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Short communication: Forage particle size and fat intake affect rumen passage, the fatty acid profile of milk, and milk fat production in dairy cows consuming dried distillers grains with solubles

H. A. Ramirez Ramirez,*[1] K. J. Harvatine,† and P. J. Kononoff*[2]
*Department of Animal Science, University of Nebraska, Lincoln 68583-0908
†Department of Animal Science, The Pennsylvania State University, University Park 16802

ABSTRACT

Four ruminally cannulated Holstein cows averaging (±SD) 116 ± 18 DIM and 686 ± 52 kg of BW were used in a 4 × 4 Latin square design with a 2 × 2 factorial arrangement of treatments to test the effects of forage particle size and concentration of corn oil on milk fat depression. Cows were housed in individual stalls, milked daily at 0700 and 1800 h, and individually fed daily at 0900 h for ad libitum consumption allowing approximately 10% orts. Four 28-d periods, in which each cow was offered 1 of 4 TMR, included reduced-fat dried distillers grains with solubles at 30% of dietary DM and differed in forage particle size by inclusion of chopped grass hay (LONGP) or grass hay pellets (SHORTP) and 0 or 2% corn oil (CO). Dietary treatments were 0% corn oil + short particle size (CO0+SHORTP), 0% corn oil + long particle size (CO0+LONGP), 2% corn oil + short particle size (CO2+SHORTP), and 2% corn oil + long particle size (CO2+LONGP). Dry matter intake and milk yield were not affected by treatment averaging 26.5 ± 1.19 kg/d and 32.8 ± 3.34 kg/d, respectively. A decrease was found in 3.5% FCM with the inclusion of oil resulting in 34.6 and 26.6 ± 2.6 kg/d for 0 and 2% oil diets, respectively. An oil × size interaction was found for milk fat concentration resulting in 2.27, 3.02, 3.62, and 3.62 ± 0.23% for CO2+SHORTP, CO2+LONGP, CO0+SHORTP, and CO0+LONGP, respectively. Fat yield was reduced from 1.22 to 0.81 ± 0.09 kg/d with 2% oil diets. Cows consuming diets with long particle size spent 29 more minutes eating compared with the cows consuming short particle size (198 and 169 ± 15 min/d). Rumination time decreased from 504 to 400 ± 35 min/d for cows consuming short particle size compared with long particle size. Total chewing was reduced from 702 to 570 ± 4 min/d when cows consumed short particle size. Feeding long particle size decreased rate of passage of DM from 3.38 to 2.89 ± 0.42%/h; concomitantly mean retention time increased from 31.7 to 38.4 ± 5.36 h for diets containing long particle size. The results of this experiment show that effects of oil on milk fat depression were less severe when cows consumed long particle size, suggesting that dietary manipulations that modify rumen kinetics also affect milk fat production in dairy cows consuming reduced-fat dried distillers grains with solubles supplemented with corn oil.
Key words: chewing activity, milk fat, rumen kinetics

Short Communication

Compared with long forage particles, small forage particles pass out of the rumen more rapidly and may result in reduced rumination times and rumen pH. Saliva production is an important feature of the ruminant digestive process because saliva acts as a buffer agent that helps maintain pH in the rumen. Saliva secretion occurs continuously but is more pronounced during eating and rumination (Maekawa et al., 2002). Rapid fermentation of carbohydrates, lower buffering capacity in the rumen, and high supply of PUFA are factors that contribute to milk fat depression (**MFD**; Kalscheur et al., 1997a,b). These changes may lead to low ruminal pH and altered biohydrogenation pathways that result in formation of bio-active isomers of CLA that may inhibit milk fat synthesis in the mammary gland (Bauman and Griinari, 2001).

The corn-ethanol industry currently implements technology that partially removes fat from the solubles fraction of dried distillers grains with solubles (**DDGS**); this results in production of reduced-fat DDGS (**RFDDGS**). The removal of fat is considered as removal of energy from DDGS; interestingly, reports by Mjoun et al. (2010) and Castillo-Lopez et al. (2014b) indicate that cows maintain milk yield when RFDDGS are fed up to

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[1]Current address: Department of Animal Science, Iowa State University, Ames, IA 50011.
[2]Corresponding author: pkononoff2@unl.edu

30% of dietary DM. This may be because dairy cows may be more energetically efficient when fed RFDDG (Foth et al., 2015). If energy shortage is of concern, fat supplementation may compensate, but according to Abdelqader et al. (2009) and Ramirez Ramirez et al., (2015), supplementation with corn oil may result in MFD associated with high supply of rich source of long-chain PUFA. In addition, rations containing high proportions of DDGS are often low in effective fiber; therefore, we sought to further evaluate the effects of added fat and forage particle size milk fat production and rumen fermentation of dairy cows fed RFDDGS. We hypothesize that the addition of long-chain PUFA to diets containing a high inclusion rate of RFDDGS supplemented with corn oil will result in MFD but that increasing forage particle size may reduce the extent of this condition.

Experimental cows were cared for according to the guidelines stipulated by the University of Nebraska Institutional Animal Care and Use Committee. Cows were housed in individual stalls and milked at 0700 and 1800 h and had access to an exercise area for approximately 2 h after each milking session. Cows were individually fed once daily at 0900 h for ad libitum consumption allowing approximately 10% refusals; which were collected, weighed, and recorded individually. Four ruminally cannulated Holstein cows averaging (±SD) 116 ± 18 DIM and 686 ± 52 kg of BW were used in a 4 × 4 Latin square design with a 2 × 2 factorial arrangement of treatments to test the effects of forage particle size and concentration of corn oil on milk fat depression. In four 28-d periods, each cow was offered 1 of 4 TMR (Table 1) that included RFDDGS at 30% (DM basis). Days 1 to 21 of each period were considered as an adaption period; data collected during the last 7 d were considered for statistical analyses. Dietary treatments were (on a DM basis) 0% corn oil + short forage particle size (**CO0+SHORTP**), 0% corn oil + long forage particle size (**CO0+LONGP**), 2% corn oil + short forage particle size (**CO2+SHORTP**), and 2% corn oil + long forage particle size (**CO2+LONGP**). The RFDDGS was originated from a back-end process of centrifugation of the condensed solubles portion of the feedstuff (POET Nutrition Inc., Sioux Falls, SD). To manipulate forage particle size, a single lot of timothy grass (*Phleum pratense*) was harvested and processed as hay into round bales or ground through a 4.8-mm screen to make pellets (Dehy Alfalfa Mills, Arlington, NE). Subsequently, round bales of grass hay were chopped in a tub grinder equipped with a 7.62-cm screen at the Agricultural Research and Development Center of the University of Nebraska (near Mead, NE). By design, treatments were similar in chemical composition except for ether extract content when diets included corn oil. When formulating the 2% corn oil diets, a proportion of soy hulls was removed to allow inclusion of corn oil.

Samples of TMR, forages, and concentrates were collected on d 27 and 28 of each period and subsequently pooled by period. The Penn State Particle Separator was used to measure particle size distribution of the different TMR as described by Heinrichs and Kononoff (2002). Feed samples were dried at 55°C in a forced-air oven to determine DM. After determination of DM, samples were ground (1-mm screen; Wiley mill, Arthur H. Thomas Co., Philadelphia, PA) and stored at room temperature. Samples of forages and concentrates were analyzed by an external laboratory (Cumberland Valley Analytical Services, Hagerstown, MD). Analyses included DM (method 930.15; AOAC International, 2000), N (method 990.03; Leco FP-528 Nitrogen Combustion Analyzer, Leco Corp. St. Joseph, MI), NDF (Van Soest et al., 1991), starch (Hall, 2009), ether extract using diethyl ether as the solvent (method 2003.05; AOAC International, 2006), ash (method 942.05; AOAC International, 2000), and P by inductively coupled plasma (method 985.01; AOAC International, 2000). Chemical composition of TMR was estimated from analysis of forages and concentrates and their proportion in the diet.

Milk production was measured daily and milk samples were collected during the a.m. and p.m. milking of d 26, 27, and 28 and preserved using a pellet of 2-bromo-2-nitropropane-1,3 diol. Milk samples were analyzed for fat, true protein (AOAC International, 2000), lactose, and SNF using a B2000 Infrared Analyzer (Bentley Instruments, Chaska, MN) by Heart of America DHIA (Manhattan, KS), and MUN was determined using a modified Berthelot reaction concentration (ChemSpec 150 Analyzer, Bentley Instruments) by the same laboratory. Yields of milk components were estimated according to milk weight and time of collection. Daily milk yield was averaged over the last 7 d of each period. An additional milk sample was taken at the times previously described for determination of individual fatty acids. For this purpose, individual samples were frozen immediately after milking, and at the completion of the experiment, one composite per cow in each period was obtained by mixing proportional aliquots according to milk weight and time of collection. Fatty acid analysis of milk was performed by an external laboratory (Department of Animal Science, The Pennsylvania State University, University Park) as described by Rico and Harvatine (2013).

On d 21 of each period, ruminal fluid samples were collected over 10 time points (0, 1, 2, 4, 6, 8, 11, 14, 18, and 23 h) postfeeding. At each time point, samples of