Nutritional Value of Seaweed to Ruminants

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Abstract: We compared the nutritional quality (apparent digestible dry matter (ADDM), crude protein, total phenolics, gross energy), of 3 seaweed species (*Alaria esculenta, Ascophyllum nodosum, Fucus vesiculosis*) to that of 3 woody browse species (*Acer rubrum, Thuja occidentalis, Abies balsamea*), lichen (*Usnea* spp.), and winter rye (*Secale cereale*) for ruminants. The ADDM's of the 3 seaweeds (63–80% DM) were 11–167 % DM higher and crude protein contents (12.1–14.6% DM) were 68–186% DM higher than the 3 browse species. Seaweeds had lower total phenolics (5.5–10.3% DM) and gross energy (12–15 KJ/g DM), and moderate digestible energy (DE) contents (9–10 KJ/g DM) compared to the browse species. The 3 browse species had ADDM's of 30–57% DM, crude protein contents of 5.1–7.2% DM, total phenolic concentrations of 11.6–16.4% DM, and DE contents of 6–12 KJ/g DM. Winter rye and lichen had the lowest total phenolic concentrations (1.3 and 1.9% DM) of forages examined, and had lower ADDM's (35 and 40% DM), DE contents (6–7 KJ/g DM), and crude protein (7.8 and 5.7% DM) than seaweeds. The relatively high DE and protein contents of seaweed may explain high deer densities of Maine coastal islands where browse availability and use appears to be low.

Key words: seaweed, *Alaria esculenta, Ascophyllum nodosum, Fucus vesiculosis*, winter, digestibility, nutrient content.

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Introduction

Coastal ruminant populations may be nutritionally restricted during winter due to potential food shortages. In many instances white-tailed deer (*Odocoileus virginianus*) in Maine survive on islands where available browse is sparse. In these areas, the deer may have found alternative food supplies. Use of seaweed has been reported for insular and coastal populations of red deer (*Cervus elaphus*) in Scotland (Clutton-Brock *et al.*, 1982) and Sitka black-tailed deer (*O. hemionus sitkensis*) in Alaska (Hanley & McKendrick, 1985). Use of seaweed by white-tailed deer has been observed in coastal Maine.

The objective of this study was to assess the potential nutritional value of three species of seaweed and compare them to some common winter forages.

Material and methods

Three species of seaweed, *Alaria esculenta, Fucus vesiculosus,* and *Ascophyllum nodosum,* were collected within the intertidal zone in Acadia National Park, Maine (44° 20' latitude, 68° 12' longitude), at low tide on 3 April 1990. Approximately 10 kg of each species was placed in plastic bags.

Current annual growth of balsam fir (*Abies balsamea*), northern white cedar (*Thuja occidentalis*), red maple (*Acer rubrum*), and the arboreal lichen, old man's beard (*Usnea* spp.), were collected in the University of Maine Forest, Old Town, Maine USA (44° 55' latitude, 68° 40' longitude) in February 1990. Rye (*Secale cereale*) was collected from farm land in Charleston and Corinth, Maine USA (45° 01' latitude, 69° 01' longitude) in January 1990.

Samples were freeze-dried for 4 days and ground through a Wiley Mill using a 20 mesh screen. Subsamples were oven-dried at 100 C for 48 hours to determine percent dry matter.

Crude protein (CP) (percent of nitrogen x 6.25) was determined by micro-Kjeldahl technique, gross energy by bomb calorimetry, fiber analysis by sequential detergent analysis (Mould & Robbins, 1981; Goering & Van Soest, 1970), and total phenolics by colorimetry, with standard solution of gallic acid (Singleton & Rossi, 1965). The average values of duplicate samples were used in all analyses except dry matter calculation, unless the duplicates varied by more than 5%. If duplicates were not within 5% a 3rd sample was examined.

ADDM's were estimated for each plant species using the equation of Mould & Robbins (1982). This equation was used to provide an estimate of digestibility (Robbins, 1983: 286–287) and not as a representation of true digestibility. Strey & Brown (1989) found a similarity in estimates using Mould & Robbins (1982) equation and their *in vivo* values. Apparent digestible energy (ADE) and apparent digestible protein (ADP) were estimated from the regression equations of Robbins *et al.* (1975).

Table 1. Gross energy, crude protein, and total phenolic content of seaweed and ruminant forages.

	Gross Energy	Crude Protein	Total phenolics
Species	(KJ/g DM)	(% DM)	(% DSM)
Balsam fir	21.993	7.2	16.4
White cedar	22.310	5.8	11.7
Red maple	20.146	5.1	16.2
Rye	17.180	7.7	1.3
Lichens	18.255	5.7	1.9
Ascophyllum	14.673	12.1	10.3
Alaria	12.401	14.6	5.5
Fucus	15.180	14.1	5.7

Results

The CP content of the 3 seaweed species (12.1–14.6% DM) were 168–186% DM greater than the 3 woody browses (5.1–7.8% DM), lichen (5.7% DM) or rye (7.7% DM) (Table 1). Total phenolic concentrations of the seaweeds (5.5–10.3% DM) were less than the browses (11.7–16.4 % DM) but greater than lichen (1.9% DM) and rye (1.3% DM).

The seaweeds contained more cell solubles than any other forage tested and had less cellulose and lignin than any other forage except lichen (Table 2). Based on the equation of Mould & Robbins (1982), the seaweeds had greater ADDM's than other forages examined (Table 3). However, the DE content of seaweeds were less than that of balsam fir and white

Table 2. Detergent analysis results for seaweed and ungulate forages. Values are % DM.

Species	NDF	NDS	ADF	Hemicellulose	Lignin	Cellulose	Cutin	Ash
Balsam Fir	33.5	66.5	24.9	8.6	9.0	10.4	4.7	0.7
White Cedar	40.2	59.7	31.6	8.7	8.9	12.3	9.9	0.6
Red Maple	66.4	33.6	51.7	14.7	19.5	26.8	5.1	0.2
Rye	74.5	25.5	44.6	29.9	9.7	28.2	3.8	2.9
Lichens	42.9	57.1	6.3	36.7	2.4	0.3	3.4	0.1
Ascophyllum	22.0	78.0	13.1	8.9	6.2	0.4	5.7	0.8
Alaria	9.9	90.5	8.5	1.4	2.3	3.5	1.3	1.3
Fucus	21.3	78.7	12.6	8.7	6.1	0.9	5.6	0.1

NDF = Neutral Detergent Fiber
NDS = Neutral Detergent Solubles
ADF = Acid Detergent Fiber

Table 3. Apparent digestibility of dry-matter (ADDM), energy (DE), and protein (AD Protein) in seaweed and ruminant forages.

Species	ADDM (% DM)[a]	ADE (% DM)[b]	DE (KJ/g)	AD Protein (% DM)[c]
Balsam fir	56.8	55.6	12	28.2
White cedar	49.5	48.3	11	10.9
Red maple	29.9	29.0	6	–0.7
Rye	35.4	34.3	6	32.9
Lichens	39.8	38.8	7	10.5
Ascophyllum	63.5	62.2	9	55.2
Alaria	80.1	78.3	10	62.2
Fucus	64.0	62.7	10	61.1

[a] Mould & Robbins (1982) ADDM (% DM) = (1.06*NDS–18.06) + (161.39–36.95*ln (lignin cutin content of ADF))/100), NDS = Neutral Detergent Solubles, ADF = Acid Detergent Fiber

[b] Robbins *et al.* (1975) Apparent digestibility of energy (ADE) = –0.713 + 0.991 (ADDM)

[c] Robbins *et al.* (1975) Apparent digestibility of protein = 95.7 – (488.3/percent crude protein)

cedar because the concentration of gross energy in seaweed was low. The DP of seaweed was also greater than the other forages examined.

Discussion

Based on our results seaweed could be a potentially valuable alternative food for coastal and insular ruminants. The relatively high CP, NDS, and ADDM value of seaweed compared to balsam fir, white cedar, red maple, lichen, and rye, and intermediate phenolic content, indicates that seaweed could provide deer with a high quality food source during winter when other food sources appear to be scarce. Ford *et al.* (1994) used the Mould & Robbins (1982) equation for predicting differences between treatments. Similarly, our ADDM values in this study are presented as estimates (Robbins, 1983: 286–287) and are provided for purposes of comparing the species examined in this study and not to attempt a comparison with data from other work. However, our estimated ADDM values for (*Thuja occidentalis* and *Usnea* are similar to *in vitro Thuja occidentalis* and *Usnea/Evernia mesomorpha* values reported by Jenks & Leslie (1988):

The CP of seaweeds are greater than most other winter forages and are above the generally accepted requirement for adult white-tailed deer of 6–10% DM (French *et al.*, 1956; McEwen *et al.*, 1957). The only common forages that approached this requirement level were rye (7.8% DM) and balsam fir (7.23% DM).

Plant phenolic compounds can reduce platatability and even reduce digestibility by binding with proteins (Robbins *et al.*, 1987). The relatively low phenolic content of seaweed would indicate that the phenolics in these plants would not greatly affect intake or digestion.

Little is known of winter forages on the islands along the Maine coast. Deer are known to overwinter on nearshore and offshore spruce-fir islands with sparse forage. Anecdotal reports of deer consumption of seaweed and concentrations of deer fecal pellet-groups in the intertidal zone indicate that consumption of seaweed occurs in the wild along the Maine coast. However, deer may be seeking salt rather than food from the intertidal zone.

Although no rumen contents were examined in this study, acclimation or inoculation of rumen microorganisms that are suitable for seaweed digestion may be a key factor in seaweed utilization. Because of the unique fiber contents and high salt content of seaweed, special adaptation of ruminal microbes would be required for the maximum use of the seaweed. Though the salt content of seaweed may preclude its use as a solitary food, it could be consumed with other forages to increase overall diet quality without reaching toxic levels of salt in the diet.

Based on these results, seaweed should be further investigated as a component of winter habitat of coastal ruminants. Additional analyses of seaweeds should be performed to confirm or refute our results and feeding trials should be conducted to test the effect of sea salts on diet selection of seaweeds.

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