Reducing the Variation between Formulated and Consumed Rations*

Bill Stone

Diamond V - Technical Support and Field Research, 4619 Wyckoff Rd., Auburn NY 13021
Email: bstone@diamondv.com

Take Home Messages

- Excessive variation in the ration can result in variation in production and health issues.
- Variation can be reduced by feedstuff analyses, and the type and number of ingredients included in the diet.
- Proper sampling of forages is a must.
- The feeder is an integral part of any effort made to increase the consistency and uniformity of the consumed ration. They must be trained in many areas of feeding management.
- Feeders should be aware of the amount of variation that occurs within a silo, and how their method of obtaining feed from the silo can reduce this variability.
- Loads of feed need to be accurately prepared. Concentrate and forage premixes can improve accuracy, while electronic feed recording systems allow for the monitoring of load preparation.
- Sorting can dramatically affect the ration consumed by a given cow. Preventing forages from being too long (> than about 5 cm (2")), having adequate medium sized particles in the ration, and adding water or wet ingredients can help to reduce sorting.

Introduction

Variation happens. Too much is definitely bad, leading to fluctuations in production (Figure 1) and spikes in health disorders (Table 1). Both of the dairies shown in Figure 1 milk around 600 cows. Herd A has much more consistent daily production than Herd B, with production usually varying by

*Adapted from a paper presented at the 2003 Cornell Nutrition Conference less than a pound. A BST production cycle is evident in Herd B, along with several 3-4 pound daily production swings. Variation in the feeding program could easily account for the production variation evident in Herd B. Herd A monitors load preparation on a daily basis. Table 1 contains data from another herd; notice how the DAs are grouped by date. Errors in load preparation are a prime consideration when problems like this occur. Ketosis, rumen acidosis and laminitis, and probably even hemorrhagic bowel syndrome can occur from excessive variation in the consumed ration.

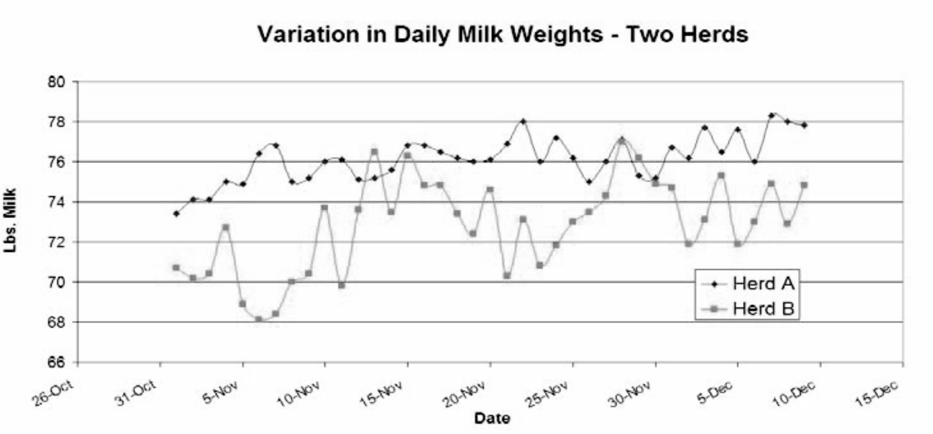

Figure 1. Daily average milk production from two dairies. There is much more daily variation evident in Herd B than in Herd A. A fourteen day BST cycle is also evident in Herd B.

Table 1. The occurrence of displaced abomasums in a New York dairy.

ID	Lact #	DIM @ DA	Event	Date of DA	Remark
2699	2	24	DA	8-4-03	Stitch
2683	2	10	DA	8-4-03	Surgery
2682	2	8	DA	8-4-03	Surgery
2293	2	355	DA	8-5-03	RDASurg
2121	3	210	DA	8-14-03	RDASurg
2364	3	38	DA	8-21-03	Rolled
2694	2	16	DA	8-25-03	Oper
2753	2	18	DA	8-25-03	Stitch
2364	3	42	DA	8-25-03	Stitch

Notice especially that the DAs are grouped by date. It may also be helpful to realize that most DAs occurred later than usual, with two in mid to late lactation cows, and that all DAs occurred in second and greater lactation cows.

Don't get complacent if the daily kilograms of milk shipped vary little in a given herd. Significant variation could still be occurring across groups and within individual cows.

This paper will present areas in the nutrition and feeding program that can lead to excessive ration variation, suggest what degree of variation is acceptable, and describe ways to minimize variation. Potential causes of variation from the feeds, the ration formulation, the feeder, and the cows will be discussed.

▪ Managing Ration Variability Through Feed Analyses, Selection, and Mixes

As nutritional consultants, we want to provide feeding recommendations that have a high probability of supporting a desired level of milk production. Accurate intakes are part of the equation and will be discussed shortly. The first step in reducing ration variability is to know the composition of the ration ingredients; this is the main reason that forages are analyzed. Tabular values are often used in ration formulation for concentrate feeds. This is completely acceptable as long as the nutritionist is confident that the tabular values accurately describe the feeds. All feedstuffs are variable; some, such as distillers grains, bakery by-products, animal proteins and fats, are typically more variable than others (e.g. soybean and canola meals, dry corn) (St-Pierre, 2007; NRC, 2001). Ration variation is reduced and milk production may be increased when inherently more consistent ingredients are fed. Ration variation is further reduced by designing a ration with an increased number of feedstuffs, and by purchasing feed mixes from a feed manufacturer with a quality control system in place (Table 2).

St-Pierre (2007) indicates how this process can reduce ration variability, using crude protein (CP) as an example. The variance contributed by a given feedstuff is the product of the measured variance in a nutrient of a given feedstuff times the square of the amount of the feedstuff fed. In the provided example (Table 2), using forage analyses compared to forage CP tabular values reduced the ration's CP variance score from 3606 to 723; this was due to a reduction in the forage's CP variance contribution from 3190 to 307. The ration was reformulated to further reduce the variance in CP, bringing it down to only 257. The decreased variance resulted from a change in the forage allocation (the alfalfa silage was reduced in half, corn silage increased and some hay was added), and the feeding of a greater number of more consistent concentrates. Grain mixes reduce ration variability of a nutrient via three mechanisms: a greater number of ingredients can be included; more consistent feeds may be fed; and the manufacturer can have quality control procedures in place. It is important to realize that doubling the amount of a feedstuff quadruples its contribution to the variance of the ration, as indicated by the following formula (St-Pierre, 2007):

> $VAR\ (aX) = a^2\ VAR\ (X)$, where "a" is the amount of an ingredient fed, and "X" is the variance of the nutrient in the feedstuff.

The combined approach of forage analyses, consistent ingredients, and quality feed mixes should result in improved production. Additionally, rations can be balanced closer to an animal's requirements when these concepts are implemented. This has always been important for cost reasons; it becomes even more critical as nutrient excretion becomes more closely monitored.

Corn silage is typically more consistent than haylage in DM, fiber levels, and fermentation profiles. Ration consistency can be improved by increasing the amount of corn silage in the diet. A typical northeast dairy ration will often have approximately 60% of the forage base as corn silage, although this percentage can be considerably higher. Of course, it becomes even more critical that this ingredient is consistent and its properties known as it becomes a greater component of the diet.

Farms purchasing commodities should evaluate each load prior to or immediately following unloading for any signs of mold, contaminants, and unanticipated color, temperature, odor, and DM. Areas of concern should be addressed and the load potentially rejected.

Table 2. Expected mean crude protein level and variance in either a simple TMR without forage analyses, a simple TMR with forage analyses, and a TMR with forage analyses and a multi-component feed prepared by a feed manufacturer[1].

	Rations formulated with concentrate tabular values and								
	tabular forage values			forage analyses			multi-component feed and forage analyses		
Ration Ingredient	Lbs DM	Lbs CP	Variance	Lbs DM	Lbs CP	Variance	Lbs DM	Lbs CP	Variance
Alfalfa silage	16.8	3.36	2964	16.8	3.36	282	8.1	1.6	64.8
Corn silage	11.2	1.00	226	11.2	1.00	25	16.1	1.4	46.6
Alfalfa hay							2.7	0.5	6.0
Corn meal	12.9	1.26	67	12.9	1.26	67	6.5	0.6	16.7
Wheat midds							4.0	0.8	19.2
Ground barley							3.2	0.4	8.0
DDG	6.8	2.06	324	6.8	2.06	324	3.0	0.9	63.0
CGF							3.0	0.7	15.3
SBM-48	3.6	1.95	25	3.6	1.95	25	2.7	1.4	13.1
Soyhulls							1.0	0.1	1.0
Canola meal							1.0	0.4	2.5
Mins/vits	0.9	0	0	0.9[2]	0	0	0.9[2]	0	0
Total	52.2	9.63	3606	52.2	9.63	723	52.7	9.27	257

[1]St-Pierre, 2007

[2]Estimated

▪ The Critical First Step in Minimizing Ration Variability (Yawn…): Collecting a Sample for Analysis

It sounds boring and extremely basic, but collecting the sample for analysis is the first critical step in minimizing nutritional variation. The size of most bunker silos necessitates that the dairy, not the nutritional consultant, must collect forage samples for laboratory analyses. Sample collectors need to be properly trained in the appropriate manner of sample collection. They need to realize that the sample they collect needs to accurately represent what is going to be fed.

The process of collecting a sample of silage for analysis is simple. However, the sampler must remember that the objective is to collect a sample that accurately represents the silage being fed. If silage along the top and sides of the silo is fed separately, then it should be sampled separately. It would be entirely inappropriate to collect grab samples as high as one could reach, and then not bother to sample the upper half of the silo. Likewise, if the sampler was using a loader to vertically scrape the silage to collect the sample, and a large amount of silage from the upper region collapsed into the collection pile, then the sample would most likely contain a higher proportion of silage from the upper regions of the silo. Variation within a silo must be considered during the collection of a sample for DM or a more complete analysis. Due to the manner in which bunker silos are typically filled, one would expect much more variation from top to bottom than from side to side. Obviously, this would not be the case if it was not filled in even layers across the width of the silo, or if water was entering one side of the silo. A representative pile of feed can be obtained with a backhoe or silage defacer by digging a trench near the midsection of the silo, or by scraping across the entire face with the loader bucket. A loader bucket does not work as well in digging a vertical “trench” in one area of the silo because it is very difficult to remove a uniform depth across the height of the silo. The large pile of collected feed now needs to be mixed. Although this could be done by hand with a silage fork, the mixer wagon is much easier, and is better at breaking up clumps of haylage. However, many mixer wagons will contain a few hundred pounds of residual feed. The contaminating feed can be diluted by adding a loader bucket of the forage to be tested, briefly mixing, and then discharging. The collected forage can now be added to the mixer wagon, mixed for a few minutes, and then discharged. The pile should then be subsampled throughout with a silage fork or by using a two-handed scooping motion. The subsample is remixed by hand or with the silage fork or a scoop shovel, carefully inverting the pile as it is mixed and spreading the sample across the dry bunker floor so that it is about 2-4” deep. Finally, a single-handed scooping motion is used to collect feed from throughout this pile for the sample that will be submitted for DM or laboratory analysis. Care should be taken to grab all silage particles within the area “scooped” with your hand, otherwise fines can be left behind.

The recommended frequency of testing for DM and laboratory analysis really varies with the dairy. Dairies with narrow harvest windows that pay close attention to crop dry matters at harvest and that either have a small number of plant varieties or that fill their silos in continuous horizontal layers will not need to sample as frequently as those that do not follow these practices. As a minimum, ensiled forages should be tested weekly for DM and monthly with a more complete laboratory analysis. St. Pierre and Weiss (2007) used modeling techniques which indicated that monthly sampling of forages may be most economical for a herd of 50 cows, while herds with more than approximately 500 cows should test weekly. More frequent analyses should be run if DM and fiber results vary by more than five percent (e.g. 30% to 31.5%). Many dairies that premix their forages prior to feeding will run daily DM on these forages.

▪ Minimizing the Effect of Feedstuff Variability Within Bunker Silos

Forages, and haylages in particular, have a large potential for variation. The degree of variation at a given dairy depends largely on its ability to manage their cropping and harvesting systems. One advantage that bunker silos have over upright silos and bags is that ensiled feed from a given load or field is spread over a larger area of the silo. Thus, changes in forage dry matter (DM) or chemical measurements occur more gradually than in other storage systems. However, variation can still occur across the height of a silo. To estimate this potential variation, eleven corn silage and nine haylage bunker silos from nine dairies located in central New York were evaluated (Stone et al., 2003). Samples were collected on six dairies with a backhoe, on two dairies with a loader bucket, and on one dairy with a face shaver. Sample collection was designed to reflect the feed that would be obtained if a feeder obtained a loader bucket of feed from a region (upper, middle, or lower) of the silo as compared to a bucket obtained from the entire height of the silo face. Silos above (n = 15) approximately 3.7 meters (12 ft) in height were split into thirds for sampling, while those less (n = 4) than approximately 3.7 m were split into halves. The vertical trench was dug to a depth of about 20 to 30 cm (8–12”). Feed removed from each section was thoroughly mixed and then subsampled to obtain a sample approximately 5-10% the size of the removed silage pile. This sample was then again thoroughly mixed and finally subsampled for analysis of DM, ADF, NDF, CP, lactate and VFA with wet chemical procedures (Dairy One, Ithaca, NY). The entire sample (approximately 3 liter) was ground for analytical procedures.

Two test silos (one alfalfa and one corn silage) were used to evaluate the consistency of the sampling and the laboratory procedures. The sampling procedure described above was duplicated once for each silage pile obtained from the upper, middle, and lower sections of the silos. These samples were then examined in triplicate for DM and NDF, and singly for ADF, CP, lactate and VFA to compare the consistency of sampling and laboratory procedures. Generally, the results were very consistent (Figure 2). This indicates that the measured variation within silage regions was actually occurring.

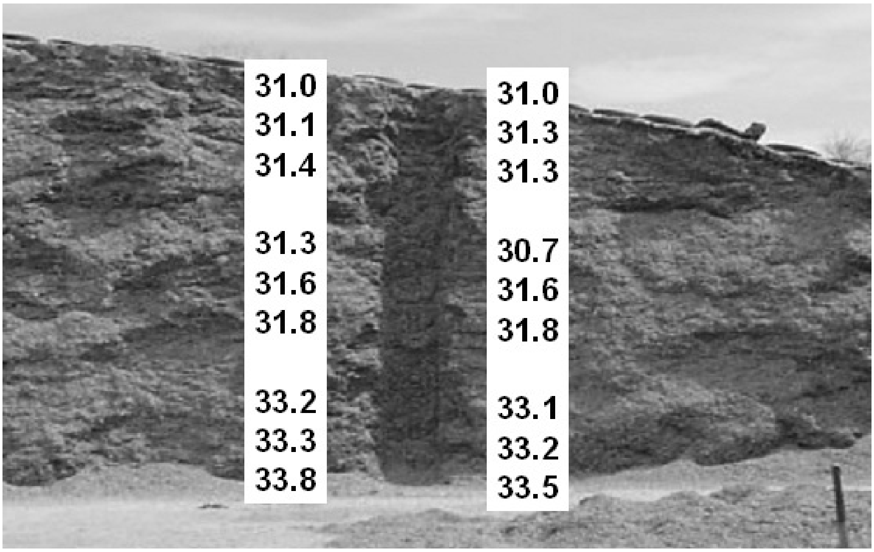

Figure 2. Dry matter results obtained from a corn silage bunker silo using proper sampling techniques.

A trench 20 - 30 cm deep was dug into a corn silage silo with a backhoe. The silage was segregated into three piles obtained from the upper, middle, and lower thirds of the silo. These piles were mixed with a silage fork and then sub-sampled twice to form two smaller, approximately 14 kg DM piles. These sub-piles were then further mixed and subsequently sampled twice for analysis. The two samples obtained from each region of the silo were tested in triplicate for DM. The results within and between samples for each region of the silo were very consistent, as the DM results indicate.

Within each silo, deviations from the minimum analytical result for DM, ADF, NDF, CP, and VFA were determined. Maximum deviations within a given silo were determined by dividing the range by the minimum analyzed value. For example, a silo with measurements of 44.5, 41.2, and 36.6 would have a maximum deviation of 21.6% ([44.5 – 36.6]/36.6).

Haylage varied more than corn silage (Table 3), although there were examples of extreme variation, particularly in DM, in both crops. In some situations a feeder could be delivering an entirely different ration from one load of feed to the next if care was not taken in obtaining the forage from the silo. The average deviations in DM for corn silage and haylage were used to estimate the effect of feeding from regions of the silo (as opposed to from the entire face) and of improperly obtaining a sample for DM analysis. For example, a 54.5% forage ration can range from a 52.8 to a 56.4% forage diet if forage DM were properly obtained (from the entire height or face of the silo), and then the feeder fed by regions. The range would increase to 51 to 59%

forage if the sample collected for DM analysis was obtained from one of the regions of the silo (as high as someone could reach, for example), and then the feeder also fed according to regions. Variation like this could result in groups of cows being completely out of feed one day, and having a large surplus the next. Digestive disturbances would be expected to increase with a fluctuating feeding program. Dairy feed personnel need to be aware of this variation, and of the difference it can make to the final ration delivered to the cow. Techniques to minimize forage variation, such as obtaining each bucket of feed from the height of the silo face or the premixing of forages obtained from across the entire face of the silo, should be part of feeding standard operating procedures on dairies. Some dairies have reduced ration variability by premixing each forage and running a DM prior to feeding. Silage face shavers can vastly improve bunker face management, and reduce ration variation by mixing forages from across the height of the silo.

Table 3. Deviations between different regions (upper, middle, and lower) in nine haylage and eleven corn silage bunker silos.

	DM	CP	ADF	NDF	NEL	Lactic	Acetic	Total VFA
Haylage results								
Smallest deviation, %	5.2	3.3	1.1	5.4	1.6	5.2	25	7
Largest deviation, %	44.7	52.1	20.0	24.8	20.0	646	163	287
Average deviation, %	21.0	17.6	10.7	14.7	9.9	112	72	69
Median deviation, %	19.4	9.5	9.9	14.4	9.3	57	50	38
Corn silage results								
Smallest deviation, %	1.3	2.5	2.3	0.5	1.4	3.8	11.2	0.1
Largest deviation, %	55.0	29.5	18.3	18.6	5.6	48.7	131	41.3
Average deviation, %	12.3	11.0	8.4	8.6	3.1	25.6	53.7	20.5
Median deviation, %	8.3	10.0	8.6	8.4	2.8	26.0	29.9	21.4

▪ When Is Reformulation Necessary?

Despite everyone's best efforts, there will be some variation in sample collection and laboratory procedures. To get some idea of the size of this variation, validation data from the bunker silo survey described above was used to estimate the expected sampling deviation, while two commercial laboratories provided the variability typically seen with their lab standards. Means and standard deviations for DM and NDF in 18 alfalfa haylage and corn silage samples (six from the upper, middle, and lower thirds of each bunker silo) were used to estimate the variation from sample collection. The laboratory standards were the same dried, ground forages used over an extended time in each laboratory (Table 4).

Table 4. Variation from sampling and laboratory procedures.

	DM		NDF[1]	
Sampling variation[2]	Mean	SD	Mean	SD
Haylage – upper third	29.8	0.6	44	0.9
Haylage – middle third	30.6	0.2	41.8	1.0
Haylage – lower third	31.9	0.6	37	0.9
Corn silage – upper third	31.2	0.2	38.8	2.0
Corn silage – middle third	31.5	0.4	36.2	1.6
Corn silage – lower third	33.4	0.3	34.1	1.5
Laboratory variation[3]	Lab #1 Forage Standard		Lab #2 Forage Standard	
Alfalfa hay	Mean	SD	Mean	SD
CP, % DM	18.8	0.2	21.5	.22
NDF, % DM	38.2	1.2	40.7	0.6

[1]Laboratory analyses were performed by laboratory #1.

[2]Six samples (36 total) were collected from silage that had been obtained from the upper, middle, and lower thirds of a haylage and corn silage bunker silo. These results were used to estimate the variation expected from sampling.

[3]Two commercial laboratories provided variation seen in their lab standards.

Dry matter results were the most consistent, with standard deviations averaging less than half a point. Although DM results obtained from both Koster testers and microwave ovens have been consistent with a laboratory standard (Oetzel et al., 1993), the relatively small sample size and the quality of the scales used on most farms would be expected to increase the standard deviation (SD) of on-farm measurements.

Figure 4 contains daily DM from two haylage and one corn silage bunker silo. All forages were premixed in the mixer wagon and the sample for analysis obtained from the discharged feed. On-farm DM measurements were obtained with a Koster tester. Laboratory DM measurements (larger solid shapes) were also included. First of all, there is more DM variability in the haylages than in corn silage; this is expected considering the manner in which both crops are harvested. Laboratory and on-farm DM measurements for corn silage were essentially identical; they were very close for all measurements with the third cutting with the exception of the October 12 measurement. Laboratory DM measurements were consistently lower in the first cutting for the first four measurements, while the Dec. 17 result was inexplicably higher than the on-farm number. Ideally, split samples would be taken and measured on-farm and sent to the lab. These lab samples were taken from the premixed silage pile by another farm employee, and the samples were not split. If a systematic bias was found between laboratory and on-farm DM measurements, as what appears to be happening with the first cutting, then the farm derived DM could be proportionately adjusted.

When should DM be adjusted? First of all, a change in forage DM can really start to change the ration, and the amount of feed delivered to the cow. For example, in a 55% forage diet with a 25 kg (54.5 lb) intake, each percentage point decrease in forage DM results in 0.4 kg (0.9 lb) less feed delivered to the cow. Soon cows are out of feed ("the cows ate really well today"), or they have really backed off on intakes (not really, just drier forages), and they are consuming a diet very different than what was intended. Thus, DM should be adjusted with the following thoughts in mind:

- Does the new DM result make sense (lots of rain, cows have been out of feed earlier, loader buckets weigh more or less than usual, etc.)? If it does, then make the change.
- If the change varies by more than 3 points it should be rechecked that day and at least for the next few days.
- Change DM if a new trend has been established (same result ± 1 percentage point for 3 days) and the new result differs by more than one percentage point from the current DM.
- Many dairies test DM daily so that the procedure is part of the daily routine, and then follow a decision process similar to that described in determining if the feeding DM should be adjusted.

Measurements for NDF varied more, particularly for corn silage. The laboratory NDF SD also varied. Considering sampling and laboratory deviations, changes in NDF are likely to be real and have a significant effect on animal performance when the new result differs by more than approximately 1.5 percentage points in quality forage. Laboratory variation surrounding CP measurements is trivial, with the difference likely to be real if the result varied by about 0.5 percentage points in good alfalfa hay. In dairies performing frequent (i.e. weekly) forage analyses and where the forages have not obviously changed, St. Pierre and Weiss (2007) recommend averaging a few of the recent results rather than simply using the most recent result. Weighting the results, for example a 50% weighting of the most recent measurement, 30% for the previous sample and 20% for the one taken third most recently, is also likely to improve the accuracy of the final number used in ration formulation.

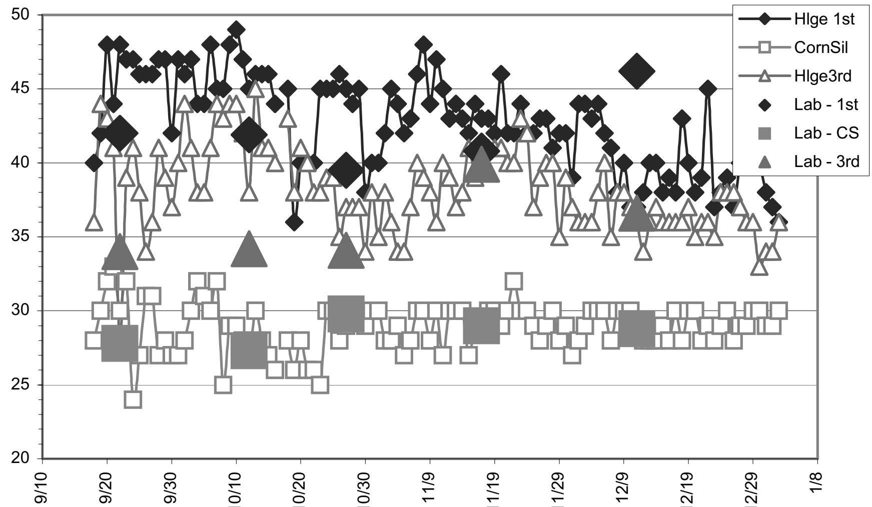

Figure 3. Dry matters of haylage (1st cutting), corn silage, and haylage (3rd cutting) determined daily on a dairy via a Koster tester, or in the laboratory (large shapes).

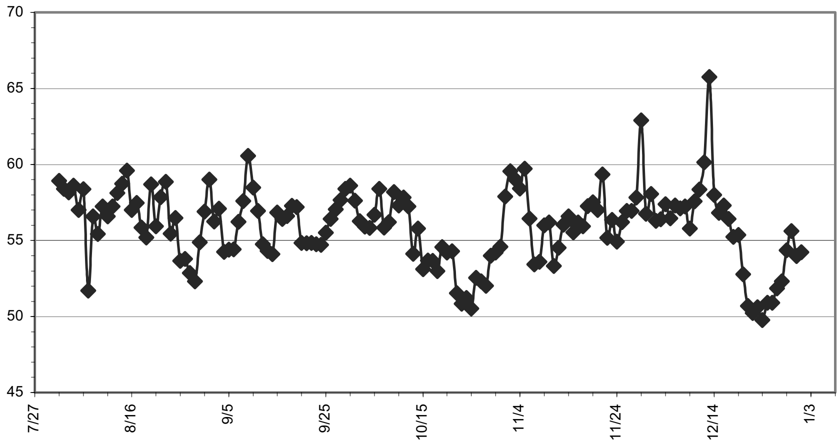

Figure 4. Daily DMI (pounds) in a group of 80 Holsteins.

Figure 4 contains daily DMI for a group of 80 Holstein cattle. Forage DM were determined weekly before 9/20, and daily thereafter. All forage was briefly premixed in the mixer wagon, unloaded, and then used in load preparation. Some of the apparent spikes in DMI (e.g. 11/21, 11/29, and 12/13) occur on approximate increments of seven, and are probably related to weekly animal movements. The decreases in intakes occurring around 10/20 and 12/20 were correlated with an increase in new corn silage and an outbreak of winter dysentery, respectively. Actual intakes can and should be within 5% of predicted intakes (based on experiences with CNCPS), or some on-farm investigating and possibly a ration adjustment may be needed.

■ The Feeder – An Integral Part of Minimizing Ration Variability

Obviously, the performance of the feeder is an integral component in the accurate preparation of a load of feed. The nutritional consultant, along with the dairy owner or manager, needs to closely work with this individual. The feeder must understand how many seemingly small things can have a huge influence on animal performance. Specifically, feeders should have an understanding of the following areas:

- The importance of their performance to the success of the dairy.
- The importance of proper sampling for DM and laboratory analysis.
- Dry matter – what it is, why it is important, and how it should be calculated. Bucholtz (1999) reported that most feeders attending MSU

Feeder Schools were uncomfortable with arithmetic, and had a poor understanding of the DM concept.

- Variability in bunker silos, and how this influences silage collection for load preparation. Ideally silage is premixed or removed with a defacer to minimize variation across the bunker.
- An accurately prepared load of feed is important; let's shoot for a 1% deviation from expected amounts of ingredients.
- Face management – use methods to keep the silage face straight, with minimal disturbance of packed silage, to minimize oxygen infiltration of the silage. Keep the amount of loose feed left at the end of feeding to a minimum.
- Spoiled silage – poor quality silage that may be located along the top and sides of the silo should be removed so that it does not impair intakes, animal performance, or health.
- The potential effect on animal performance of layers of feed within the bunker that are of poor quality or went through a bad fermentation. For example, haylage that underwent a clostridial fermentation can result in an increase in ketosis and indigestion, and a decrease in production (Lingaas and Tveit, 1992).
- Proper ingredient sequencing in load preparation and appropriate mix time. Guidelines should be established for when the mixer wagon should be started, the length of time and speed that it should run, and minimum and maximum load sizes. Feeders need to be aware that mixer wagons can rapidly reduce ration particle size (Heinrichs et al., 1999).
- Guidelines should be in place for when specific groups should be fed, the desired amount of orts, and the procedure used to adjust for changing DMI.
- Mixer wagon maintenance.

Being a feeder is a difficult, highly important position on a large dairy. Effort should be made to make it easier for a feeder to achieve the results desired of them. Ingredient mixes should be purchased or made on the dairy. This greatly minimizes the number of separate ingredients that must be added to each load, and increases the feeder's speed and accuracy. Load sheets should be printed in a font size that is easy to see, and with multiple forage DM increments and animal numbers. Scale displays should be easily visible from the loading tractor, and should have a remote that allows the scale to be zeroed after the addition of each ingredient.

Forage variation within bunkers can be reduced either by using a defacer to remove feed from the entire height of the silo, or by premixing forages. For example, a feeder could remove all of the haylage that was going to be fed for the day, briefly mix it in the mixer wagon, and then discharge the forage. Loads of feed are then quickly prepared by using the removed, premixed forage. Some feeding practices, such as splitting loads of feed between groups and thus requiring that multiple loads of feed are fed to each group, also lessen the risk of variation from load preparation.

Several of the commercially available computerized feed management software systems (EZfeed™, www.dhiprovo.com; Feed Supervisor®, www.feedsupervisor.com; Feed Watch™, www.vas.com; TMR Tracker®, www.digi-star.com) perform all of these functions, and more (Bucholtz, 2002). The systems can improve a feeder's accuracy and efficiency both through making their responsibilities easier to accomplish, and through making the feeder more responsible since (s)he can now be monitored. Dry matters and rations can be updated by the feeder in the bunk, or by someone else at the dairy office. The change in ingredient dry matter is then updated automatically in all rations. The systems typically come with a highly visible scale display. The systems can also record the accuracy with which each ingredient was added to a load, the time between ingredients, the time needed to prepare the entire load, and the total mixing time. Provided that dry matters and cow numbers are correct, and that feed isn't moved between groups when one becomes low on feed, an accurate assessment of dry matter intake can be obtained. Additionally, the software systems help in inventory management and to reduce shrink.

We are all aware that dairy cows like consistency. The feeding program can be made more consistent, and generally more successful, by feeding cows on a set schedule (e.g. when they are being milked). This can pose a problem if there is still a large amount of feed remaining. One possible solution is to try to have a fairly large ort (e.g. 5 – 8%), and then include orts as a ration ingredient and re-feed it to the cows. The ort should be evaluated to ensure that it is very similar to the TMR; steps should be taken to minimize sorting if it isn't. Orts from each group are discarded or fed to a non-lactating group on a regular basis, generally twice a week, to eliminate the possibility of continually recycling spoiled feed. Orts are discarded on a daily basis if the TMR is spoiling/heating by the end of the first day. Feed preservatives, such as inoculating with *Lactobacillus buchneri* at ensiling or adding a propionate-based preservative at feeding, can also improve the success of this approach.

▪ Cow and Bunk Management Effects Influencing the Consumed Ration

Cow sorting can lead to multiple "rations" being consumed by animals fed the same ration. Signs of sorting include "holes" eaten into the offered TMR that contain more forage and less grain than the remaining feed, a ration that looks and analyzes differently throughout the day, and variation in manure pile consistency, particle size, and grain amount. The Penn State Particle Separator (Lammers et al., 1996) is a useful tool to evaluate the uniformity of ration consumption throughout the day. However, sorting may still be occurring in individual cows even if measurements from the orts are similar to the fed ration.

Manure evaluation at this time is quite subjective (Hall, 2002). Manure can be screened with any device containing a screen size that is approximately 1/16". I use a wooden box approximately 16" (40 cm) square, 3" (7.6 cm) deep, with 1/16" (0.16 cm) wire screening stapled to the bottom. Manure samples of approximately 1.5 cups are collected from multiple representative cow piles throughout a group. These samples are then separately placed on the screen and then gently washed with a spray of water. Results should be quite consistent across manure piles; if not, sorting may be an issue.

Sorting of the ration by the cow can result in the consumption of variable rations. Typically long particles are selected against, resulting in some meals having a greater grain content than intended (Leonardi et al., 2000 and 2001; Martin, 2000). It is logical that sorting could easily result in subacute ruminal acidosis and may also increase the risk of hemorrhagic bowel syndrome.

Sorting can be minimized by avoiding excessive amounts of long material in the TMR. Added hay or straw should not be longer than 1 – 2" (Shaver, 2002). Wetter rations help the various feeds to stick together, thus making it more difficult to sort. Water, or wet feeds such as wet brewers grain or whey, can be added to reduce ration DM to less than ~ 50%, or to a level that acts to reduce the sorting problem. Palatable feeds are less likely to be sorted than unpalatable feeds (Leonardi and Armentano, 2000). The use of TMR preservatives (e.g. propionic and/or acetic acid) and *Lactobacillus buchneri* inoculation of forages at ensiling can improve the aerobic stability of the TMR (Kung et al., 2003). And finally, the addition of molasses has been reported to reduce sorting, particularly when added to the TMR (greatest reduction) or forage (Shaver, 2002).

Bunks should be managed so that adequate feed is available along the entire length of the bunk at all times. Feed needs to be pushed up frequently enough so that this is achieved; usually 8-10 times per day is necessary.

▪ Summary

Many areas influence the consistency of the consumed ration, including the dietary ingredients, diet formulation, the attitude and ability of the feeder along with the equipment available for the feeder's use, and the cow. Decide on the degree of variation that you and your clients are willing to accept, and implement management procedures to meet your consistency goals. Improvements in production consistency and cow health are two benefits that should result from these efforts.

▪ References

Bucholtz, H. 1999. Communicating with the person mixing the feed. Tri-State Dairy Nutrition Conference, Fort Wayne, IN, pp. 204-208.

Bucholtz, H. 2002. New feed management software. Tri-State Dairy Nutrition Conference, Fort Wayne, IN, pp. 99-101.

Hall, M. B. 2002. Manure evaluation: a practical tool for reading your cows. Proc. Cornell Nutr. Conf., 64th annual meeting, Syracuse, NY, pp. 145-152.

Heinrichs, A. J., D. R. Buckmaster, and B. P. Lammers. 1999. Processing, mixing, and particle size reduction of forages for dairy cattle. J. Anim. Sci. 77:180-186.

Kung, Jr., L., C. C. Taylor, M. P. Lynch, and J. M. Neylon. 2003. The effect of treating alfalfa with *Lactobacillus buchneri* 40788 on silage fermentation, aerobic stability, and nutritive value for lactating dairy cows. J. Dairy Sci. 86:336-343.

Lammers, B. P., D. R. Buckmaster, and A. H. Heinrichs. 1996. A simple method for the analysis of particle sizes of forage and total mixed rations. J. Dairy Sci. 79:922-928.

Leonardi C. and L. E. Armentano. 2000. Effect of particle size, quality and quantity of alfalfa hay, and cow on selective consumption by dairy cattle. J. Dairy Sci. 83 (Suppl. 1):272 (abstr.).

Leonardi C., L. E. Armentano and K. J. Shinners. 2001. Effect of different particle size distribution of oat silage on feeding behavior and productive performance of dairy cattle. J. Dairy Sci. 84(Suppl. 1):199 (abstr.).

Lingaas, F. and B. Tveit. 1992. Etiology of acetonemia in Norwegian cattle. 2. Effect of butyric acid, valeric acid, and putrescine. J. Dairy Sci. 75:2433-2439.

Martin R. 2000. Evaluating TMR particle distribution: a series of on-farm case studies. Pages 75-78 in Proc. 4-State Prof. Dairy Mgmt. Seminar. Dubuque, IA MWPS-4SD8. Ames, IA.

National Research Council. 2001. Nutrient Requirements of Dairy Cattle. 7th rev. ed. Natl. Acad. Press. Washington, D. C.

Oetzel, G. R., F. P. Villalba, W. J. Goodger, and K. V. Nordlund. 1993. A comparison of on-farm methods for estimating the dry matter content of feed ingredients. J. Dairy Sci. 76:293-299.

Shaver, R. D. 2002. Rumen acidosis in dairy cattle: bunk management considerations. Pages 75-81 *in* Proceedings from the 12th International Symposium on Lameness in Ruminants. Orlando, Florida.

Stone, W. C., L. E. Chase, and T. L. Batchelder. 2003. Corn silage and haylage variability within bunker silos. J. Dairy Sci. 86 (Suppl. 1):168 (abstr.).

Stone, W. C. 2004. What's this? Minimizing the variability between formulated and consumed rations. Cornell Nutr. Conf., Syracuse, NY.

St-Pierre, N. R. and W. P. Weiss 2007. Understanding Feed Analysis Variation and Minimizing its Impact on Ration Formulation. Pp. 169-184 *In* Proc. Cornell Nutr. Conf. for Feed Manufacturers.