

Nutrient Value of Saltwort (*Salicornia herbacea* L.) as Feed for Ruminants

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ABSTRACT : Saltwort (*Salicornia herbacea* L.), a kind of halophytes in Japan, is under investigation as a feed source for livestock as well as potential oilseed crop in salt marshes and salt fields. The present experiment was undertaken to analyze the nutritive value of saltwort as feed for ruminants. To determine the apparent digestibility and nutritive value of saltwort, five Japanese native goats were fed the diets consisting of alfalfa hay cubes with 15 or 20% (n=3 and n=2, respectively) inclusion levels of saltwort in the total diet on a DM basis. All the animals were randomly offered alfalfa hay cubes as a base diet or a mixed diet of alfalfa hay cubes and saltwort at maintenance level, thereafter, alternative feed (a base or mixed diet) was offered to the experimental animals (the incomplete crossover design). Analysis of the chemical composition of saltwort showed that the plant contained high levels of total ash (40.2% DM), sodium (12.7% DM) and chlorine (19.7% DM), and relatively high levels of CP (11.7% DM) and NDF (40.4% DM). Contents of TDN and digestible CP (DCP), DE and ME of saltwort were 33.5% DM, 8.4% DM, 7.4MJ/DM kg and 5.0MJ/DM kg, respectively. These results indicate that saltwort is rich in DCP and minerals (mainly sodium chloride), but poor in energy, suggesting that saltwort could be used as a mineral or CP supplement for ruminants raised around salinized areas in which high quality feed may not be available. (*Asian-Aust. J. Anim. Sci.* 2002, Vol 15, No. 7: 998-1001)

Key Words : Saltwort, *Salicornia*, Nutrient Value, Sodium Chloride, Ruminants

INTRODUCTION

Saltwort is an annual halophyte belonging to the family *Chenopodiaceae* and has an erect habit with an articulated and leafless stem. Its branching is characterized by an opposite phyllotaxis and all the branches end into spikes like inflorescences in mature plants (Shimizu, 2000). Saltwort is widely distributed in Eurasia and is resistant to saline water with sodium chloride levels comparable to those of seawater. Because its seeds are rich in oil, it had been suggested that the utilization of saltwort could become a potential oil seed crop in salt marshes or salt fields (Shimizu et al., 1997; Shimizu, 2000). Furthermore, if its straw could be used as feed for livestock, salts could be removed from salinized areas, a cause of desertification/land degradation (Kadomura, 1997), through the feeding of saltwort by animals. Indeed, the plant cultivated under different salt treatments contains a large amount of sodium chloride (about 10 to 30%) on a DM basis (Shimizu, 2000) and its biomass is relatively large compared to that of other halophytes (Glenn et al., 1998). Thus, saltwort is a new feed resource for ruminants in salinized areas (Shimizu et al., 2001).

We showed that the palatability of saltwort was high and no adverse effect was observed in goats offered a diet mixed with saltwort, *Salicornia herbacea* L. (Shimizu et al., 2001). However, there are few reports on the feeding value

of saltwort species. Nutritive value of saltwort itself has not been determined accurately, although the nutrient value of a mixed diet with another saltwort (*Salicornia bigelovii* L.) species was reported (Swingle et al., 1996). Therefore, the present experiment was undertaken to analyze the nutritive value and chemical components of saltwort as feed for ruminants.

MATERIALS AND METHODS

Saltwort

Saltwort plants (*Salicornia herbacea* L.) growing in Ushimado city, Okayama prefecture were harvested at the flowering stage when the seeds were premature in October 1998. Saltwort plants were immediately dried in an oven and milled for mixing with the experimental diet.

Experimental design and measurements

Five Japanese native castrated goats (3 to 5 years of age) raised in National Institute of Animal Industry (Ministry of Agriculture, Forestry and Fisheries, Ibaraki) were used in the study. The experimental animals were reared in separate pens, and were offered alfalfa hay cubes at maintenance level as a base diet and drinking water for one week during the pre-experimental period. All the animals were randomly offered alfalfa hay cubes as a base diet or a mixed diet of alfalfa hay cubes and saltwort at maintenance level at 9:00 for 14 days with an acclimatization period of 7 days. Thereafter, alternative feed (a base or mixed diet) was offered to the experimental animals at 9:00 for 14 days with an acclimatization period of 7 days: the incomplete crossover design was performed in the study. Feces and urine of the experimental animals

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were collected everyday between 8:30 and 9:00 during the last 7 days of each experimental period. The mixed diet contained 15 or 20% of saltwort based on DM to meet the apparent palatability in each animal (n=3 and n=2, respectively). Residues of feed in each animal were collected everyday just before the feeding. Percentage of saltwort contained in the residual feed was estimated by using the ash value. Body weight of all the animals was recorded at 8:30 on the first and last days in each feeding trial. In order to monitor ME of base and mixed diet, expired gases of the animals were collected in an open type expiration analyzing chamber for 3 days during each feeding trial and the volume of methane emitted by the animals was monitored by a infrared gas analyzer (Iwasaki et al., 1982).

Chemical compositions of alfalfa, saltwort and feces were determined according to the analysis methods described in Official Methods of Analysis (AOAC, 1990). Additionally, the amounts of NDF and ADF in the diets and feces were measured. Amounts of Na, Cl, K, Mg and Ca in saltwort were measured with an atomic absorption spectrophotometer.

Statistical analysis

Extrapolation method with the regression model ($y=ax+b$) was adopted for the estimation of the digestibility of each chemical composition when an animal would be offered saltwort only ($x=100$). In the model, variable y was defined as the digestibility of each chemical composition and variable x was defined as the percentage of saltwort intake to total intake. Interaction between the digestibility of each chemical component and the percentage of saltwort intake was determined by analyzing the slope coefficient. Comparison between mean values was performed by using t -test.

RESULTS

There was no significant difference between the initial and final body weight of the experimental animals in both feeding trials with base and mixed diets (25.9 ± 2.7 and 26.0 ± 2.8 , 26.2 ± 2.7 and 26.0 ± 2.7 kg, respectively), although residues of feed were recorded in some animals offered a mixed diet with saltwort. Mean DM intake of the goats offered a mixed diet tended to be low compared with that of the animals offered a base diet (503.0 g DM/day and 533.7 g DM/day, respectively). Goats consumed 70% of the saltwort diets offered. Mean water consumption of the goats offered base and mixed diets was similar (4.46 and 4.58 l/kg DM intake, respectively) in the present study.

Analysis of the chemical composition of saltwort used in the present study showed that the ash content of the plant was about 40% (table 1). Much of the ash in saltwort

Table 1. Chemical composition (% of dry and organic matter) of saltwort (*S. herbacea* L.) used in the present study

	% of DM	% of OM
Ash	40.2	-
Crude protein	11.7	19.5
Ether extract	1.3	2.1
Crude fiber	18.1	30.4
Nitrogen-free extract	28.7	48.1
Neutral detergent fiber	40.4	67.5
Acid detergent fiber	23.8	39.8
Gross energy (MJ/DMkg)	13.1	22.0

originated from Na and Cl (table 2). As a result, saltwort contained a fairly low level of OM and energy (table 1). Nevertheless, the CP and NDF contents in saltwort were relatively high, approximately 12 and 40% on a DM basis and approximately 20 and 68% on an OM basis, respectively. It was also shown that saltwort was rich in other minerals, especially in Mg (table 2).

The results of the extrapolation analysis revealed that the relationship between the intake and digestibility of the mixed diet was able to be expressed by a simple linear regression for any of the components, showing that there might be no interaction between the feed intake and the digestibility of any chemical compositions of saltwort. Apparent digestibility of chemical components and digestible composition in saltwort estimated by the analysis are represented in table 3. It was shown that the amount of digestible crude fiber, NDF and ADF contained in saltwort were fairly low as a result of the low digestibility of these components of the halophyte. On the other hand, it was demonstrated that the DCP level of the halophyte was relatively high. Nutrient values of saltwort estimated by the digestible composition are represented in table 4. TDN, DE and ME of saltwort showed remarkably low values due to the low gross energy and the high ash content of this plant. Methane production on a DM basis in goats offered the mixed diet with saltwort was similar to that in goats offered the base diet (2.06 ± 0.10 and 2.07 ± 0.08 KJ/Kg digestible OM).

Table 2. Mineral composition (% of dry matter) of saltwort (*S. herbacea* L.) used in the present study

Na	12.7
Cl	19.7
NaCl ^a	32.4
K	1.52
Mg	0.89
Ca	0.26

^a Composition of NaCl is calculated as total amounts of Na and Cl.

Table 3. Apparent digestibility of chemical components and digestible composition (% of dry and organic matter) in saltwort (*S. herbacea* L.) estimated by the digestive trials with 5 goats fed mixed diet

	% of DM		% of OM	
	Digestibility	Digestible	Digestibility	Digestible
Crude protein	71.77	8.36	71.41	13.92
Ether extract	25.97	0.33	27.02	0.57
Crude fiber	40.55	7.36	39.42	11.96
Nitrogen-free extract	59.18	17.01	56.58	27.20
Neutral detergent fiber	49.80	20.10	51.83	34.99
Acid detergent fiber	43.90	10.45	44.44	17.69

Table 4. Nutrient values (per dry and organic matter) of saltwort (*S. herbacea* L.) estimated by the digestive trials with 5 goats fed mixed diet

	/DM	/OM
TDN (%)	33.47	54.15
DE (MJ/kg)	7.38	12.46
ME (MJ/kg)	5.04	8.50

DISCUSSION

We determined the nutritive value of saltwort, *Salicornia herbacea* L., by using 5 Japanese native goats offered a mixed diet with saltwort. In a previous study, in which Japanese native goats were used as experimental animals and offered a mixed diet with saltwort at 20% inclusion level on a DM basis, no adverse effect was noted in feed intake (Shimizu et al., 2001). Although the reason why residual feed was observed by some animals in the present study remains unknown, it can be assumed that the difference in the level of sodium chloride contained in saltwort affected the palatability of the halophyte in goats. The difference in the total concentration of sodium chloride between the diets used in the previous and present studies might have affected the palatability of the mixed diet in goats. The previous study (Shimizu et al., 2001) had a concentration of sodium chloride of 4% in a mixed diet. On the other hand, the concentration of sodium chloride contained in the mixed diet in the present study ranged from 4.9 to 6.5%. However, it was reported that the maximum tolerable levels of sodium chloride supplement were 4% in milking cows and 9% in beef cattle and other small ruminants, and that feed intake did not exert any adverse effect on the animals under these conditions (NRC, 1984). The difference in saltwort intake of goats observed in our studies might be due to the difference in the sodium chloride level contained in saltwort itself from that in the mixed diet. In either case, feeding and mixing methods of saltwort should be improved when saltwort with high level of sodium chloride would be used as a feed stuff for ruminants.

It was reconfirmed that saltwort itself had a low OM

and energy due to the high content of ash, as reported in the previous study (Shimizu et al., 2001). It was also revealed that saltwort had low levels of the digestible crude fiber, NDF and ADF. As a result, it was shown that saltwort contained a fairly low level of DE and ME in the present study. In addition, the mixing rate of saltwort in the base diet should be limited by the sodium chloride content. This means that the halophyte would supply only small amounts of energy or fiber to livestock. On the other hand, saltwort contained relatively high levels of CP and DCP on a DM basis comparable to those in grass forages (Japanese Feeding Standard for Dairy Cattle, 1999). When saltwort is offered to ruminants raised around salinized areas with low availability in feed resources, the relatively high contents of CP and DCP in saltwort could be significant characteristics of the halophyte. In the areas where only low quality feed, such as rice straw, is available for livestock, the DCP level in feed would be especially important for animal nutrition in terms of improving fiber digestibility. Therefore, saltwort could be utilized as a supplement of DCP for ruminants raised around salinized areas in which high quality feed is not available.

The level of Mg on a DM basis in saltwort was more than threefold that of grass forages in Japan (Japanese Feeding Standard for Dairy Cattle, 1999). Saltwort also contained adequate levels of K and Ca based on the mineral requirements of beef cattle (National Research Council, 1984), although the level of Ca in saltwort was about half of that in grass forages in Japan. It was well documented that wide ranges of (Vijchulata et al., 1983 and Ibrahim et al., 1987) and deficient (Ibrahim et al., 1987 and Yano et al., 1998) mineral concentrations were observed in tropical roughages. This fact suggests that saltwort could be utilized as mineral supplement for ruminants raised around salinized areas rich in minerals in tropical countries. Further studies should be carried out to determine the level of trace minerals as well as other minerals contained in saltwort.

Based on the results obtained in the present study, we conclude that saltwort could be a suitable feeding resource for use as protein or mineral supplement for livestock reared around salinized areas where high quality feed is not available. Further studies should be conducted to analyze

the characteristics of the nutrient composition along with the growth of saltwort and feeding methods of the halophyte.

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