calliandra calothrsus* Meissner with different tannin structure. *Archivos Latinoamericanos de Producción Animal* 11:1-8 .

Malechek JC & Balph DF (1987) Diet selection by grazing and browsing livestock. In: JB Hacker & JH Ternouth (eds). *The Nutrition of Herbivores*. pp 121-132. Academic Press. North Ryde, Australia.

Milne JA (1991) Diet selection by grazing animals. *Proceedings of the Nutrition Society* 50: 77-84.

Orskov ERE (1984) *Energy allowance and feeding systems for ruminants.* Ministry of Agriculture Fisheries and Food.

Ralph MH, Panter KE & James LF (1990) Feed preferences and habituation of sheep poisoned by locoweed. *Journal of Animal Science* 68: 1354-1362.

Reid RL, Jung GA & Murray SJ (1966) Nitrogen fertilization in relation to the palatability and nutritive value of orchardgrass. *Journal of Animal Science* 25: 636-642.

Reid RL, Jung GA, Puoli JR, Cox-Ganser JM & Scott LL (1992) Nutritive quality and palatability of switchgrass hays for sheep: effect of cultivar, nitrogen fertilization, and time of adaptation. *Journal of Animal Science* 70: 3877-3888

SAS: Statistical Analysis System (1996) *SAS user's guide: statistics*, version 6.12. Institute Inc., Cary, NC.

Tilley JMA & Terry RA (1963) A two-stage technique for the in vitro digestion of forage crops. *Journal of the British Grassland Society* 18:104-109

Towhidi A (2007) Nutritive value of some herbages for dromedary camel in Iran. *Pakistan Journal of Biological Sciences* 10 (1): 167-170.

Traxler MJ, Fox DG, Van Soest PJ, Pell AN, Lascano CE, Lanna DP, Moore JE, Lana RP, Velez M & Flores A (1998) Predicting forage indigestible NDF from lignin concentration. *Journal of Animal Science* 76: 169-1480.

Undersander D, Mertens DR & Thiex N (1993) Forage analysis procedures. *Proceedings of the National Forage Testing Association, Omaha , NE*, 95-103.

Wardeh MF (1990) Camel Feeds and grazing behaviour. *Symposium of Animal Science Divisions in the Arab Universities and Workshop on Development of camel Production. United Arab Emirates*. Acsad/ASP/p 104 .

Wardeh MF, Dawa M & Ould Al-Mustafa MM (1990) The nutritive value of plant species eaten by camels (*Camelus dromedarius*). *Proceedings of the International conference on camel production and improvement. Tobruk. Libya*.

Wiseman J & Cole DJA (1990) *Feedstuff evaluation*. Cambridge University Press. Cambridge, pp. 456.

الملخص العربى

التركيب الكيميائى، قابلية الهضم و الاستساغة لتسعة أنواع من النباتات من قبل الجمل العربى المتواجد فى مقاطعة سمنان،ايران

توحيدى، أ[1] & زيهندى، م[2]

1. **قسم علم الحيوان، كلية العلوم الزراعية & علم الحيوان، جامعة طهران، صندوق بريد 4111-31587، كرج، ايران.**
2. **قسم الحيوان، كلية الزراعة، كرج جامعة أزاد الاسلامية.**

تم دراسة التركيب الكيميائى للنباتات المجموعة من مقاطعة سمنان وصحراء ايران ومدى قابلية هضمها من قبل الجمال. اوضحت الدراسة الى ان الأنواع المفيدة للتغذية هى مرتبة طبقاً للاهمية كالتالى: سالسولا اربسكيولا، سيديتزيا روزمارينس، الحاجى كاملورام، هالواكسيلون امدندرون، هالوستيشيش.، تامريكس تتراجينا، تامريكس ستريكتا وحماده ساليكورنيكا. واثبتت أيضاً الدراسة انه لا توجد علاقة بين المواد العضوية المهضومة فى صورة مادة جافة والتركيب الكيميائى لها ولا يوجد أيضاً علاقة بين أين من هذه المتغيرات واستساغة الاكل.