New techniques: TMR Audit® – a systematic approach to evaluating feeding systems to enhance production and health

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Abstract

Feeding systems need to be monitored and evaluated just like milking systems. A TMR Audit® is a systematic approach designed to evaluate the feeding program. The objectives are to look for ways to minimize variation between the formulated and consumed ration, minimize shrink, and to improve the efficiency of the feeding system. Areas evaluated include silage and feedstuff management, TMR load preparation, TMR consistency within and between loads, and feedbunk management. Management procedures should be in place to minimize top spoilage of silage stored in bunker silos and with other feedstuffs, and feeding personnel should be trained that spoiled feed needs to be discarded, not fed. Due to variation in DM and nutrient content across the face of the silo and across bales of hay or balage, it is best to premix an individual forage prior to using that forage in preparing a load of TMR. The Penn State Particle Separator can be used to evaluate TMR consistency. We have identified 10 primary factors that can lead to variation within and between loads of TMR. These factors include the following: worn equipment, mixing time, load size, levelness of mixer during mixing, loading position on the mixer box, hay or straw quality and processing, loading sequence, liquid distribution, vertical mixer auger speeds, and hay restrictor plate settings in vertical mixers. Feed efficiency can be improved by feeding multiple times per day as opposed to once daily. Feed push-ups need to be done frequently enough to ensure easy access to feed along the entire feed bunk. TMR Audits can help to improve performance and health on the dairy.

Key words: dairy, TMR, audit, production

Résumé

Les systèmes d'alimentation doivent être surveillés et évalués comme le sont les systèmes de traite. Le *TMR Audit*® est une approche systématique servant à l'évaluation des programmes d'alimentation. Les objectifs sont de trouver des moyens de minimiser la variation entre la ration prescrite et consommée, de minimiser les pertes alimentaires et d'améliorer l'efficacité du système d'alimentation. Les composantes concernées inclus la régie de l'ensilage et du fourrage, la préparation de la ration totale mélangée (RTM), l'uniformité des RTM dans le lot et entre les lots et la régie des mangeoires. Des pratiques de gestion devraient être mises en place pour minimiser la détérioration de la partie supérieure de l'ensilage remisé dans le silo-couloir et avec d'autres fourrages. Le personnel chargé de l'alimentation devrait aussi être formé pour s'assurer que les aliments souillés soient laissés de côté plutôt que donnés aux animaux. En raison de la variation dans les matières sèches et des teneurs en éléments nutritifs à travers le silo et aussi de la variation qui existe d'une botte de foin ou d'une balle d'ensilage à l'autre, il est préférable de prémélanger l'aliment avant l'utilisation de cet aliment dans la préparation d'un lot de RTM. Le *Penn State Particle Separator* peut être utilisé pour évaluer l'uniformité de la RTM. Nous avons identifié 10 facteurs qui peuvent contribuer à la variation dans un lot et entre les lots d'une RTM. Parmi ces facteurs, on retrouve les suivants : le délabrement de l'équipement, le temps de mélange, la grosseur du lot, le niveau du mélangeur durant le mélange, la position de chargement dans le mélangeur, la qualité et le traitement du foin ou de la paille, la séquence de chargement, la distribution du liquide, la vitesse de la vis d'alimentation dans le mélangeur vertical et le réglage du réducteur de foin dans le mélangeur vertical. L'efficacité de l'alimentation peut être améliorée en alimentant les animaux plusieurs fois au lieu d'une fois par jour. La redistribution des aliments doit être faite assez souvent pour faciliter l'accès aux aliments sur toute la surface de la mangeoire. L'inspection de la RTM peut améliorer la performance et la santé dans une ferme laitière.

Introduction

Much effort and emphasis is often placed on the milking system, and for good reason – every cow is exposed to it at least 2 times daily. Dairies typically have specific milking protocols, vacuum levels and pulsators are monitored, and equipment maintenance routinely performed. The feeding system, however, often does not receive nearly as much attention. While the diet may be formulated with the most advanced nutrition software, the implementation of the feeding program is often far from rigorous. A TMR Audit uses a systematic approach to evaluate the implementation of

the feeding program. The objectives are to look for ways to minimize variation between the formulated and consumed ration, and to improve the efficiency of the feeding system. Areas evaluated include silage and feedstuff management, TMR load preparation, TMR consistency within and between loads, and feedbunk management.

TMR Audits

A TMR Audit consists of an intensive evaluation of the feeding system.[4] One of its primary objectives is to reduce the amount of variation between the formulated and consumed ration. The Diamond V Technical Services team has conducted several thousand TMR Audits on dairies across the United States. Anecdotally, we have observed an improvement in performance as feeding routines were changed and TMRs became more consistent.

Keys to collecting, analyzing, and feeding a consistent forage

Forage within a bunker silo varies in DM and nutrients primarily across the vertical, but also somewhat across the horizontal, aspect of the silo. To minimize this variation, forages should first be defaced (starting from the bottom and working up), and then pushed into a central pile with the loader bucket and further mixed with the loader bucket. Forages can also be loaded into the mixer wagon, mixed for 2 minutes, and moved to a convenient loading location. The feeder should be careful to include any forage at the bottom of the silo that was not removed with the defacer. This basic procedure, which should be a standard operating protocol in all feeding systems, helps to make the TMR consistent throughout all loads of feed.

Forages should always be premixed prior to feeding or collecting a sample for analyses. This is a critical management technique that can result in more uniform DMI, improvements in cow health, and reduced variation in feed analytical results over time. Ensiled forages can be premixed by defacing or uniformly scraping across the entire face of the silo, pushing the forage into a central pile, and then mixing by either turning with the loader bucket, or loading onto the mixer wagon and mixing for 2 minutes before discharging at the desired location for load preparation. Now the forage can be used for feeding or a sample collected for analysis.[5]

Discard all spoiled feed

Moldy and/or rotting feed, and silage that has undergone clostridial fermentation can cause indigestion, reduced intakes and ruminal digestibility, and possibly abortions. Feeders should be trained in the importance of avoiding the feeding of spoiled feed.

Evaluating TMR mixing and consistency

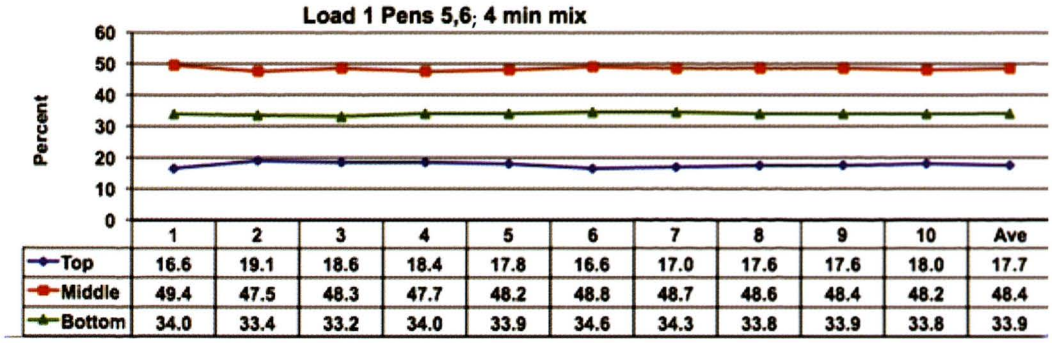
One of the objective measurements in a TMR audit is an evaluation of the TMR particle size distribution along the length of the feedbunk. Ten TMR samples, approximately 1.4l in volume and lightly packed, are collected along the feedbunk in a proportional distance to the unloaded TMR. TMR samples are then run through the Penn State Particle Separator (PSPS; 2 screens and pan) as recommended.[2,3] The particle size distributions are graphed and the coefficient of variation for each screen and the pan determined. Our goals are to have the coefficient of variation (CV) to be less than approximately 2.5% for the middle screen and pan. The top screen often has much less material on it, and hence can be more difficult to have a small CV. However, the top screen CV can be kept to less than 10% even with relatively small amounts of TMR retained on it. TMRs can be highly consistent (Figures 1a and 1b), and highly variable (Figures 2a and 2b). Although entirely anecdotal, we have observed improvements in production, milk components, and reduced digestive disturbances as CV have been reduced from above 5% to less than ~ 2.5% on the middle screen and pan of the PSPS.

The mixer wagon should also be observed when mixing a full load of feed. Are all regions of the TMR being aggressively mixed? Look carefully for areas or regions that are stagnant or moving very little. This can be an indication of a mixer problem, such as worn parts, overloaded wagon, or improper loading sequence.

The 10 primary factors contributing to TMR variability within and between loads include the following: equipment wear (augers, kicker plates, knives, etc.); mix time after the last ingredient; load size; levelness of mixer during mixing; loading position on the mixer box; hay/straw quality and processing; loading sequence; liquid distribution; vertical mixer auger speeds; and hay restrictor plate setting in vertical mixers.

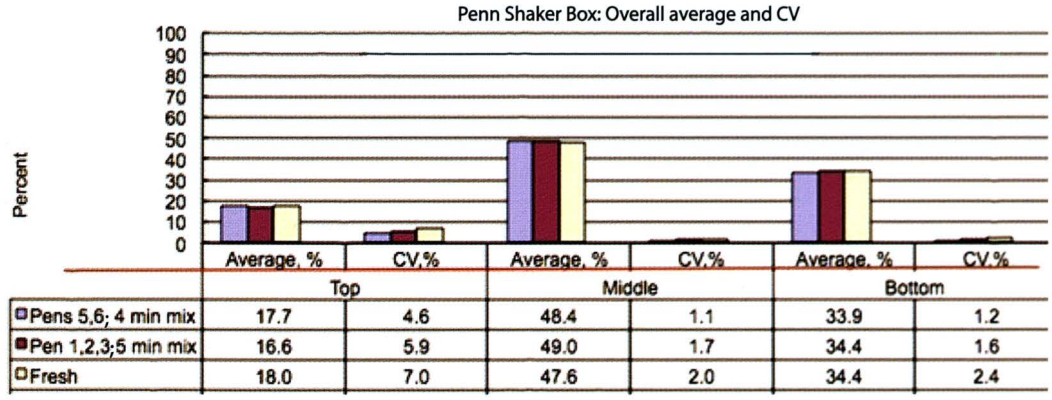
Equipment wear

Feed mixing equipment is not routinely evaluated. If the mixer is delivering a TMR, it is generally assumed to be working properly. Unfortunately, this is often not the case. Worn parts and equipment can result in poor mixing action. The kicker plate is mounted on the lateral aspect of the leading edge of the auger in vertical mixers. Most, but not all, vertical mixers utilize some type of a kicker plate to remove feed from along the bottom wall of the mixer. This allows feed from the upper aspect of the mixer to move down the wall. The mixing process occurs as feed is "falling" along the wall, and then "rising" more in the center regions of the mixer because of the auger movement. A worn kicker plate does not remove sufficient feed from the wall of the mixer, resulting in improper feed flow and inadequate mixing. Worn augers won't mix properly, while dull or missing knives won't adequately process long forage. Dairies should have regular maintenance programs, measuring the clearance between the kicker plate and the mixer wall, and evaluating augers, knives, and other parts on the mixer. Although the frequency will vary with ingredients, this should be done approximately every 500 loads.



	1	2	3	4	5	6	7	8	9	10	Ave
Top	16.6	19.1	18.6	18.4	17.8	16.6	17.0	17.6	17.6	18.0	17.7
Middle	49.4	47.5	48.3	47.7	48.2	48.8	48.7	48.6	48.4	48.2	48.4
Bottom	34.0	33.4	33.2	34.0	33.9	34.6	34.3	33.8	33.9	33.8	33.9

Figure 1a. The particle size distribution determined with the Penn State Particle Separator from 10 TMR samples collected along the feedbunk as the TMR was unloaded. This TMR was prepared with a twin-screw vertical mixer wagon (the same type as in 2a below) and is extremely consistent; the particle size distribution changes very little within a screen along the length of the feedbunk.



	Top		Middle		Bottom	
	Average, %	CV,%	Average, %	CV,%	Average, %	CV,%
Pens 5,6; 4 min mix	17.7	4.6	48.4	1.1	33.9	1.2
Pen 1,2,3;5 min mix	16.6	5.9	49.0	1.7	34.4	1.6
Fresh	18.0	7.0	47.6	2.0	34.4	2.4

Figure 1b. The mean particle size and coefficient of variation from 10 TMR samples collected from 3 different loads from the dairy in Figure 1a. This is an example of 3 TMR loads that are very consistent within a load. The goal is to have the CV be less than 2.5% for the middle screen and pan, which this dairy meets for all loads tested.

Mix time after the last ingredient

Many feeders do not use a timer to monitor mix time after the last ingredient has been added to a load. The best procedure is to utilize the timer function available on most feed management software programs, but external timers, such as phones and clocks on radios, can also be used. Most mixers need about 4 +/- 1 minutes to properly mix when run at nearly full power (1700 to 2000 RPM engine speed). This can be assessed with the TMR sampling procedure discussed above.

Load size

Feed particles mix best when they are falling, or at least dropping, together at the same time. Additionally, shrink increases if load sizes are too large and feed is spilling out of the mixer. Reel auger mixers are notoriously over-loaded. One simple technique we have learned is to simply observe the mixing action of the mixer when a full load of feed is being mixed. Feed should be actively moving in all visible areas of the load of feed.

Levelness of the mixer during mixing

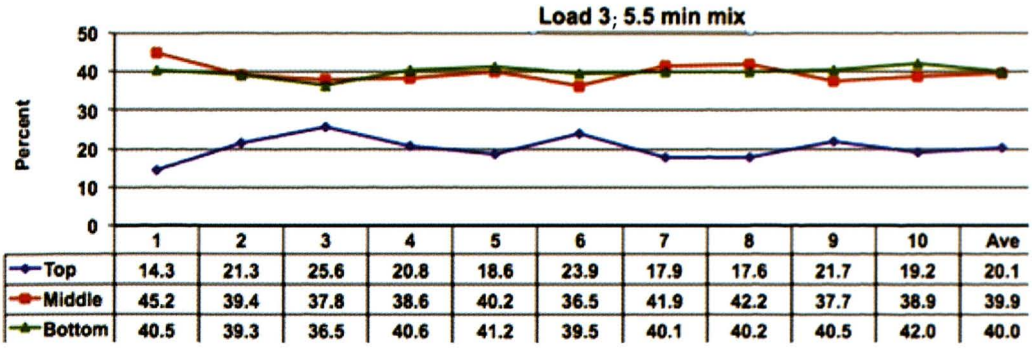
A mixer that is not level when mixing can lead to feedstuffs migrating to a region of the mixer, and to spilling out of the mixer box. Loads should be level at least during mixing, and preferably at all times. In addition to parking on level ground, sometimes the hitch can be moved up or down to level out the mixer wagon.

Loading position on the mixer box

Why make it any harder on the mixer than necessary? Targeting the loader bucket for the center of the feed mixer assists in uniform feed distribution throughout the mixer more quickly.

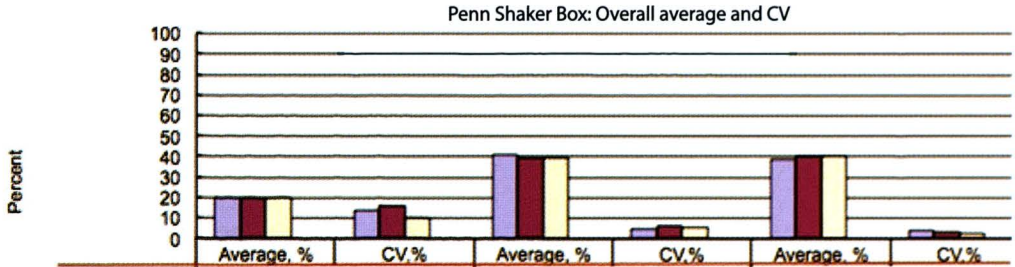
Hay/straw quality and processing

Alfalfa hay and straw should be processed to less than 2" to minimize sorting. A reasonable guideline is to have the particle size distribution of straw be approximately 1/3, 1/3, and 1/3 on the top screen, middle screen, and pan of the PSPS.[a] Most dairies process hay and straw prior to loading



	1	2	3	4	5	6	7	8	9	10	Ave
Top	14.3	21.3	25.6	20.8	18.6	23.9	17.9	17.6	21.7	19.2	20.1
Middle	45.2	39.4	37.8	38.6	40.2	36.5	41.9	42.2	37.7	38.9	39.9
Bottom	40.5	39.3	36.5	40.6	41.2	39.5	40.1	40.2	40.5	42.0	40.0

Figure 2a. The particle size distribution determined with the Penn State Particle Separator from 10 TMR samples collected along the feedbunk as the TMR was unloaded. This TMR was prepared with a twin-screw vertical mixer wagon (the same type as in Figure 1a) and is not as consistent as it should be.



	Average, %	CV,%	Average, %	CV,%	Average, %	CV,%
	Top		Middle		Bottom	
Load 2; 3 min mix	20.0	14.2	41.1	4.9	38.9	4.2
Load 3; 5.5 min mix	20.1	16.4	39.9	6.5	40.0	3.6
Load 4; 6.5 min mix	20.2	9.8	39.5	5.3	40.3	2.4

Figure 2b. The mean particle size and coefficient of variation from 10 TMR samples collected from 3 different loads from the dairy in Figure 2a. There is more variation in each load of feed than optimal; the goal is to have the CV be less than 2.5% for the middle screen and pan. A defacer was purchased, mix times were made more uniform and of adequate length through use of a timer, and the ingredient order was changed during load preparation. The result was a much more consistent TMR.

to ensure proper particle size and reduce equipment wear on the mixer. Knives must be properly maintained in mixers if the mixer is going to be used to process long forage.

Loading sequence

Equipment maintenance, load size, and mix time all trump loading sequence, but it too can affect mix uniformity. Loading sequence will depend on mixer type, ingredient type (density, particle size, moisture level, and flowability), inclusion level, and convenience of the feeder relative to ingredient location. Generally, lower density and large particle feeds (straw, hay) are loaded first, followed by dry grains, wet by-products, haylage, corn silage, and liquids. Haylage can go in earlier if clumps are present and a longer mix time is desired to try to break down clumps. However, the best way to break down haylage clumps is with a defacer. Again, sometimes experimentation needs to be done to determine the best loading sequence for a given mixer and set of feedstuffs.

Liquid distribution

Liquids should be added so that they are dispersed over the central half to two-thirds of the mixer. They are often added as the last ingredient. However, we have often seen excellent mixing results if they are added after all grains have been added to the mixer, followed by forages in increasing order of density.

Vertical mixer auger speeds

Remember that feed particles mix the best when they are falling or actively moving. If the vertical augers are moving too slowly, the feed movement may not be sufficient for feed particles to mix properly. Different companies have designed their equipment to mix at different speeds, but in general TMR consistency will be enhanced when auger speed is increased.

Hay restrictor plate settings in vertical mixers

Restrictor plates force the TMR closer to the auger, enhancing the cutting action of knives. However, they also

decrease the mixing action within the mixer. If the mixer is not being used to process forage, then the restrictor plates can be set all the way out on most mixer wagons.

Feed Bunk Management

The 2 primary initiators of a meal are the delivery of fresh feed and the cow's return to the pen from the parlor. Thus, if cows are fed once per day, the largest meal will occur the first time they are fed fresh feed in the morning, especially if this coincides with milking time.[1] This can result in a "slug" of ingested carbohydrate, a relatively large drop in rumen pH, and a decrease in ruminal efficiency. Feeding 2 to 3 times per day results in more and smaller meals, and a more stable, efficient rumen. Although pushing up feed is critical to allowing access to feed along the bunk, it does not bring animals up to the bunk nearly as much as offering fresh feed.[1]

Conclusion

A rigorous evaluation of the feeding program on a dairy can often improve herd performance and the efficiency of the feeding system. A TMR Audit can help to identify problems with the current program and potential solutions. The good news is that often the solutions involve slight changes in procedures, protocols, or equipment as opposed to large capital investments. Consider conducting TMR Audits at your clients' dairies, and see where improvements can be made.

Endnote

[a]Dann HM. Personal communication, 2012.

Acknowledgements

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