

Eating and Feeding Behavior of Dairy Cows: Dietary Influences and Impact on Production

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■ Take Home Messages

- Dairy cows have a natural daily eating and ruminating pattern. Modern lactating dairy cows may eat more often than their ancestors. Housing and feeding management should accommodate their need for frequent meals.
- There is great variation in eating and rumination time between different feeding systems and between individual cows.
- Milk fat percentage tends to increase with increased rumination time per kg of feed eaten.
- A number of factors such as light, noise and water availability may influence feeding pattern.
- Increased proportion of concentrate in the ration and reduced forage particle size result in less eating and rumination time.
- Cows can sort out and leave unpalatable or less preferred feeds in a TMR. Individual cows differ greatly in the feeds that they prefer.

■ Introduction

Over the past 50 years dairy cattle have been selected intensively for milk production. One of the results from this selection is greatly increased milk production and higher levels of feed intake. Feeding and management systems must be carefully developed to take advantage of high milk production potential without coming into conflict with natural patterns of eating and selection or causing digestive and metabolic upsets. Factors that must be taken into account include the inborn pattern of eating and rumination and the effects that the lighting system, water supply, feed particle size and palatability and preference of ration ingredients may have. These aspects of feeding

management may affect not only cow health, but also milk yield and milk composition. This paper reviews the main feeding and behavior characteristics of dairy cows that must be taken into account in a satisfactory feeding system.

■ Natural Feeding Behavior of Dairy Cows

It is well recognized that ruminants such as cattle have a natural tendency to graze and historically have depended on forages as their major source of nutrients. Van Soest (1994) has summarized the various types of ruminants and their differences in natural tendency to select different types of feeds. He concluded that cattle historically grazed about three times daily and consumed almost entirely grass and similar forages. They normally select some leaves, buds and plant stems as well as grass. Cattle have a highly developed rumen that is well suited to retain forage for long enough periods of time for extensive fermentation of highly lignified forage. Sheep and bison have similarly well developed rumens for effective utilization of low quality forages. Van Soest concluded that cattle are relatively unselective in the forage that they eat, whereas domestic sheep are somewhat more selective in the forages that they consume.

The concentrate selectors are a quite different type of ruminant from cattle. This group includes moose, white tail deer, mule deer, and roe deer. These concentrate selectors eat approximately 12 times per day under natural conditions and are highly selective in the feed that they consume. They are very adept at selecting low fibre portions of plants. Given the opportunity, they will select buds, blossoms, leaves, young shoots, flowers, tubers, seeds and fruits. They have a much faster rate of passage through the rumen and the digestive tract than cattle or the other roughage selectors.

According to Van Soest there is also an intermediate type of ruminant which may select either roughage or concentrates depending on feed availability and time of year. This type of ruminant includes goats, caribou, elk and pronghorn antelope. Intermediate types of ruminants have a natural tendency to eat five or six times daily. They are much more selective in their feeding habits than are cattle, but may be less selective than the concentrate feeders. The intermediate types do not retain feed in their rumen as long as do the roughage selectors, and hence are less able to make as effective use of lower quality forages that are mature or more lignified. Concentrate selectors spend a smaller proportion of their time ruminating than roughage selectors.

One of the questions that must be dealt with in formulating successful rations for modern dairy cows is selection of feedstuffs and physical processing of feed to arrive at rations that are readily consumed and maintain a high level of rumen fermentation over the full day. An important question for dairy herd managers is to what extent has selection changed the natural feeding pattern,

selectivity and feed preferences of dairy cows. There is evidence from research at the University of Saskatchewan that modern dairy cows do not have a strong preference for forage and that there is great variation between cows in their preference for different types of feeds. These differences in preference lead to sorting of total mixed rations so that cows are quite capable of either selecting a high forage portion or a low forage portion of a total mixed ration. Therefore, it is necessary to select ingredients carefully, and to use combinations of feeds and physical processing that do not lead cows to be highly selective in their feeding pattern. Such selectivity can result in lower milk production due to low energy intake by cows that prefer forage. It can also result in rumen acidosis and related metabolic problems as well as low milk fat percentage in cows that sort and consume concentrate.

■ Relationship of Eating and Rumination to Milk Production and Feed Intake

A well-managed feeding system provides cows with ready access to feed and a comfortable area for resting. It is important that cows have access to feed and have housing conditions that allow the cows to ruminate. Rumination (cud chewing) reduces particle size, mixes bacteria with feed and stimulates production of saliva. Saliva flow is in the range of 200 to 300 ml per minute during rumination and production of saliva is important to supply buffers that maintain rumen pH above 6.0.

Recent literature was surveyed to determine the importance of eating time and rate and rumination time and rate on milk composition and milk yield. Table 1 contains a summary of this literature. A total of 21 feeding treatments were reviewed and 16 contained a full array of information on milk yield, milk composition, feed intake and chewing and rumination data. The average milk yield in these trials was 27.8 kilograms with the lowest production being 11.2 kg and the second lowest 18.3 kg of milk daily. All other reported yields were in the mid 20 kg to mid 30 kg range.

Standard deviation is a measure of the variation of the literature values used in this summary. A standard deviation of 1.4 indicates that 67% of the 19 milk yield values in this summary fell within a range of 27.8 kg plus or minus 1.4 kg. The standard deviation as a percent of the mean is a measure of the amount of scatter in the data. The value of 5% for milk yield in Table 1 indicates a relatively narrow range. Dry matter intake in these trials averaged 20.4 kg and milk fat 3.46%. The milk yields shown are the raw values and are not adjusted to a standard milk fat percentage.

Eating time ranged from 2.4 to 7.2 hours per day with an average of 4.8. There was considerable variation in eating time with the standard deviation as a

percent of the mean being 28. Eating rate in Table 1 is expressed as minutes per kilogram of feed consumed. Therefore, a high number such as 18.6 minutes per kg is a relatively slow rate of feed consumption. An eating rate of 18.6 minutes per kg is equivalent to 54 grams of feed dry matter consumed per minute. The fastest eating rate was 6.9 minutes per kg (145 grams per minute) and the average was 14.2 minutes per kilo (or 70 grams per minute).

Twelve of the research trials reviewed used total mixed rations. One was a grazing study and the remainder of the trials were based on meal feeding of concentrate and forage. Rumination time averaged 6.6 hours per day which, when added to the eating time of 4.8 hours gave a total of 11.4 hours daily of chewing activity. Hours of rumination varied from 3.2 to 8.6 in the 19 observations of rumination time. Rumination rate (minutes of cud chewing per kg of dry matter) averaged 22.9 minutes with a range of 9 to 34.7 minutes per kg. Rumination rate showed great variation with the standard deviation being 29% of the mean. It would appear, therefore, that there are many factors that can influence rumination rate or that there are differences between the various feeding trials and the conditions under which they were conducted that resulted in much different rumination rates.

Table 1. Eating and rumination in relation to milk yield, milk fat and feed intake.

	Milk yield kg/day	Dry matter intake kg/day	Milk fat %	Eating time hr/day	Eating rate min/kg	Rumin- ation time hrs/day	Rumin- ation rate min/kg
Mean	27.8	20.4	3.46	4.8	14.2	6.6	22.9
Standard deviation	1.4	2.8	0.40	1.3	3.0	1.5	6.7
SD, % of Mean	5	14	12	28	21	22	29
Minimum	11.2	15.8	2.90	2.4	6.9	3.2	9.0
Maximum	37.5	24.8	4.28	7.2	18.6	8.6	34.7
Observations	19	18	16	21	18.	19	16

One of the reasons for using total mixed rations is that feed is readily available to cows at all times and feed intake is not limited by availability. Van Soest (1994) reported that wild cattle under natural conditions ate 3 times daily. The summary of 3 research papers and 5 ration types (all total mixed rations) show a range in number of meals per day from 10.8 to 48 (Table 2). It would appear that there has been an alteration in the natural feeding pattern through selection or through the management conditions imposed on modern dairy cows. Meal size ranged from 0.4 kg of dry matter to 2.5 kg. Meal duration ranged from 4.7 to 31.1 minutes. The papers by Vasilatos and Wangness

(1980) and Dado and Allen (1994) were using feedbunks, while those reported by Friggens et al. (1998) were from a computerized feeding system.

There is very little information in the literature on the number of rumination bouts by dairy cows at high levels of milk production. Grant et al. (1995) reported the average rumination bouts per day to be 13.7 to 16.7 while Beauchamin et al. (1997) reported 14.3 to 16.5 rumination bouts daily. It is assumed that meals taken at infrequent intervals could be associated with rumen acidosis, foot problems and reduced milk fat percentage. If cows can compensate for large meals by increasing rumination time, this may offset the undesirable effects of large meals.

Table 2. Number size and duration of meals (Total Mixed Rations)

Milk yield kg	DM intake kg	Number of meals	Meal size kg DM	Meal duration min.	Author
32.3	24.4	12.1	2.1	20.9	Vasilatos et al. 1980
37.5	24.8	10.8	2.5	31.1	Dado et al. 1994
28.7	20.0	11.3	1.8	25.9	Dado et al. 1994
-	22.3	31	0.8	5.8	Friggens et al. 1998
-	16.8	48	0.4	4.7	Friggens et al. 1998

Table 3 summarizes the correlation between eating and rumination times and milk yield, milk fat percentage and dry matter intakes using the data used to create Table 1. It must be remembered that correlation does not determine either cause or effect, but simply shows the relationship between two measurements. For example, it is not surprising that there is a high positive correlation (0.8) between milk yield and feed intake. This can be interpreted to mean that variation in feed dry matter intake accounts for 64% of the variation in milk yield ($0.8^2 \times 100 = 64\%$). It is also shown in Table 3 that as milk yield increases there is a tendency for milk fat percentage to decline. There is also a negative relationship between milk yield and minutes per kilogram of feed consumption. This means that as feed intake per minute increases, milk yield also tends to increase. Another interesting relationship is the positive correlation between milk fat percentage and rumination rate. As the minutes of rumination per kilogram of feed intake increase, so does milk fat percentage. Therefore, any factor that changes the minutes of rumination per kilogram of feed consumed may have a substantial effect on milk fat percentage.

Table 3. Correlation between eating and rumination times and milk yield, milk fat percentage and feed dry matter intake

	Milk yield	Feed DM intake	Milk fat %	Eating time	Eating rate	Rumin-ation time
Milk yield	-	-	-	-	-	-
Feed DM intake	0.80*	-	-	-	-	-
Milk fat %	-0.35	-0.40	-	-	-	-
Eating time	-0.20	-0.06	0.02	-	-	-
Eating rate	-0.34	-0.34	0.03	0.87*	-	-
Rumination time	0.12	0.25	0.26	0.15	0.21	-
Rumination rate	-0.21	-0.47*	0.47*	-0.06	0.28	0.18

*Statistically significant, $P < .05$

It seems evident that ration characteristics and housing and management that affect eating and rumination behavior may have an influence on milk yield and milk composition. It is important then to consider factors that may influence feeding and rumination behavior.

■ Conditions That Affect Feeding Behavior

There are a number of feeding behaviors that are related to milk yield, feed intake and rumination time. It may be of value to examine some of the conditions that can influence feeding behavior. It has been shown that 16 hours of light and 8 hours of darkness tend to give maximum milk yield. Presumably cows that have less than 16 hours of light do not have sufficient time to consume feed. Cows may tend to eat a large meal following light availability after a long period of darkness. This may cause digestive upsets. Under natural conditions cows will graze by starlight or moonlight. However, they may not eat at a feedbunk in a completely dark barn. Also, it has been established that cows tend to move from a dimly lit area to a more brightly-lit area. Depending on the location of light in the feedbunk area, cows may tend to avoid the feedbunk if it is in a dimly lit area.

High-pitched noises from machinery may bother animals before people working in the area notice them. People are sensitive to sound in the 1000 to 3000 hertz range. Auditory sensitivity is greatest for cattle at 8000 hertz. Noisy bearings or metal rubbing on metal may cause sound in this high range that may cause cows to avoid that area.

Lack of ready availability of water may also limit feed intake in dairy cows. The water requirement is 3 to 4 litres per kg of feed dry matter intake plus the volume of water in the milk produced. If cows cannot readily consume the required amount of water, then feed intake may be depressed.

It has been well established that forage-concentrate ratio influences milk composition. Focusing on forage concentrate ratio is no longer the best concept to use in formulating dairy rations. Measures of NDF, physically effective fibre (peNDF) and nonstructural carbohydrate must also be considered. Robinson and McQueen (1997) fed a wide range of forage to concentrate ratios and found a substantial increase in milk yield as concentrate to forage ratio increased. Their highest concentrate to forage ratio was 57% of the dry matter as concentrate. They found a significant reduction in milk fat percentage as the proportion of concentrate increased in the ration. Other research by Armentano and Pereira (1996) and Mertens (1997) has also shown a relationship between proportion of forage or NDF in the ration and milk composition. It has also been generally found that eating and rumination time is decreased as proportion of concentrate in the ration increases.

Mertens (1997) has summarized the effect of particle size of forage on the chewing activity of cows. In a variety of forages including alfalfa hay, rye grass and corn silage, chopping or grinding consistently reduced the total chewing activity per kilogram of dry matter or per kilogram of NDF.

Although it has not been linked to rumination and feeding behavior of dairy cows, there is a consistent seasonal effect on milk composition. Table 4 shows the North American pattern of high milk fat and protein in milk during late fall and low values in mid summer (Table 4). This pattern is also found in herds kept in confinement with supplementary light of 18 hours or more daily. Managing milk fat and protein content is of considerable importance given the recent introduction of multiple component pricing of milk in Western Canada. Either recognizing or managing seasonal milk composition changes is important in managing cash flow and maximizing income. At present no information is available on seasonal differences in eating and rumination times. Although it is probable that some seasonal effect related to day length may be involved, it should also be considered that environmental temperature or other stresses such as fly activity may depress rumination time.

Table 4. Seasonal pattern of milk fat and protein percentages in Saskatchewan and Alberta (%)

	Saskatchewan Provincial Average 1998-99		University of Saskatchewan Herd 1998-99		Alberta Provincial Average 1998-99	
	Fat	Protein	Fat	Protein	Fat	Protein
Mean	3.60	3.25	3.60	3.19	3.62	3.28
Standard Deviation	0.096	0.076	0.211	0.077	0.094	0.070
Maximum	3.74	3.38	3.96	3.32	3.76	3.39
Month	Nov	Nov	Jan	Oct	Nov	Nov
Minimum	3.48	3.14	3.15	3.13	3.51	3.18
Month	July	Aug	Aug	April	July	Aug

Personal Communication, Saskatchewan Milk Control Board

Another factor that must be considered in managing dairy cows is the palatability and preference that cows have for different feeds. Sorting of forages or sorting of forage and concentrate according to individual cow preference or herd preference may have an influence on eating behavior. Selection of TMR components may affect milk composition and has implications in feedbunk management practices.

■ Palatability and preference of feedstuffs

The University of Saskatchewan has been using a total mixed ration in its dairy herd feeding program for over 25 years. It has been frequently observed that cows will sort total mixed ration ingredients in the feedbunk. Individual cows appear to have a preference for either forage or concentrate. The first such observation was that some batches of dehy pellets were not readily consumed by dairy cows. This led to a series of experiments to determine palatability and preference of dairy feedstuffs. A New Zealand trial conducted almost 20 years ago demonstrated that cows would consistently make choices between preferred and less preferred feeds (Table 5).

Table 5. Feed Preferences of Dairy Cows*

Rolled barley - most preferred
Dried peas
Dairy meal
Grass silage
Corn silage
Chopped hay
Alfalfa meal
Sainfoin
Fresh pasture
Tama ryegrass
Spent brewer's grain
Molasses block - least preferred

*Adapted from Klopfer, et al. 1981

There are a number of definitions of palatability. The term "palatability" is sometimes used to describe the vigor with which a cow consumes a feed or ration. It can also be used to describe the acceptance or rejection of food when only one food is available. Dietary preference, on the other hand, is the rejection or acceptance of a feed when a group of palatable feeds are available. For example, a grazing animal may have access to a number of palatable grasses in a pasture, however, the animal may be selective and only consume certain grasses.

It has been established that cattle respond to the four primary taste groups: sweet, salty, sour and bitter. Monosodium glutamate and sodium chloride are two of the few feed additives that may increase intake. Smell may have a role in palatability and preference, but is not usually considered to be as critical as taste. The sense of touch and feel of the feed in the mouth may alter feed intake and preference. Coarse material may initially cause an undesirable sensation in the mouth and limit intake. Rough awned varieties of barley silage may have an effect on unadapted cattle. Previous experience and adaptation are important factors in feed recognition, palatability and feed preference. Past experience with a feed may be either a positive or a negative factor in an animal's selection of a feedstuff.

These factors affecting palatability and preference have been previously described (Christensen, Green Crop Dryer's Conference, 1999). In our studies on palatability and preference, cows were individually housed in tie stalls each with an enclosed feedbunk. During an 8 day adaptation period, the cows were fed a total mixed ration with one or two kilograms of the product top dressed each morning and afternoon. One of the two products to be compared was top dressed on the TMR on alternate days. Following this preliminary period, dairy

cow preference was determined over a half-hour period prior to the morning and afternoon feedings of total mixed ration on 8 successive days. In each experiment two feeds were compared. These feeds were offered in blue plastic tubs with each feed being offered for a five minute period followed by a second feed. This offering of feed was carried out for 30 minutes before the regular morning and afternoon feedings of total mixed ration. Therefore, each cow had access to each feed for 15 minutes twice daily. The total amount of feed consumed per day was used as an indication of palatability and the percentage of each of the two feeds consumed was used as an indication of preference.

A number of differences were found between processed alfalfa products. Cows preferred long cubes to short cubes and they preferred cubes without fines or dusty material to those with short or rough particles. It was also found that cows preferred alfalfa hay to Timothy hay and that cows consumed about three times as much concentrate as they consumed of the silage dry matter. In these studies it was found that there were not only differences in palatability and preferences between feeds, but that individual cows had definite preferences or dislikes for certain feeds and that not all cows preferred the same feeds. These differences in individual cow preferences may explain the sorting of total mixed rations that take place. Some cows will consistently select forage and leave concentrate, while others will readily consume concentrate and leave forage or consume it last. These differences in feed selection by dairy cows may be an important factor in explaining differences in milk composition between cows.

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