J. Dairy Sci. 91:2077–2081
doi:10.3168/jds.2007-0726

Short Communication: Salivary Secretion During Meals in Lactating Dairy Cattle

K. A. Beauchemin,*[1] L. Eriksen,† P. Nørgaard,† and L. M. Rode*[2,3]
*Agriculture and Agri-Food Canada, Lethbridge Research Centre, Lethbridge, Alberta, Canada T1J 4B1
†Department of Basic Animal and Veterinary Sciences, Faculty of Life Sciences, University of Copenhagen, Frederiksberg, Denmark

ABSTRACT

Four multiparous Holstein cows in midlactation were used in a 4 × 4 Latin square to evaluate whether source of forage influenced salivary secretion during eating in lactating dairy cows. The forages were allocated separately from the pelleted concentrates. Cows were offered 1 of 4 forages each period: barley silage, alfalfa silage, long-stemmed alfalfa hay, or chopped barley straw. Saliva secretion was measured during the morning meal by collecting masticates through the rumen cannula at the cardia of each cow. Rate of salivation (213 g/min) was not affected by forage source. However, the forage sources differed in eating rate (g of DM/min), which led to differences in ensalivation of forages (g of saliva/g of DM and g of saliva/g of NDF). On the basis of DM, ensalivation (g of saliva/g of DM) was greatest for straw (7.23) and similar for barley silage, alfalfa silage, and alfalfa hay (4.15, 3.40, and 4.34 g/g of DM, respectively). Higher ensalivation of straw could be accounted for by its higher neutral detergent fiber (NDF) content; ensalivation of NDF (g of saliva/g of NDF) was actually greatest for long-stemmed alfalfa hay (12.4) and similar for the other chopped forages (8.9). Cows consumed concentrate about 3 to 12 times faster than the various forages (DM basis), and ensalivation of concentrate was much lower (1.12 g of saliva/g of DM) than for forages. Feed characteristics such as particle size, DM, and NDF content affect salivary output during eating by affecting the eating rate. Slower eating rate and greater time spent eating may help prevent ruminal acidosis by increasing the total daily salivary secretion in dairy cows.

Key words: dairy cow, salivation, eating behavior, chewing

Feed formulation models such as the Cornell Net Carbohydrate and Protein System and CPM-Dairy incorporate the concept of physically effective fiber to account for the effects of particle size and the intrinsic properties of fiber on chewing (Mertens, 1997). These models predict rumen pH from physically effective fiber intake, and implicit in these predictions is the assumption that physically effective fiber promotes chewing, and chewing promotes salivation, which elevates rumen pH. The negative consequences of ruminal acidosis and the need to develop better predictions of rumen pH are well recognized (Krause and Oetzel, 2006). However, models of rumen pH (e.g., Argyle and Baldwin, 1988; Allen, 1997) are limited by the lack of information on salivary secretion in dairy cows fed a range of diets.

Only a few studies have measured the amount of saliva secreted during eating in lactating dairy cows and estimates range from 166 to 253 g/min (Bailey, 1961; Cassida and Stokes, 1986; Maekawa et al., 2002b; Beauchemin et al., 2003; Bowman et al., 2003). Variability in estimated salivary secretion during eating among studies may be due in part to animal variation (Maekawa et al., 2002a) and feed characteristics (Bailey, 1961). Although forages vary in physically effective fiber content and the extent to which they promote chewing, their effects on saliva secretion in lactating dairy cows have not been quantified. The objectives of this study were to determine whether rate of salivation during eating differs for different feeds.

The experiment was conducted at the Dairy Facility of the Lethbridge Research Centre with approval of the Institutional Animal Care Committee and according to the Canadian Council on Animal Care Guidelines (Ottawa, Ontario, Canada). Four ruminally fistulated multiparous Holstein cows in late lactation (average BW, 635 kg) were used in an experiment designed as a 4 × 4 Latin square. Each period consisted of 26 d, with 14 d of adaptation followed by 12 d of measurements. The cows were housed in individual stalls and milked twice daily (average yield, 20 kg/d, 4.0% fat).

Received September 26, 2007.
Accepted January 3, 2008.
[1]Corresponding author: beauchemink@agr.gc.ca
[2]Present address: 3302 Beauvais Place, Lethbridge, Alberta, Canada T1K 3J5.
[3]Contribution number: LRC38707049. The contributions of B. Farr (Agriculture and Agri-Food Canada) in planning and executing this study are acknowledged. This project was funded by Agriculture and Agri-Food Canada.

Table 1. Ingredient composition of the diets (% DM basis)

Ingredient	Barley silage	Alfalfa silage	Alfalfa hay	Barley straw
Barley silage	51.30	—	—	—
Alfalfa silage	—	52.65	—	—
Alfalfa hay	—	—	51.73	—
Barley straw	—	—	—	15.86
Molasses[1]	—	—	—	2.97
Beet pulp	32.89	34.39	43.52	61.24
Soybean meal	13.60	11.81	3.30	18.48
Dicalcium phosphate	1.57	0.60	0.90	1.10
Sodium phosphate	0.10	—	—	—
Calcium carbonate	0.50	—	—	—
Urea	—	0.50	0.50	0.30
Mineral/vitamin premix	0.05	0.05	0.05	0.05

[1]Molasses was added to the straw.

The forage and concentrate components of the ration were allocated separately. Each period, the cows received 1 of 4 forages: barley silage, alfalfa silage, long-stemmed alfalfa hay, or chopped barley straw. Each of the forages was paired with a concentrate so that the diet supplied sufficient NE_L and metabolizable protein for cows producing 25 kg of milk (NRC, 1989). Thus, the amount of concentrate offered differed among diets. The concentrates were pelleted and consisted mainly of beet pulp. Diet composition is given in Table 1, with the characteristics of forages given in Table 2.

The concentrates were fed 3 times daily in restricted quantities at 0630, 1200, and 1530 h to ensure the desired forage-to-concentrate ratio was achieved. The forages were offered for ad libitum intake twice daily at 0700 and 1600 h. Feeds were sampled daily and composited weekly for silages and monthly for hay, straw, and concentrates. The composited samples of silages were dried in a forced air oven at 55°C for 48 h to determine DM content.

On d 15 to 18 of each period, eating activities were monitored during the morning allocations of forage or concentrate. There were 2 d of measurements for each feed and cow. Because forage and concentrates were allocated separately, meals of each feed were monitored on separate days. A feeder was positioned in front of each cow, with the feeder placed on an electronic balance to record the weight. A trained observer recorded the time and weight of the feed in the feed bunk at the start and end of the morning meal to calculate meal duration and total intake per meal. A meal was said to start when the animal began to ingest the feed offered, and the meal was said to end once the animal made no further move to ingest feed for at least 5 min. For concentrates, eating rate was determined as the total intake divided by the meal duration because meals were relatively short. However, for forages, the eating rate was calculated at intervals throughout the meal. This was done by recording the time and the weight of the feed remaining in the feed bunk each time the cow lifted her head from the feeder, permitting a stable reading to be made. The time that the cow lifted her head to chew and swallow was used as the end of one interval and the start of the next; thus, there were no time gaps within meals. The eating rate for forages was calculated at each interval throughout the meal as the quantity of forage consumed divided by the duration. The mean eating rate was then calculated by averaging the eating rates determined throughout the meal.

On d 19 to 26 of each period, salivary secretion during meals was measured. Swallowed boluses of ingested forage or concentrate were collected during the morning meal for each cow on 4 nonconsecutive days, with 2 d of collection for each feed type. Collections were made through the rumen cannula at the cardia after some of the rumen contents were removed to expose this region. The collections were made using a plastic bag sewn to a wire-hoop, similar to that used by Cassida and Stokes (1986). Tactile stimulation was avoided by minimizing contact with the rumen wall and the area around the cardia. The entire amount of concentrate consumed was collected because it was not possible to detect individual boluses. The forage boluses were collected for approximately 2 min at 5-min intervals throughout the meal. The rumen contents, which had been previously removed, as well as masticate that had been collected the previous day (refrigerated and then rewarmed), were placed into the rumen at the end of the collections. The masticated feed was dried in a forced-air oven at 55°C for 48 h to determine DM content.

The amount of saliva added to feed (ensalivation rate, g/g of DM) was calculated as the difference in moisture content between the feed and the masticates. The ensalivation rate was expressed on the basis of fiber (g/g of NDF) by correcting for the NDF content of the feed. Ensalivation of concentrate was calculated for the entire masticate, whereas ensalivation of forage was calculated for each 2-min collection and averaged over all collections within the meal for each animal. Salivation rate (g/min) was calculated for each collection by dividing the quantity of saliva by the duration of the collection period. The values were averaged over the meal within animal and day to calculate the amount of saliva secreted per minute during the consumption of forage.

The dried feeds were ground (1-mm screen, Wiley mill, Arthur Hill Thomas Co., Philadelphia, PA), and chemical analyses were performed in duplicate. The DM was determined by drying the samples at 135°C for 2 h, followed by hot weighing (AOAC, 2005; method 930.15). The NDF was determined as described by Van Soest et al. (1991) using heat stable α-amylase but without the use of sodium sulfite. The ADF was determined