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In vivo digestibility and nutritive value of *Atriplex halimus* alone and mixed with wheat straw

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SUMMARY

In vivo digestibility trials were carried out using six young rams fed with *Atriplex halimus* biomass harvested in summer (A) and in early autumn (B), and with a mixture of mid-autumn *Atriplex halimus* and wheat straw (5:1 ratio on fresh matter basis) (C). *Atriplex halimus* had a high protein content (139·0, 135·9 and 193·4 g/kg DM in A, B and C respectively), but was rich in sodium chloride, especially in summer (145·9 g/kg DM), limiting its use as feed. The summer forage had a higher organic matter (OM) digestibility coefficient than the autumn forage (0·663 *v.* 0·530) but lower digestible OM intake (16·8 *v.* 29·4 g/day per kg $BW^{0·75}$). In autumn forage, the combination with straw did not influence the digestibility of organic matter, whereas it enhanced DOM intake in comparison with the *Atriplex halimus* on its own (35·7 *v.* 29·4 g/day per kg $BW^{0·75}$).

INTRODUCTION

Forage shrubs 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 digestibility and nutritive values of halophytes of the genus *Atriplex* show a wide variability in relation to the physiological phase, the ratio between stem, leaf and seed, sodium chloride content and presence of anti-nutritional factors (Hassan *et al.* 1979; Benjamin *et al.* 1992; Atiq-ur-Rehman 1995; Muñoz *et al.* 1996; Valderràbano *et al.* 1996).

Atriplex species do not have a well-balanced nutrient composition, with a high crude protein content and a low energy concentration. Moreover the crude protein contains high levels of non-protein nitrogenous compounds such as glycine, betaine and proline, derived from the physiological mechanisms of salt-tolerance (Le Houérou 1992). These compounds can be utilized by rumen microorganisms to synthesize microbial proteins when *Atriplex* is utilized in diets with highly degradable energy sources. The presence of tannins, flavonoids, saponins, alkaloids and resins in *Atriplex halimus* was noted by Bayoumi & El Shaer (1992), who also describe the veterinary use by Bedouins of *Atriplex halimus*, like other halophytes, to combat internal parasites.

With the aim of balancing the diet composition, and especially of limiting the effect of the sodium chloride and the anti-nutritional factors that reduce its palatability and feed intake, some tests have been carried out on the *Atriplex* biomass in combination with starch-containing feeds (Hassan & Abdel-Aziz 1979; Benjamin *et al.* 1992) or other conventional forages (Warren *et al.* 1990).

Atriplex halimus, which grows in semi-arid Mediterranean areas, represents a potential pasture resource in the semi-arid Sicilian inland (Stringi *et al.* 1991). Here, *Atriplex halimus*, combined with wheat straw to limit the effects of the high level of sodium chloride, could prove a valid resource for animal feeding in summer, being able to partially replace more expensive nitrogenous supplements.

In order to provide a further contribution to knowledge about the nutritional characteristics of the *Atriplex halimus* shrub in different periods, *in vivo* digestibility was determined in young rams.

MATERIALS AND METHODS

Forage from *Atriplex halimus* shrubs, growing in a typically hilly area of the Sicilian inland, was

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Table 1. *Feed chemical composition (g/kg DM) and stem, leaf and seed-ratio of* Atriplex halimus *biomass (g/100 g fresh weight)*

	Summer		Autumn	
	July	October	November	
	Atriplex	*Atriplex*	*Atriplex*	Wheat straw
Dry matter (g/kg DM)	369·6	344·0	286·8	843·5
Crude protein	139·0	135·9	193·4	38·1
Ether extract	26·8	25·3	27·0	13·0
Ash	310·9	221·0	198·0	84·7
NDF	320·4	430·2	427·0	706·4
ADF	191·2	277·0	261·8	431·5
ADL	104·3	99·4	96·1	42·2
Acid insoluble ash	1·6	3·6	2·9	35·2
Sodium chloride	145·9	92·6	104·2	n.d.*
Stems (g/100 g fresh weight)	10·1	20·0	19·3	
Leaves	89·9	70·4	77·8	
Seeds	0·0	9·5	2·8	

* n.d., not determined.

hand-stripped to remove herbaceous stems and leaves, in order to simulate the effects of sheep browsing, in three periods during 1995: (A) summer (July); (B) early autumn (October); (C) mid-autumn (November).

In each period, the forage digestibility was determined *in vivo* using six young rams of the Comisana breed, initially 8 months old, housed in individual metabolic cages and fed *ad libitum*. In the summer test a ram was omitted because it was affected by stomatitis, presumably caused by high sodium chloride content in the forage.

July and October *Atriplex halimus* forage was given alone, whereas in November *Atriplex halimus* was mixed with chopped wheat straw using a 5:1 ratio on the fresh matter basis (corresponding to a 1·7:1 ratio on a dry matter basis).

In all trials, the experimental period was divided into a 10-day preliminary and a 7-day digestibility phase. During all experimental periods, forage supplied and refused and voluntary water intake were recorded daily. During the 7-day digestibility phase, 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, sodium chloride (AOAC 1990) and the fibrous components NDF (Goering & Van Soest 1970), ADF and ADL (Van Soest & Robertson 1980).

Differences between digestibility coefficients were tested using Student's *t*-test (A *v.* B and B *v.* C).

RESULTS AND DISCUSSION

Summer *Atriplex halimus* forage (Table 1) had lower levels of NDF and ADF, and a higher content of ash and sodium chloride, than the early autumn forage. In autumn, October and November harvests differed in the ratios between stem, leaf and seed and in chemical composition. The forage utilized in November had a higher leaf percentage, partially responsible for the lower dry matter and the higher crude protein content, in comparison with the October forage. Moreover, the November *Atriplex halimus* had a lower ash content and a higher sodium chloride level, the latter being known to be present more in leaves than in stems (Wilson 1966).

The summer forage had significantly higher digestibility coefficients than the early autumn harvest (Table 2) but less was consumed (36·3 and 70·1 g/day per kg $BW^{0.75}$ DM intake, respectively) (Table 3); on the basis of these data and of forage OM content, the voluntary DOM intake of summer forage was below the maintenance energy requirement (16·8 *v.* 26 g/day per kg $BW^{0.75}$).

The low intake of the summer forage can probably be related to its high ash and sodium chloride contents; in fact Wilson (1966, 1975), Jacobs & Smit (1977), McKell (1989) and Atiq-ur-Rehman (1995) showed that palatability is reduced as ash and sodium chloride contents increase.

Autumn *Atriplex halimus* with wheat straw resulted in significantly lower digestibility for dry matter and crude protein, but higher for ether extract and NDF,

Table 2. *Digestibility coefficients* (S.E.: *A, 4* D.F.*; B and C, 5* D.F.)

	Summer	Autumn		Significance	
	Atriplex A	*Atriplex* B	*Atriplex* and wheat straw C	A *v.* B	B *v.* C
Dry matter	0·712 ± 0·0053	0·562 ± 0·0079	0·530 ± 0·0083	***	*
Organic matter	0·663 ± 0·0030	0·529 ± 0·0098	0·523 ± 0·0077	***	NS
Crude protein	0·776 ± 0·0044	0·733 ± 0·0071	0·682 ± 0·0090	***	**
Ether extract	0·085 ± 0·0174	0·051 ± 0·0320	0·166 ± 0·0074	NS	**
Ash	0·828 ± 0·0119	0·682 ± 0·0017	0·568 ± 0·0177	***	***
NDF	0·538 ± 0·0106	0·372 ± 0·0162	0·427 ± 0·0107	***	*
ADF	0·375 ± 0·0123	0·271 ± 0·0201	0·318 ± 0·0139	**	NS
Cellulose	0·579 ± 0·0255	0·417 ± 0·0202	0·448 ± 0·0159	**	NS
Hemicellulose	0·778 ± 0·0117	0·556 ± 0·0100	0·595 ± 0·0091	***	*

*** $P \leqslant 0{\cdot}001$; ** $P \leqslant 0{\cdot}01$; * $P \leqslant 0{\cdot}05$; NS, not significant.

Table 3. *Weight changes and intakes of rams* (S.E.: *A, 4* D.F.*; B and C, 5* D.F.)

	Summer	Autumn	
	Atriplex A	*Atriplex* B	*Atriplex* and wheat straw C
Rams initial live weight (kg)	38·5 ± 1·05	46·3 ± 2·03	46·1 ± 1·93
Rams weight change (%)	−2·2 ± 1·01	−1·7 ± 1·55	1·3 ± 1·45
DM intake (g/day per kg $BW^{0{\cdot}75}$)	36·3 ± 3·05	70·1 ± 5·36	80·7* ± 2·98
DOM intake (g/day per kg $BW^{0{\cdot}75}$)	16·8 ± 1·40	29·4 ± 2·30	35·7 ± 1·64
Digestible protein intake (g/day)	59·2 ± 5·75	120·8 ± 9·97	132·2 ± 8·56
NaCl intake (g/day)	78·5 ± 7·86	112·4 ± 9·02	91·4 ± 5·54
Water intake (l/day)	7·2 ± 0·95	8·3 ± 0·90	5·9 ± 0·44
Water intake (l/kg DM)	13·0 ± 1·45	6·5 ± 0·27	4·1 ± 0·15
Water intake (l/100 g NaCl)	9·2 ± 1·13	7·4 ± 0·30	6·5 ± 0·21

* 48·6 of *Atriplex h.* and 32·1 of wheat straw.

than the autumn forage alone. Overall, the presence of straw did not significantly improve the organic matter digestibility, but allowed an increase in the DOM intake and a reduction in the water consumption. Wheat straw DM intake, determined on the basis of *Atriplex halimus* forage:straw ratio in feed refused, was 39·7% of the total intake, near the value of the diet supplied (37·0%).

Both Muñoz *et al.* (1996) and Valderràbano *et al.* (1996) reported, for *Atriplex halimus* forage, lower DM digestibility coefficients in sheep than those found in the current study, respectively 0·45 and 0·44. Warren *et al.* (1990) noticed that a mixture of oat hay with stems and leaves of *Atriplex undulata* in a 1:1 ratio promoted greater DM digestibility and voluntary DM intake in sheep than both oat hay and *Atriplex* used alone. On the other hand, Atiq-ur-Rehman (1995), using different ratios between wheat straw and leaves of *Atriplex amnicola*, showed that feed intake was the highest with the 100% *Atriplex* diet.

In trials with *Atriplex* used alone, the weight loss of rams (Table 3) was consistent with intake data. In the early autumn trial the DOM intake realized could have satisfied maintenance requirements, but a small mean weight loss was detected, as a consequence of the low DOM intake of a single ram, which was below the maintenance level.

In all diets, the considerable sodium chloride content of the *Atriplex halimus* forage caused a high daily salt intake, so the water consumption was constantly high. The highest water intake (litres/day) was recorded when the autumn forage was used alone, while the mixing with straw reduced it. The increased water flow, causing a faster feed transit along the digestive tract, could have depressed the digestive utilization

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of *Atriplex halimus* on its own, in comparison with the mixed diet. In summer this circumstance was not verified, in fact a smaller absolute water intake was recorded in comparison with the autumn trial, whereas water consumption, expressed in l/kg DM, was greater. In autumn, the water intake per 100 g of sodium chloride intake was lower with the mixed diet.

CONCLUSIONS

Atriplex halimus forage, of interest for its protein and mineral contents, had a very high sodium chloride level, which seems to preclude its use both as a sole feed and in relatively great quantities. For the summer forage, good digestibility values, but a voluntary intake lower than the maintenance level, were found. For the autumn *Atriplex halimus* forage supplied alone, good digestibility values but low feed intake (near the maintenance level), were detected. The mixing of the autumn *Atriplex halimus* with a roughage byproduct like wheat straw maintained the OM digestibility at a comparable level, whereas it led to an increase in the DOM intake.

These results confirmed that the utilization of *Atriplex halimus* as a strategic feed, in periods when traditional grazing resources are particularly scarce, is possible by combining and integrating it with other traditional feeds.

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