Short communication: Effects of replacing part of corn silage and alfalfa hay with *Leymus chinensis* hay on milk production and composition

R. Yan,^{*1} S. Chen,^{†1} Xian Zhang,[‡] J. Han,^{*} Y. Zhang,^{*2} and D. Undersander[†]

^{*}Department of Grassland Science, College of Animal Science and Technology, China Agricultural University, Beijing, 100193, P. R. China

[†]Department of Agronomy, University of Wisconsin, Madison 53706

[‡]Institute of Environment, Resource, Soil and Fertilizer, Zhejiang Academy of Agricultural Sciences, Hangzhou, 310021, P. R. China

ABSTRACT

The objective of this research was to investigate the effects of replacing part of corn silage (CS) and alfalfa hay (AH) with *Leymus chinensis* hay on milk production and composition. Twenty multiparous Holstein dairy cows were used in a randomized block design for a 14-week period and 2 treatments. Treatments were (dry matter basis): (1) Non-*Leymus chinensis* hay diet (NLC; 35% CS, 15% AH) and (2) added *Leymus chinensis* hay diet (ALC; 30% CS, 10% AH, 10% *Leymus chinensis* hay). Adding *Leymus chinensis* hay increased neutral detergent fiber content and in vitro digestibility of the diet. Cows receiving the ALC diet had higher dry matter intake, milk yield, milk protein yield, lactose yield, solids-not-fat yield, and milk fat content compared with those fed the NLC diet. Somatic cell counts of cows decreased in the ALC compared with the NLC treatment. *Cis*-11 18:1 and 18:2 contents in milk increased, whereas *trans*-9 and *cis*-9 18:1 fatty acid contents decreased. *Trans*-9, *cis*-11 conjugated linoleic acid content was not influenced by adding *Leymus chinensis* hay to the diet. *Leymus chinensis* hay can be used to replace part of CS and AH in diets of dairy cows to get higher milk yield and good milk quality.

Key words: *Leymus chinensis* hay, milk production, milk composition

Short Communication

Corn silage (CS) is the predominant forage fed to lactating dairy cows in China. It is high in starch and a good source of ruminally fermentable carbohydrates (Brito and Broderick, 2006). However, when CS is the primary forage in dairy diets, nutritional limitations can occur, which could lead to increased lameness in dairy cows because of high levels of fermentable car-

bohydrates and low fiber content (Cook, 2003). Alfalfa and corn silage are complementary forages (Brito and Broderick, 2006). However, when cows were fed with CS, high-quality alfalfa may not necessarily be the best forage to increase fiber or decrease NFC, and it may be difficult to provide adequate levels of digestible fiber without providing excessive levels of highly fermentable NFC (Brito and Broderick, 2006). *Leymus chinensis* is a widely adapted perennial grass. In China, it naturally occurs in the Northeastern Plain and east of the Inner Mongolian Plateau. *Leymus chinensis* has tender stems and leaves, and good palatability. The forage yield of *L. chinensis* without irrigation is about 3,000 to 4,500 kg/hm², and the yield with irrigation reaches 6,000 kg/hm² (Chen, 2001). Sun et al. (2007) indicated that *L. chinensis* is high in fiber (69.07%) and low in water-soluble carbohydrates (5.27%), and it may contribute to good balanced diet for cows fed with CS and alfalfa. The main objective of the current study was to investigate the effects on milk production and composition when part of the CS and alfalfa hay (AH) was replaced by *L. chinensis* hay.

Twenty multiparous Holstein cows, averaging 110 ± 12 DIM and 605 ± 47 kg of BW, were used in a 14-wk experiment. The first 2 wk were the period of adaptation, and measurements were taken in the last 12 wk. Cows were randomly assigned to each group equally. Cows were housed in individual tie-stalls and had free access to water. The experimental protocol was approved by the Department of Grassland Science, College of Animal Science and Technology, China Agricultural University (Beijing, China).

The main treatment effect was type of forage in the diets. The 2 treatments (Table 1) were (DM basis): (1) non-*L. chinensis* hay diet (NLC; 35% CS, 15% AH, and 50% concentrates) and (2) added *L. chinensis* hay diet (ALC; 30% CS, 10% AH, 10% *L. chinensis* hay, and 50% concentrates). Diets were formulated to meet the NRC (2001) nutrient allowances to supply adequate ME and protein for lactating cows (600 kg of BW) producing 35 kg of milk per day with 3.5% fat and 3.0% protein.

Received June 14, 2010.

Accepted March 24, 2011.

¹These authors contributed equally to this paper.

²Corresponding author: zhangyj@cau.edu.cn

Table 1. Ingredient composition of the experimental diets

Ingredient (% of DM)	Treatment ¹	
	NLC	ALC
Corn silage	35	30
Alfalfa hay	15	10
<i>Leymus chinensis</i> hay	0	10
Corn	24	24
Wheat gluten	3	3
Corn germ meal	4	4
Soybean meal	8	8
Cottonseed meal	4	4
Distillers dried grains with solubles	3.5	3.5
Premix feed ²	1.5	1.5
Calcium hydrogen phosphate	0.5	0.5
NaCl	0.7	0.7
NaHCO ₃	0.8	0.8

¹Cows were fed a diet without *Leymus chinensis* hay (NLC) or a diet with *Leymus chinensis* hay (ALC).

²Contained 260,000 IU of vitamin A; 150,000 IU of vitamin D; 1,500 IU of vitamin E; 1,000 mg of Fe; 800 mg of Cu; 2,100 mg of Zn; 700 mg of Mn; 18 mg of Se; 25 mg of I; and 20 mg of Co (per kilogram of DM).

Data of milk yield, milk composition, and fatty acid (FA) content in milk were analyzed as a randomized block design using the mixed model procedure of SAS (PROC MIXED; SAS Institute, 2000). The model used was as follows:

Table 2. Chemical compositions of experimental diets

Composition	Treatment ¹		SEM	Forage		
	NLC	ALC		Corn silage	Alfalfa hay	<i>Leymus chinensis</i> hay
Chemical (% of DM)						
DM (%)	50.5 ^b	52.1 ^a	0.13	24.8	92.1	92.9
OM ²	94.9	95.0	0.06	94.2	91.5	94.6
NE _L ³ (Mcal/kg)	1.56	1.57		1.36	1.27	1.13
CP	16.8	16.6	0.10	9.0	16.3	8.7
Ether extract	3.4	3.5	0.02	2.8	2.5	3.4
NDF	33.6 ^b	36.3 ^a	0.14	40.5	36.6	65.8
ADF	17.7 ^b	19.0 ^a	0.08	25.6	24.3	38.1
Ash	5.1	5.0	0.02	5.8	8.5	5.4
NFC ⁴	41.1 ^a	38.6 ^b	0.07	41.9	36.1	16.7
Ca	0.81	0.77	0.06	0.45	1.63	0.21
P	0.45	0.44	0.03	0.28	0.41	0.23
IVNDFD ⁵ (48 h; % of NDF)	47.6 ^b	50.8 ^a	0.18	40.5	43.5	54.6
Fatty acid (g/100 g of total fatty acids)						
14:0	0.95	1.01	0.03	1.59	1.73	2.41
16:0	18.11	18.15	0.08	28.62	23.72	25.46
16:1	0.23	0.22	0.02	1.31	0.48	0.75
18:0	1.89	1.91	0.01	5.15	9.18	7.55
18:1	19.44	19.63	0.06	5.84	11.52	9.52
18:2	36.42 ^b	37.73 ^a	0.15	27.14	20.92	25.74
18:3	8.77	8.95	0.11	15.41	20.34	18.17
Others	14.19 ^a	12.40 ^b	0.15	14.94	12.11	10.4

^{a,b}Means within a row with different superscripts differ ($P < 0.05$).

¹NLC = diet without *Leymus chinensis* hay; ALC = diet with *Leymus chinensis* hay.

²OM = 100 – ash.

³Estimated from the NRC (2001).

⁴NFC = 100 – (NDF + CP + ether extract + ash).

⁵In vitro NDF digestibility.

$$Y_{ijl} = \mu + F_i + C_{j(i)} + W_l + e_{ijl},$$

where Y_{ijl} is the dependent variable, μ is the overall mean, F_i is the fixed effect of forages, $C_{j(i)}$ is the random effect of cow j nested within forage i , W_l is the random effect of week l , and e_{ijl} is the random residual error. Significance for effects of forage was declared at $P < 0.05$ unless otherwise noted. Tendencies for treatment effects were declared at $0.05 < P < 0.10$.

The chemical composition of the experimental diets are shown in Table 2. After replacing part of CS and AH with *L. chinensis* hay, contents of NDF and in vitro NDF digestibility (IVNDFD) in the diet increased, whereas NFC content in the diet decreased.

Table 3 shows the DMI, milk yield, milk composition, and SCC of cows fed experimental diets. According to Mertens (1994), DMI is positively correlated with NDF concentration when energy limits intake but DMI is negatively correlated with NDF content when fill limits intake. In this study, DMI should be limited by gut fill when the NDF levels of the ALC and NLC diets were 36.3 and 33.6%, respectively. However, DMI increased by 0.8 kg/d when cows were fed ALC diets compared with those fed NLC diets (Table 3). This would be due to the higher IVNDFD of the ALC diet (50.8%)

Table 3. DMI, milk yield, milk composition, and SCC of cows fed experimental diets

Variable	Treatment ¹		SEM
	NLC	ALC	
DMI (kg/d)	21.6 ^b	22.4 ^a	0.08
Milk yield (kg/d)	32.0 ^b	33.5 ^a	0.12
4% FCM ² (kg/d)	29.6 ^b	32.4 ^a	0.12
ECM ³ (kg/d)	32.2 ^b	35.0 ^a	0.13
Fat (%)	3.48 ^b	3.77 ^a	0.01
Fat (kg/d)	1.12 ^b	1.27 ^a	0.01
Protein (%)	3.12	3.14	0.01
Protein (kg/d)	1.00 ^b	1.05 ^a	0.01
Lactose (%)	5.11	5.10	0.01
Lactose (kg/d)	1.64 ^b	1.71 ^a	0.01
SNF (%)	8.93	8.94	0.01
SNF (kg/d)	2.86 ^b	3.00 ^a	0.01
SCC ($\times 10^3$ /mL)	319.4 ^a	221.0 ^b	1.77

^{a,b}Means within a row with different superscripts differ ($P < 0.05$).

¹NLC = diet without *Leymus chinensis* hay; ALC = diet with *Leymus chinensis* hay.

²4% FCM = milk (kg) $\times$ (0.4 + 15 $\times$ fat %).

³ECM = 0.327 $\times$ milk (kg) + 12.95 $\times$ fat (kg) + 7.2 $\times$ protein (kg).

compared with the NLC diet (47.6%). Other studies (Robinson and McQueen, 1992) have also demonstrated that forage fiber digestibility may influence feed intake, especially if intake is limited by the physical capacity of the reticulorumen. Increasing the fraction of fiber that is potentially digestible subjects a larger portion of the rumen fiber pool to both digestion and passage and may increase the clearance of fiber from the rumen and allow for additional feed consumption (Dado and Allen, 1996). In some previous studies, the increased DMI was the primary reason for increased milk production (Oba and Allen, 1999). The increase in milk yield in the present study was likely the result of the increase in DMI in the ALC diet.

The milk fat content increased from 3.48 to 3.77% (DM basis) when part of CS and AH were replaced by *L. chinensis* hay. Milk fat increased with the increased forage NDF (Beauchemin, 1991) and amount of digestible OM of forages in diets (Zebeli et al., 2006). In the present research, the increase in DMI could partly

Table 4. Milk fatty acids from cows fed experimental diets

Fatty acid (g/100 g of total fatty acids)	Treatment ¹		SEM
	NLC	ALC	
4:0	3.18	3.19	0.003
6:0	1.98 ^b	2.04 ^a	0.01
8:0	1.26 ^b	1.34 ^a	0.01
10:0	2.14	2.15	0.01
11:0	0.32	0.33	0.01
12:0	3.92 ^b	4.03 ^a	0.02
13:0	0.14	0.13	0.01
14:0	11.02 ^a	10.84 ^b	0.03
14:1	1.19	1.20	0.004
15:0	1.64	1.63	0.01
15:1	0.29	0.28	0.004
16:0	30.15 ^b	31.22 ^a	0.29
16:1	1.63 ^a	1.54 ^b	0.01
17:0	0.58	0.59	0.01
17:1	0.29	0.28	0.004
18:0	11.85 ^a	9.96 ^b	0.33
18:1 <i>trans</i> -9	0.31 ^a	0.20 ^b	0.004
18:1 <i>trans</i> -10	0.46	0.47	0.01
18:1 <i>trans</i> -11	1.76	1.77	0.01
18:1 <i>cis</i> -9	19.95 ^a	19.08 ^b	0.07
18:1 <i>cis</i> -11	0.67 ^b	0.74 ^a	0.01
18:2	2.55 ^b	4.26 ^a	0.02
<i>cis</i> -9, <i>trans</i> -11 CLA ²	0.74	0.76	0.01
<i>trans</i> -10, <i>cis</i> -12 CLA	0.10	0.08	0.004
18:3	0.58	0.58	0.005
SCFA ³	25.15	25.25	0.05
MCFA ⁴	34.58 ^b	35.54 ^a	0.35
LCFA ⁵	40.27 ^a	39.21 ^b	0.37
Saturated fatty acids	68.85 ^a	68.14 ^b	0.45
Unsaturated fatty acids	31.15 ^b	31.86 ^a	0.12

^{a,b}Means within a row with different superscripts differ ($P < 0.05$). ¹NLC = diet without *Leymus chinensis* hay; ALC = diet with *Leymus chinensis* hay.

²CLA = conjugated linoleic acid.

³Short-chain fatty acids ($\leq 14:1$).

⁴Medium-chain fatty acids (from 15:0 to 17:1).

⁵Long-chain fatty acids ($\geq 18:0$).

explain this change. More DMI could lead to higher fat concentration when cows were fed the ALC diet. Another reason for the increased milk fat content is the increased digestible NDF after addition of *L. chinensis* hay. Cows fed higher IVNDFD diets produced more milk fat compared with cows fed diets with lower IVNDFD (Kendall et al., 2009). In this study, the milk fat yield was higher when *L. chinensis* hay was added to the diets.

No effect of diet was found on milk protein, lactose, and SNF contents (Table 3). However, milk protein, lactose, and SNF yields increased due to high milk yield by feeding *L. chinensis* hay. Milk SCC decreased after feeding *L. chinensis* hay.

Fatty acid contents in the experimental diets are shown in Table 2. When part of the CS and AH was replaced by *L. chinensis* hay, the content of 18:2 increased.

Fatty acid profiles in milk from cows fed the experimental diets are shown in Table 4. Dietary treatments affected numerous specific FA. General responses for some specific FA, rather than all of the FA, will be discussed. In the current study, cows fed the ALC diet had a greater concentration of medium-chain FA (from 15:0 to 17:1) and lower concentrations of long-chain FA ($\geq 18:0$). No change was found in short-chain FA ($\leq 14:1$). No change occurred in *cis*-9, *trans*-11 conjugated linoleic acid (CLA) and *trans*-10, *cis*-12 CLA concentrations, whether cows were fed the NLC or ALC diet. An increase in the 18:2 concentration in the diets would lead to a higher content of *cis*-9, *trans*-11 CLA by providing more substrate isomerization and biohydrogenation. However, no change of 18:1 content was detected after addition of *L. chinensis* hay, which would not affect the biohydrogenation pathway to generate *cis*-9, *trans*-11 CLA in the mammary gland. Griinari et al. (2000) showed that a small amount of milk CLA was generated from the rumen and most milk CLA was derived from *trans*-vaccenic acid in the mammary gland, so changes only in the rumen would not significantly affect the *cis*-9, *trans*-11 CLA content in milk. This could explain why no change was observed in milk *cis*-9, *trans*-11 CLA content.

In summary, when *L. chinensis* hay was added to the diet to replace part of the CS and AH, milk yield, milk fat concentration, milk fat yield, milk protein yield, and milk lactose yield increased, and milk SCC decreased.

High-quality *L. chinensis* hay can replace part of CS and AH as a good forage source to improve milk yield and milk composition in the diet of dairy cows.

ACKNOWLEDGMENTS

The authors gratefully thank the earmarked funds for the Modern Agro-industry Technology Research System (nycytx-37) and the assistance of the crew at the third dairy farm of Sanyuanlvhe Company in Beijing, China.

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