Chemical Composition of Forage Plants From the Reindeer Preserve, Northwest Territories

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ABSTRACT: Quantitative analyses of crude protein, crude fat, crude fiber, ash, calcium, phosphorus, and carotene were performed on 9 forage species, collected on 5 dates during a year. Crude protein levels were low in most forage species by mid-winter. Phosphorus levels were low in most plants throughout the year. Lichens, an important winter forage of reindeer, appear to be deficient in crude protein, calcium, phosphorus, and carotene.

RÉSUMÉ. *Composition chimique des fourrages de la Réserve de rennes, Territoires du Nord-Ouest.* L'auteur présente ses analyses quantitatives de protéine brute, de gras brut, de fibre brute, de cendre, de calcium, de phosphore et de carotène, pour neuf espèces fourragères, recueillies à cinq moments de l'année. Pour la plupart des espèces, les niveaux de protéine brute sont bas au milieu de l'hiver, et les niveaux de phosphore sont bas toute l'année. Les lichens, important fourrage d'hiver du renne, semblent déficients en protéine brute, en calcium, en phosphore et en carotène.

РЕЗЮМЕ. *Химический состав кормовых трав в оленьих заповедниках Северо-Западных территорий.* Произведён количественный анализ сырого белка, сырого жира, сырого волокна, золы, кальция, фосфора и каротина в девяти разновидностях кормовых растений, собранных в различные сезоны года. Количество сырого белка для большинства видов кормовых растений оказалось низким в середине зимы. Содержание фосфора мало для большинства растений в течение всего года. Лишайники — важный зимний корм северных оленей, — по-видимому, совсем лишены сырого белка, кальция, фосфора и каротина.

INTRODUCTION

Scant attention has been given to chemical composition of plants used as forage by native and introduced ungulates in northern Canada. Scotter (1965) and Tener (1965) reported on analyses of forage plants used by barren-ground caribou (*Rangifer tarandus groenlandicus*) and muskoxen (*Ovibos moschatus*), respectively. Spencer and Krumboltz (1929), Palmer (1934) and Pegau (1968) reported chemical analyses of some lichens and vascular plants in Alaska. Courtright (1959) summarized the chemical composition of plants from caribou and reindeer ranges in various countries. In 1965-66, I studied the seasonal fluctuations of chemical composition in important forage plants available to reindeer on the Reindeer Preserve near Inuvik, Northwest Territories. Such data may be helpful in explaining marked deterioration in body condition and weight of reindeer during the late winter.

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METHOD

Collections were made during 5 periods: around 15 July, August and November 1965; February and May 1966. White willow (*Salix glauca*), dwarf birch (*Betula glandulosa*), and Labrador tea (*Ledum palustris* v. *decumbens*) were selected to represent the shrub forage type; polar grass (*Arctagrostis latifolia*) and cotton grass (*Eriophorum vaginatum*) the grass and grass-like forage type; and *Cladonia alpestris*, *C. mitis*, *C. rangiferina*, and *Cetraria nivalis* the lichen forage type. All samples were taken from the Inuvik region of the Reindeer Preserve: lichens from the west side of Dolomite Lake; vascular plants from an area approximately 3 miles north of Inuvik. Collections were made from the same area during each of the 5 sampling periods. Only undecayed portions of lichens were used. Table 1 shows which parts of other plants were analysed. The twigs from white willow were limited to the current or previous year's growth. It was difficult to establish current growth in dwarf birch, so we removed twigs of the size generally eaten by reindeer. These twigs were seldom more than 2 inches in length and $\frac{1}{8}$ inch in diameter. The collection periods of vascular plants represented the height of the growing season (July), onset of dormancy (August), and dormancy (November, February, and May). The physiological activity of lichens during those periods is not known.

The Agricultural Soil and Feed Testing Laboratory, Edmonton, Alberta, conducted the proximate analysis using the methods of the Association of Official Agricultural Chemists (1955), with slight modifications introduced by the Edmonton laboratory.

The mean percentage values for crude protein, crude fat, crude fiber, ash, nitrogen-free extract (NFE), calcium, and phosphorus for 9 species at 5 sampling periods were arranged into a 5 x 9 random design. The original data were transformed using the arcsin transformation (Steel and Torrie 1960). An analysis of variance was made for all nutritive constituents except carotene. White willow and dwarf birch leaves were excluded from the analysis because they were present during only 2 sampling periods. Confidence intervals of 95 and 99 per cent were used to detect significant differences between species and between sampling periods. Duncan's Multiple Range Test (Duncan 1955) was applied where significantly different values were detected by an analysis of variance.

RESULTS

Table 1 lists results of the analyses for crude protein, crude fat, crude fiber, ash, NFE, calcium, phosphorus, and carotene for the 9 species during 5 sampling periods. There were significant differences in nutrient content between forage species ($P<0.01$) but not between seasonal samples ($P<0.05$).

The protein content of lichens never exceeded 2 per cent which was significantly ($P<0.05$) lower than for the vascular plants. During the summer, protein content was higher in the leaves than in the twigs of white willow and dwarf birch. Twigs of white willow and dwarf birch were lowest in crude protein during July and highest during February and May. In contrast, polar grass and cotton grass were highest in crude protein during July and lowest during February.

Crude fat content was significantly ($P<0.05$) higher in Labrador tea and dwarf birch than in the other plants. In the other plants, crude fat content was relatively low.

The species of *Cladonia* and polar grass contained the greatest amounts of crude fiber with significantly ($P<0.05$) higher amounts than in the other forages. The average crude fiber content of the *Cladonia* spp. was 57.8 per cent compared with 11.2 per cent for *Cetraria nivalis*. Crude fiber contents of twigs from white willow and dwarf birch were considerably greater than in the leaves.

The NFE content of *Cetraria nivalis* was significantly ($P<0.05$) higher than the other forages. The *Cladonia* spp. and polar grass had significantly ($P<0.05$) lower contents of NFE than the 3 shrubs and cotton grass.

Ash contents of the 4 lichens were significantly ($P<0.05$) lower than the other forages. Ash values in *Cladonia* spp. were below the 1.0 per cent level. They were highest in polar grass.

White willow and Labrador tea contained significantly ($P<0.05$) higher levels of calcium and phosphorus than the other forages. The 3 *Cladonia* spp. had significantly lower levels of calcium and all 4 lichens had significantly lower levels of phosphorus than the other forages. The Ca:P ratio averaged 5.5:1 for all species.

The carotene content of the vascular plants varied widely with the sampling dates. The leaves of white willow and dwarf birch contained relatively high carotene levels in July and August. In most cases the amounts of carotene in lichens were too low to be detectable by the method used.

DISCUSSION

The National Research Council (1968) recommended a minimum of 4.3 to 4.6 per cent digestible protein or 7.8 to 8.4 per cent crude protein based on a total diet intake for gestation of sheep. The maintenance requirements of domestic livestock is a minimum 4.5 per cent digestible protein (Cook *et al.* 1954). Einarsen (1946) believed that black-tailed deer could not survive on forage with less than 5 per cent crude protein. If reindeer requirements are similar, summer forages such as cotton grass and polar grass contain adquate protein, but the winter diet of 55 to 90 per cent lichens (Inglis 1970, personal communication) may be deficient. However, estimates of intake of the various forages are necessary before the adequacy of the protein content can be determined with certainty.

In addition, the digestibility of lichen protein may be low. Results of Swedish experiments, reported by Nordfeldt *et al.* (1961, p. 14), indicate "That protein in lichens had a » negative » digestibility, so that reindeer lost approximately 3 grams digestible protein for each kg. dry matter of lichens consumed." The marked deterioration in body condition and weight of reindeer during the late winter, as observed by former reindeer herd managers at the Reindeer Preserve, may be caused by protein deficiency. In addition, such arctic ungulates may voluntarily reduce intake of food as winter approaches (Klein 1970).

The important energy sources are crude fat and the soluble carbohydrates in the NFE portion of plants. Dwarf birch and Labrador tea contain high levels of crude fat throughout the year. Larin (1937) suggested that the crude fat in lichen

TABLE 1. Variation in the chemical composition of forage plants from the Reindeer Preserve near Inuvik, N.W.T.

Species	Plant part	Date	*Percentage composition on a dry-matter basis*								
			Crude Protein (Nx6.25)	Crude fat	Crude fiber	NFE	Ash	Ca	P	Ca:P	Carotene mgm per pound
Salix glauca	twigs	July	3.6	2.8	35.4	55.36	2.84	0.56	0.12	4.7:1	1.0
		Aug.	4.5	2.4	34.7	56.17	2.23	0.52	0.09	5.8:1	0.2
		Nov.	5.2	3.7	36.2	52.58	2.32	0.56	0.11	5.1:1	6.0
		Feb.	6.2	4.1	33.8	53.24	2.66	0.63	0.13	4.8:1	8.3
		May	6.1	3.6	32.2	55.21	2.89	0.69	0.13	5.3:1	0.5
	leaves	July	10.9	4.1	12.4	66.44	6.16	1.00	0.34	2.9:1	45.0
		Aug.	9.7	2.9	13.5	68.56	5.34	0.99	0.18	5.5:1	25.4
Betula glandulosa	twigs	July	3.5	8.9	26.1	59.84	1.66	0.34	0.08	4.2:1	0.9
		Aug.	5.4	10.7	27.4	54.33	2.17	0.41	0.09	4.6:1	1.0
		Nov.	4.2	4.9	33.7	54.02	3.18	0.62	0.06	10.3:1	1.8
		Feb.	4.9	9.3	30.6	52.82	2.38	0.47	0.06	7.8:1	0.5
		May	6.0	9.8	28.5	53.48	2.22	0.47	0.09	5.2:1	5.4
	leaves	July	10.4	7.3	12.7	66.54	3.06	0.44	0.13	3.4:1	46.3
		Aug.	12.1	7.9	15.8	60.27	3.93	0.63	0.15	4.2:1	8.0
Ledum palustre v. decumbens	leaves	July	9.6	10.3	29.8	47.31	2.99	0.53	0.12	4.4:1	13.4
		Aug.	7.6	10.5	23.8	54.72	3.38	0.63	0.11	5.7:1	7.5
		Nov.	7.8	9.1	23.6	56.47	3.03	0.58	0.13	4.5:1	11.4
		Feb.	8.0	10.1	26.2	52.69	3.01	0.58	0.11	5.3:1	13.1
		May	7.8	10.5	26.9	51.28	3.52	0.62	0.13	4.8:1	12.8
Arctagrostis latifolia	all parts 1 inch above ground	July	8.8	8.6	45.4	40.67	4.53	0.23	0.15	1.5:1	10.4
		Aug.	5.2	1.7	45.8	43.52	3.78	0.24	0.09	2.7:1	8.8
		Nov.	2.5	0.5	52.6	41.13	3.27	0.25	0.03	8.3:1	0.6
		Feb.	2.3	0.3	55.1	39.46	2.84	0.22	0.03	7.3:1	
		May	3.0	0.4	50.2	42.65	3.75	0.21	0.05	4.2:1	

Eriophorum vaginatum	all parts 1 inch above ground	July	13.0	1.0	24.4	58.97	2.63	0.19	0.19	1.0:1	17.6
		Aug.	10.3	1.3	33.8	51.61	2.99	0.22	0.20	1.1:1	44.6
		Nov.	3.7	0.9	40.1	52.42	2.88	0.39	0.05	7.8:1	1.8
		Feb.	3.2	0.8	40.2	52.65	3.15	0.49	0.05	9.8:1	1.8
		May	3.6	2.2	40.1	51.39	2.71	0.41	0.05	8.2:1	1.6
Cladonia alpestris	living portion of the podetia	July	1.6	2.5	58.2	36.81	0.89	0.11	0.02	5.5:1	
		Aug.	1.4	2.8	69.0	26.18	0.62	0.08	0.02	4.0:1	
		Nov.	1.4	1.5	63.8	32.51	0.79	0.13	0.02	6.5:1	
		Feb.	2.0	2.9	47.3	47.07	0.73	0.11	0.02	5.5:1	
		May	1.9	2.5	47.1	47.94	0.56	0.09	0.01	9.0:1	
Cladonia mitis	living portion of the podetia	July	1.6	1.6	59.7	36.28	0.82	0.11	0.03	3.7:1	
		Aug.	1.4	1.4	58.8	37.47	0.93	0.15	0.02	7.5:1	
		Nov.	1.6	1.3	56.4	39.74	0.96	0.13	0.02	6.5:1	
		Feb.	1.5	1.7	50.2	45.80	0.80	0.14	0.06	2.3:1	
		May	1.4	1.5	48.6	47.85	0.65	0.12	0.04	3.0:1	
Cladonia rangiferina	living portion of the podetia	July	1.7	1.0	64.8	31.61	0.89	0.14	0.02	7.0:1	
		Aug.	2.0	0.4	65.7	31.03	0.87	0.13	0.05	2.6:1	
		Nov.	1.8	0.7	64.0	32.60	0.90	0.11	0.04	2.8:1	0.1
		Feb.	1.4	0.7	61.0	35.92	0.98	0.12	0.04	3.0:1	0.7
		May	1.4	0.9	52.8	44.08	0.82	0.11	0.04	2.8:1	
Cetraria nivalis	living portion of the podetia	July	1.5	2.5	14.3	79.97	1.73	0.40	0.03	13.3:1	
		Aug.	1.4	2.4	8.1	86.99	1.11	0.13	0.04	3.2:1	1.3
		Nov.	1.3	1.7	11.9	83.55	1.55	0.36	0.04	9.0:1	
		Feb.	1.4	2.6	10.3	84.18	1.52	0.36	0.05	7.2:1	
		May	1.4	1.8	11.2	83.93	1.67	0.32	0.02	16.0:1	

analyses is mainly lichen acids which are largely indigestible. Therefore, the palatability of lichens for reindeer may vary inversely with crude fat content. Except for polar grass and *Cladonia* spp. the NFE content was relatively high in all species throughout the year. Since the soluble carbohydrate portion of NFE is variable, interpretation of its importance as an energy source is difficult without actual analysis for soluble carbohydrate, lignin, hemicellulose, and cellulose. However, the NFE content of lichens is thought to be highly digestible because of low lignin content (Courtright 1959).

Crude fiber content was highest in *Cladonia* spp. Although a high crude fiber content generally indicates a high degree of lignification and thus reduced amounts of available energy, reindeer apparently digest crude fiber especially well (Nordfeldt *et al.* 1961). The conventional chemical analyses used for domestic forages may be misleading when used on lichens because of their different chemical composition. For example, crude fiber in the lichen analyses apparently contains a significant amount of lichenin and isolichenin, carbohydrates that are readily digestible by reindeer. In addition, a high fiber content of *Cladonia* spp. broken down by rumen bacteria and protozoa may liberate large amounts of energy which would be advantageous to reindeer living under extreme winter conditions.

Ash, calcium, and phosphorus concentrations were variable. Ash content was highest in the vascular plants and lowest in the lichens. Calcium levels may be low for reindeer in polar grass and the *Cladonia* spp. Phosphorus levels are below recommended levels in nearly all cases. The minimum calcium and phosphorus requirements generally recommended for maintenance of domestic livestock under range conditions are .32 and .17 per cent respectively. Beef cattle require .16 to .60 per cent calcium and .16 to .43 per cent phosphorous in ration dry matter, depending on sex, age, and condition (National Research Council 1970). The optimum calcium-phosphorus ratio is 2:1 to 1:2, and should not exceed 5:1 (Dietz *et al.* 1962). The ratio may be of little consequence so long as minimum requirements are met.

Plants eaten in summer generally contain adequate concentrations of carotene, a precursor of vitamin A which can be stored in the liver of animals. But lichens which are the principal food in winter contain little carotene. The minimum carotene concentrations required by cattle and sheep is 0.5 mg. per pound of forage for maintenance and gestation; and 1.5 to 2.5 mg. for growth and lactation. If reindeer need similar amounts, they most probably do not get enough vitamin A during the winter months.

CONCLUSIONS

The vascular forages are apparently of relatively high quality during their most nutritious period, the early growth stages of summer. This was reflected in the excellent physical state of the reindeer slaughtered during the late summer, fall, and early winter. The late winter's deterioration in carcass quality, as observed by some former herd managers, may be related to a deficiency of digestible protein in the forage, particularly in lichens.

The effects of low phosphorus and carotene levels on reindeer during the winter months require study.

The results of the chemical analyses demonstrate the importance of variety in forage types, including shrubs, grass and grass-like plants, and lichens. All three forage types can more adequately meet the nutritional needs of reindeer. For example, high calcium levels in shrubs may compensate for low levels in lichens, while lichens are a good source of carbohydrates.

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