RATION MANAGEMENT:
Impact and Consequence on Performance

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Fluctuating feed and milk prices require that dairy producers maximize income over feed costs. A major contributor to this equation is ration efficiency (milk:dry matter intake). Ration efficiency is dependent on many factors, including ingredient choice, ration formulation, and management of the feeding program.

Dry matter intake (DMI) is a key factor in sustaining high levels of milk production and maintaining good herd health. Formulating diets to contain adequate energy for high milk production often requires high levels of rapidly digestible carbohydrate. These diets often have limited space for fiber and must be closely managed to avoid creating adverse health situations. Combine these diets with the low intakes of transition, early lactation, or hospital cows, or periods of environmental stress, and there is high risk of increased health problems (acidosis, displaced abomasum).

When herd performance is poor, many times the problem is not the ration formulation on paper but rather the one actually consumed by the cow. Also, problems such as excess body condition or poor transition management may be exerting a negative influence on feed intake. Identifying these problems offer a major opportunity for dairies to enhance herd performance.

Management of feeding programs can be difficult, as measuring ration quality can be subjective. Currently, there is no standard definition of ration quality and monitoring protocols for dairy rations have not been developed. Key concepts to any business management program are:

- *If you cannot measure it, you cannot monitor it.*
- *If you cannot monitor it, you cannot manage it.*

There are many critical points between ration formulation and ration consumption by the cow that can affect herd performance. A standardized, objective protocol is needed for monitoring feed presentation on dairies. Additionally, a basic understanding of feed intake regulation may enhance creativity in bunk management schemes to further enhance program performance. This paper will briefly overview factors involved in feed intake regulation, discuss critical points throughout the system that can influence ration presentation, and present considerations for monitoring ration quality.

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FEED INTAKE

Feed intake is controlled by the brain and determined by meal frequency and size. However, intake can be influenced by animal, ration, and environmental factors (Figure 1). Combined, these are management opportunities for the dairy producer to optimize the feeding program.

Animal factors. These may include body condition, stage of lactation, reproductive status, and individual disposition. Research has demonstrated fat cows have lower appetites than thin cows at parturition, resulting in longer delays in peak milk yield (Garnsworthy and Topps, 1982). Roseler et al. (1997a) suggests that mature Holstein cows will suffer a DMI depression of 1.5 to 2.0% for each one-quarter body condition score (BCS) greater than 3.75 at calving.

The lag between peak milk production and peak DMI is a challenge in managing the fresh cow. A slow rise in post-partum feed intake may reflect metabolic problems or obese cows. Roseler et al. (1997b) reported that cows having peak milk yield in the first month of lactation had a shorter lag to peak DMI than those expressing peak milk yield during the third month of lactation. Often, problems in the fresh pen are historical and corrections need to involve the late-lactation or dry cow pens.

Reproductive and social effects are less understood, perhaps due to more individual variation. It is a common field observation that cows tend to go off feed and produce less milk when exhibiting estrus. How much of this is due to hormonal influence or increased social activity is not known. Additionally, social interactions and conflicts tend to have a more pronounced influence on behavior of the primiparous cow. Krohn and Konggaard (1979) demonstrated that first lactation cows fed separately from mature cows spent 10 to 15% more time eating, resulting in 20% greater DMI and 5 to 10% greater milk yield than herdmates that were grouped with mature cows.

Ration considerations. Voluntary intake depends on a combination of diet digestibility, passage rates, and the physical capacity of the gut. Both physical and chemical characteristics of the diet may affect feed intake.

Chemical characteristics that influence feed intake are typically associated with the production of fermentation acids. This influence is a concern with diets containing high levels of rapidly fermentable carbohydrate. When production of these acids exceed the rumen's ability to utilize or absorb them, feedback mechanisms may negatively influence diet intake. Other chemical properties that may exert regulatory feedback influences include protein solubility, dietary fat level and form, mineral levels, diet palatability, and ration moisture.

Physical limitations may be caused by rumen distension with high forage diets. However, much of the research on this subject was traditionally done with high fiber, low energy rations. With the advent of mixer wagons that can handle large amounts of forage, many of today's lactation rations have limited, if any, long-stem hay fed outside the total mixed ration (TMR). Additionally, much of the fiber fraction fed to cows in early lactation includes high quality forages, byproducts, or a combination of both. Thus, a concern with these diets is the effectiveness of the fiber. If mixer wagons are not managed correctly, extensive reduction of forage particle size may alter it's ability to stimulate cud-chewing and saliva flow to buffer the rumen.

While there is a debate over the primary regulatory factor, in reality it is probable that an interaction of several factors contribute to dry matter intake regulation. Results from Sheperd and Combs (1998) suggest that lactating cows have a combination of several factors regulating their feed intake. These researchers fed diets varying in forage content with or without ruminal infusions of acetate or propionate to mid-lactation cows. Cows in this study produced approximately 35 kg/d of milk, regardless of diet, and partitioned the extra energy (via ruminal VFA infusion) to milk fat and body weight gain. These results suggest that neither NDF fill nor a threshold for acetate utilization appeared to limit DMI. This supports the theory that intake regulation is a complex process including nutrient content of the diet, energy requirements for milk production, form of energy supplied, and factors affecting energy partitioning in the cow.

Environmental effects. Cows appear to be considerably more sensitive to heat than cold. Feed intake will begin to decline when temperatures exceed 75°F (NRC, 1988). Dry matter intakes have been shown to drop ten percent at temperatures over 80°F, with 80% humidity. The total energy intake and consequent metabolic heat load in high producing cows makes them more susceptible to reduced DMI during periods of heat stress than low producing or dry cows. Thus, investment is well justified in shading and cooling the feedlines to high producing pens to enhance summer intakes.

Another environmental challenge is periods of rapid weather changes (typically spring and fall). Although the effects of short term changes (cool nights coupled with warm days) is difficult to predict, most producers will attest that these weather patterns create problems in feed bunk management. These problems can result in roller coaster intakes and an increased incidence of displaced abomasums and other health problems. Additionally, periods of wet weather can cause changes in ingredient moisture levels resulting in significant changes in nutrient concentrations.

Cow comfort and pen density may also influence activity at the feedbunk. Haley et al. (1998) evaluated the effects of cow comfort on behavior. This group compared cows housed in large pens with soft rubber mats (high comfort index) to cows housed in narrow tie-stalls on concrete floors (low comfort index). Results suggest that cows housed in a low comfort index environment lay down for less time and had reduced frequencies of lying bouts than cows in comfortable environments. Transferring this information to the field, on-farm observations of stall use in freestall facilities can provide insight into cow comfort. Improvements in cow comfort appear to encourage feed intake, support higher milk yields, and may enhance cow longevity.

OPPORTUNITY POINTS IN FEEDING MANAGEMENT

The goals of any feed program should include high *and consistent* dry matter intakes; however, managing feeding programs is as much of an art as it is a science. Factors that can influence feed presentation range from commodity selection to mixer selection and management. Other management factors that may influence feed intakes in various pens include stocking rate, general cow comfort, ration uniformity, feeding routine, and bunk management.

Commodity variation. Although forages tend to be tested on a regular basis, consultants typically use standard values for commodity nutrient loadings. The source of these values may come from NRC, other published values, or private databases. Nonetheless, significant variation can and does occur between loads of commodities. Table 1 lists average, range, and standard deviation (SD) of protein and phosphorus values for commodities sampled in Central Texas (unpublished data). It's interesting that dairy producers purchase alfalfa hay and other forages on quality indicators, and that's also the most tested ingredient on the farm. Contrast this to little quality information available on commodities prior to purchase and little, if any, testing after purchase.

Mixer selection and management. Factors that influence the ration delivered to the cow extend to include TMR mixer selection and management. Management of the mixing program includes loading accuracy, loading sequence, mixing time, and mixer maintenance.

There are several types of TMR mixers available for commercial dairying and selection of the "best" mixer is a constant question in the dairy industry. Mixers can be crudely categorized as vertical or horizontal. Within these categories, there is a range of types including the horizontal ribbon/paddle, vertical screw, or drum mixers. There is a debate in the field over the effects of mixer type on particle size reduction. Rippel et al. (1998) evaluated 10 vertical and 10 horizontal mixers for effect of mixing time (normal or 15 minutes over-mixing) on final TMR particle size distribution. These workers observed no differences in TMR particle size distribution between horizontal and vertical mixers (Table 2). This suggests that, concerning the decision between a horizontal or a vertical mixer, it is not necessarily the choice of one type or the other but, more importantly, the management of the chosen type that affects the final ration presentation.

Several ingredient properties can influence mixing: particle size, particle shape, density, hygroscopicity, static charge, and adhesiveness (Behnke, 1996).

From this list, particle size, shape, and density appear to have the greatest impact on mix uniformity. With respect to particle size, the addition of forage and the level of forage inclusion in dairy rations presents a unique challenge to targeting adequate mixing times. The differences in forage and concentrate particle size alone will present a challenge, along with differences in particle density. On a dry matter basis, corn silage and haylage are fairly equal in bulk density; however, on an as-fed basis, corn silage tends to have a greater bulk density than haylage (Kammel et al., 1995). In addition, density of mineral ingredients can be two to three times greater than that of grain and protein, making them difficult to uniformly mix. As a general rule, lighter and larger particles tend to move upward while the smaller, more dense particles gravitate downward. It has been traditionally advised to load larger particle size ingredients (forage) first and heavier, smaller particles (mineral) last. However, with the use of individual commodities and with rations containing many ingredients with a large variation in size, shape, and density, determination of loading sequence has become a method of trial and error. Considerations in determining loading sequence need to include bulk density, forage form (processed versus long hay), and amounts.

If mixing time is insufficient, final ration composition can be altered considerably. This will be even more important if the load is split between two or more groups. Most TMR mixer manufacturers recommend mixing for 3-5 minutes. With larger mixes and a variety of separate commodities, it is common for ingredient loading to take 30-45 minutes. The question then arises: Should the mixer be active while loading?

An often overlooked consideration is the maintenance schedule for the mixer. Worn or broken mixing components do not allow the mixer to function uniformly. Numerous producers in Central Texas recognize they cannot afford to ignore mixer maintenance because of its contribution to ration uniformity. One producer even worked out a schedule for replacing or sharpening knives on a rotating basis to avoid drastic changes in forage particle breakdown when all knives are sharpened or changed at one time. In addition to mixer maintenance, cleaning and routine checks for scale accuracy cannot be overlooked.

Feeding management. Field recommendations are for the cow to be fed each time she exits the parlor. The intent here is to have fresh feed waiting for the cow upon return to the pen to stimulate intake. Stone et al. (1999) reported the feeding routines of twelve high producing herds (averaging 29,800 lbs of milk). Seventy five percent of these herds milked 3x, while the remaining 25% milked 2x. Of these herds, two fed twice daily and three fed three times per day. Four of these herds fed once daily, with the exception of the summer months where they added a second feeding. Despite the number of feedings, most herds pushed feed up to the cows multiple times per day (2-7). While dairies explore the opportunity to limit the number of hours spent mixing feed to enhance labor efficiency and reduce mixing errors with larger loads, they must recognize the importance of compensatory bunk management to make this work. A good guideline is if an extra feeding increases intake two pounds of dry matter, it is justified.

University recommendations are to provide fresh feed 21 hours per day for optimum feed intake. To maintain ad libitum intakes, a target of five percent of the amount offered should be cleaned-out. Visual observation of the orts should be done periodically for comparison against original samples to identify potential ration sorting by the animal.

Pen management. Pen density can have an impact on feed intake, especially for heifers and timid cows. For this reason, many dairies separate their heifers from older cows for most or all of their first lactation. Additionally, pen density needs to consider pen profile; while dairymen may allow up to 140% stocking rates (cow:headlock ratio) of groups in later lactation. Most dairy producers recognize the importance of managing early lactation or close-up dry cow groups to provide at least one headlock per cow to encourage feeding activity.

Additional cow comfort factors to encourage intake may include cooling (soakers and/or fans), the use of rubber mats in the area where cows stand to eat, and proper management of well-bedded, comfortable freestalls.

MONITORING THE FEEDING PROGRAM

Animal feedback. Evaluation of ration quality may include animal measures such as level of milk production, milk composition (butterfat and protein content), rumen function, and general herd health. Many times, these factors may work against each other, i.e., in the case of milk production and rumen function in the fresh or high producing cow, where nutritionists continually struggle to reach an acceptable balance between the energy and fiber in the ration. Other animal measures may include observing cud chewing activity (a minimum of 40 percent of the cows should be ruminating) and evaluation of manure for consistency and undigested feed particles.

On-farm tracking. Commercial feeding programs exist that allow producers to monitor actual commodity use and on-farm shrink (Bethard and Stokes, 1999). While these can be used to minimize on-farm shrink and assist with feed purchasing decisions, they can also give the manager specific information for use in team meetings. Information such as loading excesses of various commodities can be beneficial in making feeders aware of care needed with loading certain feedstuffs. Ingredients with potential loading difficulties (>20% variation) include alfalfa hay from large bales, premixes, and bulk mineral: ingredients with minimal loading difficulty (<10% variation) include chopped hay, silages, pelleted feeds, corn, and whole cottonseed (unpublished data). Additional identification of individual feeders with inconsistent performance can also be used by managers for training purposes.

Furthermore, many of these programs allow daily tracking of pen intake. This allows the manager to develop steps toward reducing daily variation in feed intake and lower feed wastage. Steps may involve both bunk management (cleaning, adjusting rations) and pen management (accurate head counts, closer coordination of pen movements with feed delivery). Having employees understand fluctuations and problem pens will allow special emphasis and care to be taken with these pens without losing labor efficiency. Pens containing late lactation cows typically have steady feed intakes; whereas pens containing fresh cows or cows in peak production can be susceptible to more variable intakes.

Figure 2 illustrates an actual comparison of variation in daily intakes of three groups of cattle: fresh (average 12 days in milk), peak (average 86 days in milk), and late (average 293 days in milk) lactation cows. Fresh cow intakes averaged 36 pounds (dry matter); whereas intakes of peak lactation cows averaged 56 and 55 pounds of dry matter, respectively. Standard deviation was higher in the fresh and peak lactation cows (SD=4 for both), while the deviation in the late lactation cows was minimal (SD=1). Data from this dairy indicate that transition pens (last 15 days of the dry period and first 15 days into lactation) and high production pens present the greatest bunk management challenge to producers.

Measuring ration quality. While the basic assumption of all rations is that each bite taken by the animal matches that formulated by the nutritionist, most dairy producers understand the actual rations that exist on the farm: the one formulated on paper, the one loaded in the mixer, the one delivered to the cow, and the one consumed by the cow. Feeding management can override or mask the true potential of the ration. Considerations should include accurate dry matter values of feeds, ingredient loading procedures, and correct mixing time.

The function of the TMR mixer is to uniformly distribute ration ingredients into a final product that will serve the intended purpose. In dairy rations, the final "intended purpose" is a combination of several measures.

Ration uniformity is very critical in all species, but the dairy cow provides a unique challenge due to her requirement for daily milk production and the diversity of feedstuffs in her diet. The importance of ration uniformity is perhaps better accepted in meat animal production (feedlot cattle, swine, and poultry) than it is in dairy cattle production. On-farm tests to evaluate mix uniformity have been developed with high grain diets that are typical in meat animal production. However, tracers to evaluate mix uniformity in dairy rations are lacking. Due to the inclusion of forages, dairy rations present a different degree of difficulty in assessing uniform mixing.

Several methods have been investigated for evaluating ration uniformity, including assays for selected nutrients, markers, and ion tests. The traditional chemical assay included a quantitative measurement of a selected nutrient. The problem with this is finding a nutrient with a high variation between feedstuffs. Traditional rations formulated with alfalfa, corn, and soybean meal were perhaps more conducive to this method. Table 3 illustrates the consequence of not achieving a uniform mix, with nutrients such as protein and fiber varying as much as 20 percent. However, today's dairy rations commonly include a combination of several byproducts similar in nutrient profile. Using nutrient markers becomes more difficult, because little nutrient variation exists between feedstuffs. Table 4 illustrates this example. Does the fact that less nutrient variation may occur with diets containing multiple commodities make this less important in these diets? Yes and no. *Yes,* there is more of a buffer for nutrients such as protein and fiber. *No,* there is the same risk of not getting mineral intakes that are necessary for optimal health and reproduction. Cost and turn-around time of analyses are practical limitations for on-farm use of nutrient markers.

One marker that has been used is iron filings. This process includes adding a sufficient quantity of iron filings marked with a soluble dye to achieve a 16 to 25 count per 50-100 gram sample. The filings are removed via magnets onto paper, and water is sprayed on this paper to allow counting of colored spots. The limitations to this method may be practical use with rations that contain heavy, wet feeds.

Lastly, the Quantab® Indicator (Environmental Test Systems, Inc., Elkhart, Indiana) is a method for determining the chloride ion concentration of solutions. The procedure involves extracting salt by means of a hot water soak. Titrators, consisting of a thin strip laminated with a capillary column impregnated with silver dichromate, are used for a color reaction thus allowing calculation of chloride ion concentration. This method is relatively fast (10 to 15 minutes), requires minimal lab equipment (hot water, filter paper, measuring device, and paper cups), and is relatively inexpensive ($25 for 50 tests). However, this procedure is sensitive to acidity and may pose a problem with dairy rations containing fermented feeds. The potential for using wet chemistry for individual ion analysis as a marker may work. For example, NRC level of chlorine does vary across ingredients (alfalfa = .38%; corn = .14%; SBM = .08%; wheat midds = .04%). However, the same weaknesses (commodity variation, time, and expense) exists with using ions as with protein or fiber in diets containing a variety of commodities.

While the goal is to deliver uniform batches of feed, measuring feed uniformity on dairies is a challenge. Current recommendations for proper loading sequence and mixing time are from trial and error. Visual examination of feed delivered should evaluate particle length and diameter (processing effects) and ingredient distribution (uniformity). Ingredients such as whole cottonseed can suffice as a quick visual evaluation of mix uniformity. For a more detailed uniformity analysis, sampling along the feed route for particle size distribution and evaluating variation between sample points may provide further insight into mixing management.

Accurate sampling of large mixers presents a challenge. The diversity of feeds in dairy rations makes difficult the collection of a sample representative of the total mixed ration. Care must be taken when collecting traditional "grab samples" to insure they are representative, especially if decisions will be made based on analysis. Benhke (1996) described a more accurate sampling technique involving plastic sheets placed in the feed lane and then using a quartering technique to reduce samples to a workable size. With the diversity of ingredients in dairy rations, questions arise as to what size of a sample and how many are needed to accurately represent an entire TMR mixer wagon. Also, does the sample taken from the mixer wagon represent the ration actually consumed by the cow? If not, then how should the initial sample be adjusted for feed refusals? All of these are important and methods of periodic assessment need to be worked out. Rippel et al. (1998) evaluated the sample collection process from a TMR mixer. Their procedure was to place 6.5-liter sample collection pans in the feedlane, evenly spaced from the point where unloading began to the point where the mixer would empty. This group reported that the proportion retained on the large screen (>.75"), the middle screen (.75 - .31"), or in the bottom pan (<.31") and the respective variances were unaffected by reducing the sample number from 10 to 5. However, as the sample number was reduced from 10 to 3, the coefficient of variation (CV) was significantly different ($P<.05$). These authors recommended the appropriate sample number needed to accurately represent a TMR mixer needed to be at least 5.

Assuming proper marker choice and accurate sampling technique, interpreting results in a decision making manner is the next challenge. Research at Kansas State University reports the mean, SD, and CV as indicators of mixing tests. In short, these values identify the distribution of values and condense them into one measure of the mix. Again, work from KSU identifies a CV less than 10% to represent a good mix (Table 5).

SUMMARY

In evaluating ration performance, the obvious starting point is the ration on paper. But ultimately, cow performance is supported by the ration consumed by the animal. Identifying the ration consumed and potential differences from the ration formulated should be the first step in solving farm problems, although identifying reasons for these differences is not always an easy or precise task. With the diversity of feedstuffs and TMR mixers available in commercial dairying today, achieving consistent ration presentation is as much an art as science. Most producers and nutritionists would agree that there is a connection between ration quality, herd productivity, and profitability. The challenge is to define ration quality so producers can better manage their programs.

Standardized programs for monitoring ration quality, managing the feed bunk, and optimizing feed efficiency do not exist in the dairy industry at this time. Tools such as the particle size separator can estimate the physical appearance of the ration; however, markers for use in evaluating mix uniformity are not well-developed in the dairy industry. Through trial and error, individual producers are making great strides toward identifying critical points and developing protocols within their feeding programs to eliminate ration delivery inconsistencies.

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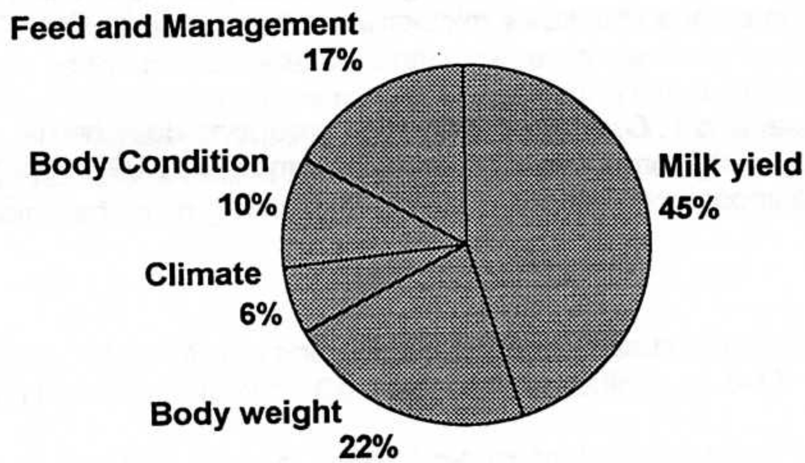

Figure 1. Factors affecting dry matter intake in lactating dairy cows and the amount of variability explained by each factor (Roseler et al., 1997b).

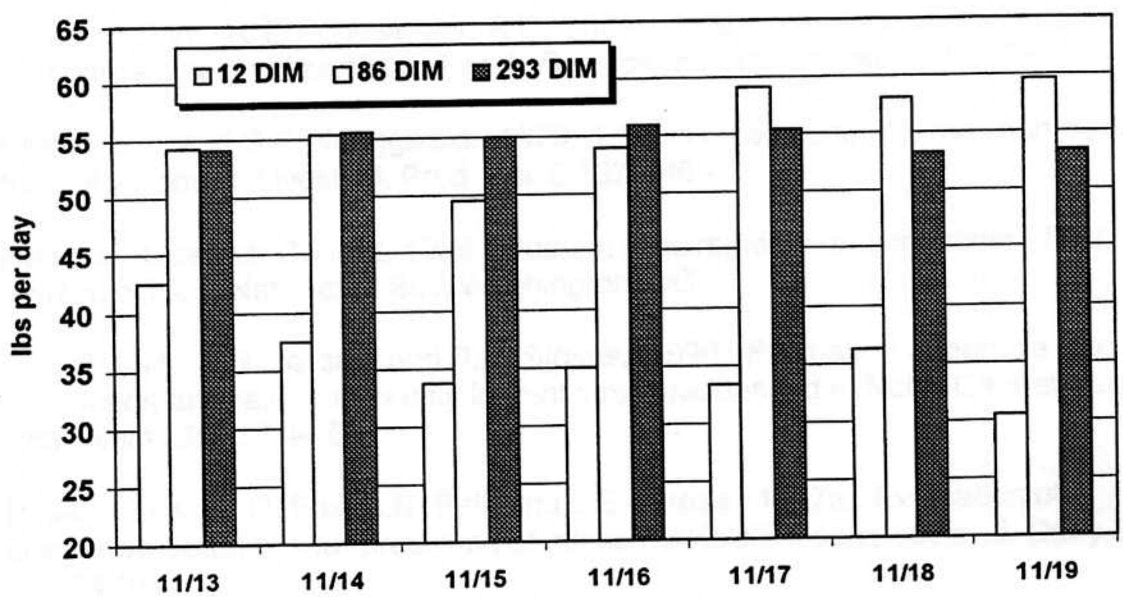

Figure 2. Daily dry matter intake variability by stage of lactation (12, 86, or 293 days in milk) in November, 1999.

Table 1. Commodity variation in Central Texas.

Ingredient	n	Crude protein, %			Phosphorus, %		
		Average	S.D.	Range	Average	S.D.	Range
Beet pulp	29	11.0	2.1	7.6 - 14.0	.10	.01	.06 - .13
Brewers grains, wet	47	29.2	5.3	23.2 - 46.0	.85	.15	.57 - 1.16
Corn, ground, dry	41	8.9	1.0	6.7 - 11.8	.33	.10	.17 - .69
Corn gluten feed	18	22.9	4.5	17.6 - 39.8	1.21	.16	.96 - 1.57
Cottonseed, whole	56	20.8	3.8	13.2 - 33.7	.61	.14	.32 - 1.02
Distillers grains, dry	15	33.1	1.74	27.9 - 35.1	1.02	.10	.90 - 1.22
Milo, roasted	23	10.8	.84	9.1 - 12.8	.33	.09	.19 - .46
Wheat midds	17	18.5	1.26	17.2 - 21.8	1.35	.33	1.08 - 2.55

Table 2. Effects of mixer type and mixing time on particle size distribution (% screen retention[1]; as-fed basis)

Mixer type	Mixing time	> .75"	.75-.31"	<.31
Horizontal	Normal	20.1	37.7	41.1
	+ 15 minutes	18.4	40.7	40.9
Vertical	Normal	20.1	36.0	43.9
	+ 15 minutes	18.9	33.8	47.3

Rippel et al., 1998.
[1] Particle size distribution as determined by the Penn State Particle Size Separator.

Table 3. Effect of mixing on the TMR analysis of an example traditional diet.

	Ration 1	Ration 2	Ration 3
Ingredient, lb per cow			
Alfalfa hay	24	30	20
Corn	20	20	20
Soybean meal	6	0	10
TMR Nutrient Analysis, %			
Crude protein	18.5	15.0	21.0
NDF	26.0	29.0	23.0

Table 4. Effect of mixing on TMR analysis on an example diet containing commodities.

	Ration 1	Ration 2
Ingredient, lb per cow		
Alfalfa hay	22	19
Corn	12	12
Soybean meal	3	3
Corn gluten feed	3	3
Whole cottonseed	5	8
Soyhulls	2	2
Hominy feed	3	3
TMR Nutrient Analysis, %		
Crude protein	18.3	18.6
NDF	35.0	35.0

Table 5. Coefficient of variation ranges and interpretations[a].

Coefficient of Variation Range	Interpretation
<10%	Satisfactory
10-25%	Needs improvement
>25%	Cause for concern

[a]Recommendations from Behnke (1996).