Diet Consistency: Using TMR Audits™ to Deliver More from Your Feed, Equipment, and People to the Bottom Line

Jeffrey H. Mikus, Ph.D.
Diamond V, Cedar Rapids, IA
Email: jmikus@diamondv.com

INTRODUCTION

Feed costs on dairies make up a considerable portion of the total costs of milk production. In many cases feed costs can be up to or greater than 60 % of the total cost of production. With this in mind, it is extremely important to get the most from your feeding system. Those things in the feeding system that can deliver the most to the bottom line are managing your feed; maintaining equipment; and having people that do their job well with an understanding of the impact on animals.

In addition to the impact of feed costs, diet consistency can also play a large role in whether a farm is profitable. It is imperative that lactating cows receive consistent diets day-after-day to provide consistent rumen function needed for high production levels.

With efficient feed utilization and rumen consistency in mind, the Technical Service Team at Diamond V developed a feed system evaluation that helps make on-farm feed production more efficient. Diamond V's team has been conducting TMR Audits™ on dairies throughout the United States and Canada for several years. In this time we have found several areas that bring real returns to the dairy with usually little out of pocket expense. The goal of TMR Audits™ are to follow feed ingredients from initial receiving to the cow and look for potential bottlenecks in the feeding systems that have the opportunity to provide financial returns to the producer.

Several hundred TMR Audits™ have been conducted by Diamond V and a few common opportunities present themselves in the following areas: feed consistency, equipment, and people.

FEED CONSISTENCY

Feed consistency is likely to have the biggest impact on dairy profitability because it not only affects rumen health of the cow, but also takes into consideration shrink, storage, and inventory management, among other things. The goal should be for feeds to be delivered to the dairy fresh and for feed to make it to the cows without nutrient loss, pathogen growth, unacceptable levels of shrink, or variability in nutrient profiles.

Nutrient Loss

Nutrient loss can be a hidden sink for profitability on the farm. Little thought is given to the consequence of nutrient instability of feed ingredients. This is especially critical when feeds have elevated moisture levels. During the audit process, the utilization of infrared imaging has helped identify opportunities where wetter feeds may be losing value. Infrared imaging helps identify areas where feed is heating and provides a visual example of that impact.

The suspects for feed heating typically are silages and wet by-products, but heating is also found in drier feeds from time to time. The diet in Table 1 is an extreme example of heating and the consequences in

Table 1. Impact of temperature change in feed ingredients on projected energy loss and corresponding projected milk lost.

Ingredient	Initial Temperature (°F)	Final Temperature (°F)	Difference (°F)	Amount in Diet (lb)
Corn Silage	76.3	110.6	34.3	60
Alfalfa Haylage	68.8	90.7	21.9	20
High Moisture Corn	80.8	118.6	37.8	6
	Projected Energy Loss from Diet		1.32 Mcal	
	Projected 3.5% Fat Corrected Milk Loss		4.02 lb	

[1]Assumes temperature changes in feeds require same amount of energy as temperature changes in water.
[2]TMR NE_l = 0.80 Mcal/lb of DM.
[3]One pound of 3.5 % fat correct milk contains 0.336 Mcal.

terms of energy and milk production lost. The diet in this example was made up of corn silage, alfalfa haylage, high moisture corn, and a mineral package. These feeds were removed from their respective storage locations 24-48 h prior to feeding, and temperature changes for theses feeds ranged from +22 °F to +38 °F. With the extreme temperature increases, the estimated loss of energy from the diet was 1.35 Mcal, resulting in a projected milk loss of 4.02 lb. Although strong assumptions are made to arrive at these projections, the reality is there is some value lost from feeds that have the opportunity to heat.

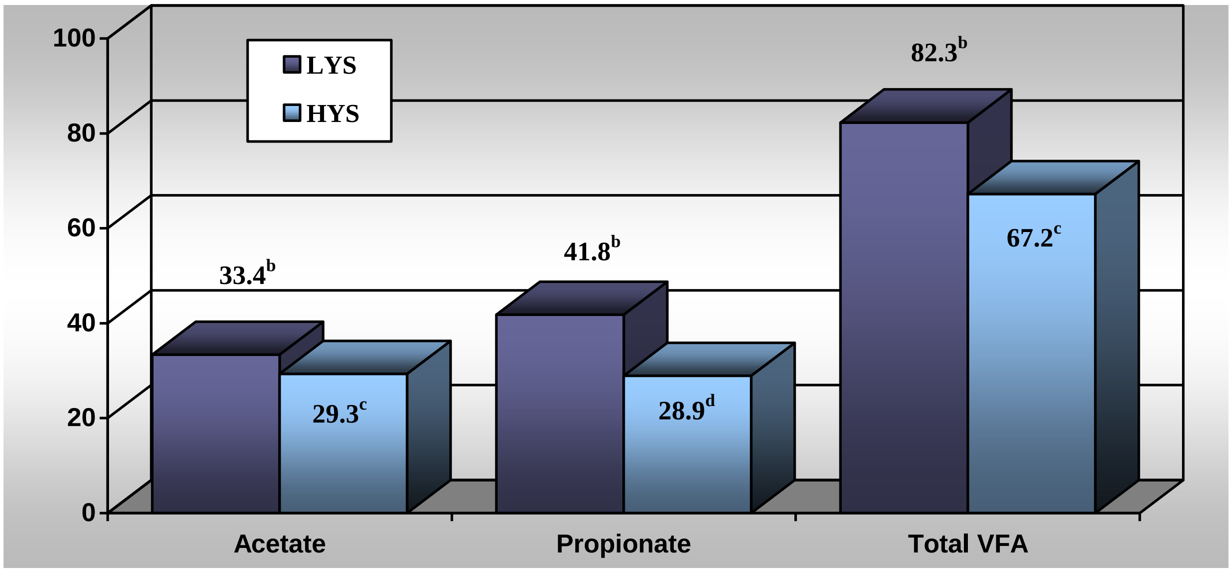
The loss of energy in the example above is most likely due to an increase in the number of microorganisms that are the culprit of heating feeds. These organisms can only create heat by utilizing energy in feeds as fuel for their metabolic processes. This results in a reduction in the energy available to the cow, resulting in the opportunity for diets to have less energy than the original diet formulation. The increase in microorganisms in these cases can be quite dramatic as shown in Table 2 (Perkins, personal communication).

Table 2. Microorganism changes in corn silage removed from the face of a pile and left loose at a silage pile for approximately 12 h.

Item	Location	
	Face	Floor
pH	3.68	3.83
Yeast count, cfu/gram	18,000	410,000
Mold count, cfu/gram	<1,000	370,000
Bacillus count, cfu/gram	5,300	730,000

[1]Samples were taken in Vermont in November.

Figure 1. Effect of corn silage with high levels of wild yeast on rumen volatile fatty acid production in an *in vitro* rumen fermentation system.



[1]LYS = Corn silage with low levels of wild yeast (<100 cfu/g);
HYS = Corn silage with high levels of wild yeasts (22 billion cfu/g).

This example shows the effect of leaving silage loose and exposed to oxygen for approximately 12 h. Dramatic increases in wild yeasts, mold, and bacteria were noted even in a mild climate (Vermont in November). There is a significant opportunity for these organisms to be detrimental to rumen microorganisms (Santos, 2011), compounding the reduction in feed quality. One example of the potential pathogenic nature of these organisms is shown in Figure 1 (Oelberg, personal communication).

Figure 1, shows the dramatic effect wild yeasts can have on volatile fatty acid production. These dramatic decreases in VFA levels would be expected to result in significant reductions in production.

Opportunities for losses of energy due to heating and increases in potentially pathogenic organisms can be reduced by following a few simple guidelines for managing silages.

1. Pack silages adequately to allow for proper fermentation.
2. Cover as soon as possible after packing to reduce oxygen exposure.
3. During feed out, remove only enough plastic for two days feeding.
4. Keep silage faces smooth and vertical.
5. Remove just enough silage for the feeding period.
6. Avoid leaving loose silage at the silage face or in the mixing area for more than 8 h.
7. Consider using an inoculant containing *Lactobacillu buchneri* at ensiling.

Opportunities to Reduce Shrink

Shrink is an incredibly underestimated area of loss on the farm. Estimates of shrink have been as high as 20 % (Brouk, 2009), and is likely in that range for many farms. Some of the biggest areas of shrink include:

1. Un-paved feed storage area/mud;
2. Lack of feeder expectations, training and feedback;
3. Wet feeds and silage not well covered due to not enough tires, holes in plastic, and plastic billowing in the wind;
4. Wind blowing feed away;
5. Poor silage face management;
6. Inadequate packing of silage leading to reduced silage densities and excessive fermentation loss;
7. Excessive refusals;
8. Loading too many ingredients into the mixer;
9. Inaccurate loading of ingredients into the mixer; and
10. Scale accuracy on the mixer.

Although not a complete list, these areas likely give the biggest opportunity for improvement. Special care should also be given to feed center layout and logistics of moving feed around the mixing area.

Another area often over looked in the conversation around shrink is the impact of inventory management. All feed inventories should be utilized in a first in-first out fashion. This should help reduce the opportunity for waste of older feeds. This is extremely important for the wetter feeds, as mentioned previously.

Nutrient Variability

Rumen consistency should be a priority when feeding cows. This can be a challenge at times due to variability among feedstuffs. Variability in feed ingredients can be high anywhere, but greater variability often occurs in silages, hays, and some by-products. Variability problems seem to have been reduced in distiller's products as production practices have improved.

Silages are interesting cases due to the dynamic nature of silage storage areas. In piles, silage will be different from top to bottom and center-to-outside. This is likely due to differences in packing density, fermentation profiles, and crop fields. Bagged silages, likewise, will vary from one end to the other. Observations, during the process of conducting audits, have shown differences in DM on silage faces as much as 29 % (Tegeler, personal communication). The average deviation among regions (bunker divided into thirds vertically) in DM in a bunker silo survey was 10 % for corn silage and 20 % for haylage. Neutral detergent fiber (**NDF)** numbers have been observed to have differences of as much as 17 % (Stone, 2003). One very good way to mitigate the variability in silages is to remove what is needed for the feeding period and mix into one central pile. This pile should only be disturbed for feeding to reduce the oxygen exposure. This should provide a more consistent product for feeding.

Hay variability is another area that can cause some issues. Hays should be labeled well and if multiple hay sources are used in a diet, feeders should be aware of the proper amounts of each lot. One can attempt to mix different hays in one area and then load the mixer, but this is often difficult to do consistently. Ideally, proper amounts of each can be added to the mixer. Then the feeder must strictly adhere to proper mixing times. Mixer blades must be sharp to properly process hay and allow for proper mixing. To ensure reduced variability, this is even more critical when adding different hays to the mixer.

EQUIPMENT

One of the most important aspects of TMR Audits™ is observations concerning condition and function of feeding equipment. Mixers, scales, loaders, and other equipment around the feeding area are often overlooked as critical points for consistent diet production. Through observations of the facilities, several common areas for improvement are found on many farms. These include: mixer condition, scale accuracy, and improper ingredient loading.

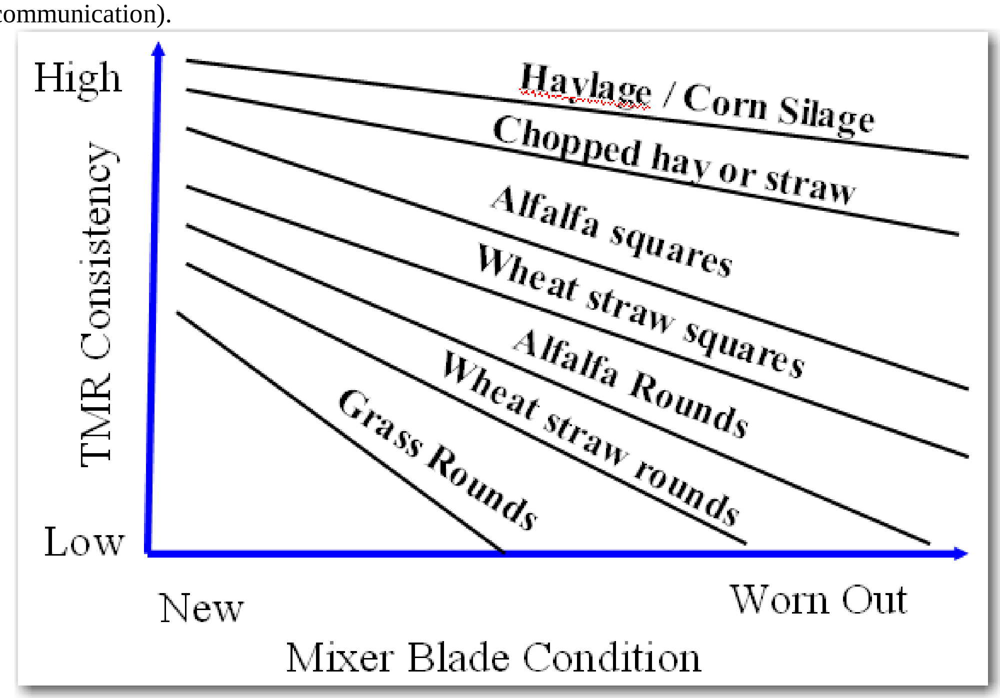
Mixer Condition

Mixers often behave differently between brands and models. For this reason, it is very important for feeders and managers to be extremely familiar with their equipment. Two areas of focus for mixers include: blades and kicker plates.

Blade wear in mixers can be extremely variable and very dependent on types of feeds utilized. Guidelines for blade changes are not easy to recommend due to wear variability, but blades in most cases need to be changed at least quarterly and often more frequently in cases where course forages are being fed. Forages, and hays specifically, are the major contributor to blade wear.

In addition to processing forages, blades play a major role in the ability for mixers to efficiently produce a consistent diet. Figure 2, shows an approximation of the impact of type of forage and mixer blade condition on diet consistency. Figure 2 graphically demonstrates the expected diet variability associated with worn mixer blades. It also shows that silages tend to have little impact on diet consistency, primarily due to reduced particle lengths. Hay types, hay quality, and baling method can have a major impact on diet consistency; with round bales and grass hays providing the most inconsistent diets, particularly when equipment starts to wear.

Figure 2. Effect of forage and mixer blade condition on TMR consistency (Oelberg, personal communication).



Although blade wear can lead to inconsistency, when focusing on the mixer, kicker plate wear is usually the biggest contributor to TMR inconsistency. Kicker plates are likely the most important piece of equipment within the mixer, and the most over looked. Kicker plates are small pieces of metal typically found on the leading edge of the augers in vertical mixers. The function of kicker plates is to move feed into areas that allow augers to adequately mix. A few brands do not incorporate kicker plates in their design, but the augers are designed to provide the lift that kicker plates provide. Equipment service companies should know specific kicker plate locations and tolerances, and manufacturers can provide this information if producers are doing their own maintenance.

A very good indication of kicker wear is a trail of feed around the outer edge of the mixer tub. Worn kickers do not have the ability to move feed away from the tub wall and into the mix, or move feed to the load-out door. Like blade wear, specific recommendations on changing kickers is difficult due to mixer and diet types.

Scale Accuracy

Diet variability and shrink can be greatly influenced by how accurate the scales are on the mixing equipment. Harner (2011) describes two types of errors with scales (Table 3). The first type (Type 1) is when the scales are off by a certain percentage. For example, the mixer may show weights 10 % lower than the actual weight of each ingredient: a 2,000 lb inclusion ingredient would have 1,800 lb added to the mixer, while a 100 lb inclusion would result in 90 lb going into the mixer.

The second error (Type 2) is when scales are inaccurate by a certain weight. All ingredients, no matter the amount needed would be off by a certain weight. If the scales were weighing 25 lb heavy, a 2,000 lb ingredient would result in 2,025 lb being added, and a 100 lb ingredient inclusion would result in 125 lb in the mixer.

Both examples result in a significant change in the diet composition and present an opportunity for unwanted shrink. With this in mind, scales should be checked often and calibrated when needed. The most accurate way to check scales is to use a commercial scale company, but there are two ways to check scale accuracy on farm. The first way is to weigh the mixer on the drive over scales empty, half full, and full with known quantities of feed. If differences are found, scales should be calibrated.

The second method would be to check each of the four load cells under the corners of the mixer. This is most easily done with two people and safety in mind. With the mixer safely off, one person climbs on the mixer above each of the four load cells. The load cells should read the same for all load cells. If there is a difference, the scales should be recalibrated. Using this method, bad cells may be located and should be replaced.

Improper Ingredient Loading

One very big revelation from conducting TMR Audits™ has been the impact of ingredient loading on diet consistency. This not only includes position in the mix order, but also how the ingredient is delivered to the mixer.

Much discussion can be had around mix order, but through audit observations, the following order fits most scenarios:

1. Large squares or rounds of hay/straw
2. Dry fine ingredients/feed additives
3. Cotton seed and/or on-farm premixes
4. Haylage
5. Corn silage
6. Wet byproducts
7. Liquids

It is important to keep low inclusion products toward the front of the mix order to allow for complete distribution in the diet. Care should also be taken to make sure dry fine ingredients are either mixed thoroughly throughout the mix, and/or added before wetter feeds. This helps prevent clumping of ingredients that may prevent complete dispersal.

Also note that in some cases hays can be very easily processed, so there may be opportunity at times to move hay lower in the mix order.

Table 3. Impact of Type 1 and Type 2 scale errors on shrinkage (Harner, 2011).

Feed Ingredient	Daily Feed lb/hd	Ingredient Weight per 10 ton Batch (lb)	Type 1 Error with 10 % Extra		Type 2 Error with 30 lb extra	
			Actual Weight (lb)	% Error	Actual Weight (lb)	% Error
Alfalfa Hay	12	2,460	2,710	10	2,490	1.2
Corn Silage	35	7,180	7,900	10	7,210	0.4
Flaked Corn	14	2,870	3,160	10	2,900	1.0
Almond Hulls	6	1,230	1,355	10	1,260	2.4
Canola Meal	4.5	925	1,015	10	955	3.2
Dry Distillers Grains	4	820	900	10	850	3.7
Whole Cotton Seed	3	615	675	10	645	4.9
Rumen By-pass Fat	0.5	105	115	10	135	28.6
Minerals and Vitamins	1.5	310	340	10	340	9.7
Liquid Whey	15	3,080	3,385	10	3,110	1.0
Molasses	2	410	450	10	440	7.3
TOTAL		20,000	22,000	10	20,330	1.7

In addition to mix order, loading location in the mixer can have a significant effect on diet consistency. Proper loading location in twin screw vertical mixers is between the augers. This allows for proper ingredient distribution throughout the mixer. When ingredients are added to one end of vertical mixers, the ingredients tend to stay on that end of the mixer.

Figures 3 and 4 show the impact of loading liquid supplement on the back auger of a twin screw vertical mixer. The addition of the supplement to the back of the mixer resulted in large differences in DM from the front of the load-out to the end of the load-out. This was also true for crude protein, resulting in a diet that was not representative of the diet that was formulated.

Parking mixers in areas that are not level will also lead to inconsistent diets. In these cases, the most dense feeds tend to move toward the lowest portion of the mixer. These observations are often made on farms that do not use cement for a mixing pad, or when the feeding area has a lot of waste that is not cleaned up on a regular basis.

One equipment issue can also result in similar changes. Some manufacturers produce vertical mixers with independent hydraulic driven gear boxes. If the hydraulic pressures are different between augers, the augers spin at different rates resulting in unacceptable feed processing and variation in the diet. In these cases, feed migrates away from the auger that is moving the fastest and one should visibly be able to see the difference in feed amounts from front to back. Mixers of this type are most often found in truck mounted situations.

Horizontal mixers and triple screw vertical mixers should be loaded in the middle of the mixer box to provide a consistent diet.

PEOPLE

Independent of the opportunities mentioned above, the biggest opportunity and assets on the farm are the people that are feeding. It is extremely important that feeders understand the very important role they play on the dairy and the implications of how they conduct their jobs.

Training should be a regular part of the feeder’s job. Many opportunities exist for continued learning in this area, both on and off the farm. Training should include proper techniques, consequences of errors on production, equipment up-keep, and safety.

Areas for opportunity often encountered during audits include consistent feed delivery, coordination of feeding and other on-farm tasks, and organization and cleanliness in the feeding area.

Feed Delivery

Very often on farms, pens are completely full or crowded. In these cases, competition for feed can be significant. One easily correctable error often seen on farms is incomplete feed delivery. Feeders should deliver feed to all of the headlocks in a pen to allow for equal access by all cows. Feed push-up should also allow for redistribution of feed, so cows can eat anywhere along the feed bunk. There are cases where feeding pressure is highest in certain areas, and this can be remedied by feeding slightly more feed in these areas. This often occurs around crossovers in free stalls and near water troughs.

Figure 3. Effect on dry matter of loading a liquid supplement on the back auger of a twin screw vertical mixer (Oelberg, personal communication).

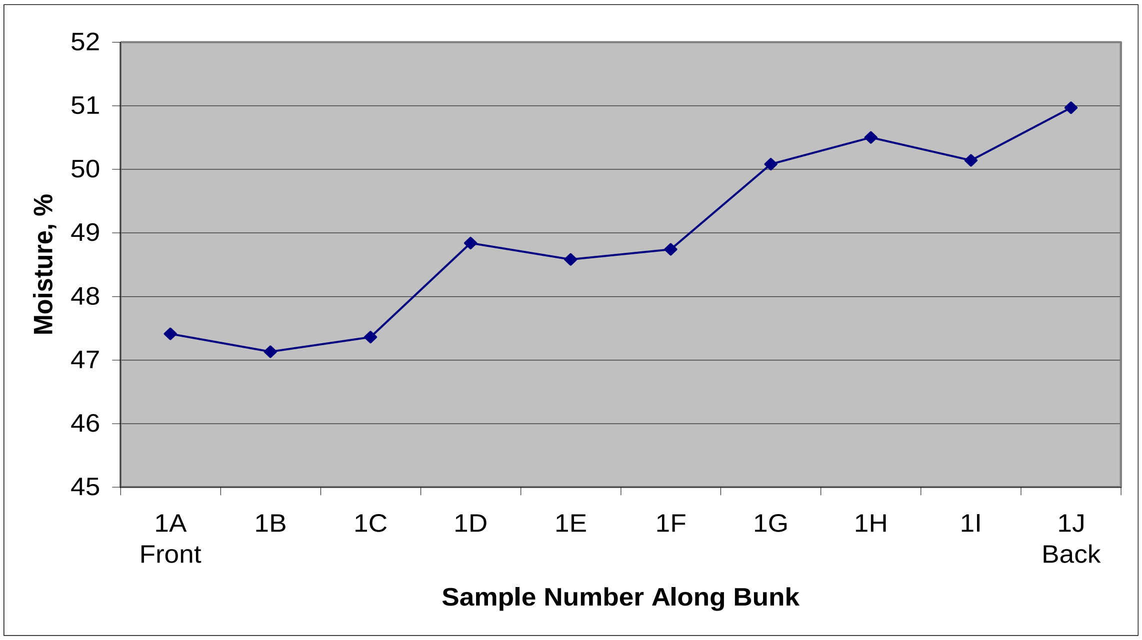
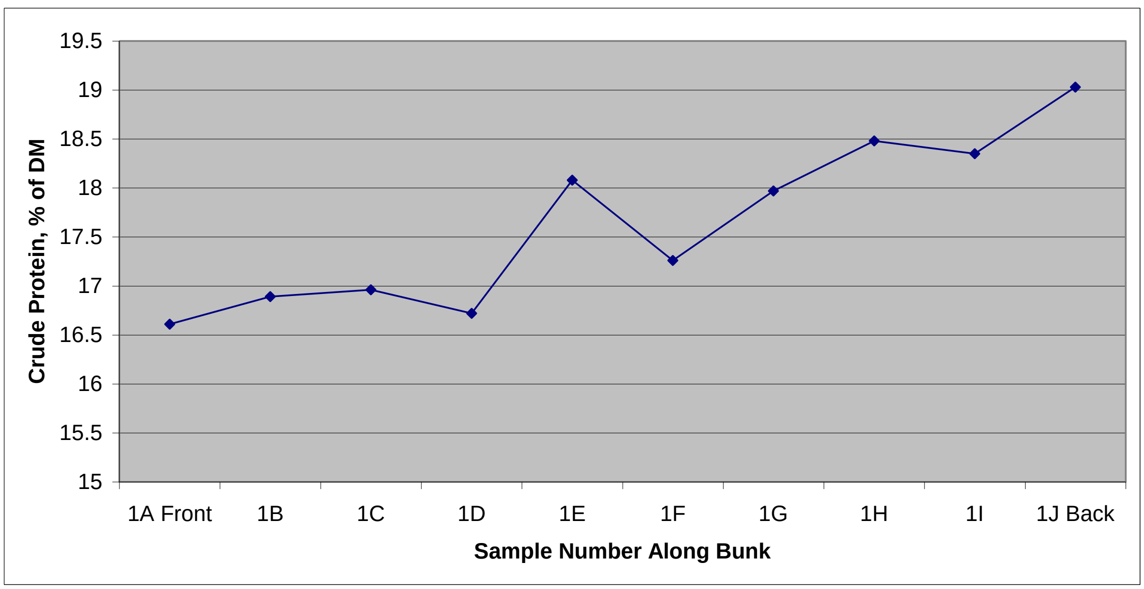


Figure 4. Effect on crude protein of loading a liquid supplement on the back auger of a twin screw vertical mixer (Oelberg, personal communication).



Feeders should strive to deliver or push-up feed before cows come back from the parlor, and never just before cows go to the parlor. Cows should have access to plenty of fresh feed after milking. It is critical that feed is delivered or pushed-up before cows return and not after. Cows will lie down within minutes of returning to their pens if feed is not available, resulting in missed opportunities for efficient feed utilization. If cows are fed immediately before being pushed to the parlor, the pushers will have significant difficulties moving cows away from the bunks.

Feeding Area

The feed mixing area should be considered the feeder's office and should be kept in a clean organized manner. Feeders should clean the area daily to prevent large amounts of waste and a cluttered area. Organization should also be key, and feeders should be expected to keep the area in order so they are not slowed by unnecessary and inefficient movement. One very important thing for everyone on the farm to keep in mind is that the feeding area should be off limits to anyone but the feeder to prevent accidents from occurring.

CONCLUSIONS

The use of TMR Audits™ has been very successful in identifying opportunities for streamlined production without significant capital investment. Several opportunities are frequently encountered which can easily be implemented, delivering returns to the bottom line through improvements in production efficiencies.

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