

Performance of Lactating Dairy Cows Fed Either Alfalfa Silage or Alfalfa Hay as the Sole Forage¹

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ABSTRACT

Alfalfa was harvested from alternate windrows as 40% DM silage or hay in small rectangular bales and fed in two 12-wk 4 × 4 Latin square trials, each with 20 multiparous lactating cows (4 with ruminal cannulas). Diets contained (DM basis) 69 (trial 1) or 66% (trial 2) alfalfa, 26 to 33% high moisture corn, 1.3% minerals and vitamins, and about 1.6 Mcal of NE_L/kg of DM. In trial 1, second-cutting silage (21.2% CP) and hay (19.7% CP) containing 35% NDF were fed in diets: 1) silage (17.3% CP), 2) hay (16.3% CP), 3) silage with 3% fish meal (19.1% CP), and 4) hay with 3% fish meal (18.1% CP). Cows had lower DMI and lost BW on diet 1. Yields of milk and milk components were similar on diets 1 and 2 and greater on diet 3 than on the other three diets, except that fat yield was greater on diets 1 and 3 than on diets 2 and 4. In trial 2, first-cutting silage and hay containing 19.9 and 16.5% CP and 40 and 41% NDF were fed in diets: 1) silage (16.8% CP), 2) hay (14.6% CP), 3) silage with 3% fish meal (18.2% CP), and 4) hay with 3% fish meal (16.0% CP). Cows had lower DMI and lost BW on diets 1 and 3. Generally, yields of milk and milk components were lower on diet 1 than on diets 2, 3, and 4; only protein yield was greater on diet 4 than on diet 2. In both trials, fish meal increased mean protein

yield 100 g/d on silage and 30 g/d on hay. Apparent digestibilities of DM, NDF, and ADF; concentrations of NH₃ and total AA in the rumen; and urea in milk and blood were greater when cows were fed silage. The energy value of alfalfa silage exceeded that of hay, but absorbed protein was more limiting for alfalfa silage than for hay when fed to lactating cows as the sole forage.

(Key words: alfalfa silage, alfalfa hay, milk yield, protein utilization)

Abbreviation key: AH = alfalfa hay, AS = alfalfa silage, HMC = high moisture corn, HSFM = high solubles fish meal, LSFM = low solubles fish meal.

INTRODUCTION

In addition to being an important dietary forage, alfalfa represents a major protein source for lactating cows. However, experimental evidence indicates that excessive ruminal degradation results in inefficient utilization of alfalfa protein, which may depress yields of milk and milk protein (3). The NPN content of alfalfa silage (AS) typically ranges from about 50% (8) to as high as 87% (21) of total N, and the NRC (22) has fixed the RUP of AS at 23% and that of alfalfa hay (AH) at 28%. However, King et al. (17) reported that ruminal escape of protein in AH was about twice that of AS in abomasally cannulated sheep. Moreover, Makoni et al. (18) observed a RUP for AS of only 10%. Increases in milk and protein yields were significant for lactating cows fed all of their forage as AS (at 50 to 70% of dietary DM) when solvent soybean meal was replaced with sources higher in RUP, such as roasted soybeans (14), expeller soybean meal (8), or fish meal (6). Cows fed all AS diets yielded more milk and milk protein when they were abomasally infused with casein (13)

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and when they were fed expeller soybean meal rather than equal DM from high moisture corn (9).

Roffler and Satter (27) compared the effect on concentrations in blood of branched-chain AA (an indicator of RUP supply to the small intestine) of replacing corn silage in the diet of yearling heifers with alfalfa ensiled at 44 or 64% DM or with dehydrated alfalfa pellets. When alfalfa was substituted for corn silage and CP intake rose from 1.1 to 2.1 kg/d, the magnitude of the increase in branched-chain AA in blood with 64% DM AS and dehydrated alfalfa was about fourfold that with 44% DM AS. Merchen and Satter (19) reported greater NAN digestion in the small intestine when cows were fed AS with 66% DM versus AS with 29 or 40% DM. Extensive heating in the silo with drier AS may have reduced ruminal degradation of protein; hence, response to dietary RUP sources likely varies with DM content of alfalfa forage.

Increased mechanization and decreased field losses have encouraged greater harvest of AS and reduced feeding of AH to dairy cows. The objective of this study was to determine

the relative protein value for yield of milk and milk components of AS and AH when fed as the only forage.

MATERIALS AND METHODS

Trial 1

Second-cutting alfalfa was mowed on June 25 and June 26, 1991, field wilted, and harvested from alternate windrows as AS at about 40% DM or AH in small rectangular bales at about 85% DM. Neither AS nor AH was rained on. The AS was chopped to a theoretical length of 1.0 cm and ensiled in two concrete stave tower silos; AH was stored under shelter. Twenty multiparous Holstein cows ($\bar{X} \pm SD$) of 620 ± 55 kg of BW, parity 3.9 ± 1.8 , 38 ± 10 DIM, and 41 ± 4 kg/d of milk were blocked into five groups of nearly equal DIM, parity, and milk yield. Four of the cows were ruminally cannulated. Cows within groups were assigned randomly to five 4×4 Latin squares; the four diets fed in the Latin squares contained (DM basis; Table 1) 1) 69% AS and 30% high moisture corn (HMC); 2) 70% AH

TABLE 1. Composition of diets.¹

Item	Trial 1				Trial 2			
	AS	AH	AS + FM	AH + FM	AS	AH	AS + FM	AH + FM
	(% of DM)							
AS	69.1	...	69.1	...	65.9	...	65.9	...
AH	...	69.6	...	69.6	...	65.7	...	65.7
HMC	29.6	29.1	26.5	26.1	32.9	33.1	29.8	30.1
HSFM	...	...	3.1	3.0	...	...	...	...
LSFM	...	...	...	...	...	...	3.0	3.0
Dicalcium phosphate	.7	.7	.7	.7	.7	.7	.7	.7
Trace-mineralized salt ²	.5	.5	.5	.5	.5	.5	.5	.5
Vitamin premix ³	.1	.1	.1	.1	.1	.1	.1	.1
Chemical composition								
CP	17.3	16.3	19.1	18.1	16.8	14.6	18.2	16.0
NDF	28.9	28.8	29.0	28.9	32.5	33.4	32.5	33.4
ADF	19.7	19.3	19.6	19.1	23.4	23.3	23.1	23.1
NE _L ⁴ , Mcal/kg of DM	1.65	1.65	1.64	1.65	1.60	1.58	1.59	1.57

¹AS = Alfalfa silage, AH = alfalfa hay, FM = fish meal, HMC = high moisture corn, HSFM = high solubles fish meal, and LSFM = low solubles fish meal.

²Provided 27 mg of Mn, 27 mg of Zn, 17 mg of Fe, 7 mg of Cu, 40 mg of I, .30 mg of Se, and .10 mg of Co/kg of DM.

³Provided 3880 IU of vitamin A, 730 IU of vitamin D, and .73 IU of vitamin E/kg of DM.

⁴Computed from estimated NE_L contents of alfalfa (20) and NRC (22) tables.

and 29% HMC; 3) 69% AS, 27% HMC, and 3% fish meal; and 4) 70% AH, 26% HMC, and 3% fish meal. Fish meal was Menhaden type (Zapata-Haynie Co., Hammond, LA) containing a large proportion of soluble protein and was designated high solubles fish meal (HSFM). Diets were fed for 3-wk periods (total of 12 wk). The study was designed to test the effects of RUP supply. Milk yield responses to postruminal infusion of protein are very rapid, occurring within 24 h (7). Hence, 1 wk was considered to be adequate for adaptation to RUP supply; data on mean yield and intake from the last 2 wk of each period were analyzed. Milk yield was recorded at daily a.m. and p.m. milkings. Milk was sampled at one p.m. and a.m. milking midway through wk 2 and 3 of each period and analyzed for fat, protein, lactose, and SNF contents by infrared analysis (Wisconsin DHI Cooperative, Madison). Cows were weighed on 3 consecutive d at the start of the trial and at the end of each period.

Diets were fed for ad libitum intake as TMR. Feed was offered once daily at 1000 h, and orts were recorded once daily; feeding rate was adjusted daily to yield orts equal to about 5% of feed offered. A sufficient number of bales of AH were chopped (2.5 cm theoretical length of cut) once every period to allow uniform mixing of AH into the TMR. Weekly composites of each TMR, type of orts, AS, chopped AH, and HMC were collected from daily samples of about .5 kg and stored at -20°C , except that AH was stored at room temperature (25°C). Weekly samples of HSFM were collected and stored at room temperature. The AS content of as-fed diets was adjusted at the beginning of each period based on DM determined at 60°C (48 h).

Blood was sampled 4 h after feeding on d 21 of each period from the coccygeal artery or vein of each cow. Blood was heparinized and stored at 2°C for about 12 h when plasma was prepared and deproteinized using four volumes of plasma to one volume of 15% (wt/vol) 5-sulfosalicylic acid and then stored at -20°C . Deproteinized plasma was analyzed for glucose and urea (4). On d 21, a single fecal grab sample also was collected from each cow. Samples of strained ruminal fluid, taken on d 21 from the four ruminally cannulated cows from the ventral sac at 0 (just prior to feeding),

1, 2, 3, 4, and 6 h after feeding, were prepared by straining contents of the rumen through two layers of cheese cloth. After pH was measured, ruminal fluid was preserved by addition of 1 ml of 50% (vol/vol) H_2SO_4 /50 ml of ruminal fluid and stored at -20°C . Samples were thawed and centrifuged at $30,000 \times g$ for 15 min at 2°C ; supernatants were analyzed for NH_3 and total AA (4).

Duplicate composites of diet ingredients were prepared from each period by grinding samples as follows: frozen HMC and AS were mixed with small pieces of dry ice and ground through a sausage grinder; AH and HSFM were ground through a 1-mm screen (Wiley mill; Arthur H. Thomas, Philadelphia, PA). Ingredient composites were analyzed for CP by Kjeldahl using a copper digestion catalyst [Kjeltabs[®]; Tecator Inc., Herndon, VA (1)], NDF and ADF (26), ADIN (15), and indigestible ADF (11). The NDF determinations were made using heat-stable α -amylase and Na_2SO_3 (D. R. Mertens, 1991, personal communication). Samples of HSFM were analyzed for ether extract (1). The AS and AH were analyzed for NPN (21). Samples of TMR and orts were analyzed for DM (60°C for 48 h); DMI was computed on this basis. The actual proportion of dietary DM from each component was computed from DM determined by toluene distillation (12) for AS and HMC and at 105°C (1) for AH and HSFM. The NE_L content of the TMR was calculated using the NE_L of AS and AH, computed from NDF (20), and the NE_L reported for HMC and HSFM in NRC (22) tables. Feces were thawed and dried at 60°C for 72 h, ground through a 1-mm screen, and analyzed for DM, NDF, ADF, and indigestible ADF. Total tract apparent digestibilities were calculated using indigestible ADF as an internal marker (10) and were based on indigestible ADF in TMR computed from feed ingredients. Ruminal protein degradation rate and escape were estimated for HSFM using a modified (6) inhibitor in vitro system (5). Composites of AH and freeze-dried AS were assayed for ruminal protein degradation rate and escape (V. D. Peltekova, 1994, unpublished data) using an alternative in vitro system without inhibitors in which rate was estimated from net NH_3 appearance and net microbial growth (16). Compositions of the TMR, forage, and HSFM fed in trial 1 are in Tables 1, 2, and 3, respectively.

TABLE 2. Composition of alfalfa forages fed during trials 1 and 2.¹

Components	Trial 1		Trial 2	
	AS	AH	AS	AH
DM, %	41.3	85.0	40.6	85.9
NDF, % of DM	35.4	35.2	40.0	41.4
ADF, % of DM	26.5	25.7	31.6	31.6
Ash, % of DM	9.6	9.1	11.2	10.2
CP, % of DM	21.2	19.7	19.9	16.5
NPN, ² % of total N	49.4	7.7	54.4	8.3
k_d , ³ /h	.039	.136	.038	.143
Estimated RUP, ⁴ % of CP	31	28	28	26
NE _L , ⁵ Mcal/kg of DM	1.56	1.56	1.46	1.43

¹AS = Alfalfa silage; AH = alfalfa hay.

²Proportion of total N soluble in 10% (wt/vol) TCA (21).

³Ruminal degradation rate (k_d) estimated in vitro from net NH₃ release plus net microbial growth [V. D. Peltekova, 1994, unpublished data; (16)].

⁴Estimated RUP, percentage = $B[k_p/(k_p + k_d)]$, where B = (100 - NPN) and a fractional ruminal passage rate (k_p) of .06/h was assumed (5, 16).

⁵Values for NE_L for alfalfa forages computed from NDF using the equation of Mertens (20).

Results were analyzed as a 4 × 4 Latin square, replicated five times for DMI, BW change, milk yield and composition, blood plasma data, and apparent digestibilities, and replicated once for ruminal data, using the general linear models procedure of SAS (29). The model for the replicated Latin square included square, cow within square, period within square, treatment, and interaction of period by treatment. Period by treatment was significant for protein yield ($P = .041$), and this interaction was included in the model for that variable. Interactions of period by treatment were not significant for any other variable tested ($P \geq .13$), so they were pooled with the residual. The model for the ruminal Latin square included only cow, period, and treatment. When dietary treatment effects were significant ($P < .05$), mean separation was by least significant difference.

Trial 2

This trial was a replicate of trial 1 with a few exceptions. First-cutting alfalfa, mowed on June 1, 1992, was harvested as AS or AH and stored as in trial 1; neither AS nor AH was rained on (composition in Table 2). The 20 multiparous Holstein cows used in this trial were ($\bar{X} \pm SD$) of 610 ± 55 kg of BW, parity

3.1 ± 1.3, 40 ± 12 DIM, and 42 ± 3 kg/d of milk; blocking and assignment to the 4 × 4 Latin squares were as in trial 1. Slightly greater amounts of HMC were fed in the Latin squares in trial 2 (DM basis; Table 1): 1) 66% AS and 33% HMC; 2) 66% AH and 33% HMC; 3) 66% AS, 30% HMC, and 3% fish meal; and 4) 66% hay, 30% HMC, and 3% fish meal. Menhaden fish meal (Zapata-Haynie Co.) containing little soluble protein and designated

TABLE 3. Composition of fish meal protein supplements fed during trials 1 and 2.¹

Components	Trial 1 (HSFM)	Trial 2 (LSFM)
CP, % of DM	68.3	67.8
Ether extract, % of DM	9.9	6.4
ADIN, % of total N	.56	.50
k_d , ² /h	.066	.034
Intercept (B), % of CP	97.2	97.8
Estimated RUP, ³ % of CP	46	63

¹HSFM = High solubles fish meal; LSFM = low solubles fish meal.

²Ruminal degradation rate (k_d) determined with the inhibitor in vitro system (5).

³Estimated RUP, percentage = $B[k_p/(k_p + k_d)]$, where a fractional ruminal passage rate (k_p) of .06/h was assumed (5).

low solubles fish meal (Sea Lac[®]; LSFM) was fed in this trial. Compositions of the TMR, forage, and LSFM fed in trial 2 are in Tables 1, 2, and 3, respectively. Experimental design, milk sampling and analysis, feeding protocol, feed sampling and analyses, and blood, fecal, and ruminal sampling and analysis were as described for trial 1 except that apparent digestibility of OM also was determined. Statistical analysis also was essentially as in trial 1, except period by treatment was significant for apparent digestibility of DM ($P = .005$) and OM ($P = .011$); these interactions were included in the model for those variables. Otherwise, interactions of period by treatment were not significant ($P \geq .11$) and were pooled with the residual.

RESULTS AND DISCUSSION

Trial 1

The AS had 1.5 percentage units more CP than the AH (Table 2), reflecting greater leaf loss during normal baling plus the chopping used prior to mixing AH into the TMR. Rotz et al. (28) observed mean CP of 20.1 and 19.0% in AS and AH, respectively. The AH diets were 1.0 percentage unit lower in CP (Table 1). Fermentation losses of nonfiber DM, indicated by greater ash content in AS, tended to compensate for leaf loss such that NDF and ADF contents of AS and AH were similar. The low fiber contents of AS and AH and the high estimated NE_L (Table 2) indicated that these forages were of high quality. Despite the expected greater NPN in AS, ruminal degradation rate of protein in fraction B was slower for AS than for AH, and estimated protein escape was similar for these two forages. This estimate of degradation rate was computed from net NH_3 release plus net microbial CP formation and was assumed to proceed as a single, first-order process over the 6 h of incubation (16). After 6 h, net release of degraded CP as NH_3 N was similar in AS and AH incubations, but less degraded CP from AS was recovered as net microbial protein synthesis: 5.5 vs. 7.1 mg of microbial N/100 ml ($P < .01$; V. D. Peltekova, 1994, unpublished data). If capture of degraded CP as microbial protein had been greater in vivo on AH diets, then protein utilization would be better for diets

based on AH than on AS (2). Presence of the large NPN pool in AS may make it inappropriate to estimate protein escape using single, first-order rates for degradation and passage. Use of a bi-exponential model to describe both a rapidly degrading pool for soluble N (NPN plus soluble protein) and a more slowly degrading pool for residual N now is being tested. This approach may avoid the confounding of interpretation that results from using single degradation rates and extents for AS and AH proteins.

Milk yield and other performance traits are in Table 4. On the AS diet, DMI was lower than on the other three diets and BW was lost. When cows were fed AS, they yielded milk with greater fat content but lower contents of protein and SNF than when fed AH. Except for greater fat yield on the AS diet, yields of milk and milk components did not differ on the AS and AH diets without added protein. However, the moderate RUP source HSFM (Table 3) increased yields of milk, FCM, protein, and SNF on the AS diet but not on the AH diet.

Although not different for DM, apparent digestibilities of NDF and ADF were greater on both AS diets (Table 5). Greater fiber digestion may have increased ruminal synthesis of the fat precursor acetate on AS diets relative to that on AH diets, which may be related to the greater fat yield on AS (Table 4). Greater fiber digestion and gross efficiency (milk yield per DMI; Table 4) and the significant increase in milk yield with HSFM addition as an RUP supplement to AS, but not AH, were consistent with greater energy content of the AS diets. Nelson and Satter (24) observed increased rates of in situ DM digestion and decreased ruminal retention times for AS versus AH. The present results suggested that milk yield was limited on AS diets by inadequate absorbed protein but was limited on AH diets by energy supply. For example, RUP supplementation increased protein yield 80 g/d on AS, but only 20 g/d on AH.

Higher ruminal concentrations of NH_3 and total AA on AS diets (Table 6) probably were due to greater content of degradable NPN in AS diets and the 1.0 percentage unit higher CP in AS diets (Table 1). Urea concentrations in milk and, particularly, blood (Table 6) more clearly reflected dietary CP intakes than ruminal NH_3 on these diets. A strong correlation of

TABLE 4. Effect of diet on DMI, BW gain, and yield of milk and milk components (trials 1 and 2).¹

Item	Trial 1						Trial 2					
	AS	AH	AS + FM	AH + FM	SE	P > F ²	AS	AH	AS + FM	AH + FM	SE	P > F
DMI, kg/d	22.5 ^b	23.3 ^a	23.3 ^a	23.8 ^a	.3	.008	22.0 ^c	24.6 ^a	23.2 ^b	24.6 ^a	.2	<.001
BW change, kg/d	-40 ^b	.39 ^a	.20 ^a	.52 ^a	.13	<.001	-38 ^b	.51 ^a	-.04 ^b	.45 ^a	.14	<.001
Milk, kg/d	35.9 ^b	35.7 ^b	37.2 ^a	36.3 ^{ab}	.3	.030	34.6 ^b	36.5 ^a	37.5 ^a	37.5 ^a	.4	<.001
3.5% FCM, kg/d	34.9 ^b	33.5 ^b	36.3 ^a	34.4 ^b	.5	.002	34.6 ^c	36.0 ^b	37.3 ^a	37.1 ^{ab}	.5	<.001
Fat												
%	3.34 ^a	3.14 ^b	3.36 ^a	3.17 ^b	.05	.005	3.53	3.42	3.47	3.45	.07	.804
kg/d	1.19 ^{ab}	1.12 ^c	1.25 ^a	1.15 ^{bc}	.02	.002	1.21 ^b	1.24 ^{ab}	1.30 ^a	1.29 ^a	.02	.003
Protein												
%	3.02 ^b	3.08 ^a	3.12 ^a	3.08 ^a	.02	.017	2.90 ^b	3.01 ^a	2.99 ^a	3.06 ^a	.03	.008
kg/d	1.08 ^c	1.09 ^{bc}	1.16 ^a	1.11 ^b	.01	<.001	1.00 ^c	1.10 ^b	1.12 ^{ab}	1.14 ^a	.01	<.001
Lactose												
%	4.79	4.81	4.73	4.78	.02	.110	4.86	4.75	4.76	4.80	.04	.490
kg/d	1.72	1.73	1.76	1.74	.02	.334	1.68 ^b	1.73 ^{ab}	1.79 ^a	1.80 ^a	.02	.005
SNF												
%	8.56 ^b	8.64 ^a	8.60 ^{ab}	8.61 ^a	.02	.012	8.52	8.50	8.51	8.62	.07	.758
kg/d	3.07 ^b	3.08 ^b	3.20 ^a	3.13 ^{ab}	.03	.024	2.94 ^c	3.10 ^b	3.19 ^{ab}	3.23 ^a	.04	<.001
Efficiency, milk/DMI	1.60 ^a	1.53 ^b	1.60 ^a	1.52 ^b	.05	.005	1.59 ^a	1.49 ^b	1.62 ^a	1.53 ^b	.02	<.001

^{a,b,c}Means within trial having different superscripts differ ($P < .05$).

¹AS = Alfalfa silage, AH = alfalfa hay, and FM = fish meal.

²Probability of a significant effect of diet.

TABLE 5. Effect of diet on apparent nutrient digestibility in the total tract (trials 1 and 2).^{1,2}

Item	Trial 1				Trial 2				
	AS	AH	AS + FM	AH + FM	AS	AH	AS + FM	AH + FM	P > F ³
DM	61.5	62.3	62.2	62.2	61.9 ^a	57.4 ^b	61.7 ^a	58.4 ^b	.6
OM	ND	ND	ND	ND	63.7 ^a	58.9 ^b	64.0 ^a	60.3 ^b	.6
NDF	34.0 ^b	30.5 ^c	36.2 ^a	31.8 ^c	40.4 ^a	33.9 ^b	42.1 ^a	36.3 ^b	.9
ADF	34.2 ^b	29.5 ^c	36.5 ^a	30.4 ^c	42.1 ^a	35.6 ^b	43.9 ^a	35.7 ^b	.8
Digestible ADF	88.7	88.8	94.7	91.7	84.8 ^{ab}	78.9 ^c	89.4 ^a	80.3 ^{bc}	1.7

^{a,b,c}Means within trial having different superscripts differ ($P < .05$).

¹AS = Alfalfa silage, AH = alfalfa hay, FM = fish meal, and ND = not determined.

²Apparent digestibility estimated using indigestible ADF as internal marker (10).

³Probability of a significant effect of diet.

TABLE 6. Effect of diet on concentrations of urea in milk and urea and glucose in blood plasma and on pH and concentrations of N metabolites in ruminal fluid (trials 1 and 2).¹

Item	Trial 1				Trial 2				
	AS	AH	AS + FM	AH + FM	AS	AH	AS + FM	AH + FM	P > F
Milk urea, mM	5.83 ^b	5.82 ^b	6.75 ^a	6.78 ^a	4.62 ^b	3.68 ^c	5.45 ^a	4.76 ^b	<.001
Blood plasma Urea, mM	7.29 ^b	6.81 ^c	8.36 ^a	8.49 ^a	5.53 ^b	3.82 ^d	6.00 ^a	5.03 ^c	<.001
Glucose, mg/dl	76.8	80.7	78.1	78.2	52.2	55.5	54.1	53.9	.068
Ruminal fluid pH	6.01	6.01	6.11	6.04	6.41 ^a	6.18 ^b	6.33 ^{ab}	6.20 ^b	.046
NH ₃ , mM	15.8 ^a	9.8 ^b	16.7 ^a	10.4 ^b	13.9 ^a	5.5 ^b	15.1 ^a	6.6 ^b	<.001
Total AA, mM	3.0 ^a	1.2 ^b	2.4 ^a	1.0 ^b	3.7 ^a	.6 ^b	3.6 ^a	.9 ^b	.008

^{a,b,c}Means within trial having different superscripts differ ($P < .05$).

¹AS = Alfalfa silage, AH = alfalfa hay, and FM = fish meal.

²Probability of a significant effect of diet.

urea in milk to dietary CP, but not to ruminal NH_3 , also was observed by P. Huhtanen (1993, personal communication). Data reported by Oltner and Wiktorsson (25) indicated that milk urea was a linear function ($r^2 = .92$) of the dietary ratio of CP to metabolizable energy. Blood glucose concentrations were uninfluenced by diet.

Trial 2

The CP differential between AS and AH was greater in trial 2 (AS had 3.4 percentage units more CP than AH; Table 2), reflecting more extensive leaf losses during baling and chopping than in trial 1. A possible explanation might be greater leaf fragility for first-cutting (trial 2) than for second-cutting (trial 1) alfalfa. Nelson and Satter (23) observed mean differences between AS and baled AH of plus 2.0 and 1.2 percentage units of CP, respectively, for first- and second-cutting alfalfa. The AS diets contained 2.2 percentage units more CP (Table 1). Ash differential between AS and AH also was higher than in trial 1, but NDF and ADF contents of AS and AH were similar (Table 2). Fiber contents and amounts of estimated NE_L were typical of alfalfa forage of high quality (22). The NPN content was greater, but degradation rate was apparently lower, and estimated ruminal escape was numerically greater, for AS than for AH protein also in this trial (Table 2). Although net release of degraded CP as NH_3 N was similar in AS and AH incubations after 6 h, as in trial 1, less degraded CP from AS tended to be recovered as net microbial protein synthesis (5.0 vs. 6.4 mg of microbial N/100 ml; $P = .11$). Slower ruminal protein degradation may enhance microbial yields. Beaver et al. (2) reported increased duodenal flow of microbial protein, but not dietary protein, when silages made from formaldehyde-treated white clover and ryegrass were fed to cattle. Greater net in vivo synthesis of microbial protein may have contributed to the observed protein advantage of AH over AS and is worthy of further investigation.

Feed DMI, BW change, and milk yield traits from trial 2 are in Table 4. The DMI and BW change were lower on both AS diets. Nelson and Satter (24) reported that DMI averaged 2.2 kg/d less for lactating cows fed diets

containing AS than for those fed AH. Except for fat and lactose yields, which were not different, yields of milk, FCM, and milk components were greater on the AH than on the AS diet without added protein supplement. However, the high RUP source LSFM (Table 3) increased yields of milk, FCM, and milk components on AS; RUP supplementation increased yield of only protein and SNF on the AH diet (Table 4). Addition of LSFM increased protein yield 120 g/d on the AS diet but only 40 g/d on the AH diet. The greater apparent digestibilities of DM, OM, NDF, ADF, and digestible ADF (i.e., total ADF minus indigestible ADF) on the AS diets than on the AH diets (Table 5) showed more clearly than in trial 1 that the energy content of AS exceeded that of AH harvested at equal maturity (24). Milk yield per unit of DMI was greater on the AS diets, but this trait was confounded by relative BW losses on the AS diets (Table 4). Nelson and Satter (23) reported improved feed efficiency of cows fed AS than those fed AH.

As in trial 1, ruminal concentrations of NH_3 and total AA were greater on AS diets than on AH diets (Table 6), probably because the AS diets had greater RDP and higher dietary CP (Table 1). Again, urea concentrations in milk and blood (Table 6) reflected intake of dietary CP rather than ruminal NH_3 ; mean concentrations of milk urea were 5.0 and 4.2 mM and ruminal NH_3 14.5 and 6.1 mM on AS and AH diets, respectively. Milk and blood urea may not serve as clear indicators of excessive ruminal protein degradation. As in trial 1, blood glucose was uninfluenced by diet (Table 6). However, mean glucose concentration in blood in trial 2 was only 69% of that in trial 1; dietary NE_L was lower in trial 2 (Table 1). Milk fat content was uninfluenced by diet in this trial, and fat yield tended to parallel milk yield (Table 4).

CONCLUSIONS

The AS contained 1.5 and 3.2 percentage units more CP than AH; NDF and ADF contents of AS and AH were equal in both trials. The DMI of cows was greater on AH than on AS. Without RUP supplement, milk and protein yields were equal in one trial, but greater on AH than on AS in the other trial. Sup-

plementation with RUP increased mean protein yield 100 g/d on AS and 30 g/d on AH in both trials. Ruminal concentrations of NH₃ and total AA and urea concentrations in milk and blood were lower on AH diets than on AS diets. Digestibilities of DM and OM (one trial) and of fiber (both trials) were greater on AS diets than on AH diets. The energy value of AS exceeded that of AH, but the protein value of AH exceeded that of AS. Greater absorbed protein supply from AH may be partly mediated through increased microbial protein synthesis. Supplementation with RUP is more critical for cows on AS than on AH diets.

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