Timothy Grass or Alfalfa Silage for Cows in Midlactation: Effect of Supplementary Barley[1]

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ABSTRACT

Twenty-four multiparous Holstein cows averaging 104 d of lactation were used in a trial with a split-plot design to evaluate the nutritive value of two silages, timothy grass or alfalfa, both treated with formic acid and stored in plastic bag silos. Silages were offered for ad libitum intake either alone or with 17 or 34% (dry matter basis) dry-rolled barley. Both silages contained similar amounts of acid detergent fiber (ADF) (27.5 and 26.7% for timothy grass and alfalfa, respectively). After 110 d of storage, alfalfa silage contained higher amounts of organic acids and NH_3 N but had lower soluble N. Total dry matter intake (DMI) and silage DMI were similar between cows fed both silages. Increased barley proportion decreased silage DMI (19.2 to 14.2 kg/d). Apparent total tract digestibility of dry matter was unaffected by treatment. The digestibility of neutral detergent fiber and ADF was higher for the timothy grass silage than for alfalfa silage and was unaffected by the barley percentage added to either silage. Milk yield was lower (23.9 to 22.6 kg/d) for cows fed the highest proportion of barley. The 4% fat-corrected milk yield was unaffected by treatment. Percentages of fat, protein, and total solids in milk were higher for cows fed diets with the higher barley content. Milk fat and protein yields were similar among treatments. Urea in blood was lower for cows fed timothy grass silage than for cows fed alfalfa silage (4.68 vs. 6.23 mg/100 ml). These results suggest that timothy grass silage and alfalfa silage, when stored at a similar ADF content, have comparable nutritive value for midlactation cows.

(**Key words**: timothy grass silage, alfalfa silage, midlactation)

Abbreviation key: **A:P** = ratio of acetate to propionate, **AS** = alfalfa silage, **TGS** = timothy grass silage.

INTRODUCTION

The response of dairy cows to a given increment of concentrate varies with the quality of the basic forage used (2). Nutritionists consider legumes to be superior to grass; therefore, few studies (2, 9, 14, 21, 35, 37) have been conducted with lactating cows to compare these two types of forages.

A method used to increase the energy density of a diet and subsequent milk yield is to decrease the ratio of forage to concentrate. Nevertheless, grasses and legumes, in general, contain different amounts of fiber (NDF and ADF) and differ in digestibility, which may alter the effect of the interaction between forage and concentrate on cow performance (37).

Barley is a popular feed ingredient used in the dairy industry of the northern United States and Canada because it is extensively grown, readily available, and less expensive than corn and other cereal grains. Studies with early lactation dairy cows have reported either no effect (12) or a decrease (9, 23) in milk yield when barley replaced corn in the diet. However, this response might have been affected by the interaction of forage and grain type when both forages contain similar amounts of ADF (9).

Studies using timothy grass silage (**TGS**) (4, 21, 24) showed that milk yield was low during midlactation when silage was offered as the sole feed. However, milk yield at <24 kg/d could be maintained without supplemental concentrate when forage digestibility was high (7, 11, 18). This result supports the assumption that energy intake might limit milk yield by decreasing the quality of forage and increasing the amount of forage ADF in the diet (4, 28, 33). Therefore, increasing the quality of forages by reducing the

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ADF content could have an important impact on cow performance.

Beauchemin et al. (3) and Tessmann et al. (32), using alfalfa silage (**AS**), and Martin (17), using TGS, reported a linear increase in milk yield when the concentrate was increased in diets based on silage. In general, a reduction in fiber content of the diet caused by a change in forage species (legume vs. grass) lowered silage DMI (37).

Early cut TGS and AS, preserved using formic acid, stored in plastic bag silos, and fed as the only source of forage, have not been evaluated for cows in midlactation when these silages were fed with or without supplemental barley. Therefore, dairy producers in cold climates might need to evaluate the milk yield response to TGS and AS and to the incremental addition of farm-grown barley during midlactation. The present experiment assessed the effect of TGS and AS containing similar amounts of ADF and three percentages of barley on the voluntary feed intake and performance of dairy cows in midlactation.

MATERIALS AND METHODS

Silages

A sward of early boot pure timothy grass (*Phleum pratense* L.) and an alfalfa (*Medicago sativa* L.) sward at vegetative stage were used in the present experiment. Cattle manure slurry (23 tonne/ha for timothy) and poultry manure slurry (18 tonne/ha for alfalfa) were applied on April 20. The forages were harvested between May 15 and June 6, 1993 and chopped with a precision chopper adjusted to a theoretical chop length of 3 mm. During mowing, forages were treated with formic acid (80%) at the rate of 7 L/tonne and were field-wilted to 20% DM. All materials were ensiled (two silos for each source of forage) in two layer (white outside, black inside) polyethylene bag silos (8 mm thick; Agripac™; Alberta Ag-Industries Ltd., Westlock, AB, Canada) using a silage compactor (Roto Press™; Sioux Automation, Sioux City, IA) for mechanical compaction at 5 kg/cm^2.

Cows and Treatments

Twenty-four multiparous Holstein cows at 104 ± 15 DIM ($\overline{X}$ ± SD) and 590 ± 20 kg of BW yielding 26 ± 2 kg/d of milk were blocked according to DIM and milk yield during a preliminary 28-d period. Cows within each block were paired according to milk yield, and pairs were assigned to one of the treatments. Treatments were arranged in a split-plot design in which the main plots were silage type (TGS or AS), and the subplots were three percentages of dry-rolled barley (0, 17, or 34% on a DM basis) distributed as a 3 × 3 Latin square balanced for residual effects.

Samples of barley were obtained daily during the collection period and composited weekly. Barley (Leger variety with a density of 0.62 kg/L) was dry-rolled on the farm and contained [DM basis ($\overline{X}$ ± SD)] 24.5 ± 2.5, 8.5 ± 0.7, and 2 ± 0.05% of NDF, ADF, and N, respectively; gross energy was 4 ± 0.07 Mcal/kg of DM, and particle size of barley was 2.89 ± 0.3 mm. Barley was top-dressed, and the amount offered was calculated on the basis of DM consumed during the previous day. Also, all cows received a mineral and vitamin supplement (Table 2).

Cows were housed in individual tie stalls with rubber floor mats. Silages were offered for ad libitum intake once daily at 1400 h, and orts were recorded at 1300 h the next day. Cows were milked daily at 0700 and 1700 h.

Measurements and Sample Analyses

Each experimental period lasted 28 d. During the last week of each experimental period, individual feed intake was measured daily, and milk yield was recorded at each milking. Milk samples were taken at each milking on a proportional basis on d 24 to 26 of each period and were analyzed for fat, protein, and lactose contents by infrared analysis (Québec DHIA Laboratory, Saint-Hyacinthe, QC, Canada). Milk was also assayed for total solids (freeze-drying), NPN (percentage of total N not precipitated with TCA), and fatty acids. Milk fatty acids were determined by GLC (model 5890; Hewlett Packard Co., Avondale, PA) and identified using methyl ester standards (Alltech Associates, Inc., Deerfield, IL) according to the methods of Chouinard et al. (4). Fatty acids in milk were expressed as a percentage of the fatty acids that were resolved. The NE_L in diets (megacalories per kilogram of DM) was estimated (36) from the metabolizable energy (digestible energy × 0.82) concentration (20). Silages were sampled daily during the collection period, composited on a weekly basis, dried at 70°C for 72 h in a forced-air oven, and ground through a 1-mm screen before chemical analysis. On the last day of each collection period, blood from the coccygeal vein or artery was obtained at 1000 h in nonheparinized collection tubes, placed on ice, and stored at 4°C. After 1 h, tubes were sent to the Pathology Department of the Québec Ministry of Agriculture, Fisheries, and Food (Ste-Foy, QC, Canada) for analysis of serum urea, total protein, globulin, albumin, and NH_3.

Apparent Total Tract Digestibility

During the last 15 d of each collection period, all cows received 30 g/d of Cr_2O_3 as an indigestible marker to determine total tract nutrient digestibility. The Cr_2O_3 was premixed with ground barley and pelleted (22). Grab samples of feces (500 g) were obtained rectally at 0800 and 1600 h on d 21 to 28 of each period and frozen. Before analysis, the fecal samples were dried at 70°C for 72 h in a forced-air oven, ground through a Wiley mill (2-mm screen; Arthur H. Thomas Co., Philadelphia, PA), and composited (DM basis) for each cow and each period.

Laboratory Procedures

Composited samples of ingredients and feces were analyzed for ash-corrected NDF and ADF (34), ash, and Kjeldahl N using a copper digestion catalyst [Kjeltabs™; Tecator Inc., Herndon, VA (1)]. Gross energy was determined using an adiabatic bomb calorimeter (Parr Instrument Co., Moline, IL). Silage samples were also analyzed for ADIN (34). Concentrations of Cr in total mixed diets, orts, and feces were measured according to the method of Christian and Coup (6).

A portion of the undried, ensiled forage was analyzed for pH, soluble N (22), VFA, and NH_3 N. A 20-g aliquot was extracted in 100 ml of distilled water for 40 min, and pH was determined using a pH meter. Another 20-g aliquot was extracted in 200 ml of 0.1*N* HCl for 2 d, and the liquid extract was used for VFA analysis. The samples of aqueous silage extract were deproteinized using TCA. Analyses of VFA and lactic acid in the deproteinized aqueous extract were carried out using HPLC (Beckman System Gold, Mississauga, ON, Canada). Serum samples were assayed for urea (miligrams/100 ml), total protein (grams per liter), albumin (grams per liter), and globulin (grams per liter) using an autoanalyzer (Hitachi 705 model; Boehringer Manheim Canada, Laval, QC, Canada). Serum NH_3 concentration (grams per liter) was determined using a Kodak Echtachem DT analyzer (Eastman Kodak Co., Rochester, NY) at the Pathology Department of the Québec Ministry of Agriculture, Fisheries, and Food.

Statistical Analysis

Data on silage composition were analyzed by ANOVA as a completely randomized design using the procedures of SAS (29). Feed intake, apparent total tract digestibility, and cow performance data were analyzed as a split-plot design; silage type (AS or TGS) was the main plot, and barley percentages were subplots arranged in 3 × 3 Latin square (29). The specific model was

$$Y = m + S_j + S_jR_iC(L) + A_k + A_kS_j + P_l + P_lS_j + E_{ijkl}$$

where

Y = expected response;
m = overall mean;
S_j = effect of silage type;
$S_jR_iC(L)$ = effect of interaction of silage type, yield, and column within square (error A);
A_k = effect of barley;
P_l = effect of period;
A_kS_j, P_lS_j = interactions between main and secondary effects; and
E_{ijkl} = residual error.

Contrasts were tested using the residual eror to determine whether the response to increased barley supplementation was linear or quadratic. Effects of silage type were tested using error A (df = 22). The main effect of barley percentage and the interaction between silage type and barley percentage were tested with the residual error. Data were analyzed using the GLM procedure of SAS (29). When a significant interaction was detected, the Bonferroni *t* procedure was used to compare treatment means (16). Differences were considered to be significant at $P < 0.05$ unless otherwise noted.

RESULTS AND DISCUSSION

Silage Composition and Fermentation Characteristics

Both TGS and AS contained similar amounts of DM and ADF (Table 1), but AS contained less NDF and more N, and total acids than did TGS. The difference in NDF and N contents between silages was an expected result because legumes usually contain less NDF and more N than do grasses (2, 14, 35, 37). The AS contained 22% more NH_3 N and 13.2% less water-soluble N (percentage of total N) than did TGS. Based on the concentration of NH_3 N (percentage of total N), pH, and concentrations of acetic, propionic, and butyric acids, both silages were considered to be well preserved (27). The use of formic acid at harvesting and compaction at ensiling in plastic bag silos might have reduced the effect of forage type on fermentation characteristics of silage.

Feed Intake

The barley used in the present experiment contained more NDF and ADF than reported by others (15, 20), but N content was similar to the published values. Barley starch and degradation in the rumen were not measured; however, Kong et al. (15) reported a content of 54.4% starch in the variety of barley used in our study. Overton et al. (23) observed that 74.4% of barley starch was digested in the rumen, but the variety of barley was not provided.

Consumption based on the chemical composition of the diets (Table 2) showed that silage DMI was not affected by forage type (P = 0.12) but was reduced from 19.2 to 14.2 kg/d (linear and quadratic; P < 0.01) when barley was increased from 0 to 34% (Table 3). Total DMI was not affected by forage type but was increased (quadratic; P < 0.02) as barley supplementation increased. The effect of barley supplementation on silage DMI and total DMI agrees with the results of other studies (2, 3, 4, 17, 25) in which silage DMI decreased and total DMI increased with each increment of increase in the concentrate that was based on starch. However, Overton et al. (23) observed that total DMI of lactating cows decreased linearly as barley in the diet replacing corn increased from 0 to 100%. Total DMI as a percentage of BW averaged 3.14% and was higher with barley supplementation (quadratic; P < 0.01).

TABLE 1. Chemical composition of silages.

Item	Silage	
	Timothy grass	Alfalfa
pH	4.0	4.2
DM, %	24.4	26.3
NDF, % of DM	49.7[a]	34.3[b]
ADF, % of DM	27.5	26.7
Gross energy, kcal/kg of DM	4.3[b]	4.4[a]
Total N, % of DM	2.3[b]	3.2[a]
ADIN, % of Total N	5.3	5.3
NH_3 N, % of Total N	4.6[b]	5.9[a]
Water-soluble N, % of total N	50.8[a]	44.1[b]
Organic acids		
Total acids,[1] g/kg of DM	98.4[b]	122.5[a]
Lactic, % of total	76.4	79.8
Acetic, % of total	13.5	8.9
Propionic, % of total	0.01	0.01
Formic, % of total	5.9	9.0
Butyric, % of total	ND[2]	ND

[a,b]Means within a row with different superscripts differ (P < 0.05).

[1]Sum of lactic, acetic, propionic, and formic acids.

[2]Not detected.

When NDF intake, rather than total DMI, was considered, cows fed TGS consumed more NDF (1.5 kg/d and 0.24% of BW; P < 0.01) than did cows fed AS, and, for both silages, NDF intake was reduced when 34% barley was fed (P < 0.01; Table 3). The relationship between dietary NDF content and the DMI of cows was negative (r = –0.33). Mean NDF intake (1.2 ± 0.2% of BW) was similar to the 1.2 ± 0.1% of BW suggested by Mertens (19) as the limitation point for feed intake for cows in mid to late lactation.

Intake of ADF, expressed either as kilograms per day or as a percentage of BW, was similar between silages and was reduced as the percentage of barley increased (P < 0.01; Table 3). Cows fed diets containing AS consumed more N (0.63 vs. 0.48 kg/d; P < 0.01) and NE_L than did cows fed diets containing TGS (P < 0.03; Table 3). The NE_L intake for cows fed both silages decreased linearly as barley increased (P < 0.01). The observed N, ADF, and NE_L intakes were expected results because of the content of these nutrients in the diets. An interaction between silage type and barley percentage was observed for N intake but not for intakes of silage DM, total DM, NDF, ADF, or NE_L. Cows fed more barley gained less BW (linear; P < 0.02; Table 3) than did cows fed the other diets; however, mean BW was not affected by treatment.

Total Tract Digestibility

Total tract digestibilities of DM, OM, and gross energy were similar for both silages (P > 0.05; Table 4). Digestibility coefficients for NDF and ADF were higher, and coefficients for N were lower (P < 0.01), for TGS than for AS. Previous studies (10, 30, 37) have also reported higher NDF digestibilities for grasses than for legumes in dairy cows. The higher N digestibility of diets containing AS might have resulted from the higher N content in these diets. In general, the addition of barley to diets reduced total tract digestibility of all fractions, which agrees with the results of Overton et al. (23) who reported a reduction in DM digestibility in the total tract as barley increased in the diet. No interaction of silage and barley percentage was observed for digestibilities of DM, OM, ADF, NDF, N, and gross energy. The results of this trial are contrary to those of trials (2, 17, 28) in which no effect of concentrate on the digestibility of dietary nutrients was reported.

Milk Yield and Composition

Milk yield was similar between cows fed both silages (P > 0.05; Table 5) but was reduced as the

TABLE 2. Composition of diets offered.

	Timothy grass			Alfalfa		
	0%[1]	17%	34%	0%	17%	34%
	(% of DM)					
Ingredient						
Alfalfa silage	...	...	...	98.8	81.8	64.8
Timothy grass silage	98.8	81.8	64.8	...	...	...
Dry-rolled barley	...	17.0	34.0	...	17.0	34.0
Mineral and vitamin mix[2,3]	1.2	1.2	1.2	1.2	1.2	1.2
Chemical composition						
DM, %	27.2	31.6	38.5	27.3	31.5	37.7
	(% of DM)					
NDF	45.9	42.9	37.8	34.2	32.9	31.5
ADF	27.9	25.2	22.0	26.0	23.6	21.2
N	2.6	2.5	2.4	3.2	3.1	2.9
Gross energy, Mcal/kg of DM	4.3	4.3	4.2	4.4	4.3	4.3
Calculated NE_L,[4] Mcal/kg of DM	1.5	1.4	1.2	1.5	1.4	1.2

[1]Barley percentage.

[2]Mineral and vitamin mix for the total mixed diet based on alfalfa silage contained 3% Ca, 9% P, 8% Mg, 10% Na, 300,000 IU of vitamin A, 100,000 IU of vitamin D, and 3000 IU of vitamin E.

[3]Mineral and vitamin mix for the total mixed diet based on timothy grass silage contained 15% Ca, 5% P, 8% Mg, 10% Na, 500,000 IU of vitamin A, 150,000 IU of vitamin D, and 3000 IU of vitamin E.

[4]Calculated from the metabolizable energy (digestible energy × 0.82) concentration (20, 36).

percentage of barley increased ($P < 0.02$). The reduction in milk yield was probably due to the lower intake of NE_L observed as barley increased in the diet. However, yield of 4% FCM and lactose percentage were not affected by treatment ($P > 0.05$). Weiss and Shockey (37) found that milk yield was similar between cows fed grass silage and those fed legume silage but increased as concentrate in the diet increased from 20 to 40%. Even as percentages of concentrate increased from 0 to 38% in diets based on TGS, Chouinard et al. (4) found no effect on milk yield. However, others (2, 17, 28, 31) observed a linear response of milk yield and 4% FCM yield as concentrate increased. Overton et al. (23) reported a

TABLE 3. Effect of type of silage and percentage of barley on intake and BW of midlactation dairy cows.

	Timothy grass			Alfalfa				Effect[1]		
Item	0%[2]	17%	34%	0%	17%	34%	SE	S	B	S × B
								P		
Intake, kg/d										
Silage DM[L,Q,3]	18.5	17.1	14.1	20.0	18.0	14.7	0.37	0.12	0.0001	0.38
Total DM[Q]	18.5	19.7	19.5	20.0	20.8	20.2	0.37	0.12	0.02	0.45
NDF[L,Q]	8.5	8.5	7.8	6.9	6.8	6.4	0.16	0.0001	0.0008	0.75
ADF[L,Q]	5.1	4.9	4.3	5.2	4.9	4.3	0.10	0.94	0.0001	0.81
N[L,Q]	0.47[c]	0.49[c]	0.47[c]	0.65[a]	0.64[a]	0.60[b]	0.01	0.0001	0.0008	0.02
NE_L,[L,Q] Mcal/d	28.3	27.7	23.8	30.2	28.2	25.3	0.49	0.03	0.0001	0.29
Intake, % of BW										
DM[Q]	2.89	3.10	3.08	3.20	3.33	3.24	0.05	0.17	0.01	0.44
NDF[L,Q]	1.33	1.33	1.22	1.09	1.09	1.02	0.02	0.002	0.0005	0.69
ADF[L,Q]	0.81	0.78	0.68	0.83	0.78	0.69	0.01	0.74	0.0001	0.80
Mean BW, kg	613	618	640	642	638	602	2.12	0.60	0.62	0.64
BW Change,[L] kg/d	0.55	0.34	0.14	0.31	0.43	0.04	0.13	0.33	0.02	0.45

[a,b,c]Means within a row with different superscripts differ ($P < 0.05$).

[1]S = Silage type, B = barley percentage (0, 17, and 34%), and S × B = interaction between S and B.

[2]Barley percentage.

[3]Linear (L) or quadratic (Q) effect of barley percentage ($P < 0.05$).

TABLE 4. Effect of type of silage and percentage of barley on total tract apparent digestibility of nutrients in midlactation dairy cows.

Item	Timothy grass			Alfalfa			SE	Effect[1]		
	0%[2]	17%	34%	0%	17%	34%		S	B	S × B
	(%)							P		
DM[L,3]	74.2	72.4	69.2	71.7	68.0	69.2	1.33	0.14	0.01	0.24
OM[L]	72.3	70.5	67.3	69.1	65.3	66.9	1.40	0.08	0.01	0.23
N[L]	67.5	65.5	61.8	74.4	70.9	69.7	1.46	0.0003	0.001	0.57
NDF[L]	72.4	69.8	65.6	59.1	56.4	56.0	1.84	0.0004	0.02	0.19
ADF[L]	70.2	67.3	63.1	57.9	52.9	53.2	2.02	0.0001	0.006	0.24
Gross energy[L]	70.7	63.6	51.7	68.3	60.3	53.4	2.01	0.31	0.0001	0.25

[1]S = Silage type, B = barley percentage (0, 17, and 34%), and S × B = interaction between S and B.

[2]Barley percentage.

[3]Linear (L) effect of barley percentage ($P < 0.05$).

decrease in milk yield of midlactation cows as corn was replaced by barley in the diet.

In the present trial, milk fat content and yield were unaffected by silage type, but milk fat percentage was linearly increased from 4.29 to 4.59% ($P < 0.01$; Table 5) as barley supplementation increased. This result disagrees with those of other studies (17, 25) in which no relationship between concentrate percentage and fat percentage was found; in general, however, concentrate at >40% reduced milk fat percentage (8, 13, 26) because of a decreased ratio of acetate to propionate (**A:P**) in the rumen (37). Therefore, the high milk fat observed when barley was supplemented in the present study could have been the result of increased A:P. Nevertheless, Overton et al. (23) observed an increase in the milk fat content of cows in midlactation when barley starch was increased in the diet, but the A:P in the rumen was lowered. Therefore, factors other than the A:P may affect milk fat percentage.

Milk protein and NPN percentages were similar between cows fed both silages ($P > 0.05$; Table 5), but milk protein concentration increased from 3.33 to 3.70% (linear; $P < 0.01$), and NPN (percentage of N) decreased from 7.21 to 6.35% ($P < 0.01$), as the percentage of barley in the diet increased. Others (2, 17, 23, 28), observed that the protein content of milk increased as concentrate based on cereals increased in the diet. Milk protein yield was not affected by treatment ($P > 0.05$). No interaction of silage type and barley percentage was observed for milk yield or for main components ($P > 0.05$).

Under the conditions of the present experiment, the total solids in milk increased as the barley percentage in the diet increased, which might explain the higher percentage of fat and, partially, the higher protein content in milk. Therefore, the increase in milk protein percentage with barley supplementation could have resulted from the reduction in milk yield rather than from the supply of nutrients because the protein yield was unaffected.

TABLE 5. Effect of type of silage and percentage of barley on BW and milk yield and composition in midlactation dairy cows.

Item	Timothy grass			Alfalfa			SE	Effect[1]		
	0%[2]	17%	34%	0%	17%	34%		S	B	S × B
								P		
Yield										
Milk,[L,3] kg/d	23.4	23.9	22.6	24.3	23.3	22.6	0.46	0.95	0.02	0.30
4% FCM, kg/d	24.2	25.9	24.4	25.4	24.5	24.4	0.48	0.84	0.25	0.06
Fat,[L] %	4.24	4.59	4.60	4.35	4.39	4.58	0.08	0.87	0.002	0.17
Fat, kg/d	0.99	1.09	1.02	1.05	1.01	1.02	0.02	0.90	0.33	0.08
Protein,[L] %	3.37	3.56	3.65	3.33	3.54	3.70	0.05	0.98	0.0001	0.60
Protein, kg/d	0.78	0.84	0.81	0.81	0.82	0.82	0.01	0.93	0.07	0.24
Lactose, %	4.57	4.56	4.55	4.64	4.63	4.59	0.02	0.37	0.14	0.74
TS,[L] %	13.26	13.79	13.88	13.40	13.65	13.95	0.10	0.94	0.0001	0.35
NPN,[L] % of Total N	6.89	6.85	5.93	7.55	6.96	6.78	0.25	0.09	0.006	0.34

[1]S = Silage type, B = barley percentage (0, 17, and 34%), and S × B = interaction between S and B.

[2]Barley percentage.

[3]Linear (L) effect of barley percentage ($P < 0.05$).

Higher proportions of $C_{14:1}$ and Δ-11-*trans*-$C_{18:1}$ and lower proportions of $C_{15:0}$, $C_{17:0}$, *cis*-Δ-11-$C_{18:1}$, $C_{18:2}$, and $C_{18:3}$ milk fatty acids were observed for cows fed TGS (Table 6). In general, silage type did not affect $C_{8:0}$ to $C_{14:0}$ fatty acids in milk. Supplementation with barley increased the proportions of $C_{8:0}$, $C_{10:0}$, $C_{12:0}$, $C_{14:0}$, $C_{14:1}$, $C_{16:0}$, $C_{16:1}$, and $C_{18:3}$ and lowered the proportions of $C_{17:0}$, $C_{18:0}$, Δ-11-*trans*-$C_{18:1}$, and *cis*-Δ-11-$C_{18:1}$ fatty acids in milk. These findings for milk fatty acids are consistent with those of Chouinard et al. (4) who used midlactation cows fed timothy silage and reported that increasing the amount of concentrate from 0 to 38% altered the composition of milk fatty acids. In the present trial, interactions of silage type and barley percentage occurred for $C_{16:0}$, *cis*-Δ-11-$C_{18:1}$, $C_{18:3}$, and $C_{20:4}$. In the present experiment, the relationship between *trans*-$C_{18:1}$ and the milk fat percentage appeared to support the hypothesis of Gaynor et al. (8) and Piperova et al. (26) that there is an inverse relationship between *trans* milk fatty acids and milk fat. But, under the conditions of the present trial, the concentration of *cis*-$C_{18:1}$ also decreased as milk fat increased. In the present work, the variation in milk fat percentage might have possibly been related to variations in milk total solids.

Blood Components

Despite higher N intake (Table 3), only urea concentration was higher, and albumin was lower, for cows fed AS ($P < 0.01$; Table 7) than for cows fed TGS; however, urea concentration was decreased by barley supplementation ($P < 0.01$). An interaction between silage type and barley percentage existed for urea. Urea variations in blood were positively ($r = 0.38$; $P < 0.01$) correlated with milk NPN. Concentrations of NH_3 in blood varied as barley percentage varied (quadratic; $P < 0.01$) but were not affected by silage type. Neither total protein nor globulin concentration was affected ($P > 0.05$) by treatment. These values were similar to those previously reported (5) for cows in a similar stage of lactation. The lack of effect of forage type on milk protein might be explained by the higher urea in serum observed when cows were fed AS, which could indicate that the AS N was used less efficiently than was the TGS N.

CONCLUSIONS

In the present trial, conservation characteristics of immature TGS (27.5% ADF) and AS of similar ADF content were not different when formic acid was applied at harvesting and silages were well compacted

TABLE 6. Effect of type of silage and percentage of barley on milk fatty acids.

	Timothy grass			Alfalfa				Effect[1]		
	0%[2]	17%	34%	0%	17%	34%	SE	S	B	S × B
	(% of milk fat)							*P*		
$C_{4:0}$	4.64	4.56	4.60	4.59	4.57	4.36	0.09	0.49	0.29	0.33
$C_{6:0}$	3.40	3.41	4.49	3.35	3.45	3.32	0.04	0.39	0.52	0.08
$C_{8:0}$[L,3]	1.92	1.96	2.00	1.85	1.97	1.90	0.03	0.30	0.02	0.14
$C_{10:0}$[L,Q]	4.20	4.37	4.52	4.09	4.54	4.42	0.08	0.92	0.0002	0.16
$C_{12:0}$[L,Q]	4.01	4.24	4.43	3.85	4.40	4.38	0.08	0.92	0.0001	0.17
$C_{14:0}$[L]	12.48	12.63	12.67	12.28	13.00	12.84	0.14	0.76	0.007	0.13
$C_{14:1}$[L]	1.29	1.33	1.38	1.05	1.16	1.24	0.04	0.02	0.003	0.33
$C_{15:0}$	1.42	1.39	1.37	1.82	1.86	1.87	0.03	0.0001	0.95	0.37
$C_{16:0}$[L]	31.18	32.78	32.59	32.02	31.83	32.94	0.41	0.91	0.02	0.09
$C_{16:1}$[L]	1.62	1.64	1.74	1.47	1.55	1.62	0.06	0.41	0.04	0.83
$C_{17:0}$[L]	0.78	0.74	0.68	1.03	0.97	0.93	0.01	0.0001	0.0001	0.73
$C_{18:0}$[L]	8.53	8.36	8.13	8.68	8.12	8.08	0.15	0.89	0.006	0.46
trans-Δ-9-$C_{18:1}$	0.01	0.01	0.01	0.01	0.01	0.01	0.0003	0.33	0.38	0.38
trans-Δ-11-$C_{18:1}$[L]	4.05	3.35	2.79	3.64	2.91	2.26	0.08	0.001	0.0001	0.69
cis-Δ-9-$C_{18:1}$	17.57	16.64	16.84	16.79	16.30	16.69	0.36	0.57	0.15	0.66
cis-Δ-11-$C_{18:1}$[L]	0.52[bc]	0.43[d]	0.48[bc]	0.71[a]	0.68[a]	0.59[ab]	0.02	0.0001	0.008	0.02
$C_{18:2}$	1.64	1.54	1.63	1.80	1.74	1.69	0.05	0.01	0.34	0.37
$C_{18:3}$[L]	0.54[b]	0.46[c]	0.44[c]	0.74[a]	0.74[a]	0.67[a]	0.01	0.0001	0.0001	0.006
$C_{20:4}$[Q]	0.12[a]	0.10[b]	0.11[ab]	0.10[b]	0.10[b]	0.11[ab]	0.004	0.46	0.04	0.01

[a,b,c,d]Means within a row with different superscripts differ ($P < 0.05$).

[1]S = Silage type, B = barley percentage (0, 17, and 34%), and S × B = interaction between S and B.

[2]Barley percentage.

[3]Linear (L) or quadratic (Q) effect of barley percentage ($P < 0.05$).

TABLE 7. Effect of type of silage and percentage of barley on blood metabolites in midlactation dairy cows.

	Timothy grass			Alfalfa				Effect[1]		
Item	0%[2]	17%	34%	0%	17%	34%	SE	S	B	S × B
									P	
Urea,[L,Q,3] mg/100 ml	4.6[c]	4.9[c]	4.6[c]	6.6[a]	6.5[a]	5.6[b]	0.17	0.0001	0.002	0.03
Serum metabolites, g/L										
NH_3[Q]	0.19	0.18	0.20	0.19	0.19	0.21	0.007	0.40	0.01	0.39
Total protein	77.6	76.9	76.7	75.7	74.8	74.5	0.63	0.15	0.23	0.95
Albumin	40.1	39.5	39.8	37.6	38.3	37.8	0.29	0.01	0.94	0.09
Globulin	37.4	37.3	36.8	37.9	36.3	36.5	0.47	0.91	0.08	0.28

[a,b,c]Means within a row with different superscripts differ ($P < 0.05$).

[1]S = Silage type, B = barley percentage (0, 17, and 34%), and S × B = interaction between S and B.

[2]Barley percentage.

[3]Linear (L) or quadratic (Q) effect of barley percentage ($P < 0.05$).

at ensiling. Cows fed TGS consumed similar amounts of DM and yielded equivalent amounts of milk and 4% FCM as did those fed AS. For cows in midlactation that were fed high silage diets and that yielded <25 kg of milk/d, forage type had less effect on DMI and milk composition than did barley supplementation. Cows fed AS had higher blood urea and yielded milk containing more NPN than did cows fed TGS. Regardless of silage type, barley decreased blood NPN and increased milk protein concentration. These data show that, under conditions similar to those of this study, TGS can be an alternative to AS as a forage for cows in midlactation.

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