A note on forage solubility and fermentation characteristics in winter and summer feeds of Finnish reindeer[1]

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Abstract: The fiber and nitrogen composition and fermentation and solubility characteristics of a few typical summer browses and a sample of winter lichens were studied. The lichen sample was very high in hemicellulose, but low in acid detergent fiber (ADF). The summer browses were much higher in ADF. Fermentation losses were low for all samples but were lowest for lichens. Solubility losses in boiled rumen fluid were relatively low, but dry matter losses with amylase treatment accounted for over half of the in vitro digestible dry matter of summer browses and eventually all of the dry matter losses from lichens. Nitrogen disappearance from all samples was uniformly high. There appears to be ample reason to pursue similar studies with reindeer forages.

Key words: reindeer, feed, lichen, pasture plants, chemical composition *Betula nana*, *Cladina* spp., *Betula tortuosa*, *Salix* spp., *Carex* spp.

Rangifer, 9 (2): 41—45

Introduction

The semi domestic reindeer (*Rangifer tarandus* L.) has adapted its metabolic strategies to extremely widely varying environmental conditions. In winter, its diet consists mainly of lichens, which are low in protein and minerals, but a rather abundant source of complex carbohydrates (Nieminen and Heiskari, 1988). On the other hand, summer feeds are high in protein and minerals and usually contain more starch and considerably more cellulose the do the lichens.

Soluble nutrients are immediately available for digestion and absorption. In contrast, ruminal fermentation, while slower, provides a more constant supply of nutrients as well as a mechanism for recycling.

This study was designed to look, in a preliminary way, at the solubility and fermentability characteristics of typical winter and summer reindeer feeds as a guide to more detailed studies on relative solubility and fermentability as related to nutritional strategies of reindeer in greatly divergent environments.

Materials and methods

Sample collection and treatment. Hand collections were made of browse (leaves, young stems and buds) from *Betula tortuosa* (BT), *B. nana* (BN), *Salix* spp. (S), and sedges which consisted of *Carex* spp. (C), all of which form a major part of the summer reindeer diet. These were compared with a sample (L) of mixed terrestrial lichens (mainly *Cladinia* spp). The samples were frozen shortly after collection and kept at -10°C until use. They were then weighed and lyophilized, ground through a Wiley Mill with a 1 mm screen and kept in a cool, dry room until analyses were performed.

Chemical analysis. Samples were analyzed for nitrogen (N) by standard Kjeldahl procedures (AOAC, 1975) and for neutral detergent fiber (NDF) and acid detergent fiber (ADF) by the procedures of Goering and van Soest, 1970. A separate sample of the lyophilized forage was subjected to drying at 100°C and all other analyses were reported on a dry matter basis as corrected by this dry matter value. No other analyses were conducted with the oven-dried samples. All analyses were performed in duplicate.

In vitro analysis. Forages were subjected to 5 treatments with duplicate tubes for each treatment. Three treatments were standard (Tilley and Terry, 1963) *in vitro* dry matter disappearance fermentations at 12, 24 and 48 hours of incubation. Pepsin digestion, however, was not performed. Another 48 hour fermentation was performed with both amylase (amylase of bacillus spp. origin Sigma Chemical Co. St. Louis, Catalogue No. A-1278) treatment and pepsin treatment following fermentation (Robertson and Van Soest, 1977). Inoculum was obtained from a fistulated cow fed a diet of alfalfa hay. In addition, there were two other treatments, one using inoculum killed by boiling and lasting for 12 hours and the other using the same boiled inoculum but with an amylase treatment at the end of the 12 hour incubation period. These last treatments were designed to study solubility and to estimate the non-cellulolytic enzymatic disappearance of carbohydrates.

The same five treatments were used in additional *in vitro* fermentation. The nitrogen content of the forage and the residue were used to determine nitrogen disappearance.

Results

Chemical analysis. The partial composition of forages is presented in Table 1. The L sample was drier than the browse samples and was considerably lower in crude protein (CP). L also contained a very high level of NDF, but a surprisingly low value for ADF. Similar values for the browse species indicated relatively high ADF and NDF.

Solubility and digestibility. Dry matter solubility was approximately 10 percent for all summer forages (Figure 1). Lichen, however, had essentially no soluble dry matter, al-

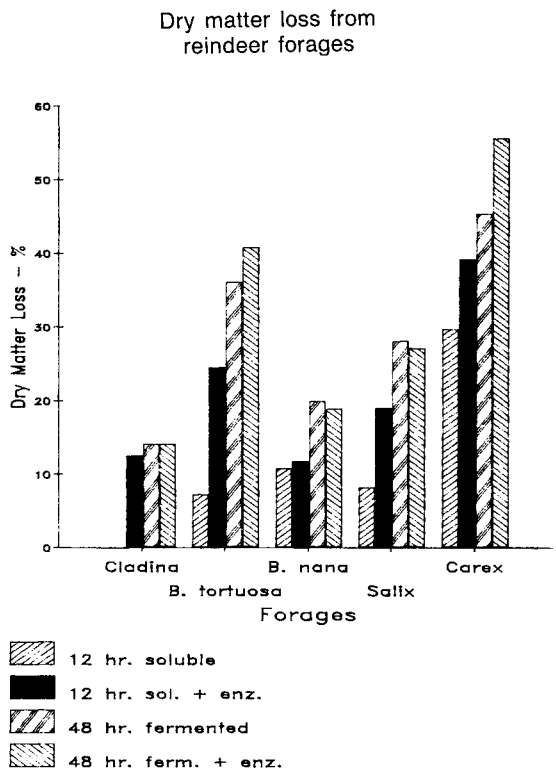

Fig. 1. Dry matter solubility and fermentability of reindeer forages.

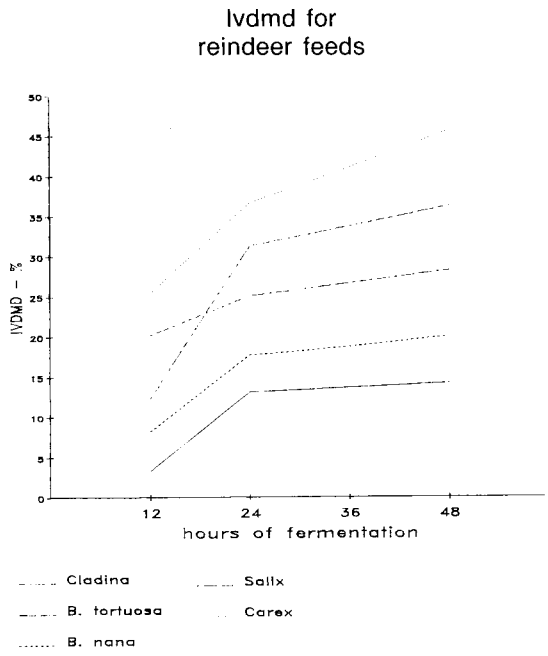

Figure 2. *In vitro* dry matter disappearance with time of fermentation with bovine rumen fluid of reindeer forages.

Table 1. Partial chemical composition of reindeer feeds[1]

Forage	DM	CP[2]	NDF[2]	ADF[2]	Hemicellulose[3]
Reindeer lichen (*Cladinia* spp.) (L)	87.0	3.2	77.3	8.0	69.3
Betula tortuosa (BT)	24.7	23.9	42.8.	30.4	12.4
Betula nana (BN)	32.5	17.5	63.9	54.5	9.4
Salix spp. (S)	21.3	25.1	64.0	59.3	4.7
Carex spp. (C)	38.9	15.9	44.0	41.7	2.3

[1] Data are mean values of duplicate samples.
[2] Percent of DM.
[3] NDF-ADF.

Table 2. Percent nitrogen loss of reindeer feeds

	Cladina spp.	*B. tortuosa*	*B. nana*	*Salix* spp	*Carex* spp.
12 hr soluble	74.6	85.0	83.0	88.6	90.0
12 hr soluble plus amylase	93.9	88.9	83.5	85.6	88.0
48 hr fermented	93.6	89.2	85.5	90.0	89.3
48 hr fermented	87.4	88.9	80.8	87.2	89.3

though a measurable portion was made soluble by the enzyme.

Fermentation losses (Figure 2) increased with time but none were very great. The greatest fermentative losses were by C, followed by BT, S, BN and lastly, L. In fact, the loss of DM from L after fermentation and enzyme treatment was not different from the loss after the amylase treatment alone.

Nitrogen losses during fermentation (Table 2) were around 90% for all forages. There was no additional loss of nitrogen due to pepsin treatment after fermentation. In fact, most of the nitrogen was lost due to solubility in boiled rumen fluid alone.

Discussion

The most dramatic observations of plant composition were the very high NDF and low ADF values for L. This was also reported by Heiskari and Nieminen, 1987. It demonstrates the inadequacy of Weende crude fiber in evaluating such unconventional feed sources. Considering the rather unusual solubility and fermentation characteristics of L, it might also be suggested that the Van Soest analyses are likewise inadequate to describe reindeer feeds. Perhaps the investigation of a number of fractions of ADF might be a useful field of study.

Additionally, it may be useful to subdivide the nitrogen fraction, especially for the summer browse species. It would appear that a significant proportion of the N is in non-protein form and that estimates of protein are really higher than total compositional distribution would warrant. Thus, the nitrogen-free extract or the nitrogen-free cell content values obtained from proximate analysis would conceivably be higher if correction were made for non-protein nitrogen. Such values, which represent soluble carbohydrates and related energy components, are important in considering the nutritive value of feeds for concentrate-selecting ruminants (Hoffman, 1988).

The high disappearance of N from all samples during solubilization and fermentation leads to two conclusions. The first is that a large proportion of the N is in non-protein form or in the form of very soluble and, putatively, digestible protein. The second is that the low apparent digestibilities of crude pro-

tein reported for lichens (Nieminen et. al., 1986; Nieminen and Heiskari, 1988) are largely the results of low N intake with the consequent large contribution of metabolic fecal nitrogen to the fecal losses.

Lichen dry matter was completely insoluble but the summer browses were appreciably soluble, especially so when treated with amylase. In fact, solubility in rumen fluid plus amylase provided well over halft of the DM disappearance of the summer browses. This suggests that soluble nutrients play an important part in the nutritional contribution of the early summer feeds.

The poor fermentability of the feeds, especially L, indicates that the bovine inoculum was not suitable for the substracts tested, but especially for L. Heiskari and Nieminen (1987) have shown increased digestion of reindeer feeds when reindeer rumen contents as contrasted with sheep rumen fluid were used as inocula. We repeated our work with sheep inocula and obtained results identical with those reported. Any definitive statements of fermentability must be made on the basis of an adapted inoculum. The present data cannot, therefore be used for firm conclusions. They do suggest, however, that there are differences between summer and winter feeds in the relative proportion of solubility and fermentability. More importantly, this work illustrates that total dry matter loss determined *in vitro* is the sum of solubility plus fermentation and that digestive strategies will be different depending upon the relative amounts of each.

The winter reindeer has a very efficient means of recycling and conserving protein and minerals (Nieminen 1980) and, indeed, this recycling also serves to conserve water and, consequently, energy. If it is assumed that fermentation of carbohydrate in the rumen is the central mechanism in these conversation pathways, it would follow that the winter reindeer ought to be a roughage consumer according to Hoffmans (1988) classification. This would require that the main winter feeds of the unsupplemented reindeer would be low in pre-fermentation solubility and would be fermentable at a sustained rate. In vitro digestibility values for lichen of 10.5 to 33.6 % (Heiskari and Nieminen, 1987) depending on the source of inocula have been reported. Such values are still rather low but this indicates that some of the NDF of lichen is digestible, by adapted micro-organisms.

The rate of digestion is also important and needs to be studied: Nitrogen recycling and mineral conservation would be most efficient with low, sustained, rather than high, but variable rates of digestion. Therefore, digestion extent of L at 72 and even 96 hours should be important to determine.

It would also be interesting to assume that, during summer, the reindeer is a concentrate selector in order to take advantage of the ample supply of new plant growth. Summer feeds would therefore be high in pre-fermentation solubility and be easily digested in the post-ruminal gastrointestinal tract. This would allow the animal the ability to lessen its reliance on rumen fermentation, which is slow and inefficient for non-fiber energy sources and can be an obstacle to rapid energy acquisition. Since as much as 75% of the dry matter disappearance was accounted for by solubility plus amylase treatment, it can be seen that non-fiber or post-ruminal digestion could account for a substantial part of the energy contribution of the summer feeds.

As suggested in the title, these data represent only a preliminary examination, on a few samples, of winter vs summer feeds for reindeer. Interpretation of these data suggest, however, that deeper examination of the nature of fiber fractions and the relationships between solubility and fermentability of both summer and winter feeds should provide important inferences regarding the nutritional strategies of reindeer under the wide variation of evironments they face.

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Manuscript received 24 January, 1989.