Nutritive Characterization of Certain Grass Hays in Northern New Mexico

JOE D. WALLACE, R. E. LENINGTON, AND L. W. HARMS

Highlight: *Botanical and chemical composition along with nutrient digestibility were studied on five grass hays from north-central New Mexico. Although botanical composition varied widely among the hays, they were similar in most chemical constituents and in digestibility of these constituents. Crude protein was the most variable chemical constituent and was also the most variable component in digestibility among the hays. Digestible protein contents for the hays were closely related to their crude protein percentages. By comparing nutrient composition to nutrient requirements for cattle, an estimate of the feeding value of the hays was obtained. All hays contained sufficient energy and all but one sufficient protein for pregnant cows, but most hays were deficient in these nutrients for lactating cows or growing calves.*

Throughout many higher elevation areas of the western range area, grass hays are used for wintering cattle. These hays commonly make up part or all of the ration for wintering weaner calves and replacement stock and often serve as feed for the entire herd when range forage is under snow cover. New Mexico grass hays are generally harvested in late summer and early fall, and yields vary with both summer rainfall and previous winter precipitation.

Grass hays are harvested from valley bottoms and low-lying areas which receive additional run-off water. In northern New Mexico such hays are commonly referred to as "vega hay." Botanical species found in such grass hays are highly variable but generally represent plants indigenous to respective areas where they are harvested. In some areas, e.g., Chama Valley in upper Rio Arriba County, grass hays are chiefly composed of timothy (*Phleum pratense*).

The objective of this study was to nutritionally characterize certain grass hays representative of some of those fed in northern New Mexico. Nutrient composition and digestibility along with metabolizable energy and nitrogen balance were determined for each hay studied. Important nutrient composition values were compared to recommended nutrient requirements (NRC, 1970) for different classes of cattle.

The authors are associate professor and graduate assistants, Department of Animal, Range and Wildlife Sciences, New Mexico State University, Las Cruces.

The research is Journal Article number 510 from the New Mexico Agricultural Experiment Station, Las Cruces.

Manuscript received February 8, 1974.

Experimental Procedure

Description of the Hays

Grass hays were collected from five locations representing four counties (Colfax, Mora, San Miguel, and Rio Arriba) in north-central New Mexico. All hays were baled prior to collection in the summer and fall of 1972 and were coarsely-chopped (2 to 3 cm lengths) and fed during the winter of 1972-73. Elevation in the areas from which hays were harvested ranges from 1830 to 2440 m; average annual precipitation varies from about 38 to 46 cm.

Sub-samples of each hay were hand-separated by species to determine botanical composition (Table 1). Two hays had high contents of timothy while the other hays contained varying mixtures of native grasses. Forb content ranged from 2.2 to 5.5%. The Cimarron grass hay was harvested from an area which had not been recently used for hay production and, consequently, contained 19% old growth (forage from previous years' growth). Old growth content among other hays was less than 1%. Stage of maturity for individual species making up each hay varied somewhat but, in general, all species were classed as late-bloom to mature. Each hay was cut only once during the year.

Metabolism Trials

Nutritive values for all hays were established by feeding them to sheep in conventional digestion trials. Sheep, rather than cattle, were used because of the greatly reduced feed requirement and because previous research has indicated that digestibility values for the same forage are interchangeable between sheep and cattle (Alexander et al., 1962; Blaxter and Wainman, 1961; Langlands, Corbett and McDonald, 1963).

Each hay was fed to the same six crossbred wether lambs (averaging 31 kg in weight) in metabolism stalls equipped to collect the total excretion of feces and urine. A 10-day preliminary period followed by a 7-

Table 1. Botanical composition (%) of northern New Mexico grass hays.

Species	Native grass hays			Timothy hays	
	Cimarron	Springer	Las Vegas	Chama	Springer
Agropyron smithii	22	–	–	1	–
Bouteloua gracilis	–	27	69	–	–
Muhlenbergia spp.	10	–	24	–	–
Panicum obtusum	10	21	1	–	–
Phleum pratense	–	–	–	64	85
Poa spp.	–	–	–	5	1
Sporobolus airoides	18	29	–	2	–
Trifolium spp.	–	–	–	6	–
Forbs	4	5	5	2	5
Miscellaneous grasses	16	17	1	19	8
Old growth[1]	19	1	<1	1	<1

[1] Old growth represents the portion of plant material left from the previous year.

day collection period was used with each hay. Daily rations were fed at a level of 60 g dry matter per unit of metabolic body weight and were fed in equal parts twice daily. Aliquot samples of hay, refusals, feces and urine were taken during collection periods of each trial.

Apparent digestion coefficients were determined for dry matter, organic matter, crude protein, fiber, lignin, and gross energy. Fiber and lignin analyses were according to acid detergent procedures (Van Soest, 1963). Gross energy values were determined in an oxygen bomb calorimeter. Other chemical analyses procedures were those of A.O.A.C. (1965).

Nitrogen (N) balance studies were conducted with each hay; regression analyses were used to estimate metabolic fecal N and endogenous urinary N excretion (Elliot and Topps, 1964). Toluene was used to prevent ammonia losses from urine collection and storage vessels.

Metabolizable energy (ME) values were established for each hay by deducting urine and methane energy losses from digested energy. Urine energy was determined directly on lyophilized urine samples while methane losses were calculated according to Blaxter and Clapperton (1965). TDN values for the hays were derived from ME values, i.e., 3.6155 Mcal ME = 1 kg TDN (NRC, 1970).

Since this study was purposely an attempt to characterize northern New Mexico grass hays and not to compare areas or hays of differing botanical composition, it was felt that statistical comparisons among hays were unwarranted.

Results and Discussion

Chemical Composition and Digestibility

Although botanical composition (Table 1) varied widely among the five hays, chemical composition was quite similar (Table 2). The most variable chemical constituent was crude protein which ranged from 5.5 to 10.3%. Crude protein values for the native hays were close to those for rush-sedge meadow hay (Raleigh et al., 1964). Lower crude protein in Cimarron native hay was probably due to its higher old growth content compared to other native grass hays studied (Table 1). Crude protein in timothy hays was similar to those found by Lloyd et al. (1961). Higher protein level in Chama timothy as compared to that from Springer was due partially to differences in clover (*Trifolium* spp.) content (Table 1). Lignin also varied among hays studied, with the lowest value (4.7%) found for Cimarron hay despite its relatively high content of old growth.

Table 2. Chemical composition (%) of dry matter and digestibility (%) by sheep of northern New Mexico hays.

	Native grass hays			Timothy hays	
Constituent	Cimarron	Springer	Las Vegas	Chama	Springer
Chemical composition					
Dry matter, %	95.4	95.1	93.8	95.0	93.5
Ash, %	7.7	8.1	8.8	8.2	6.6
Protein, %	6.8	10.3	9.9	8.2	5.5
Fiber, %	41.1	37.9	42.6	40.2	42.0
Lignin, %	4.7	5.3	9.2	6.1	9.3
Gross energy, Mcal/kg	4.37	4.47	4.39	4.35	4.49
Digestion coefficients[1]					
Dry matter	55 (4.4)	58 (1.3)	54 (2.3)	56 (1.0)	52 (2.1)
Organic matter	58 (4.1)	60 (1.3)	56 (1.4)	57 (1.0)	54 (2.2)
Protein	44 (9.3)	63 (4.1)	65 (3.0)	56 (9.2)	35 (2.4)
Fiber	51 (5.7)	51 (3.7)	53 (2.1)	44 (2.7)	47 (3.5)
Lignin	−5 (8.7)	8 (6.3)	21 (2.3)	10 (5.8)	20 (8.2)
Gross energy	54 (3.6)	55 (1.3)	54 (2.2)	54 (1.1)	53 (2.3)

[1] Digestion coefficients represent means of 6 sheep and values given in parenthesis are standard deviations.

Digestibility values were also quite similar among hays (Table 2) and were considered reasonable for the quality of forages studied. Dry matter digestibility for the native grass hays agreed closely with those found by Gallup and Briggs (1948) for Oklahoma prairie hay and to those reported by Raleigh et al. (1964) for meadow hay. Digestibility values for the timothy hays were somewhat lower than those found by Brown et al. (1968) but were close to those of Kivimae (1966) for timothy cut at a similar growth stage. The timothy hays used in this study were slightly higher in most digestion coefficients than timothy hay harvested in the full- to post-bloom stage in Canada (Lloyd et al., 1961).

Fiber digestibility tended to be higher in native grass hays than in timothy hays with differences ranging from 4 to 9 percentage units. Fiber digestibility did not appear to be negatively related to lignin content as has generally been reported. Fiber digestion did, however, seem to be influenced by digestibility of the lignin fraction, with those hays having increased lignin digestion also having higher fiber digestion coefficients within each hay category (Table 2).

Highly variable results in lignin digestibility as well as negative digestion coefficients for this constituent are not uncommon (Forbs and Garrigus, 1950; Watkins, 1955; Wallace and Van Dyne, 1970). Because of this point, use of lignin in ratio procedures to indirectly estimate for-

Table 3. Energy and nitrogen balance data from sheep fed northern New Mexico grass hays.[1]

	Native grass hays			Timothy hays	
Measurement	Cimarron	Springer	Las Vegas	Chama	Springer
Energy flux (Mcal/day)					
Intake	2.63	3.02	2.41	2.89	2.57
Feces	1.19	1.32	1.10	1.33	1.20
Digested	1.44	1.70	1.31	1.56	1.37
Urine	0.14	0.17	0.11	0.13	0.10
Methane[2]	0.19	0.22	0.18	0.21	0.18
Metabolized	1.11	1.31	1.02	1.22	1.09
Nitrogen flux (g/day)					
Intake	6.5	11.1	9.0	8.7	4.7
Feces	3.6	4.1	3.2	3.8	3.1
Digested	2.9	7.0	5.8	4.9	1.6
Urine	2.9	5.2	2.4	4.2	1.0
Retained	0.0	1.8	3.4	0.7	0.6

[1] Each value represents the mean of 6 observations.
[2] Calculated according Blaxter and Clapperton (1965).

age digestibility would seem questionable.

Energy and Nitrogen Metabolism

Energy and nitrogen (N) balance data resulting from sheep metabolism trials with each hay studied are given in Table 3. Variation in energy intake by sheep fed the five hays was due to differences in dry matter intake coupled with slight differences in gross energy content of the hays (Table 2). Fecal energy was responsible for most of the energy loss in the balance studies, accounting for 45.6% of the energy intake when averaged over all five hays.

Urinary energy losses ranged from 7.3 to 10% of the energy digested and averaged 8.8% across all hays. In comparison, Blaxter (1962) quotes a figure of 10% as a "normal" expectancy when urinary energy is expressed as a percent of energy digested on forage rations.

Methane energy losses were calculated using the formula from Blaxter and Clapperton (1965) in which Mcal methane energy per Mcal food intake was determimined as: 0.047 (% digestible energy) + 4.67. Calculated methane energy losses averaged 13% of digested energy which agrees quite well with published results on similar forages (Graham, 1969: Wallace, Knox and Hyder, 1970).

As noted in Table 3, N intake by sheep varied considerably among hays. This was largely due to differences in N content of the hays (Table 2). Compared to N intake, N losses in the feces were less variable, while those in the urine were equally as variable. When fed the Cimarron hay, sheep were in N equilibrium; with all other hays they were in positive N balance. Australian workers (Milford and Haydock, 1965) indicated that a minimum level of dietary protein necessary to promote positive N balance in sheep fed forage rations was 7.8%. In this study two hays, Cimarron grass hay and Springer timothy, were below this level (Table 2); however, sheep fed the latter hay were in a slight positive balance.

A measure of efficiency of N utilization from N balance trials is the percentage of digested N which is retained (Graham, 1964). With this approach, native hays from Springer and Las Vegas had efficiency percentages of 26 and 59, respectively. Likewise, values of 14 and 38% were found for Chama and Springer timothy hays, respectively.

The relation of urinary N (Y) and N intake (X) in grams per day gave the equation, $Y=.564X-1.26$ with a standard error of ±0.040. The intercept, 1.26, serves as an estimate of endogenous N excretion in grams per day. This value is essentially the same as that found by Wallace et al. (1970) on similar forages.

Metabolic fecal N, estimated by regression between N intake and fecal N loss, was 0.47 g per 100 g of dry matter intake, which is slightly lower than commonly reported values of .50 to .55 g (McDonald et al., 1966; Mitchell, 1962).

Feeding Value of the Hays for Wintering Cattle

Energy, protein, and phosphorus deserve first consideration in the wintering of range cattle. In Table 4, the composition of these are given for each hay studied, as are National Research Council (1970) suggested requirements for classes of cattle most likely to be fed such hay. Energy composition and requirements are given both as metabotizable energy (ME) and total digestible nutrients (TDN).

The ME content of these hays were slightly higher than those found by Kelsey et al. (1973) for N-fertilized and unfertilized grass hay (1.80 and 1.63 Mcal/kg, respectively). These workers studied blue grama hay harvested at the full-bloom stage in south-central New Mexico. In the present study, all hays were adequate in ME (or TDN) for pregnant cows but, if fed alone, would be inadequate for either lactating cows or growing calves.

Digestible protein values (Y) for the hays were closely related to their crude protein percentage (X) and could be accurately predicted using the equation, $Y=0.93(X)$ - 2.93. This equation also indicates that true digestibility of protein was 93% (Elliot and Topps, 1964). Digestible protein for hays in this study were similar to those for blue grama hay (Kelsey, 1971). All hays except Springer timothy meet digestible protein requirements for pregnant cows. Only two of the hays (Springer and Las Vegas native grass hays) contain sufficient digestible protein for lactating cows and none have adequate amounts for growing calves (Table 4.)

Phosphorus content of the hays studied were, in general, higher than those found by Watkins and Repp (1964). These workers investigated 14 range grasses collected to simulate grazed forage in different seasons at various locations in New Mexico and found that only during the brief period of early growth did grasses contain adequate phosphorus for beef cattle. Phosphorus levels in the present hays were lower than those reported for blue grama hay (0.35%) by Kelsey (1971). Most ranchers in the western

Table 4. Nutritive composition of northern New Mexico grass hays compared to nutritive requirements[1] for different classes of beef cattle.

Item	Nutrients			
	ME (Mcal/kg)	TDN[2] (%)	Digestible protein (%)	Phosphorus (%)
Composition				
Native grass				
Cimarron	1.84	51	3.0	0.16
Springer	1.94	54	6.5	0.24
Las Vegas	1.85	51	6.4	0.21
Timothy				
Chama	1.84	51	4.6	0.20
Springer	1.92	53	1.9	0.10
Requirements				
Cattle class and wt				
Growing calf (200 kg - .5 kg/day gain)	2.28	63	7.1	0.20
Pregnant cow (450 kg)	1.80	50	2.8	0.16
Lactating cow (450 kg)	2.06	57	5.4	0.22

[1] N.R.C. 1970. Nutrient requirements of beef cattle.
[2] Calculated from ME, 3.6155 Mcal ME = 1 kg TDN (N.R.C., 1970).

range area provide a free-choice phosphorus supplement in combination with salt; consequentely, the lower phosphorus levels (particularly that for Springer timothy) is not regarded as a serious problem.

The authors do not contend that hays studied in the present experiment are representative of all hays harvested in northern New Mexico nor that any one hay from a specific location adequately represents that area. As is well established, the principal factor affecting nutritive value of forage plants is stage of maturity (Brown et al., 1968); thus, grass hay from a single field may vary widely from year to year depending on when it is cut. It is also granted that hays used in these studies were collected rather imprecisely; however, they were harvested in a manner typical of most ranchers in northern New Mexico. Data obtained in this study furnish some broad guidelines on the nutritive value of hays grown in this area.

Literature Cited

Alexander, R. A., J. F. Hentges, J. T. McCall, and W. O. Ash. 1962. Comparative digestibility of nutrients in roughages by cattle and sheep. J. Anim. Sci. 21:373-376.

Association of Official Agricultural Chemists. 1965. Official Methods of Analysis. (10th Ed.). Ass. Offic. Agr. Chem. Washington, D. C. 957p.

Blaxter, K. L. 1962. The Energy Metabolism of Ruminants. Hutchinson and Co., London. 329p.

Blaxter, K. L., and J. L. Clapperton. 1965. Prediction of the amount of methane by rumants. Brit. J. Nutr. 19:511-522.

Blaxter, K. L., and F. W. Wainman. 1964. The utilization of the energy of different rations by sheep and cattle for maintenance and for fattening. J. Agr. Sci. 63:113-128.

Brown, P. H., R. E. Blaser, and J. P. Fontenot. 1968. Effect of spring harvest date on nutritive value of orchardgrass and timothy. J. Anim. Sci. 27:562-567.

Elliot, R. C., and J. H. Topps. 1964. Studies on protein requirements of ruminants. 3. Nitrogen balance trials on Blackhead Persian sheep given diets of different energy and protein content. Brit. J. Nutr. 18:245-252.

Gallup, W. D., and H. M. Briggs. 1948. The apparent digestibility of prairie hay of variable protein content, with some observations of fecal excretion by steers in relation to their dry matter intake. J. Anim. Sci. 7:110-116.

Graham, N. McC. 1964. Utilization by fattening sheep of the energy and nitrogen in fresh herbage and in hay made from it. Aust. J. Agr. Res. 15:974-981.

Graham, N. McC. 1969. Relation between metabolizable and digestible energy in sheep and cattle. Aust. J. Agr. Res. 20:1117-1122.

Kelsey, R. J. 1971. Chemical composition and digestibility of unfertilized and nitrogen-fertilized blue grama. MS Thesis. New Mexico State Univ., Las Cruces. 164p.

Kelsey, R. J., A. B. Nelson, G. S. Smith, and R. D. Pieper. 1973. Nutritive value of hay from nitrogen-fertilized blue grama rangeland. J. Range Manage. 26:292-294.

Kivimae, A. 1966. Estimation of digestibility and feeding value of timothy. Proc. Int. Grassl. Congr. 10:389-393.

Langlands, J. P., J. L. Corbett, and I. McDonald. 1963. The indirect estimation of the digestibility of pasture herbage. J. Agr. Sci. 61:221-226.

Lloyd, L. E., H. F. M. Jeffers, E. Donefer, and E. W. Crampton. 1961. Effect of four maturity stages of timothy hay on its chemical composition, nutrient digestibility and nutritive value index. J. Anim. Sci. 20:468-473.

McDonald, P., R. A. Edwards, and J. F. D. Greenhalgh. 1966. Animal Nutrition. Oliver and Boyd, Ltd., London. 407p.

Milford, R., and K. P. Haydock. 1965. The nutritive value of protein in subtropical species grown in south eastern Queensland. Aust. J. Exp. Agr. Anim. Husb. 5:13-17.

Mitchell, H. H. 1962. Comparative Nutrition of Man and Domestic Animals. Academic Press, Inc. New York. Vol. II 840p.

National Research Council. 1970. Nutritient requirements of domestic animals. Nutrient requirements of beef cattle. Nat. Res. Counc. Washington, D. C. 30p.

Raleigh, R. J., C. B. Rumburg, and J. D. Wallace. 1964. Digestibility of native flood meadow hay at different stages of growth. Proc. West. Sec. Amer. Soc. Anim. Sci. 15:LV(1-5).

Van Soest, P. J. 1963. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. J. Ass. Offic. Agr. Chem. 46:829-835.

Wallace, J. D., K. L. Knox, and D. N. Hyder. 1970. Energy and nitrogen value of sandhill range forage selected by cattle. J. Anim. Sci. 31:398-403.

Wallace, J. D., and G. M. Van Dyne. 1970. Precision of indirect methods for estimating digestibility of forage consumed by grazing cattle. J. Range Manage. 23:424-430.

Watkins, W. E. 1955. Digestibility of range grasses and grass-legume mixtures. New Mexico Agr. Exp. Sta. Bull. 400. 18p.

Watkins, W. E., and W. W. Repp. 1964. Influence of location and season on the composition of New Mexico range grasses. New Mexico Agr. Exp. Sta. Bull. 486. 33p.