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Performance and nitrogen use efficiency in mid-lactation dairy cows fed timothy cut in the afternoon or morning

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ABSTRACT

Shifting cutting from morning to afternoon has been shown to increase the concentration of nonstructural carbohydrates in forages. We hypothesized that, compared with a total mixed ration containing timothy baleage and silage cut in the morning (a.m.-cut TIM), a total mixed ration containing timothy baleage and silage cut in the afternoon (p.m.-cut TIM) would improve animal performance and N use efficiency in mid-lactation Holstein cows due to enhanced supply of ruminal fermentable energy. The objective of this study was to compare the effects of p.m.- versus a.m.-cut TIM on milk yield, concentrations and yields of milk components, ruminal metabolism, and plasma concentrations of AA in mid-lactation Holstein cows. Ten (6 ruminally cannulated) primiparous cows averaging 139 ± 13 d in milk and 550 ± 56 kg of body weight, and 6 (2 ruminally cannulated) multiparous cows averaging 128 ± 11 d in milk and 632 ± 57 kg of body weight at the beginning of the experiment, were used in a crossover design. Each period lasted 21 d with 14 d for diet adaptation and 7 d for data and sample collection. The concentration of nonstructural carbohydrates (water-soluble carbohydrates plus starch) was numerically greater in the p.m.- versus the a.m.-cut TIM and averaged 13.2 ± 1.06% and 12.2 ± 1.13%, respectively. Treatment × parity effects were observed for milk urea N, feed efficiency, and milk N efficiency, whereas parity effects were observed for nutrient intake, milk yield, and plasma concentration of several essential and nonessential AA. Intakes of dry matter (19.3 versus 18.6 kg/d) and nonstructural carbohydrates (2.56 versus 2.31 kg/d), and yields of 4% fat-corrected milk (23.1 versus 22.2 kg/d), energy-corrected milk (25.0 versus 24.1 kg/d), milk fat (0.91 versus 0.88 kg/d), and milk protein (0.77 versus 0.73 kg/d) were all greatest with feeding p.m.-cut TIM. Milk yield (23.5 versus 22.7 kg/d) tended to increase in cows fed p.m.-cut TIM. The ruminal fermentation profiles and plasma concentrations of AA were mostly unaffected by treatments. However, ruminal valerate (1.01 versus 1.17 mol/100 mol) and plasma Gly (172 versus 188 μM) were lowest with feeding p.m.-cut TIM. Overall, feeding mid-lactation dairy cows a total mixed ration that consisted of p.m.-cut timothy baleage and silage significantly increased dry matter intake and yields of milk, milk fat, and milk protein.
Key words: dairy cow, milk yield, nonstructural carbohydrates, timothy

INTRODUCTION

In general, forage sources are rich in RDP but poor in NSC [defined herein as water-soluble carbohydrates (**WSC**) or total ethanol soluble carbohydrates (**TESC**) plus starch], leading to unbalanced supplies of NH_3-N and fermentable energy in the rumen. Plant C fixation occurs at a greater rate than C exportation during daylight, resulting in accumulation of NSC in tissues of grasses and legumes as the day progresses (Bowden et al., 1968; Lechtenberg et al., 1971; Gordon, 1996; Morin et al., 2011). Delaying cutting from early morning to late afternoon has been shown to increase the concentrations of NSC in legumes such as alfalfa (*Medicago sativa* L.; Brito et al., 2008) and red clover (*Trifolium pratense* L.) (Pelletier et al., 2010; Antaya et al., 2015). Shifting cutting from morning to afternoon has also been shown to increase the concentrations of NSC in several grass species including orchardgrass (*Dactylis glomerata* L.) (Burner and Belesky, 2004), gamagrass [*Tripsacum dactyloides* L.] and switchgrass (*Panicum virgatum* L.) (Huntington and Burns, 2007), and tall fescue [*Schedonorus phoenix* (Scop.) Holub], reed canarygrass (*Phalaris arundinacea* L.), smooth bromegrass (*Bromus inermis* Leyss), meadow bromegrass (*Bromus biebersteinii* Roemer & J.A. Schultes),

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and Kentucky bluegrass (*Poa pratensis* L.; Pelletier et al., 2010). Collectively, these data confirm that most forage species are likely to have a greater NSC concentration when cut in the afternoon than in the morning.

Timothy (*Phleum pratense* L.) is one of the most important cool-season grasses grown in cold regions of North America, Scandinavia, Russia, and Japan (Berg et al., 1996). Our group was the first to demonstrate that daytime cutting management affects the concentration of NSC in timothy (Bertrand et al., 2008; Pelletier et al., 2009, 2010; Morin et al., 2012). Specifically, Bertrand et al. (2008) showed that the concentration of NSC was 29% greater in timothy herbage harvested in the afternoon than in the morning, which was primarily driven by a proportional increase in sucrose concentration (+46%). Similarly, Pelletier et al. (2009) showed that timothy cut in the afternoon had greater concentrations of NSC (+53%), WSC (+60%), and sucrose (+87%) compared with timothy cut in the morning. More recently, Pelletier et al. (2010) demonstrated that among 8 forage species, timothy ranked third behind red clover and tall fescue in the concentration of NSC (mean = 8.42%) across cutting times and growth periods. To the best of our knowledge, we are not aware of any study to date in which lactating dairy cows were fed TMR consisted of p.m.- versus a.m.-cut timothy baleage or silage.

We hypothesized that, compared with a TMR containing timothy baleage and silage cut in the morning (**a.m.-cut TIM**), a TMR containing timothy baleage and silage cut in the afternoon (**p.m.-cut TIM**) would improve performance and N use efficiency in mid-lactation Holstein cows due to enhanced ruminal supply of readily fermentable energy. The objective of this study was to compare the effects of p.m.- versus a.m.-cut TIM on milk yield, concentrations and yields of milk components, ruminal metabolism, and plasma concentrations of AA in mid-lactation Holstein cows.

MATERIALS AND METHODS

Care and handling of the animals used in the current experiment were conducted as outlined in the guidelines of the Canadian Council on Animal Care (1993). This study was approved by the Institutional Animal Care Committee of the Dairy and Swine Research and Development Centre (Sherbrooke, QC, Canada).

Timothy Cut and Harvest

The timothy (cultivar 'Champ') herbage harvested as baleage and used in the current study was grown in an 8-ha field (95% timothy and 5% red clover) located at the Agriculture and Agri-Food Canada Normandin Research Farm in Normandin (48°51′N, 72°32′W; QC, Canada). The summer regrowth (i.e., second cut) of half of the field was cut on August 26, 2008, in the afternoon (1800 to 2030 h; p.m.-cut timothy baleage), whereas the second half of the field was cut on August 27, 2008, in the morning (0600 to 0830 h; a.m.-cut timothy baleage). Timothy was cut at the heading stage of development (stages 58 to 60; Simon and Park, 1983) yielding approximately 2 t of DM/ha. Forage was cut using a conventional mower conditioner, tedded, and field-wilted to about 60% DM, which was attained at approximately 1200 h on August 28, 2008. Between 1230 and 1330 h in the afternoon of August 28, 2008, p.m.- and then a.m.-cut timothy were harvested as baleage using a large rectangular baler (New Idea model 7333, Agco Corporation, Duluth, GA) and wrapped with stretch plastic using a bale wrapper (Équipement Anderson model 680-S, Chesterville, QC, Canada). Minimum and maximum air temperatures were, respectively, 11.4 and 21.3°C on August 26, 5.8 and 24.1°C on August 27, and 8.5 and 25.9°C on August 28, 2008. The global radiation observed the day before cutting (i.e., August 25, 2008) averaged 20.6 MJ/m^2 compared with a clear sky maximum value of 26.5 MJ/m^2 potentially expected at this location. A total of 84 bales (42 p.m.-cut and 42 a.m.-cut) were made and later transported to the Dairy and Swine Research and Development Centre of Agriculture and Agri-Food Canada located in Sherbrooke (45°24′N, 71°54′W; QC, Canada) for the animal study. The time elapsed between timothy baling and feeding to the cows (d 1 of the study) was approximately 150 d.

The timothy (cultivar 'Champ') silage used in the current study was grown in 2 pure stand fields (total of 16 ha) located at the Dairy and Swine Research and Development Centre Farm (Sherbrooke, QC, Canada). The spring growth (i.e., first cut) of half of the field was cut on June 12, 2008, in the afternoon (1800 to 2030 h; p.m.-cut timothy silage), whereas the second half of the field was cut on June 13, 2008 in the morning (0600 to 0830 h; a.m.-cut timothy silage). Timothy was cut and harvested as silage at the heading stage of development, yielding approximately 3 t of DM/ha. Forage was cut using 2 mower conditioners (model 4032 WA; Kverneland Group, Drummondville, QC, Canada) and field-wilted to about 30% DM, which was attained at approximately 1500 h on June 13, 2008. Between 1500 and 2000 h of June 13, 2008, p.m.- and then a.m.-cut timothy were harvested as silage using a forage harvester (model 900, New Holland Agriculture, Turin, Italy) and stored in 2 silo plastic bags using a 9′ model silo bagger (Kelly Ryan, Blair, NE). Minimum and maximum air temperatures were, respectively, 8.9 and 19.8°C on June 12, and 6.0 and 25.8°C on June

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