SHORT COMMUNICATION

The effect of partial replacement of corn silage on rumen degradability, milk production and composition in lactating primiparous dairy cows

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ABSTRACT

The objective of this experiment was to evaluate the effects of partial replacement of corn silage with long alfalfa hay and/or coarse chopped wheat straw on neutral detergent fibre (NDF) rumen degradability, milk yield and composition in late lactating dairy cows fed diets with 50% forage on dry matter basis. Twelve late lactating Holstein primiparous cows including four cows equipped with a rumen cannula, averaging 210 ± 20 d in milk and weighing 575 ± 50 kg were randomly assigned in a 4x4 Latin square design. During each of four 21-d periods, cows were fed 4 total mixed diets that were varied in the forage sources: 1) 50% corn silage (CS), 2) 35% corn silage + 15% wheat straw (CSW), 3) 35% corn silage + 15% alfalfa hay (CSA), 4) 25% corn silage + 10% wheat straw + 15% alfalfa hay (CSWA). The production of milk averaged 18.55, 20.41 and 20.06 kg/d for unadjusted milk production, 4% fat corrected milk, and solid corrected milk, respectively, and was not affected by treatments. Likewise, milk composition or production of milk components was not affected by diets and averaged 4.69% fat, 3.66% protein, 4.51% lactose, 866 g/d fat, 665 g/d protein, 824 g/d lactose. Treatments had no effect on in situ NDF solubility, degradable and potential degradability of all diets, whereas the effective degradability (ED) of NDF was greater for cows fed CS diet than for cows fed CSW, CSA and CSWA diets (P<0.05). These values suggested that the partial replacement of corn silage with alfalfa hay and/or wheat straw has no unfavourable effect on the productive parameters.

Key Words: Corn silage, Milk production, Rumen degradability.

RIASSUNTO

EFFETTI DELLA PARZIALE SOSTITUZIONE DI INSILATO DI MAIS SULLA DEGRADABILITÀ RUMINALE, PRODUZIONE E COMPOSIZIONE LATTEA IN VACCA PRIMIPARE

L’obiettivo di questo lavoro è stato quello di valutare gli effetti della parziale sostituzione dell’insilato di mais con fieno di medica e/o paglia di frumento trinciata sulla degradabilità ruminale della fibra neutro detersa (NDF), sulla produzione laitée e sulla sua composizione in vacche da latte in lattazione avanzata -
ta alimentate con razioni contenenti il 50% di foraggio sulla Sostanza Secca.

Le bovine Holstein primipare, di peso medio di 575 ± 50 kg, in lattazione avanzata, in media 210 ± 20 d, 4 delle quali fornite di cannula ruminale, sono state casualmente distribuite secondo un disegno a Quadrato Latino 4x4.

Nel corso di quattro periodi di 21 giorni sono state utilizzate 4 diete miste che differivano per la fonte di foraggio: 1) 50% silomais (CS), 2) 35% di silomais + 15% paglia di frumento (CSW), 3) 35% silomais + 15% fieno di medica (CSWA), 4) 25% silomais + 10% paglia di frumento + 15% fieno di medica (CSWA).

La produzione media di latte è stata pari a 18,55, 20,41 e 20,06 Kg/d rispettivamente per la produzione non corretta, la quantità corretta al 4% di grasso e quella corretta per i solidi totali; non è stata ricontrata alcuna influenza del trattamento alimentare.

Allo stesso modo la composizione del latte e la quantità totale delle diverse frazioni non sono state influenzate dalle diete e hanno mostrato valori medi pari a: 4,69% e 866 g/d di grasso, 3,66% e 665 g/d di proteine, 4,51% e 624 g/d di latte.

Non si sono osservati effetti su NDF solubile, degradabile e potenzialmente degradabile in situ, mentre la degradabilità effettiva dell’NDF (EDNDF) è stata più alta per la dieta CS rispetto alle altre (P< 0,05).

Questa risultati suggeriscono che la parziale sostituzione di silato di mais con fieno di medica e/o paglia di grano non esercita effetti sfavorevoli sui parametri produttivi in vacca in avanzata lattazione.

Parole chiave: Insilato di mais, Produzione lattea, Degradabilità ruminale.

Introduction

Corn silage is one the most popular forages fed to dairy cows because it has good agronomic characteristics, yields high concentrations of nutrients, ensilates well, and incorporates easily into total mixed ration (TMR) (Neylon and Kung, 2003). Most commercial dairy rations contain high levels of concentrate and high quality corn silages that are often finely chopped. These types of diets are highly fermentable in the rumen and encourage maximum milk production; however, they can lead to a variety of metabolic disorders, including reduced fibre digestion, milk fat depression (Beauchemin and Bhanan-Smith, 1990), subclinical ruminal acidosis, displaced abomasum, lameness, and fat cow syndrome (NRC, 2001).

These negative effects may be decreased using the coarse forage sources such as alfalfa hay (AH) and wheat straw (WS) because of their buffering capacity as coarse particles stimulate chewing activity hence increase saliva output. The partial replacement of corn silage with long AH and/or coarse chopped WS positively affect rumen fermentation characteristics, fibre digestion, milk fat and composition. Beneficial effects of supplemental hay in silage based diets may depend upon such factors as feeding ingredients separately and mean particle length of the diet (Santini et al., 1983). Allen (1997) reported that the physical effectiveness of dietary particles can affect feed intake, digestive efficiency, milk production and composition, and health of the cow. Studies investigated the effect of peNDF, instead of corn silage with long AH and/or WS are scarce.

The aim of this experiment was to investigate the effects of partial replacement of corn silage with long AH and/or coarse chopped WS on NDF rumen degradability, milk production and compositions in late lactating Holstein primiparous dairy cows.

Material and methods

Forages

Corn silage was obtained from Uludag University, Faculty of Veterinary Medicine farm. Whole plant corn (hybrid C955, Monsanto Company, St. Louis, MO, USA) was harvested at about 26.5% dry matter (DM) using a self-propelled forage harvester (without kernel processing unit; Tosun Tarim, Izmir, Turkey) set to
Table 1. Ingredients and chemical composition of the total mixed diets.

| Item                                      | CS\(^1\) | CSW\(^2\) | CSA\(^3\) | CSWA\(^4\) |
|-------------------------------------------|----------|----------|----------|-----------|
| Ingredients (% DM):                       |          |          |          |           |
| Corn silage\(^5\)                         | 50.00    | 35.00    | 35.00    | 25.00     |
| Wheat straw\(^6\)                         | 0.00     | 15.00    | 0.00     | 10.00     |
| Alfaheel hay\(^7\)                        | 0.00     | 0.00     | 15.00    | 15.00     |
| Barley grain ground                       | 10.81    | 13.74    | 14.39    | 13.19     |
| Wheat grain ground                        | 14.27    | 16.82    | 14.27    | 17.92     |
| Soybean meal ground, 44% CP               | 16.47    | 11.47    | 12.89    | 10.72     |
| Sunflower meal ground                     | 7.15     | 6.74     | 7.15     | 6.91      |
| Calcium carbonate                         | 1.07     | 1.01     | 1.07     | 1.04      |
| Vitamin-mineral premix\(^8\)              | 0.05     | 0.05     | 0.05     | 0.05      |
| Salt (NaCl)                               | 0.18     | 0.17     | 0.18     | 0.17      |
| Total                                     | 100      | 100      | 100      | 100       |
| Chemical composition:                     |          |          |          |           |
| Dry matter                                | %        |          |          |           |
| Crude protein                             | % DM     | 16.13    | 15.19    | 17.38     | 16.45     |
| Ether extract                             | " "     | 3.18     | 3.08     | 2.98      | 2.54      |
| Neutral detergent fibre                   | " "     | 39.57    | 43.21    | 38.17     | 41.53     |
| FNDF\(^9\)                                | " "     | 27.82    | 31.06    | 26.96     | 29.11     |
| Acid detergent fibre                      | " "     | 23.31    | 23.36    | 23.18     | 25.63     |
| Acid detergent lignin                     | " "     | 3.85     | 4.71     | 4.51      | 5.10      |
| NFC\(^10\)                                | " "     | 35.82    | 32.46    | 34.85     | 32.60     |
| Starch                                   | " "     | 27.61    | 24.78    | 26.00     | 25.39     |
| Ash                                      | " "     | 5.30     | 6.06     | 6.62      | 6.88      |
| FME\(^11\)                                |         |          |          |           |
| Mcal/kg/DM                                | 2.49     | 2.39     | 2.45     | 2.39      |
| NEL\(^12\)                                | " "     | 1.63     | 1.58     | 1.61      | 1.57      |

\(^1\)CS = 50% corn silage and 50% concentrate, \(^2\)CSW = 35% corn silage + 15% wheat straw and 50% concentrate, \(^3\)CSA = 35% corn silage + 15% alfalfa hay and 50% concentrate, and \(^4\)CSWA = 25% corn silage + 10% wheat straw + 15% alfalfa hay and 50% concentrate. \(^5\)Corn silage analysis (DM basis): NDF, 55.64%, \(^6\)wheat straw (DM basis): NDF, 77.22%, \(^7\)alfalfa hay (DM basis): NDF, 49.89% \(^8\)Supplied per kg of premix (Kavimix VM, Kartal Kimya A.S., Gebze, Turkey): Vitamin A 12000000 IU, Vitamin D, 3000000 IU, Vitamin E 30 g, Mn 50 g, Fe 50 g, Zn 50 g, Cu 10 g, I 0.8 g, Co 0.1 g, Se 0.15 g, Antioxidant 10 g \(^9\)FNDF: Percentage neutral detergent fibre from forage, calculated from ingredient analysis. \(^10\)NFC: Non-fibre carbohydrate, %; calculated as: 100 - (NDF, % + CP, % + EE, % + ash, %). \(^11\)FME: Fermentable Metabolisable Energy; Calculated from AFRC (1993). \(^12\)NEL: Net energy lactation; Calculated from NRC (2001).

Obtain a 10.0 mm theoretical cut length. The chopped forage was placed in a horizontal silo (300 ton capacity), covered with nylon plastic, and ensiled for approximately 3 months. The AH was harvested during second cutting in a middle flowering stage and preserved as AH in small rectangular bales of 20 kg. The hay was stored in barns. The WS was chopped using a miller rotary hay mill (Model No: S8002, Tosun Tarim) equipped with a 5-cm screen.
Table 2. Dietary particle size distribution, peNDF, peNDFI, NDFI and DMI values of total mixed diets (DM basis).

|                | CS\(^1\) | CSW\(^2\) | CSA\(^3\) | CSWA\(^4\) | SE  | P    |
|----------------|---------|---------|---------|-----------|-----|------|
| Dry matter % retained: |         |         |         |           |     |      |
| >19.0 mm       | 3\(^b\) | 14\(^b\) | 12\(^b\) | 24\(^b\)  | 1.2 | ***  |
| 19.0 to 8.0 mm  | 41\(^a\)| 27\(^b\) | 27\(^bc\)| 19\(^c\)  | 2.1 | **   |
| 8.0 to 1.18 mm  | 40\(^b\) | 40\(^a\) | 49\(^a\) | 42\(^b\)  | 1.3 | ***  |
| <1.18 mm       | 16\(^a\)| 16\(^a\) | 12\(^b\) | 15\(^a\)  | 0.7 | *    |
| Pe\(^f\)       | 0.84\(^b\) | 0.84\(^b\) | 0.88\(^a\) | 0.85\(^b\) | 0.1 | ***  |
| peNDF\(^b\) %DM | 33.24\(^b\) | 36.30\(^a\) | 33.59\(^b\) | 35.30\(^b\) | 0.2 | ***  |
| peNDFI\(^7\) kg DM/d | 5.1\(^b\) | 5.1\(^b\) | 5.2\(^b\) | 5.6\(^a\) | 0.04 | ***  |
| NDFI\(^a\)     | 6.1\(^b\) | 6.9\(^a\) | 5.9\(^b\) | 6.6\(^a\) | 0.08 | ***  |
| DMI\(^b\) kg/d | 15.32 | 16.00 | 15.53 | 15.84 | 0.1 | ns   |

\(^1\)CS = 50% corn silage and 50% concentrate, \(^2\)CSW = 35% corn silage + 15% wheat straw and 50% concentrate, \(^3\)CSA = 35% corn silage + 15% alfalfa hay and 50% concentrate, \(^4\)CSWA = 25% corn silage + 10% wheat straw + 15% alfalfa hay and 50% concentrate. \(^5\)Physical effectiveness factors (pef) were determined by the fraction retained on a 1.18 mm sieve using horizontal shaking with Penn State Particle Separator. \(^6\)peNDF was measured as the NDF content of the Total Mixed Ration multiplied by the pef from Mertens (1997). \(^7\)peNDF = peNDF intake. 

Cows and diets

At the beginning of treatment, twelve lactating Holstein primiparous cows were randomly assigned in a 4x4 Latin square design according to the pregnancy stage, day in milk and body weight (80 ± 20 d, 210 ± 20 d, 575 ± 50 kg, respectively). One of the three cows in each group was cannulated ruminally with soft plastic cannulas of 10 cm internal diameter (Ankom, pliable rumen cannula # 29, 4 inches, NY, USA). Cows were housed in individual tie stalls and all diets were formulated for a 600 kg cow producing 20 kg/d of milk with 5.6% fat and 3.0% true protein by using the National Research Council (NRC) guidelines (2001). Throughout the experiment, cows were fed twice daily (09:00 and 21:00 h) at 110% of expected intake with TMR. The rations were mixed by hand, for each cow at different meal. There were a total of 4 periods, and each period consisted of 14 d of adaptation to diets and 7 d of experimental measurements. Cows were fed diets with 50:50 forage to concentrate ratio (basis on DM). During each period, animals were offered one of the four diets that were varied in the forage source, proportion and particle size (Table 1): 1) 50% corn silage (CS), 2) 35% corn silage + 15% wheat straw (CSW), 3) 35% corn silage + 15% alfalfa hay (CSA) and 4) 25% corn silage + 10% wheat straw + 15% alfalfa hay (CSWA).

Feeds offered and orts were measured and recorded daily during the last 7 d of each period to calculate feed intake. The TMR samples were collected once weekly for particle distribution analysis. One kg of each TMR samples (CS, CSW, CSA, and CSWA) was obtained weekly. Particle size distributions of TMR samples were determined using the Penn State Particle Separator.
(PSPS) containing 3 sieves (19, 8 and 1.18 mm) and a pan as described by Kononoff et al. (2003a) (Table 2). The TMR samples were dried in a forced-air oven at 60°C for 48 h for DM and NDF weekly. Physically effective neutral detergent fibre (peNDF) is an estimate of physically effective fibre and is calculated by multiplying the proportion of feed greater than 1.18 mm in length by total ration NDF (Mertens, 1997).

Experimental cows were milked twice daily at 06:00 and 18:00 h, and milk weights were recorded (Milko Scope MK II, De Laval, Sweden). Milk samples were collected daily from morning to evening milking. Milk samples were then pooled daily based on milk yield, and pooled samples were immediately submitted to the Department of Food Hygiene & Technology Laboratory (Faculty of Veterinary Medicine, University of Uludag, Bursa, Turkey) for compositional analysis. Milk samples were analysed for fat, protein and lactose using Gerber, Kjeldahl (Nx6.38) and polarimetric methods, respectively, as described by AOAC (2002). Production of 4% fat corrected milk (FCM) was calculated from unadjusted milk production (UMP) and milk fat percentage (F) by the equation of Gaines (1928): FCM = UMP (0.4 + (0.15 x F)). Production of solids corrected milk (SCM) was calculated from UMP, F, protein (P), and Lactose (L) percentages from the equation of Tyrell and Reid (1965): SCM = UMP x (0.1224 x F) + (0.0710 x P) + (0.0635 x L) - 0.0345.

In situ measurements

Ruminal degradation of TMR diets were measured using in situ in bags made from nitrogen-free polyester; these bags have a pore size of 50 microns (Ankom, R1020-10 x 20 cm, forage bags, 14502, NY, USA). When the representative TMR diets were prepared for in situ measurement, individual feed ingredients were sampled in duplicate, and the same TMR samples were used in each period. TMR diets were dried at 60°C for 48 h and ground through a 2 mm screen. The samples were weighed (5 g sample) into nylon bags. Starting on d 15 of each experimental period, four duplicate nylon bags containing four TMR diets were incubated in the rumen of each cow for 2, 4, 8, 12, 24, 48, 72, and 96 h during the four periods. Incubations were done on four ruminally cannulated cows during each of the four periods. After each incubation time, a bag of each TMR was withdrawn from the rumen; bags were plunged into cold water for 10 min to arrest fermentation. Bags were then washed for approximately 120 min in cold water and dried in a forced-air oven at 60°C for 48 h, and then analysed as described later for NDF. To determine DM losses during bag incubation, 4 nylon bags (5 g sample) of each TMR diet (no incubated) were washed in lukewarm water for 1 h at 39°C, washed in cold water and then oven dried for 60°C for 48 h. Percentages of disappearance of NDF at each incubation time were calculated from the proportion remaining in the bag after incubation in the rumen. The disappearance rate was fitted to the following equation ("O"rskov and McDonald, 1979):

\[
\text{Disappearance of NDF} = a + b (1 - e^{-t})
\]

Where: a = the readily soluble fraction (% of total), b = the fraction potentially degraded in the rumen (% of total), a+b = potential degradability, t = time of rumen incubation (h), c = the fractional rate of degradation of b. The parameters, a, b and c, were obtained by fitting the data using a non-linear model, based on Marquardt’s method, performed by the NONLIN procedure of SPSS software (2006). The effective degradability (ED) of NDF (EDNDF) was calculated by the equation of "O"rskov and McDonald (1979) as: EDNDF = a + [(b x c) / (k + c)], where k is the estimated rate of outflow from the rumen. The EDNDF was estimated using a ruminal outflow rate of 5%/h.

Chemical analyses

The dietary samples were dried in a forced-air oven at 60°C for 48 h for measurement of DM content and then ground through a 1-mm diameter
screen using a laboratory 3303 Mill (Hundenge, Sweden). Crude protein was determined by the Kjeldahl method (AOAC, 2002). Ash was determined by combustion at 550°C for 6 h. The NDF, Acid Detergent Fiber (ADF) and lignin contents were determined using the methods described by Van Soest et al. (1991) with heat-stable amylase (Sigma No: A-3306, Sigma Chemical Co., St Louis, MO, USA) and sodium sulfite used in the NDF procedure. Starch was measured on composted samples by a colorimetric assay including a pure cornstarch sample as described by Bal et al. (2000).

Statistical analyses

Milk yield and composition data and rumen degradability parameters were analysed as a 4x4 Latin square. Data were analysed by ANOVA using the general linear model procedure of SPSS (2006) to examine the effect of cow, period, and forage sources, followed by the Tukey test procedure.

Results and discussion

Ingredients and chemical composition of the total mixed diets were shown in Table 1 and CS diet had less DM content than the others due to the highest ratio of corn silage that has low DM. The low DM content of the corn silage was probably a result of the early maturity at harvest. Thus, the corn silage had low starch and the high NDF content that was higher than the AH. Experimental diets contained different amounts of added AH and WS substituted for corn silage, because their NDF content differed, diets also differed in NDF content. The CP content of the AH was high relative to the other forages, and the CSA diet also was higher CP content compare with the other diets.

Particle size analysis, peNDF, peNDF intake (peNDFI), NDF intake (NDFI), and DM intake (DMI) data are presented in Table 2. The proportion of particles retained on the 19.0 mm screen

### Table 3. Effects of partial replacement of corn silage on milk yield and milk composition.

| Item                  | CS\(^1\) | CSW\(^2\) | CSA\(^3\) | CSWA\(^4\) | SE  | P    |
|-----------------------|----------|-----------|-----------|-----------|-----|------|
| Yield                 |          |           |           |           |     |      |
| Milk kg/d             | 18.47    | 18.34     | 18.64     | 18.75     | 0.15| ns   |
| 4% FCM\(^5\)          | 20.35    | 20.30     | 20.09     | 20.89     | 0.18| ns   |
| SCM\(^6\)             | 20.08    | 19.85     | 19.87     | 20.45     | 0.17| ns   |
| Fat g/d               | 863.53   | 864.07    | 842.31    | 892.57    | 10.16| ns   |
| Protein %             | 675.09   | 640.07    | 669.81    | 673.11    | 6.52| ns   |
| Lactose               | 832.06   | 797.52    | 840.77    | 826.91    | 8.63| ns   |

\(1^{CS} = 50\%\) corn silage and 50\% concentrate, \(2^{CSW} = 35\%\) corn silage + 15\% wheat straw and 50\% concentrate, \(3^{CSA} = 35\%\) corn silage + 15\% alfalfa hay and 50\% concentrate, and \(4^{CSWA} = 25\%\) corn silage + 10\% wheat straw + 15\% alfalfa hay and 50\% concentrate. \(5^{FCM}\) Fat corrected milk. \(6^{SCM}\) Solids corrected milk.

\(\text{ns: } P > 0.05.\)
Table 4. Effects of partial replacement of corn silage on ruminal nutrient kinetic parameters and the effective degradability of NDF.

|                | CS\textsuperscript{1} | CSW\textsuperscript{2} | CSA\textsuperscript{3} | CSWA\textsuperscript{4} | SE  | P   |
|----------------|------------------------|------------------------|------------------------|------------------------|-----|-----|
| Neutral Detergent Fibre: |                        |                        |                        |                        |     |     |
| a % total DM    | 3.75                   | 2.43                   | 3.08                   | 2.83                   | 0.39| ns  |
| b % total DM    | 57.28                  | 55.81                  | 59.43                  | 56.50                  | 0.84| ns  |
| c %/h           | 0.027                  | 0.024                  | 0.026                  | 0.023                  | 0.002|     |
| a+b % total DM  | 61.03                  | 58.24                  | 62.55                  | 59.33                  | 0.92| ns  |
| ED at 5%/h      | 23.78\textsuperscript{a} | 21.39\textsuperscript{b} | 21.68\textsuperscript{c} | 20.72\textsuperscript{c} | 0.43| *   |

\textsuperscript{1}CS = 50% corn silage and 50% concentrate, \textsuperscript{2}CSW = 35% corn silage + 15% wheat straw and 50% concentrate, \textsuperscript{3}CSA = 35% corn silage + 15% alfalfa hay and 50% concentrate, and \textsuperscript{4}CSWA = 25% corn silage + 10% wheat straw + 15% alfalfa hay and 50% concentrate.

ns: P > 0.05. * P < 0.05.

PD = potential degradability; ED = effective degradability.

\textsuperscript{a, b, c} means in the same row with different superscripts differ according to P value indicated.

\textsuperscript{a, b, c} see NDF formula.

of the CS diet was lower (P < 0.001) than in the other diets. Although the physical effectiveness factor (pef) of the CSA was higher (P < 0.001) than those of other groups, peNDF of CSA was lower. This result is related to the lower NDF content of CSA. The peNDF contents of the diets were 33.24, 36.30, 33.59 and 35.30% of DM, for CS, CSW, CSA and CSWA diets, respectively. Cows fed diets containing CSW and CSWA had greater peNDF (% of DM), NDFI, and peNDFI than did cows fed CS and CSA (P < 0.001). Gencoğlu and Turkmen (2006) reported that increasing peNDF of the diets and the intake of amount particles > 19.0 mm may be among the factors affecting total chewing activity of dairy cattle.

The DMI (averaged 15.7 kg/d) did not differ between the diets. Belyea \textit{et al.} (1985) reported that decreased forage particle size increased intake of cows fed only forage, but forage particle size had no effect on intake of cows fed forage plus concentrate because ruminal fill was not a limiting factor for DMI. On the other hand, West \textit{et al.} (1997) stated when corn silage (control diet) was replaced with bermudagrass or AH (15% or 30%, respectively), DMI decreased from 22.9 to 22.0 kg/d. However, there was no difference in milk yield for cows fed diets containing hay than for cows fed the control diet. The lack of difference in DMI may be due to low DMI (averaged 15.3-16.0 kg/d) which depends on the late lactating period.

Milk yield and composition data are presented in Table 3. Woodford and Murphy (1988) indicated that the addition of hay to silage diets did not always increase milk production. However, Beaudemoin and Buchanan-Smith (1990) have observed higher milk production often associated with increased DMI, from supplementation of alfalfa silage with hay. In this study, replacing corn silage with AH and WS did not affect milk yield, FCM and SCM. This can be due to having cows in late lactation. Robinson \textit{et al.} (1987) reported that late lactation cows produce less milk with a higher milk fat content than do early lactation cows. Efficiency of milk production, expressed as SCM/DMI, increased from 1.24 to 1.31 when cows fed CSW replaced with CS but was not significantly affected by the dietary treatments.
The milk fat percentage and yield ranged from 4.55 to 4.78% and 842 to 893 g/d, respectively, and were not affected by treatments. The milk fat percentages were high in this experiment, probably because of the low milk yield, having late lactating cows, high NDF corn silage. The requirement for peNDF of dairy cows was determined by Mertens (1997), who suggested that should be 22% of ration DM to maintain an average ruminal pH of 6.0 and 20% of ration DM to maintain the milk fat percentage of early to Midlactation Holstein cows at 3.4%. Based on measurements using the PPS, several studies reported that increased intake of peNDF increased milk fat content (Yang et al., 2001; Kononoff and Heinrichs, 2003) and decreased milk protein content (Kononoff and Heinrichs, 2003), but others did not find any effects of peNDF on milk composition (Beauchemin et al., 2003; Kononoff et al., 2003b). Results obtained from the current study showed that cows fed with the CSW and CSWA diets had higher peNDF than CS and CSA (Table 2) but the peNDF did not affect the milk fat percentage. It can probably be stated that all diets provided adequate amounts of peNDF. Likewise, Zebeli et al. (2006) observed that milk parameters are less sensitive to the effects of dietary peNDF than are other variables, such as ruminal pH, chewing activity, and fibre digestibility. Low milk fat content was consistent with low mean rumen pH (5.50) and low ratio of acetate to propionate (range of 1.7 to 2.0) (Yang and Beauchemin, 2003). In the current study, the daily mean ranged from 6.24 to 6.42 and from 4.00 to 4.50 for rumen pH and acetate/propionate, respectively (Gencoglu and Turkmen, 2006). The percentages of milk fat in all diets were higher compared with those observed in other studies (Beauchemin et al., 2003; Kononoff and Heinrichs, 2003). In addition, these results are consistent with Mertens (1983) who reported that FCM yield was the greatest for cows fed diets based on AH, corn silage, or bermudagrass hay when dietary NDF content was 35% for each diet. Mertens (1997) concluded that effects of particle size on milk fat content were likely to be observed when NDF levels were lower than the minimum recommended requirement. There may be another explanation for this situation. Due to corn silage particle size for cows fed with CS, low milk fat percentage can be expected but milk fat percentage might be compensated by high EDNDF which was higher than other diets (P<0.05) (Table 4).

The milk protein percentage and yield ranged from 3.62 to 3.69% and 640 to 675 g/d, respectively, and were similar among diets. Grieve et al. (1986) reported that similar milk protein content across treatments probably resulted from similar energy content of diets and organic matter digestibility in the total tract because milk protein is positively correlated with dietary energy. In this study, the diets had similar fermentable energy content (Table 1); therefore milk protein might also be unchanged by the dietary treatments. The milk lactose percentage and yield ranged from 4.47 to 4.56% and 797 to 840 g/d, respectively, and were not affected by dietary treatments (Table 3).

Predicted parameters of rumen degradation of NDF in the four TMR diets and their effective degradability are shown in Table 4. Treatments had no effect on in situ NDF soluble, degradable and potential degradability of all diets, whereas the EDNDF was greater for cows fed CS diet than for cows fed CSW, CSA and CSWA diets. This is related to cell-wall lignifications, leading to a reduction in substrate susceptibility to microbial degradation (Tamminga and Van Vuuren, 1988). Because WS and AH have higher lignifications than the corn silage.

Conclusions

According to the results of our study, replacing corn silage with alfalfa hay and/or wheat straw has no effect on DMI, milk yield, FCM and SCM in late lactating cows. Milk fat percentage may be constant when diets have adequate
amounts of peNDF. It is concluded that the partial replacement of corn silage with alfalfa hay and/or wheat straw has no unfavourable effect on the productive parameters.

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