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Winter nutritive content of black sagebrush (*Artemisia nova*) grown in a uniform garden

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WINTER NUTRITIVE CONTENT OF BLACK SAGEBRUSH (*ARTEMISIA NOVA*) GROWN IN A UNIFORM GARDEN[1]

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ABSTRACT.— Winter crude protein content, in vitro digestibility, and productivity were determined for seven accessions of black sagebrush (*Artemisia nova*) grown in a uniform garden. No significant differences were detected among the accessions for any of these attributes. Mean crude protein was 6.8% of dry matter. Accessional range was from 5.8% to 7.3%. Mean in vitro digestion was 54.8% of dry matter; accessional range, 51.9% to 57.2%. Mean current year's growth (a measurement of productivity) was 4.3 cm; accessional range, from 3.7 to 5.1 cm. In comparison to other winter forages, black sagebrush ranks high for winter levels of crude protein and very high in winter digestible dry matter but low in productivity.

Protein and energy-producing compounds are two of three nutrients commonly listed as being deficient in the winter diet of ruminants on native ranges (Dietz 1965, Halls 1970, Nagy and Wallmo 1971, Welch and McArthur 1979a). Plants that retain significant amounts of green leaves during the winter usually contain higher levels of protein and are more digestible than those that shed their leaves (Ensminger and Olentine 1978, Welch 1983). We have reported significant differential preference of wintering mule deer (*Odocoileus hemionus hemionus*) among seven accessions of black sagebrush (*Artemisia nova*) (Behan and Welch 1985). Significant variation in winter nutrient levels among accessions of a related species, big sagebrush (*A. tridentata*), grown in a uniform garden has been reported (McArthur and Welch 1982, Welch and McArthur 1979b, Welch and Pederson 1981), but there has been little information until now concerning variation in winter nutrient levels among accessions of black sagebrush. We undertook this study to determine the winter nutritive content of seven accessions of black sagebrush grown in a uniform garden.

MATERIALS AND METHODS

On a uniform shrub garden located at the Gordon Creek Wildlife Management Area[4] near Helper, Utah, seven accessions were selected to determine in vitro digestibility, productivity, and levels of crude protein. The accessions had been transplanted as seedlings from various native source locations (Table 1). Within each accession, seven individual plants were randomly selected to furnish the vegetative tissue needed for testing. Because of heavy grazing on twig tips by wintering mule deer, composite sampling had to be used for the Spring Valley and Wingate Mesa accessions. Only twigs with terminal buds and leaves were collected from the plants. Sampling occurred on 3 December 1982.

Vegetative samples (current year's growth of stems and leaves) were collected from each plant, placed in separate paper bags and frozen on site with dry ice. Individual samples were placed in separate plastic bags tied and sealed in a second bag. The double-bagged samples were stored at −35 C until ground.

The samples were ground while submerged in liquid nitrogen in a motorized mortar and pestle. This was done to prevent loss of volatile substances such as monoterpenoids that may suppress cellulolytic microorganisms and to aid in grinding the samples (1/2 mm, Hobbs et al. 1985). Next the ground samples were stored in airtight containers at −35 C until needed for protein determination or digestion trials.

Crude protein levels were determined by the Kjeldahl method (Association of Official

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[4]The shrub garden at the Gordon Creek Wildlife Management Area is cooperatively maintained by the Utah Division of Wildlife Resources (Wildlife restoration funds W-82-R, job 1) and the Intermountain Research Station.

TABLE 1. Locations by county, state, and landmark, or town where each of seven accessions of black sagebrush (*Artemisia nova*) were collected.

Accession	Location
Pine Valley Ridge	Millard, Utah (Desert Experimental Range)
Manti	Sanpete, Utah (Manti)
Black Mountain	Sevier, Utah (Salina)
Spring Valley	White Pine, Nev. (Jct. US-93, 6, and 50)
Dove Creek	Dolores, Colo. (Dove Creek)
Wingate Mesa	San Juan County, Utah (Fry Canyon)
Fremont Junction	Sevier, Utah (Fremont Jct.)

TABLE 2. Mean winter crude protein, in vitro digestibility, and productivity for seven accessions of black sagebrush (*Artemisia nova*) grown in a uniform garden. Protein and digestibility data are expressed as percent of dry matter. Productivity data are expressed in length of leader growth in centimeters. Means for all measurements were found not to be significantly different.

Accession	Crude protein (%)	Digestibility (%)	Leader growth (cm)
Spring Valley[1]	5.8	54.6	3.7
Manti	6.5	57.2	4.1
Black Mountain	6.9	55.9	3.7
Fremont Junction	6.9	55.6	5.1
Dove Creek	7.1	55.6	4.6
Wingate Mesa[1]	7.2	51.9	3.9
Pine Valley Ridge	7.3	53.5	4.5

[1]Samples of the Spring Valley and Wingate Mesa accessions were composited and not included in the analysis of variance.

Analytical Chemists 1980). Crude protein data are expressed as a percentage of dry matter. We used the in vitro digestion procedure as outlined by Pearson (1970), except 1.0 g of fresh tissue was placed in digestion tubes. Rumen inoculum was collected from a slaughterhouse steer fed a ration of alfalfa hay and corn. Welch et al. (1983) have reported that inoculum source has little effect on the ranking of the digestibility of range forages. Results of the digestion trials are expressed as a percentage of dry matter digested.

Percentage values for the crude protein were transformed (arcsin) before performing a completely random analysis of variance. Percentages for in vitro digestion were in the range that did not require transformation prior to the analysis of variance. For significant F ratios, Student-Newman multiple range test ($P < 0.05$) was used to determine differences among treatment means. Because of the composite sampling, the Spring Valley and Wingate Mesa accessions were not included in the analysis of variance for crude protein and in vitro digestion.

Prior to deer use, the plants were used to determine current year's growth, an indicator of production. Current year's growth was determined by measuring the annual leader length of 15 leaders per plant. Leader lengths were measured to the nearest centimeter from the terminal leaf bud scars to the tip of the current terminal leaves. The leaders were selected at random over the entire crown of the plants. A plant mean was calculated from the 15 measurements. Current year growth data were expressed as centimeters and were statistically analyzed as described for crude protein and in vitro digestion.

RESULTS AND DISCUSSION

Results of the crude protein determinations are given in Table 2. Mean winter crude protein content for black sagebrush was 6.8%. Accessional range was from 5.8% to 7.3%. The Pine Valley Ridge accession contained the highest amount of crude protein at 7.3%. No significant differences among the accessions were detected.

Our crude protein levels are considerably less than the 11.7% level reported by Sheehy (1975) and less than the 8.5% reported by the National Academy of Sciences (1964). We are not sure that the latter figure was for the winter period. Averaging the three studies, black sagebrush winter crude protein content would be about 9.0% of dry matter. A winter crude protein level of 9.0% ranks high among winter range forages (Table 3).

Winter in vitro digestibility of the seven accessions of black sagebrush is given in Table 3. Mean in vitro digestibility was 54.8% of dry matter digested. Accessional range was from 51.9% to 57.2%. The Manti accession was the most readily digested at 57.2%. No significant differences were detected among the acces

TABLE 3. Mean winter crude protein content (percentage of dry matter) of some range plants.

Plant	Crude protein	Range	Reference
Agropyron desertorum (green-regrowth)	15.0		19*
Artemisia tridentata	11.4	(9.9–14.2)	1, 2, 3, 4, 6, 8, 12, 16, 19
Cercocarpus ledifolius	10.1	(9.6–10.6)	3, 7
Atriplex canescens	9.6		11
Artemisia nova	9.0	(6.9–11.7)	12, 20, 17
Prunus virginiana	8.7	(7.6–9.9)	3, 5, 10, 15
Cowania mexicana	8.6	(8.4–8.8)	5, 13
Purshia glandulosa	8.5	(8.0–9.0)	3, 13
Juniperus scopulorum	8.4		1
Populus tremuloides	7.8	(6.5–9.5)	3, 10, 15
Chrysothamnus nauseous	7.8	(5.9–7.8)	1, 10
Cercocarpus montanus	7.8	(7.2–8.4)	1, 5, 8
Purshia tridentata	7.8	(6.7–9.1)	1, 3, 4, 7, 8, 10, 13
Atriplex confertifolia	7.7		9
Juniperus osteosperma	6.6	(5.9–7.6)	3, 5, 7
Chrysothamnus viscidiflorus	5.9		19
Amelanchier alnifolia	5.9	(5.5–6.2)	3, 10
Rosa woodsii	5.8	(5.4–6.1)	15, 18
Quercus gambelii	5.3	(5.1–5.4)	5, 16
Fallugia paradoxa	4.8		13
Amelanchier utahensis	4.8		15
Agropyron desertorum	3.9		10
Native grass	3.6		3
Stipa comata	3.5	(2.9–4.0)	9, 10
Oryzopsis hymenoides	3.0	(2.5–3.5)	10, 17

*Reference:
1. Dietz et al. 1962
2. Welch and McArthur 1979b
3. Tueller 1979
4. Bissell et al. 1955
5. Smith 1957
6. Smith 1950
7. Smith 1952
8. Medin and Anderson 1979 (Data converted to dry matter basis)
9. National Academy of Sciences 1975
10. National Academy of Sciences 1958
11. Welch and Monsen 1981
12. Sheehy 1975
13. Welch et al. 1983a
14. Welch and Monsen 1984
15. Dietz 1972
16. Kufeld et al. 1981
17. National Academy of Sciences 1964
18. Welch and Andrus 1977
19. Urness et al. 1983
20. This study

sions. Our mean in vitro digestibility compares favorably with reports by Sheehy (1975) at 53.1% and with Welch et al. (1983b), also at 53.1%. Mean in vitro dry matter digestibility for the three studies is 53.7%. Black sagebrush ranks very high in digestibility among winter range forages (Table 4). Ammann et al. (1973) estimated that dry-matter digestibility of 50% would provide sufficient energy for maintenance.

Mean current year's growth was 4.3 cm, accessional range, 3.7 to 5.1 cm. The Fremont Junction was the most productive at 5.1 cm (Table 2). No significant differences among the accessions were detected. Black sagebrush is not as productive as other winter range forages such as big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*), fourwing saltbush (*Atriplex canescens*), and true mountain mahogany (*Cercocarpus montanus*) (McArthur and Welch 1982, McArthur et al. 1983). Black sagebrush is adaptable to sites where the more productive species do not grow.

Black sagebrush ranks high in winter levels of crude protein and very high in digestible dry matter in comparison to other forages. Phosphorus content is probably high also (National Academy of Sciences 1964). From a qualitative point of view winter nutrient content of black sagebrush is exceeded only by big sagebrush (Tables 3 and 4; Welch 1983).

Lack of significant differences among the seven accessions for the three characters tested suggests that breeding and selection schemes stressing improvement of these attributes would be fruitless. We have reported earlier that wintering mule deer significantly preferred the Pine Valley Ridge accessions over the other accessions tested (Behan and

TABLE 4. Mean winter in vitro digestion of some range plants. Data are expressed as a percentage of dry matter digested.

Plant	Dry matter digested	Range	Reference
Artemisia tridentata	57.4	(49.9–67.0)	2, 3, 4, 5, 6, 7, 10*
Artemisia spinescens	57.0		8
Artemisia nova	53.7	(53.1–54.0)	3, 8, 14
Sporobolus cryptandrus	53.2		8
Agropyron smithii	50.2		10
Oryzopsis hymenoides	50.0	(45.7–54.2)	8, 10
Cercocarpus ledifolius	49.1	(44.7–53.5)	4, 6
Rosa eglanteria (hips)	49.1		6
Hilaria jamesii	48.2		8
Stipa comata	48.1		10
Agropyron spicatum	45.5		10
Ceratoides lanata	44.7		8
Chrysothamnus nauseous	44.4		10
Atriplex confertifolia	43.4		8
Amelanchier utahensis	41.0		1
Prunus virginiana	38.8	(26.3–51.3)	1, 11
Atriplex canescens	38.3		9
Cowania mexicana	37.6		12
Purshia glandulosa	35.8		12
Amelanchier alnifolia	34.6		10
Kochia prostrata	32.2		13
Fallugia paradoxa	29.8		12
Quercus gambelii	28.1		2
Purshia tridentata	25.4	(19.8–30.0)	4, 6, 10, 12
Cercocarpus montanus	24.3	(20.0–28.5)	4, 6

*References:
1. Dietz 1972
2. Kufeld et al. 1981
3. Sheehy 1975
4. Urness et al. 1977
5. Wallmo et al. 1977
6. Welch and Pederson 1981
7. Pederson and Welch 1982
8. Welch et al. 1983b
9. Welch and Monsen 1984
10. Ward 1971
11. Uresk et al. 1975
12. Welch et al. 1983a
13. Welch and Davis 1984
14. This study

Welch 1985). Also, Clary and Beale (1983) noted that pronghorn and domestic sheep both preferred black sagebrush that grows on the Desert Experimental Range in Pine Valley. This is the same kind of black sagebrush as our collection from the Pine Valley Ridge (just north of the Desert Experimental Range). We will be testing the adaptation range of the Pine Valley Ridge accession in preparation for releasing it through the Soil Conservation Service's plant material program as a superior cultivar of black sagebrush for improving winter ranges for domestic sheep, pronghorn, and mule deer.

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