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Use of a Metabolizable Protein System to Predict Deficiencies in Diets of Cattle Grazing Sandhills Native Range and Subirrigated Meadow

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Summary

Diet samples from native range and subirrigated meadows were collected with esophageally-fistulated cows and analyzed for CP, IVDMD, in situ protein degradability, and fiber components. Escape protein (EP) and degradable intake protein (DIP) of the samples were calculated. The objectives of this research were to characterize the seasonal changes in forage quality and protein degradability of diet samples and to use a metabolizable protein system to predict deficiencies in energy, degradable protein, and metabolizable protein. The subirrigated meadow was very high in CP in late April and early June but declined during July before increasing in August as regrowth occurred. Meadow samples were highest in IVDMD during periods of active growth (April, June, July, and August). Native range samples were highest in CP and IVDMD during June, July and August, which is the period of active growth for these warm season species. The metabolizable protein system, in general, predicted that during gestation, degradable protein was more deficient than metabolizable protein. However, during lactation, metabolizable and degradable protein were both deficient when cows were fed meadow hay or grazed dormant forage.

Introduction

Many Sandhills ranches have two distinctly different forage resource bases; native upland range and subirrigated meadow. These two sites have different grass species composition and different plant growth characteristics. Familiarity with the nutritional composition of these sites is a valuable management tool for cattle producers in the Sandhills. The grazing animal has the ability to select a diet that is higher in nutritive value than would be obtained by analyzing clipped samples of the same pasture. The use of esophageally-fistulated animals to sample pastures gives the best estimate of the animal's diet.

A metabolizable protein system (NRC, 1985) expresses protein requirements on a degradable intake protein (DIP) and a metabolizable protein (MP) basis. Degradable intake protein is the protein which is degradable in the rumen and available to the microorganisms present in the rumen. Metabolizable protein is the sum of the digestible microbial protein flowing to the small intestine and the digestible escape protein flowing to the small intestine. Metabolizable protein is the protein which the animal uses for maintenance, growth, lactation, and gestation. Expressing protein requirements in this manner should enable producers to more precisely estimate type and amount of supplemental protein needed compared to simply using the crude protein system.

The objectives of this research were to characterize the seasonal changes in forage quality and protein degradability of diet samples and to use a metabolizable protein system to predict deficiencies in energy, degradable protein, and metabolizable protein.

Procedure

Diet samples were collected on both subirrigated meadows and native range sites at Gudmundsen Sandhills Laboratory using esophageally-fistulated cows during different times of the year throughout 1992. Samples were freeze-dried, ground, and analyzed for CP, IVDMD, NDF, ADF, neutral detergent insoluble nitrogen (NDIN), in situ protein degradability, and acid detergent insoluble nitrogen (ADIN). Based on these values, rumen escape protein and rumen degradable protein of the samples were calculated.

The native range pastures had been lightly grazed in the spring. These pastures are typically used as winter pastures. The subirrigated meadow was hayed in July and then grazed in the fall of the year.

Precipitation during April and May was 1.8 and 2.8 inches below normal, respectively. Total precipitation for the 1992 calendar year was 4 inches below normal. Average high temperatures in June, July and August were 7 to 10°F below normal. In late May, two consecutive days of below freezing overnight lows (30 and 20°F) were recorded which likely influenced grass growth and quality patterns.

When laboratory analysis was completed, the metabolizable protein system (NRC, 1985) was used to predict dietary deficiencies in Net Energy for Maintenance (NEm), MP, and DIP. Estimates of grazed dry matter intake were based on previous research conducted at the Gudmundsen Sandhills Laboratory. **All requirements calculated in Tables 3-5 were obtained using thermoneutral conditions. The reader is cautioned that under conditions of cold stress, requirements for energy increase.** No supplement was included in the calculations of nutrient balances. Therefore these should only be used as guidelines.

Assumptions were as follows:

1. Mature cow body weight = 1100 lb
2. Milk production = 18 lb per day
3. Calving Date = March 1 for spring calving cows
4. Calving Date = July 1 for summer calving cows
5. Weaning Date = October 15 for spring calving cows
6. Weaning Date = Dec 31 for summer calving cows
7. Meadow hay was assumed to be of average quality (8% CP, 56% TDN)
8. No supplement was included in any calculations.
9. DIP requirement equals IVDMD x .13
10. Estimates of dry matter intake were based on previous research conducted at the Gudmundsen Sandhills Laboratory.
11. For the growing heifer, weaning weight = 500 lb and breeding weight was 715 lb (65% of mature body weight).

Differences from these assumptions will result in changes in requirements.

Results

Table 1 shows the seasonal changes in chemical composition and digestibility for diet samples collected from the subirrigated meadows in 1992. Because the subirrigated meadows at Gudmundsen Sandhills Laboratory are made up predominantly of cool season species, CP increased rapidly in the spring and then declined over the summer before increasing again during the fall as regrowth occurred. Crude protein was very high in diet samples collected in late April and remained high at the June collection. In vitro dry matter digestibility was also high at the

(Continued on next page)

Table 1. Laboratory analysis of meadow diet samples collected at Gudmundsen Sandhills Laboratory in 1992

Sample date and type		CP (%)	NDIN[a] (%)	ADIN[a] (%)	Escape protein (%)	Degradable protein (%)	NDF (%)	ADF (%)	IVDMD (%)
1/28/92	Meadow	10.26	.64	.10	2.06	7.58	65.41	42.59	51.14
3/17/92	Meadow	14.07	.77	.18	1.58	11.35	56.58	35.87	61.27
4/24/92	Meadow	25.26	.79	.02	1.86	23.26	42.29	23.44	71.89
6/3/92	Meadow	20.34	.64	.11	1.32	18.34	44.75	26.44	71.27
7/10/92	Meadow	9.8	.49	.08	1.11	8.22	61.26	32.12	68.04
8/5/92	Meadow	18.25	.71	.05	1.59	16.36	45.4	35.21	66.82
9/23/92	Meadow	14.82	.52	.09	1.04	13.22	52.14	31.60	59.82
10/15/92	Meadow	12.03	.55	.11	1.09	10.25	51.6	35.65	60.17
12/16/92	Meadow	6.42	.40	.14	.75	4.81	69.51	45.52	56.27

[a] NDIN, Neutral Detergent Insoluble Nitrogen; ADIN, Acid Detergent Insoluble Nitrogen.

April and June collections. Conversely, NDF and ADF values were relatively low at these collection dates. Forage CP declined during the summer months before increasing in August as regrowth started to occur. The CP remained quite high into October before declining in December after growth had ceased. The diet samples collected on the subirrigated meadow were also relatively high in IVDMD as only the January and December samples were below 60% IVDMD. Escape protein of the meadow diet samples ranged from .75 to 2.06% of dry matter. The highest EP values were noted in January.

Table 2 shows the seasonal changes in chemical composition and digestibility of diet samples collected from native upland range sites. On the native upland range sites CP increased later relative to the subirrigated meadows since the upland sites contain more warm season grass species. Grass growth on these sites started in late April as the CP content approached 12%. The cool season species present on these sites initiate growth earlier than the warm season species and the CP content was higher than expected in April. Crude protein values for the diet samples remained between 11 and 13% for the duration of the summer before declining to 6% by late September. In vitro dry matter digestibility was highest during the summer months (the period of active growth). Cows were able to select a diet containing greater than 5% CP throughout the winter months. Escape protein of the range diet samples was highest during the summer months and declined during periods of dormancy. This is contrary to what occurred with the meadow samples.

Table 3 shows the nutrient balance predictions for mature spring calving cows. When cows were fed meadow hay during lactation (March, April, and May), they were in negative energy balance, had a MP deficit, and were slightly deficient in DIP. A DIP deficiency also occurred when cows grazed native range in September, December, and January. The MP system predicted a DIP deficiency of about 200 g/day for cows grazing dormant winter range. This is larger than the 140-168 g/day deficiency predicted by Hollingsworth-Jenkins et al (p. 14 of this report). The MP system assumes no net recycling of nitrogen (urea) through the saliva. Recycling could have occurred under the conditions of that study. In addition, the MP system assumes an efficiency of conversion of TDN to bacterial CP of 13%. This value is then used as the DIP requirement (TDN * .13). The efficiency could be lower than the 13 % on dormant forages. This would reduce the DIP requirement. According to the MP system, cows had ample nutrient supply during the remainder of the year.

It is assumed in the MP system that the DIP requirement will be met. Therefore a DIP deficiency does not reduce MP in the MP system. Metabolizable protein can be supplied by either bacterial CP or EP. In this system, since it is assumed that DIP deficiencies will be met, MP deficiencies can only be met by supplying EP. Supplying additional DIP beyond the requirement will not increase MP supply.

The MP system was also used to calculate the requirements of a two year old spring calving cow (data not shown). The results were very similar to the mature spring calving cow (nutrient deficits occurred during the same

Table 2. Laboratory analysis of range diet samples collected at Gudmundsen Sandhills Laboratory in 1992

Sample date and type		CP (%)	NDIN[a] (%)	ADIN[a] (%)	Escape protein (%)	Degradable protein (%)	NDF (%)	ADF (%)	IVDMD (%)
1/28/92	Range	5.45	.39	.13	.75	3.88	72.89	45.74	55.66
3/17/92	Range	5.30	.33	.04	.87	4.19	71.31	45.75	52.15
4/24/92	Range	11.80	.74	.09	1.95	9.27	64.18	32.97	65.42
6/3/92	Range	11.32	.76	.08	2.27	8.54	69.02	35.16	65.41
7/10/92	Range	12.59	.90	.12	2.53	9.31	66.19	32.96	67.31
8/5/92	Range	11.44	.80	.16	2.04	8.39	65.07	36.98	64.77
9/23/92	Range	6.28	.51	.09	1.49	4.23	69.3	41.95	59.81
12/16/92	Range	5.80	.39	.05	1.15	4.34	71.04	44.88	53.76

[a] NDIN, Neutral Detergent Insoluble Nitrogen; ADIN, Acid Detergent Insoluble Nitrogen.

Table 3. Nutrient balances for a spring calving cow as predicted by the metabolizable protein system (NRC, 1985)

Diet	Meadow hay		Range				Meadow		Range		Meadow hay	
Item	April	May	June	July	August	Sept.	Sept.	Oct.	Dec.	Jan.	Feb.	March
NEm balance, Mcal	-1.5	-2.5	1.9	4.9	3.9	.6	3.1	6.3	2.2	2.1	.7	-1.1
MP available, g	576	576	877	908	747	556	669	595	476	418	524	524
MP requirement, g	733	802	764	696	627	570	570	531	454	401	556	656
MP balance, g	-157	-226	113	212	120	-14	99	64	22	17	-32	-132
DIP available, g	768	768	1044	1336	1135	506	1619	1277	463	468	698	698
DIP requirement, g	799	799	1018	1135	1009	776	931	898	663	687	727	727
DIP balance, g	-31	-31	26	201	126	-270	688	379	-200	-219	-29	-29
DM Intake, lb	24.2	24.2	26.4	28.6	26.4	22	26.4	25.3	20.9	20.9	22	22

Table 4. Nutrient balances for a spring-born heifer (8 months of age through calving) as predicted by metabolizable protein system (NRC, 1985)

Diet	Meadow hay				Range				Meadow		Range	Meadow	Meadow hay	
Item	Nov.	Jan.	March	May	June	July	August	Sept.	Sept.	Oct.	Dec.	Dec.	Jan.	March
NEm balance, Mcal	-.5	-.5	-.3	-.2	1.8	2.3	1.7	.2	1.6	1.4	-.8	——	-1.2	-3.4
MP available, g	238	267	295	324	565	565	523	404	467	430	392	375	417	445
MP requirement, g	375	396	417	438	561	564	585	441	441	449	488	488	534	726
MP balance, g	-137	-129	-122	-114	4	1	-62	-37	26	-19	-96	-113	-117	-281
DIP available, g	317	355	393	431	672	831	795	368	1128	924	381	465	555	593
DIP requirement, g	330	370	410	449	656	707	707	564	649	650	546	601	578	618
DIP balance, g	-13	-15	-17	-18	16	125	88	-196	479	274	-165	-136	-23	-25
DM Intake, lb	10	11.2	12.4	13.6	17	17.8	18.5	16	18.4	18.3	17.2	18.1	17.5	18.7
Body weight, lb	500	560	620	680	710	770	830	860	860	890	950	950	1000	1100
DM Intake, % of BW	2	2	2	2	2.39	2.31	2.23	1.86	2.14	2.06	1.81	1.91	1.75	1.70

Table 5. Nutrient balances for a summer calving cow as predicted by metabolizable protein system (NRC, 1985)

Diet	Range		Meadow			Range			
Item	August	Sept.	Sept.	Oct.	Dec.	Dec.	Jan.	March	June
NEm balance, Mcal	2.3	-2.8	-.3	-.3	.1	-1.5	2	2.4	4.3
MP available, g	747	556	669	595	501	501	440	488	804
MP requirement, g	733	802	802	764	627	627	412	432	556
MP balance, g	14	-246	-133	-169	-126	-126	28	56	248
DIP available, g	1135	506	1610	1277	622	487	492	443	957
DIP requirement, g	1009	776	931	898	804	698	723	677	934
DIP balance, g	126	-270	688	379	-182	-211	-230	-234	23
DM Intake, lb	26.4	22.0	26.4	25.3	24.2	22.0	22.0	22.0	24.2

months as for the mature cow). However, the magnitude of the nutrient deficits was larger for the two-year old cow at each given time point.

Table 4 shows the nutrient balances for a spring born replacement heifer from weaning until two months prior to her first lactation. The table includes a target weight for each month (providing all requirements are met). The most serious deficits occurred when feeding meadow hay. Energy, MP, and DIP were all deficient any time meadow hay was fed. Degradable intake protein deficits also occurred during September and December while grazing range and in December while grazing meadow regrowth. Metabolizable protein deficits occurred during August and December while grazing native range, and during December while grazing meadow regrowth. A slight energy deficit also occurred during December while grazing native range.

Table 5 shows the nutrient balances for a mature summer calving cow. Energy, MP, and DIP deficits occurred during September and December while grazing native range. During September and October, cows were deficient in MP and slightly deficient in energy while grazing meadow regrowth. Degradable intake protein deficiencies occurred in December, January, and March on range and in December while grazing the meadow regrowth. Metabolizable protein deficiencies also occurred in December on both range and meadow.

In general, the metabolizable protein system predicted that when lactating cows were fed meadow hay or grazed dormant forage, they were deficient in DIP, MP, and energy. For gestating cows which were not lactating, the metabolizable protein system predicted that only DIP was deficient.

Protein supplements differ in the proportion of the protein which is degradable and the portion which is escape protein. Examples of sources high in DIP would be sunflower meal, alfalfa hay, corn steep liquor, urea, and biuret. Sources which contain both degradable and escape protein would be soybean meal and cottonseed meal. Sources which are high in escape protein but contain very little DIP would be blood meal and feather meal.

For the gestating cow, a supplement high in DIP is adequate because she is not deficient in MP. For the lactating cow, which needs both DIP and MP, a supplement which contains both degradable and escape protein is necessary. For the growing heifer, a supplement containing some EP as well as DIP is necessary when she is fed meadow hay after weaning and before calving.

Use of the metabolizable protein system should allow producers to more accurately predict the type and amount of supplements necessary to winter the cow herd. By feeding the correct type of supplement at the proper time, overall cost of supplementation could be reduced.

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