Effect of Replacing Alfalfa Silage With High Moisture Corn on Nutrient Utilization and Milk Production

S.C. Valadares Filho, G.A. Broderick, R.F.D. Valadares and M.K. Clayton

Introduction

Alfalfa silage (**AS**) is one of the most important forages fed to dairy cows in the U.S. However, during ensiling, more than half of the CP in AS is degraded to NPN. Utilization of the NPN in AS is stimulated by high moisture ear corn (**HMC**) and other high energy feeds because its extensive fermentation increases microbial protein formation in the rumen. However, feeding rates for high energy feeds must be limited because lactating cows require adequate amounts of dietary fiber to maintain rumen health. General guidelines for providing adequate effective fiber in the diet and maintaining optimal DM intake include feeding between 25 to 35% total NDF, maintaining a minimum of 18% forage NDF, and feeding between 33 to 40% non-fiber carbohydrates. The objective of this experiment was to determine how much HMC-based concentrate can be safely fed in AS based diets to maximize utilization of the NPN in AS.

Materials and Methods

Twenty-four multiparous Holstein cows, averaging 610 kg BW and 40 kg/d milk yield, were assigned to six 4 X 4 Latin squares with 3-wk periods (total 12 wk). Data from ruminal sampling is reported in the companion Research Summary. Four diets (Table 1), fed as TMR, contained (DM basis) 80, 65, 50 or 35% AS as the sole forage plus 20, 35, 50 or 65% concentrate. The HMC was ground through a 1-cm screen using a hammer mill just prior to feeding. Diets were held isonitrogenous by adding soybean meal and urea as AS was decreased; urea was added to maintain NPN at 43% of total N. All cows were injected with bST. Milk samples were collected on d-12 and d-19 of each period and analyzed for fat, protein, SNF and milk urea N (**MUN**). Fecal grab samples also were collected from each cow to estimate apparent nutrient digestibility using indigestible ADF as an internal marker. Wk-1 of each period served as adaptation time, and milk yield and DM intake data were collected during wk-2 and wk-3 of each period. The general linear models procedure of SAS was used for all statistical analyses. Dietary concentrate level (% of DM) at the maximum response was determined for significant quadratic equations.

Results and Discussion

Alfalfa silage fed in this trial averaged 37% DM, 20.7% CP and 47.6% NDF (DM basis), and 55% NPN (% of total N). The NPN and CP content was similar to that of AS found in commercial tower silos; however, NDF content was higher and more typical of AS from bunker silos. Thus, all diets, including that with 65% concentrate, contained greater than the recommended minimum of 25% total NDF and 18% NDF from forage (Table 1). Each replacement of 15 percentage units of AS with concentrate decreased total NDF by about 5% and increased NE_L (computed from NRC tables) by an average 0.09 Mcal/kg DM (Table 1). There was a linear increase in apparent OM digestibility with decreasing AS in the diet (Table 2); this may be attributed to reduced fiber and increased content of more digestible nonstructural carbohydrates in the diet. The linear decline in NDF and ADF digestibility with increasing dietary concentrate (Table 2) was in agreement with many reports; increased intake of nonstructural carbohydrates likely would reduce ruminal pH and, thus, depress fiber digestibility. Digestibility of ADF had a significant quadratic response to increasing concentrate with a maximum predicted at 32% dietary concentrate (Table 3).

We anticipated quadratic responses in this trial, including a decline in feed intake, with decreasing AS, due to adverse ruminal effects of high concentrate feeding. Significant linear and quadratic effects of replacing AS with concentrate were observed on intakes of DM, NDF and digestible OM (**DOM**), and on BW change in this study (Table 2). Intake of DM ranged from 4.0 to 4.2% of BW for cows fed 35 to 65% concentrate, similar to the 4% of BW cited by the NRC for 600 kg cows producing 40 kg/d of FCM. There was a quadratic response in DM intake (Fig. 1), with a maximum at 51% dietary concentrate (Table 3). As expected, maximal NDF intake occurred at high AS—27% dietary concentrate (Table 3). Intake of NDF was unusually high and, except at 65% concentrate, exceeded the 1.2% of BW suggested as maximal by Mertens (Proc. 46th Ga. Nutr. Conf., Univ. Georgia, 1985), reaching 1.5% of BW on the two highest AS diets (Table 2). Feed intake may have been limited at higher AS levels in this trial by rumen fill of undigested feed residues. Maximum DOM intake, a measure of TDN intake, occurred at 71% concentrate, which was greater than the highest concentrate level actually fed in this trial. Gain of BW was greatest on 35 and 50% concentrate, intermediate on 65% concentrate, while cows fed 20% concentrate lost BW. The maximum for BW gain was at 44% dietary concentrate (Table 3).

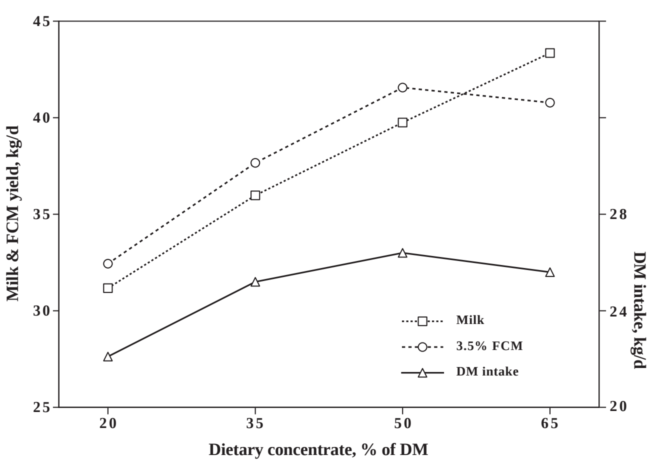

Figure 1. Mean daily yield of milk and 3.5% FCM and DM intake over the last two wk of the 3-wk Latin square for cows fed diets containing (% of DM) 20, 35, 50 and 65% concentrate.

Data on milk yield and composition are in Table 2. Milk yield increased linearly with the increased concentrate in the diet (Fig. 1). The linear increase of milk yield may be attributed to increased DOM intake with decreased dietary AS. Production efficiency (milk/DM intake) followed a response that had different shape from the other quadratic curves: a minimum for milk/DM intake was found at 27% concentrate in the diet (Table 3). However, yield of 3.5% FCM followed a quadratic response (Fig. 1); maximum FCM was predicted at 57% dietary concentrate (Table 3). Milk fat content was unchanged from 20 to 50% concentrate, but declined 0.6 percentage unit at 65% dietary concentrate. This classic pattern of depressed milk fat content with elevated intake of nonstructural carbohydrates resulted in a quadratic response in milk fat yield (Table 3), despite milk secretion being greatest at 65% concentrate. Maximum fat yield occurred at 43% concentrate and 57% AS in the diet. The changes in the pattern of ruminal fermentation, including reduced acetate, increased propionate, and reduced acetate: propionate ratio (described in the companion Research Summary), reflected the lower fiber digestion and intake (Table 2) at the highest levels of concentrate.

Effectiveness of high concentrate feeding to stimulate utilization of AS NPN should be indicated by production responses. Milk content and yield of protein and SNF increased linearly as greater amounts of dietary concentrate replaced AS (Table 2). Elevated microbial protein synthesis with greater energy intake would be expected to increase amino acid supply for milk protein synthesis. Diets containing 35 to 65% concentrate also were supplemented with increasing amounts of soybean meal. Soybean meal CP likely contributes more escape protein than does AS CP. Increased ruminal propionate formation with increased dietary concentrate would be expected to spare amino acids from catabolism for lactose synthesis. Lowest MUN concentration, reflecting improved ruminal utilization of degraded protein and recycled urea, was obtained in cows fed 65% concentrate (Table 2). Maximal MUN was estimated to occur at 31% dietary concentrate (Table 3).

Summary and Conclusion

As dietary concentrate was increased, OM digestibility increased linearly but NDF digestibility was linearly depressed. A number of maxima were identified in this trial when HMC-based concentrate replaced AS in lactating cows fed AS as the only forage. Maximum NDF intake occurred at 27% concentrate while maximal intake of DM and DOM occurred at, respectively, 51 and 71% concentrate. Maximal fat yield occurred at 43% dietary concentrate, while maximal yield of FCM occurred at 57% dietary concentrate. However, yields of milk, protein and SNF did not give quadratic responses and were continuing to increase at 65% dietary concentrate.

Table 1. Composition of diets.

Item	Dietary concentrate (% of DM) 20	35	50	65
	- - - - - - - - - - - - - - (% of DM)	- - - - -	- - - - -	- - - - -
Alfalfa silage	79.60	65.26	50.30	35.30
High moisture ear corn[1]	18.80	30.87	43.63	56.44
Solvent soybean meal	. . .	1.87	3.54	5.22
Urea	. . .	0.41	0.84	1.26
Dicalcium phosphate	0.60	0.60	0.61	0.61
Sodium bicarbonate	0.50	0.50	0.50	0.50
Potassium magnesium sulfate[2]	. . .	0.09	0.18	0.27
Salt	0.30	0.30	0.30	0.30
Mineral and vitamin premix[3]	0.10	0.10	0.10	0.10
Chemical composition				
CP	19.5	20.1	19.9	19.7
NE_L,[4] Mcal/kg	1.40	1.48	1.57	1.66
NDF	42.9	38.2	32.6	27.7
ADF	33.5	29.5	23.9	18.9
Indigestible ADF	19.9	16.8	13.1	9.7
OM	88.5	88.8	90.8	92.3
K	2.12	1.83	1.52	1.23

[1]High moisture ear corn was ground with a hammer mill through a 1.0 cm screen.

[2]Contained (per kilogram) 111 g Mg, 184 g K, and 222 g S.

[3]Provided (per kilogram of DM) 27 mg of Mn, 27 mg of Zn, 17 mg of Fe, 7 mg of Cu, 0.40 mg of I, 0.30 mg of Se, 0.10 mg of Co, 3880 IU of vitamin A, 730 IU of vitamin D, and 0.73 IU of vitamin E.

[4]Computed from estimated NE_L content of alfalfa and from NRC tables.

Table 2. Effect of replacing dietary alfalfa silage with concentrate on nutrient digestibility and intake, and on yield of milk and milk components.[1]

	Dietary concentrate (% of DM)						
Item	20	35	50	65	SEM	L	Q
OM digestibility, %	55.1[d]	59.5[c]	62.6[b]	67.6[a]	0.5	< 0.001	0.603
NDF digestibility, %	37.4	36.7	36.3	35.0	0.7	0.016	0.693
ADF digestibility, %	38.1[a]	38.4[a]	37.6[a]	35.0[b]	0.7	0.104	0.032
DM intake, kg/d	22.1[b]	25.2[a]	26.4[a]	25.6[a]	0.5	< 0.001	< 0.001
NDF intake, % of BW	1.51[a]	1.53[a]	1.37[b]	1.13[c]	0.03	0.002	< 0.001
DOM intake, kg/d	10.8[c]	13.5[b]	15.0[a]	15.9[a]	0.3	< 0.001	0.004
BW Change, kg/d	-0.17[b]	0.63[a]	0.58[a]	0.11[ab]	0.14	< 0.001	< 0.001
Milk, kg/d	31.2[d]	36.0[c]	39.8[b]	43.4[a]	0.6	0.002	0.338
Milk/DM intake	1.41[b]	1.42[b]	1.50[b]	1.71[a]	0.03	0.069	0.005
3.5% FCM, kg/d	32.4[c]	37.7[b]	41.6[a]	40.8[a]	0.8	< 0.001	< 0.001
Fat, %	3.77[a]	3.83[a]	3.77[a]	3.16[b]	0.09	< 0.001	< 0.001
Fat, kg/d	1.32[b]	1.43[ab]	1.49[a]	1.32[b]	0.04	0.001	0.001
Protein, %	2.85[c]	2.94[bc]	3.01[ab]	3.06[a]	0.03	< 0.001	0.516
Protein, kg/d	1.01[c]	1.09[bc]	1.19[ab]	1.28[a]	0.03	< 0.001	0.982
SNF, %	8.37[c]	8.51[bc]	8.64[ab]	8.68[a]	0.04	< 0.001	0.216
SNF, kg/d	2.96[c]	3.19[bc]	3.41[ab]	3.64[a]	0.07	< 0.001	0.998
MUN, mg/dl	25.0[ab]	25.7[a]	24.0[b]	20.6[c]	0.35	< 0.001	< 0.001

[a,b,c,d]Means in rows with different superscripts differ ($P < 0.05$).
[1]DOM = digestible OM, L = probability of linear effect, MUN = milk urea N, Q = probability of quadratic effect.

Table 3. Significant linear and quadratic regressions on dietary concentrate level.[1]

Variable (Y)	Type	Equation	(R^2)[2]	Maximum[3]
Apparent digestibility				
OMD, %	Linear	$Y = 49.7 + 0.271\ C$	0.871	. . .
NDFD, %	Linear	$Y = 38.5 - 0.0520\ C$	0.488	. . .
ADFD, %	Quadratic	$Y = 35.1 + 0.210\ C - 0.00325\ C^2$	0.529	32.3%
Intake and BW change				
DM intake, kg/d	Quadratic	$Y = 14.9 + 0.448\ C - 0.00437\ C^2$	0.738	51.3%
NDF intake, % of BW	Quadratic	$Y = 1.32 + 0.0153\ C - 0.000280\ C^2$	0.821	27.3%
DOM intake, kg/d	Quadratic	$Y = 5.97 + 0.281\ C - 0.00198\ C^2$	0.808	71.0%
BW change, kg/d	Quadratic	$Y = - 2.09 + 0.125\ C - 0.00141\ C^2$	0.464	44.3%
Milk yield and MUN				
Milk yield, kg/d	Linear	$Y = 26.1 + 0.269\ C$	0.913	. . .
Milk yield/DM intake	Quadratic	$Y = 1.39 - 0.0116\ C + 0.000214\ C^2$	0.762	(27.1%)[4]
3.5% FCM yield, kg/d	Quadratic	$Y = 19.7 + 0.760\ C - 0.00667\ C^2$	0.861	57.0%
Fat, %	Linear	$Y = 4.17 - 0.0126\ C$	0.613	. . .
Fat yield, kg/d	Quadratic	$Y = 0.901 + 0.0264\ C - 0.000304\ C^2$	0.750	43.4%
Protein, %	Linear	$Y = 2.77 + 0.00462\ C$	0.613	. . .
Protein yield, kg/d	Linear	$Y = 0.885 + 0.00602\ C$	0.770	. . .
SNF, %	Linear	$Y = 8.24 + 0.00726\ C$	0.746	. . .
SNF yield, kg/d	Linear	$Y = 2.66 + 0.0151\ C$	0.827	. . .
MUN, mg/dl	Quadratic	$Y = 21.2 + 0.282\ C - 0.00448\ C^2$	0.891	31.4%

[1]C = Dietary concentrate (% of DM), ADFD = ADF digestibility, DOM = digestible organic matter, MUN = milk urea N, NDFD = NDF digestibility, and OMD = organic matter digestibility.
[2]Coefficient of determination.
[3]Dietary concentrate content (% of DM) at maximum determined by taking first-derivative of quadratic equations, where significant.
[4]The quadratic equation for milk yield/DM intake has the opposite shape and taking the first-derivative identifies the dietary concentrate content (27.1% of DM) at the minimum.