J. Dairy Sci. 101:1–13
https://doi.org/10.3168/jds.2017-13920

Effect of straw particle size on the behavior, health, and production of early-lactation dairy cows

R. E. Coon,* T. F. Duffield,† and T. J. DeVries*[1]
*Department of Animal Biosciences, and
†Department of Population Medicine, University of Guelph, Guelph, Ontario, N1G 2W1, Canada

ABSTRACT

The objective of this study was to determine the effect of reducing the particle size of wheat straw in a total mixed ration (TMR) on cow behavior, health, and production in early lactation. For 28 d after calving, 41 multiparous Holstein cows were individually provided either 1 of 2 TMR with 9% wheat straw (dry matter basis) chopped (1) using a 2.54-cm screen (short; n = 21) or (2) using a 5.08-cm screen (long; n = 20). Cows were housed in freestall pens during both the dry and lactating period. Enrollment in the trial was on a rolling basis and cows were evenly distributed by parity and milk production between treatments. Wireless telemetry boluses were used to measure reticulorumen pH. Automated systems recorded TMR dry matter intake, milk yield, and rumination activity. The TMR and orts samples were collected every 3 d to determine feed sorting. A particle separator was used to separate feed samples into 4 fractions: long (>19 mm), medium (<19 mm, >8 mm), short (<8 mm, >4 mm), and fine (<4 mm) particles. Feed sorting was calculated as actual intake of each particle fraction expressed as a percentage of its predicted intake. Cows sorted the longest TMR particles differently by treatment; on the long treatment cows sorted against long particles (94.2 ± 1.9%), whereas on the short treatment cows did not sort for or against these particles (99.7 ± 1.9%). Data were analyzed in mixed-effect linear regression models and fitted with polynomial functions over the 28 d of observations. The fitted data indicated treatment differences in linear coefficients, quadratic coefficients, and cubic coefficients for mean time (min/d) below a reticulorumen pH of 5.8 and milk yield. Rumination time (min/d) differed between treatments for quadratic and cubic coefficients. Cows on the short treatment linearly increased in dry matter intake at a greater rate than cows on the long treatment. Mean reticulorumen pH decreased at a greater rate for cows on the long treatment than for cows on the short, as indicated by differences between linear coefficients. Cows on the short treatment tended to produce 75 kg more milk cumulatively during the first 28 d in milk than cows on long treatment. These results suggest that cows fed a diet with longer straw particles selected against physically effective fiber, which may have contributed to greater fluctuations in rumination time, reticulorumen pH, dry matter intake, and milk production in early lactation.

Key words: dairy cow, sorting, pH, rumination, straw

INTRODUCTION

When provided a TMR, dairy cows often sort their feed, typically favoring small grain components and avoiding longer forage particles (Leonardi and Armentano, 2003; Leonardi et al., 2005a; DeVries et al., 2007). Particle size of forages is one of the primary factors influencing feed sorting, with smaller particles being less easily sorted than longer particles (Miller-Cushon and DeVries, 2017). Additionally, high palatability of the concentrate components of the TMR motivates cows to sort in favor of these smaller components and against the longer forage ingredients (Nombekela et al., 1994; Miller-Cushon and DeVries, 2017).

Intake of dietary forage is important, as it primarily contributes the physically effective NDF (**peNDF**) portion of the diet, which is responsible for stimulating rumination and improving fiber digestibility (Yang and Beauchemin, 2006a,b; Zebeli et al., 2012). Sorting behavior can result in an over-consumption of easily fermented carbohydrates and an under-consumption of peNDF (Miller-Cushon and DeVries, 2017). This unbalanced diet, as a result of sorting, may lead to an increased risk of SARA (DeVries et al., 2008); an overconsumption of grains relative to peNDF can cause a buildup of VFA and a resultant prolonged depression of the rumen pH (<5.6–5.8 for multiple hours per day) characteristic of SARA (Steele et al., 2016). Subacute ruminal acidosis can lead to decreased DMI,

Received September 30, 2017.
Accepted March 5, 2018.
[1]Corresponding author: tdevries@uoguelph.ca

milk production, and fiber digestibility (Plaizier et al., 2008). Fresh cows are especially vulnerable to SARA because of the abrupt transition from a low-energy diet to a more highly fermentable diet at calving (Steele et al., 2016). It is important that transition cows are not able to easily sort their feed during this time, as this behavior likely exacerbates the condition through over consumption of easily fermented carbohydrates and under consumption of effective fiber.

Nutritional management of fresh cows can be difficult because there are competing demands for nutrient-dense concentrate components to sustain lactation and for sufficient forage to maintain good rumen function. It is important that the dietary fiber in the diet be presented in a manner that discourages sorting to ensure a balanced diet that stimulates rumination. Reducing the particle size of the forage sources increases NDF intake and decreases sorting against the long particles and for fine particles (Miller-Cushon and DeVries, 2017). A forage particle size that is large enough to stimulate rumination, yet small enough to prevent sorting against the forage component may, thus, reduce the risk of SARA in early-lactation dairy cows.

The objective of our research was to determine if reducing the particle size of wheat straw in a diet for early-lactation cows would have positive effects on cow behavior, health, and production. We hypothesized that a diet with a smaller particle size wheat straw would minimize sorting behavior while maintaining DMI levels and rumination, resulting in a stabilization of reticulorumen pH.

MATERIALS AND METHODS

Animals and Housing

Forty-one multiparous Holstein cows (parity = 2.8 ± 1.1 postcalving; mean ± SD) were used in this study, which took place at the University of Guelph Livestock Research and Innovation Centre Dairy Facility (Elora, Ontario, Canada). At approximately 17 d before calving, cows were enrolled in the study; this time frame allowed for a minimum 3-d training period in addition to 2 wk of baseline data collection before calving. During this time, cows were housed in a close-up pen and trained to eat out of individual automated feed bins (Insentec B.V., Marknesse, the Netherlands). Each cow was assigned her own bin, and trained to eat only out of that bin during the 3-d period. At approximately 2 wk before calving (d −13.4 ± 4.9), cows had an average BW of 847.7 ± 77.6 kg and an average BCS of 3.7 ± 0.34. The close-up pen had 12 automated feed bins, 24 freestalls, and 2 water troughs. There were never more than 12 cows in the close-up pen at one time, ensuring that each cow had access to her own individual feed bin. Cows spent 3.1 ± 3.2 d in the maternity pen before calving and 5.2 ± 3.3 d in the maternity pen after calving. The maternity pens were individual boxstalls (3.5 × 4.9 m) with individual access to feed and water. After calving, cows were milked in their maternity pens using a portable milking system.

Dry cows were fed a dry cow TMR (Tables 1 and 2) 1×/d between 1000 and 1100 h. The total amount of feed offered was adjusted daily to target approximately 10% refusals per bin (actual = 14.7 ± 12.3%). The dry cow feed bins were cleaned out each day at approximately 0930 h every morning. After calving and following exit from the maternity pens, cows were moved to a lactating pen and again assigned to an individual feed bin. The lactating cow pen had 15 automated feed bins, 30 freestalls, and 2 water troughs. There were never more than 15 cows in the lactating pen at one time, ensuring that each cow had access to her own individual feed bin. Lactating cows were fed 1×/d between 1300 and 1400 h. The total amount of feed offered was adjusted daily to target approximately 10% refusals per bin (actual = 13.0 ± 15.6%). Lactating cows were milked 2×/d at 0500 and 1700 h in a milking parlor.

The use of cows and experimental procedures complied with the guidelines of the Canadian Council on Animal Care (2009) and were approved by the University of Guelph Animal Care Committee (Animal Use Protocol #2518).

Experimental Design

Sample size and power analyses were used to calculate (as per Morris, 1999) the minimum number of replicates needed per treatment (n = 20) to detect a 10% level of observed mean difference for the primary outcome variables, including DMI, rumination, sorting, and milk production. Estimates of variation for these variables were based on previously reported values (DeVries et al., 2007; DeVries and Gill, 2012). Due to the likelihood of technical complications associated with the monitoring equipment used in our study, more than 20 cows per treatment were initially enrolled in the study to ensure the target sample size was achieved.

Upon calving, cows were randomly assigned to 1 of 2 dietary treatments (Table 1, 2), a TMR that differed in the length of the wheat straw component in that diet (Table 2), specifically (1) straw chopped with a 2.54-cm screen (short; n = 21) or (2) straw chopped with a 5.08-cm screen (long; n = 20) For both treatments, straw was chopped using a bale processor (Haybuster Model H-1150, Jamestown, ND). Cows were fed these treatment diets from 1 to 28 DIM. Treatment allocation was reviewed throughout the study to ensure it was