Effect of Feeding Macerated Alfalfa Silage on Digestibility and Milk Production by Dairy Cows

G.A. Broderick, T.J. Kraus, R.G. Koegel, E. Schneeberger and M. Mauries

Introduction

Ease of mechanization, lower field losses and reduced weather damage have made ensiling the method of choice for harvesting alfalfa in the Midwest U.S. Increasing the ruminal fermentability of alfalfa would be as beneficial to dairy cows as feeding higher concentrate because it would increase both the supply of energy from VFA and protein from microbial protein synthesis. Several small studies showed that macerating alfalfa before ensiling reduced NPN formation in the silo, improved ruminal fiber digestion, reduced ruminal protein degradation, and improved milk yield in lactating cows. The objectives of this research were to determine whether the macerated alfalfa produced with a prototype, capable of producing sufficient forage for large feeding studies has the same improved nutritional value as that obtained using previous machines and to confirm, in larger and statistically more powerful studies, the benefits of macerating alfalfa silage.

Materials and Methods

Alfalfa was harvested using either a conventional mower-conditioner (Control) or the prototype maceration-mat machine (Macerated), field wilted to 40 to 50% DM and ensiled in upright concrete stave silos (first-cutting), or in upright concrete stave silos plus AgBags (second-cutting). In a 2 x 2 Latin square digestibility trial (Trial 1), 20 cows, including four with ruminal cannulas, were blocked by DIM and randomly assigned to diets containing (DM basis) 29% high moisture corn plus 70% of either Control or Macerated second-cutting alfalfa silage from AgBags. Diets were fed for two week periods before switching. Digestibility of DM, organic matter (OM), NDF and ADF was estimated using five fecal grab samples/cow per period; indigestible ADF was used as the internal marker. Ruminal samples were analyzed for ammonia and total amino acids. In the lactation trials (Trial 2 and Trial 3), negative control (Control alfalfa) and test (Macerated alfalfa) diets were formulated with high forage contents; both diets were to be identical except for forage source. A third diet was formulated containing Control alfalfa but with a greater proportion of concentrate. In Trial 2 (second-cutting), 45 multiparous cows were fed a high energy standard diet for two weeks and milk yield data collected for use in covariate analyses. Cows then were blocked by DIM into 15 groups of three and randomly assigned to one of the three experimental diets (Table 1). Two of the cows fed each diet were dropped from the trial because they developed mastitis or because of low production. After Trial 2 was completed, the 11 lowest producing cows were replaced and cows also were fed the standard diet for two weeks to collect covariate milk yield data. Trial 3 (first-cutting) was begun by re-randomizing and re-assigning the 42 highest producing cows to one of the three experimental diets. These also differed from those in Trial 2 in that diets A and B contained less forage and all three diets were supplemented with ruminant-grade fish meal (Table 1). Cows were fed their diets for all 10 weeks of Trial 2 and 3. Cows were injected biweekly with rBST; intake, milk yield, apparent digestibility using two fecal grab samples/cow (indigestible ADF as internal marker), and BW changes were measured in both trials.

Results and Discussion

The second-cutting alfalfa silages fed in Trials 1 and 2 contained (DM basis) 21.1% CP, 40.5% NDF and 33.2% ADF (Control), and 21.3% CP, 42.3% NDF and 34.5% ADF (Macerated). In Trial 1 (70% dietary forage), although DM and OM digestibility were not influenced by treatment, apparent digestibility of NDF and ADF was greater on Macerated than Control alfalfa silage (Table 2). Also, ruminal concentrations of ammonia ($P < 0.10$) and total amino acids ($P < 0.02$) were lower on Macerated alfalfa, perhaps because its greater digestibility stimulated microbial growth. However, in Trial 2, neither milk composition nor yield were altered by feeding Macerated alfalfa compared to Control when this silage was included at 64% of diet DM (Table 3). Moreover, no differences in apparent digestibility between the Macerated and Control diets were detected (Table 2). However, compared to the diet with 64% Macerated alfalfa, feeding greater concentrate (as high moisture corn)

Table 1. Composition of diets fed during lactation trials.

Ingredient	A (Negative Control)	B (Macerated)	C (Positive Control)
		(% of DM)	
Trial 2			
Control Alfalfa Silage	63.7	- - -	48.6
Macerated Alfalfa Silage	- - -	63.8	- - -
Rolled high moisture corn	31.1	31.0	40.5
Solvent soybean meal	- - -	- - -	5.4
Roasted Soybeans	4.2	4.1	4.1
Dicalcium phosphate	0.5	0.5	0.4
Sodium bicarbonate	- - -	- - -	0.45
TMS (+ Se)[1]	0.3	0.3	0.3
Dynamate[2]	0.1	0.1	0.1
Vitamin ADE concentrate[3]	0.1	0.1	0.1
Composition (DM basis)			
CP (%)	17.6	17.7	17.9
NE_L (Mcal/kg)[4]	1.62	1.70	1.69
NDF (%)	32	32	29
Trial 3			
Control Alfalfa Silage	61.3	- - -	51.8
Macerated Alfalfa Silage	- - -	59.8	- - -
Rolled high moisture corn	35.1	36.5	41.3
Solvent soybean meal	- - -	- - -	3.4
Low solubles fish meal	2.9	2.9	2.9
Dicalcium phosphate	0.5	0.5	0.4
Sodium bicarbonate	- - -	- - -	0.45
TMS (+ Se)[1]	0.3	0.3	0.3
Dynamate[2]	0.1	0.1	0.1
Vitamin ADE concentrate[3]	0.1	0.1	0.1
Composition (DM basis)			
CP (%)	18.0	17.8	18.2
NE_L (Mcal/kg)[4]	1.55	1.60	1.60
NDF (%)	34	34	31

[1]Provided (/kg of DM): Mn, 27 mg; Zn, 27 mg; Fe, 17 mg; Cu, 7 mg; I, 0.40 mg; Se, 0.30 mg; and Co, 0.10 mg.
[2]Provided (/kg of DM): Mg, 110 mg; K, 180 mg; S, 220 mg.
[3]Provided (/kg of DM): vitamin A, 3880 IU; vitamin D, 730 IU; and vitamin E, 0.73 IU.
[4]Computed from estimated NE_L contents of alfalfa silage and NRC tables.

increased protein and SNF content of milk as well as yield of milk, protein, lactose and SNF (Table 3). Fat yield was not influenced by diet in this trial. Interestingly, there were trends ($P < 0.10$) for greater digestibility of OM and NDF on the diet with Macerated alfalfa versus the higher concentrate diet (Table 2). These results suggested that, although maceration improved apparent digestibility of second-cutting alfalfa silage, this change did not result in significantly greater milk yield under the conditions of this experiment.

The first-cutting alfalfa silages fed in Trial 3 contained (DM basis) 21.3% CP, 45.9% NDF and 36.1% ADF (Control), and 21.4% CP, 46.0% NDF and 36.3% ADF (Macerated). Milk composition was not influenced by diet in this trial. However, when cows were fed diets containing about 60% silage DM, milk yield was greater ($P = 0.04$) on Macerated than on Control alfalfa and increases in yields of protein, lactose and SNF approached significance ($P < 0.10$) in this trial (Table 3). Feeding greater amounts of high moisture corn with the Control alfalfa did not result in increased yields of milk or milk components compared to feeding 60% Macerated alfalfa (Table 3). As in Trial 1, fat yield was not influenced by diet. Comparing the two diets with about 60% forage, apparent digestibility of DM and OM was greater ($P < 0.01$) on Macerated than Control alfalfa (Table 2). Rather than roasted soybeans, fish meal was the source of undegraded protein fed in this trial; also, the higher concentrate diet contained only eight (rather than 15) percentage units more high moisture corn than did the diet with Macerated alfalfa (Table 1). The amino acid pattern of the undegraded protein in fish meal is more complementary to microbial protein than is that in roasted soybeans. The protein substitution, as well as the greater amount of high moisture corn, may have interacted with the higher fiber content of first-cutting alfalfa to improve the relative response to Macerated silage. Under the conditions of this experiment, there was a clear advantage to feeding Macerated alfalfa, compared to the Control, untreated alfalfa.

Summary and Conclusion

Processing alfalfa immediately after cutting using a prototype maceration-mat machine before the forage was ensiled increased apparent digestibility of DM and fiber in both first- and second-cutting forage. Compared to control, feeding macerated second-cutting alfalfa (42% NDF) did not significantly increase yield of milk or milk components when fed at about 64% of dietary DM. However, feeding macerated, first-cutting alfalfa (46% NDF) improved yield of milk and milk components when fed at about 60% of the DM in

Table 2. Effect of feeding Control or Macerated alfalfa silage on apparent digestibility of DM, organic matter, NDF and ADF (all trials).[1]

Diet	Dietary forage (% of DM)	Apparent digestibility of DM	Organic matter	NDF	ADF
Trial 1 (second-cutting)					
Control	70	59.5	61.4	34.3	28.6
Macerated	70	59.7	60.9	39.7	33.6
SEM[2]		0.6	0.6	0.5	0.5
$P > F$[3]		0.791	0.552	< 0.001	< 0.001
Trial 2 (second-cutting)					
A	64	61.2	62.5	41.6	41.7
B	64	62.2	63.5	41.5	40.1
C	49	60.6	61.6	39.6	38.1
SEM		0.7	0.7	0.8	0.9
$P > F$		0.304	0.152	0.144	0.021
A vs. B[4]		0.332	0.263	0.971	0.198
B vs. C[4]		0.129	0.055	0.092	0.115
Trial 3 (first-cutting)					
A	61	58.8	60.3	41.2	40.3
B	60	61.3	62.8	41.6	40.6
C	51	61.5	62.9	40.3	39.1
SEM		0.6	0.6	0.8	0.9
$P > F$		0.006	0.006	0.449	0.466
A vs. B		0.007	0.005	0.725	0.828
B vs. C		0.779	0.944	0.222	0.247

[1]Apparent digestibility was estimated using indigestible ADF as an internal marker.
[2]SEM = Standard error of the mean.
[3]Probability of a significant effect of diet.
[4]Probability of a significant difference of orthogonal contrast.

diets containing fish meal as the source of undegraded protein. We interpret these results to indicate that maceration improves utilization of both first- and second-cutting alfalfa; however, lactation responses are greater, and more easily detected, with higher fiber alfalfa and the magnitude of this response is influenced by the protein quality of supplemental undegraded protein. Milk yield on diets with 60% macerated, first-cutting forage was equivalent to that on 52% untreated forage.

Table 3. Effect of feeding Control or Macerated second-cutting (Trial 2) or first-cutting (Trial 3) alfalfa silage on DMI, BW gain, and production of milk and milk components.

	Diet[1]					Contrasts[4]	
Item	A	B	C	SEM[2]	*P* > F[3]	B vs. A	B vs. C
Trial 2							
DMI, kg/d	24.9	25.9	26.7	0.5	0.063	0.252	0.206
BW gain, kg/d	0.31	0.47	0.33	0.07	0.243	0.121	0.175
Milk yield, kg/d	37.7	38.7	42.7	0.7	< 0.001	0.893	< 0.001
3.5% FCM, kg/d	35.5	35.8	37.8	0.8	0.174	0.963	0.101
Fat, %	3.24	3.21	2.93	0.13	0.230	0.886	0.123
Fat, kg/d	1.19	1.20	1.22	0.05	0.927	0.896	0.802
Protein, %	2.99	3.03	3.21	0.06	0.015	0.319	0.050
Protein, kg/d	1.12	1.14	1.34	0.03	< 0.001	0.696	< 0.001
Lactose, %	4.94	4.98	5.00	0.05	0.571	0.403	0.891
Lactose, kg/d	1.84	1.88	2.09	0.05	0.004	0.902	0.004
SNF, %	8.65	8.74	8.93	0.09	0.043	0.221	0.174
SNF, kg/d	3.23	3.30	3.74	0.08	< 0.001	0.810	< 0.001
Milk yield : DMI	1.52	1.51	1.61	0.03	0.063	0.435	0.022
Trial 3							
DMI, kg/d	26.5	27.1	26.5	0.7	0.702	0.461	0.477
BW gain, kg/d	0.33	0.45	0.34	0.15	0.798	0.557	0.569
Milk yield, kg/d	34.4	36.5	37.6	0.8	0.019	0.042	0.445
3.5% FCM, kg/d	35.4	36.8	38.4	1.2	0.220	0.350	0.414
Fat, %	3.72	3.57	3.70	0.13	0.630	0.372	0.456
Fat, kg/d	1.27	1.30	1.37	0.06	0.434	0.689	0.388
Protein, %	3.35	3.36	3.48	0.07	0.327	0.990	0.195
Protein, kg/d	1.14	1.22	1.30	0.03	0.004	0.061	0.115
Lactose, %	4.69	4.73	4.75	0.07	0.822	0.687	0.833
Lactose, kg/d	1.62	1.74	1.78	0.05	0.084	0.080	0.738
SNF, %	8.72	8.76	8.91	0.11	0.478	0.814	0.361
SNF, kg/d	2.99	3.20	3.32	0.08	0.023	0.055	0.406
Milk yield : DMI	1.32	1.35	1.42	0.04	0.179	0.458	0.264

[1]Diets were: A = Negative Control (Trial 2, 64% and Trial 3, 61% Control alfalfa silage); B = Macerated (Trial 2, 64% and Trial 3, 60% Macerated alfalfa silage); and C = Positive Control (Trial 2, 49% and Trial 3, 51% Control alfalfa silage).
[2]SEM = Standard error of the mean.
[3]Probability of a significant effect of diet.
[4]Probability of a significant difference of orthogonal contrast.