Forages and Feed Delivery

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SUMMARY

Feed efficiency can be used to economically evaluate the relationship of feed and forage to milk production. Low quality forages increase dry matter intake and feed costs. Providing function fiber is important to maintaining rumen health, optimizing milk components and avoiding feed sorting when evaluating forage form. Manure consistency can be related to forage changes and quality. Corn silage continues to be a consistent and economical source of animal nutrients with hybrid selection and surface spoiling key management considerations.

INTRODUCTION

Forages continue to have a major impact on ration formulation, feed costs, and animal health. With forage representing 33 percent of total feed costs and 15 percent of total cost of producing milk, researchers and extension specialists continue to look at ways to improve forage systems (Table 1). This paper will discuss feed efficiency, corn silage hybrids, surface spoilage, feed sorting, milk components, and manure evaluation as field opportunities related to forage systems.

EVALUATING FEED EFFICIENCY

Dairy efficiency (DE) or feed efficiency can be calculated by expressing the pounds of 3.5 percent milk produced per pound of dry matter consumed. Table 2 illustrates Wisconsin herd data summarized by various production groups. Factors affecting dairy efficiency include the following aspects and their relationship to DE:

- Days in milk (fewer days in milk raises DE)
- Lactation number (first cows have lower DE)
- Changes in body condition score (cows losing weight have higher DE)
- Growth requirements (growing cows have lower DE)
- Milk components (high components drop DE unless corrected)
- Forage quality (high quality raises DE)
- Environmental stress (heat or cold stress lowers DE)
- Rumen environment (rumen acidosis lowers DE)

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Dairy efficiency values under 1.3 pounds of 3.5 percent FCM for Holstein cows indicate poor feed conversion while values over 1.5 are optimal. Ten high producing herds in northern Illinois ranged from 1.4 to 1.5 DE (all cows combined in one group with one TMR). Three Jersey herds converted to 3.5 percent milk fat corrected milk had DE over 1.4 (also one group herds fed one TMR). To convert milk production to 3.5 percent fat correct milk (FCM), use the following formula.

3.5% FCM = (0.434 X pounds of milk) + (16.216 X pounds of milk fat)

For example, a herd of Jersey cows producing 60 pounds of milk containing 5 percent milk fat would have an adjusted 3.5% FCM of 74.7 pounds

3.5% FCM = (0.434 X 60) + (16.216 X 60 pounds of milk X 0.05 fat content)

High quality forages may result in DE over 1.7 (for example 80 pounds of milk and less than 47 pounds of dry matter). Before calculating DE, subtract weigh-backs or orts to correct for feed not consumed. Additional milk yield and dry matter intake relationships are listed below for on-farm comparisons.

- For each pound of additional dry matter intake (above current feed intake levels), milk production should increase by two pounds.
- Each day, 13 pounds of dry matter consumed by Holstein cows are needed to meet the cow's maintenance energy requirements (10 Mcal of net energy). Subtracting 13 pounds of dry matter from total dry matter intake determines energy available for milk production. Multiplying the remaining dry matter by 2 can estimate milk production potential. For example, a high group of Holstein cows consuming 53 pounds of dry matter can support 80 pounds of milk (53 lb of DM - 13 lb of DM for maintenance equals 40 pounds of DM times 2). Jersey dry matter requirements for maintenance are 2.5 pounds lower.

CORN SILAGE APPLICATIONS

Selection of corn silage hybrids is an important tool dairy managers have available. Seed corn companies have stacked traits and plant characteristics that will allow for optimal forage quality and quantity. Table 3 illustrates the range in quality and quantity using the Wisconsin Milk 2000 equation to predict milk per ton of corn silage (quality) and per acre of corn silage (quantity and quality). The equations and calculations allow comparison of corn hybrids and types, but should not be applied to specific farms because genetic, ration formulation, and environmental conditions are not considered. Values needed to calculate Milk 2000 for corn silage include dry matter percent, yield, crude protein content, 48 hour in vitro NDF (neutral detergent fiber) digestibility, NDF percent, and starch percentage. The following guidelines can be considered with corn silage programs:

- Harvesting time should be dictated by dry matter content (from 30 to 38 percent), depending on type of silage storage. Milk line is not a good indication of optimal ensiling conditions or time.
- All corn silage should be plant processed. Greater nutrient improvement can be expected with drier and harder kernel corn silage varieties, but proper adjustment of the equipment allows corn silage to process properly with some economic advantage at most stages of maturity.
- All corn silage should be inoculated to improve dry matter recovery and dry matter digestibility. Kansas workers report an 8.7:1 benefit to cost ratio when using a research proven inoculant.
- Raising cutting height by 14 inches reduced NDF content by seven units while reducing yield by five to eight percent. Type of cattle consuming the forage (heifers can utilize lower nutrient content forage), earlier harvesting (stalk is wetter), and nitrates reduction (higher levels are in the lower stalk area) are factors that can impact cutting height.
- Plant several hybrids to spread harvest window, reduce the risk of poor pollination, heat stress, plant emergence, and growing condition risks.

Discarding surface spoilage on stored corn silage is critical. Damaged silage has a foul odor, black color, and slimy consistency. This spoiled feed can occur under polyethylene sheets and uncovered piles and bunkers. The top three feet of corn silage was allowed to spoil in a bunker silo and fed to steers with rumen cannulas in a Kansas study. The normal corn silage in the ration (90 percent corn silage and 10 percent concentrate) was replaced with zero, 25, 50 and 75 percent spoiled silage (Table 4). The addition of surface spoiled silage had large negative effects on dry matter intake and nutrient digestibility. The initial 25 percent replacement with spoiled feed had the largest impact and destroyed the integrity of the forage mat in the rumen. Spoiled material must be discarded and not mixed with other wholesome corn silage.

FORAGE AND GRAIN PARTICLE SIZE

Measuring forage particle size using Penn State particle boxes continues to be a popular way to objectively evaluate if forage and TMR have optimal forage particle size. Place a 200 to 300 gram sample in the box and shake until all feed has been exposed to the holes in each box. Compare the weight in each box to the guidelines in Table 5. Field observations indicate that if the top screen in TMR is over 15 percent, cows may sort the ration. To calculate the amount of effective fiber, subtract the percent in the bottom box from 100. Next, calculate the amount of "long" NDF contributed by silage by multiplying the pounds of silage dry matter times the percent silage NDF times the percent silage in the top and middle box. Feed particles in the middle box may be more important than those in the top box. The Penn State box can also be used to evaluate weigh back or orts to determine if feed sorting has occurred. One guideline is that the percent of feed in each box in the weigh back should be plus/minus five percentage points of the original TMR.

The Penn State particle box has been updated by adding a fourth box. The new sieve has openings of 0.05 inch (similar to the number 16 grain screen) or 1100 microns. The feed that passes through this box moves out of the rumen quickly (similar to the liquid phase) or is rapidly fermented due to greater surface area. Guidelines for the top and second box have not changed. The new box can be ordered from NASCO (800-558-9595). If your current Penn State box is rectangular in shape (newer unit), you will need to purchase only a new individual box. If you have the older square box, you will need to purchase all four boxes (the new rectangular box does not fit).

Grain (corn and barley) processing can impact rumen and total track digestibility. Illinois workers use the following set of sieves to measure corn particle size to optimize digestion and complement forage sources.

- Top screen (number 4 or 4750 micron) captures whole and large particles
- Second screen (number 8 or 2360 microns) represents cracked corn
- Third screen (number 16 or 1180 micron) represents “cow” corn particles
- Fourth screen (number 30 or 600 micron) represents “pig” corn particles
- The pan which represents powder or feed grade starch

No dry corn should appear on the number 4 screen (passes undigested), less than 10 percent on the number 8 screen, 25 to 35 percent on the number 16 screen (slow released starch in the rumen and small intestine digestion), 50 to 60 percent on the number 30 screen (finely ground feed for rumen fermentation), and less than 15 percent in the pan (rapidly available starch for rumen microbes). If the ration contains higher levels of hay/haylage, lower amounts of corn, and by-product feeds, corn grain particle size could be reduced. Reducing corn particle size will increase the risk of rumen acidosis. Brass U.S. Standard sieves can be purchased from Fisher Scientific (800-766-7000) or Seedboro Equipment Company (312-738-3700). Prices vary from $200 to $260 per set of five. Another approach to measure ground corn is to use a flour sifter (similar to a number 14 or 16 screen) to estimate particle size. Finely processed corn will have one third remaining on the flour sifter (two thirds will pass through).

EFFECTIVE FIBER AND THE ROLE OF STRAW

Adding wheat straw to dry cow rations (three to nine pounds) and lactating dairy cow rations (one half to two pounds) increases dry matter intake and reduces metabolic disorders, especially displaced abomasum. Straw has unique particles (over one inch in length) that remain in the rumen for over 48 hours, long after feed processing. These particles float, contributing to the rumen raft and cud chewing. Straw also can stimulate total ration intake as it is clean (no mold) and is palatable to cows. As forage quality increases with precise chopping of silage and less long fiber length due to TMR units, long (1 to 2 inches in length) and indigestible NDF (lignified fiber) may be needed. Strategically adding one to three pounds of straw does not cause dry matter reductions and may stimulate rumen digestion of the organic matter. While continued emphasis on forage quality is warranted, meeting rumen function is also needed.

Based on field experience, a dairy manager or nutritionist can calculate the amount of physically effective NDF (pe IL NDF) in each feed ingredient using the Penn State box to measure forage particles, grain screen to evaluate grains, and estimated values for by-products. Each feed is measured for the percent NDF in the feed, assigned an effective IL NDF value for the feed, and the amount of dry matter fed in the TMR for that feed ingredient is estimated/weighed. Table 6 illustrates this concept. The advantages of this approach are listed below.

- All forage NDF is not equal depending on processing effects. For example, haylage could vary from 20 to 60 percent in the bottom box (using the three box Penn State unit).
- Each feed ingredient is evaluated for its effective NDF based on particle size.
- A target value can be used for pe IL NDF-Penn (18 to 20 percent of the ration dry matter).

Reviewing the example in Table 6, the level of “chemical” (lab analyzed) NDF is satisfactory (30 percent) while the level of pe IL NDF-Penn is low (12.6 percent) due to finely chopped haylage and unprocessed corn silage. Table 7 contains field guidelines for pe IL NDF values to use to calculate values.

IMPACT OF FORAGE ON FEED SORTING

The cow’s ability to sort feed is a concern on dairy farms as it results in variable nutrient intake and rumen function. In a Wisconsin field study, during the initial 12 hours, cows did not consume long particles, leading to low effective fiber consumption. This resulted in several different rations that were available and consumed by the cow during the 24 hour period. To minimize feed sorting, the following management guidelines may be helpful:

- Watch cow-eating patterns to see if cows “attack” fresh feed or nuzzle, push, and/or search for palatable feeds.
- Reduce forage length to 1 to 2 inches to avoid sorting and selection. Pre-processing of hay and straw may be needed prior to adding to the TMR mixer.
- Increase legume and grass forage quality to improve palatability (relative forage quality or RFQ > 150).
- Plant processing of corn silage will optimize corn plant, cob, and grain particle size.
- Add 7 to 15 pounds of water to “stick” feed ingredients together.
- Use 3 to 5 pounds of a liquid feed ingredient to reduce fines and enhance total ration palatability.
- Feed TMR more frequently to reduce the amount offered and subsequent sorting during each feeding period.
- Adjust weigh back to determine an optimal amount to minimize sorting.

MILK COMPONENTS AND FORAGE RELATIONSHIPS

Evaluating milk fat components can provide information about the forage program. Milk protein and fat test patterns should follow normal breed values listed in Table 8. If milk components are below breed average or the ratio of milk protein to milk fat is not optimal for the breed, the genetic levels are not being achieved.

The ratio of milk protein to milk fat can be used to determine if milk fat depression has occurred. Milk fat inversions can be defined as when individual cows have milk fat tests that are less than 0.2 point below the milk protein test. For example, a Holstein cow with a 3.0 percent milk protein test and 2.8 percent milk fat test or lower would be inverted using true protein test values. If over 10 percent of the cows in the herd have milk fat inversions greater than 0.2 points, look for causes of milk fat depression. Another guideline is that any cow one full point below the breed average for milk fat percent may have milk fat depression (for example a Holstein cow below 2.6 percent fat when the herd average is 3.6 percent milk fat). Forages can impact milk components in the following ways:

- If rations contain low quality forage, the milk fat test can be high as a result of high levels of rumen acetate being produced (milk yield is normally reduced).
- High corn silage based rations can increase milk protein content as rumen microbial protein synthesis is enhanced.
- The milk fat test can decline due to a shortage of effective fiber as the rumen pH drops leading to formation of trans unsaturated fatty acids and reduced microbial growth.
- Wet haylage can lower the milk protein test as excess degraded protein cannot be captured by rumen microbes leading to a shortage of amino acids.
- Corn silage-based rations can be limiting in lysine while alfalfa-based rations can be limiting in methionine. Amino acid imbalances and shortages can lead to lower milk protein synthesis and milk yield.
- Corn silage and dry hay rations can be low in soluble and degradable protein, limiting microbial growth and amino acid production.

FORAGES AND MANURE EVALUATION

Dairy managers watch manure changes as a guide when making feed changes. Fresh, undisturbed piles of feces or droppings may provide valuable clues on the nutritional status of the cow. Three aspects of manure evaluation can be considered.

Washing manure through a screen (6 to 8 squares per inch or 2200 micron) allows the dairy manager to quickly "see" if feed processing and digestion are optimal. Take a cup of fresh manure (about 400 grams) and wash it with a stream of warm water (cold water takes longer) through the screen, removing the digested material. It typically takes about 30 seconds if your screen has sides allowing for more water pressure. Look for the following remaining feed particles.

- Finding pieces of barley or corn grain with white starch remaining indicates that some feed value was lost.

- If the seed and starch pieces are hard, additional grinding or processing may be needed to expose the starch to rumen microbial fermentation or lower gut enzymatic digestion.
- Corn kernels from corn silage reflect that the seed was too hard for digestion and chewing by the cow (kernel processing can solve this situation). Mature and dry corn silage can lead to this observation. Corn silage varieties can be selected for softer starch allowing for more digestion.
- Whole cottonseeds that appear in the washed manure reflect a loss of feed nutrients. These cottonseeds are not caught in the rumen mat and thus are not rechewed during rumination.
- If roasted whole or split soybean seeds are observed, they must be processed finer. Wisconsin workers suggest breaking roasted soybeans into fourths or eighths.
- Forage particles over one half inch may reflect a lack of long forage particles to maintain the rumen mat and adequate cud chewing.

Michigan workers developed a scoring system to evaluate fresh manure. Consistency is dependent on water and fiber content of the manure, type of feed, and passage rate. A scale of 1 to 5 is listed below with a fecal score 3 as optimal.

- Score 1. This manure is very liquid with the consistency of pea soup. The manure may actually "arc" from the cow. Excess protein or starch, too much mineral, or lack of fiber can lead to this score. Excess urea in the hindgut can create an osmotic gradient, drawing water into the manure. Cows with diarrhea will be in this category.
- Score 2. This manure appears runny and does not form a distinct pile. It will measure less than one inch in height and splatters when it hits the ground or concrete. Cows on lush pasture will commonly have this manure score. Low fiber or a lack of functional fiber can also lead to this manure score.
- Score 3. This is the optimal score! The manure has a porridge-like appearance, will stack up 1 ½ to 2 inches, have several concentric rings, a small depression or dimple in the middle, make a plopping sound when it hits concrete floors, and it will stick to the toe of your shoe.
- Score 4. The manure is thicker and stacks up over 2 inches. Dry cows and older heifers may have this type of manure (this may reflect that low quality forages are fed and/or a shortage of protein). Adding more grain or protein can lower this manure score.
- Score 5. This manure appears as firm fecal balls. Feeding a straw-based diet or dehydration would contribute to this score. Cows with a digestive blockage may exhibit this score.

Manure scores 1 and 5 are not desirable and may reflect a health problem, in addition to ration limitations. Scores 2 and 4 may reflect a need to rebalance the ration. As cows progress through their lactation, manure score may also shift, as outlined below:

- Fresh cows (score 2 to 2 ½)
- Early lactation cows (2 ½ to 3)
- Late lactation cows (3 to 3 ½)
- Far off dry cows (3 to 4)
- Close up dry cows (2 ½ to 3 ½)

Increasing the amount of degradable, soluble, or total protein; decreasing the amount or physical form of the fiber; increasing starch level; decreasing grain particle size (such as fine grinding or steam flaking); and consuming excess minerals (especially potassium and sodium) can cause manure scores to decline.

The color of manure is influenced by feed, amount of bile, and passage rate. Manure from cows on pasture is dark green while that from cows on hay-based rations is brown. Manure from high grain-based diets is more gray-like. Slower rates of passage cause the color to darken and the manure to become more ball-shaped with a shine on the surface due to mucus coating. Score 1 may be more pale due to more water and less bile content. Hemorrhage in the small intestine causes black and tar-like manure, while bleeding in the rectum results in red to brown discoloration or streaks of red.

Analyzing manure has variable results. Illinois workers analyzed manure from cows in early lactation to track the impact of days in milk, dry matter intake, and milk production on the level of starch, fecal dry matter, and fecal pH. There were wide ranges in values (Table 9), and no relationships could be measured statistically. Manure samples (500 grams) were also screened and dried fecal residue weighed using 2200, 1120, and 500 micron screens. No differences in the amount of dry fecal residue remaining on each of the three screens were measured (total amount in a wet 500 gram sample reported).

CONCLUSIONS

Forage levels in dairy rations will increase in the future. Increased emphasis on meeting rumen (effective fiber) and cow (dry matter intake) requirements, economics (feed efficiency), selecting optimal forage types, and maintaining forage quality during storage will be focal points. Dairy managers and nutritionists will monitor cow, ration, and feed bunk benchmarks to optimize levels of forages in dairy rations.

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Table 1. Illinois feed costs by feed categories for 2003.

	DM/day (lb)	Cost/ lb DM ($)	Cost/day ($)
Forage	26	0.055	1.43
Grain	10	0.04	0.40
Fiber (cottonseed)	5	0.07	0.35
Protein		0.14	0.56
Mineral	1	0.35	0.35
Additives			0.10
Consulting			0.10
Total	46		3.29

Table 2. Dairy efficiency values for a Wisconsin dairy herd (Hutjens, 2001).

Group	Cow (no)	DIM (days)	Milk (lb)	DMI (lb)	Feed ($)	IOFC ($)	DE (lb/lb)
1st lact fresh	54	27	42	44	3.06	1.98	0.95
1st lact high	196	124	79	50	3.15	6.33	1.58
1st PG	100	225	64	53	2.67	5.01	1.21
2nd+ fresh	59	20	60	52	3.63	3.57	1.15
2nd + lact high	215	80	101	58	3.65	8.47	1.74
2nd +lact PG	220	276	67	51	2.85	5.19	1.31

Table 3. Impact of various corn hybrids from 1995 to 2000 based on U of WI silage trials using estimated milk per ton and per acre with Milk 2000 (Shaver, 2003).

		Milk 2000		Milk 2000	
Hybrid	No	(lb/ton DM)	($/tonDM)	(lb/acre)	($/acre)
Brown mid rib	12	3410	409	21,500	2481
High oil	12	3040	365	22,500	2701
Bt	130	3140	377	25,000	3000
Nutri-Dense	10	3240	389	24,300	2917
Leafy	70	3110	374	24,600	2952
Waxy	56	3090	371	22,600	2712
All hybrids	2407	3110	374	24,400	2929

Table 4. Effect of the level of spoiled silage on DM intake and nutrient digestibility (Whitlock et al, 2000).

	Ratio of normal to spoiled silage in forage portion of the ration			
Item	Normal	75:25	50:50	25:75
DM intake (lb/day)	17.5	16.2	15.3	14.7
OM digestibility (%)	75.6	70.6	69.0	67.8
CP digestibility (%)	74.6	70.5	68.0	62.8
NDF digestibility (%)	63.2	56.0	52.5	52.3

Table 5. Forage and TMR recommendations using the Penn State Box (adapted from Hutjens, 2001).

	Corn Silage	Haylage	TMR
	------------ % on each screen (wet basis)--------------		
Top box	5 to 15	> 40	10 to 15
2nd box	> 50	> 40	40 to 50
3rd box	< 30	< 20	< 30
4th box (pan)	< 5	< 5	< 15

Table 6. An example dairy ration with calculated chemical and effective NDF.

Feed	lb DM (lb)	NDF (%)	NDF (lb)	pe IL NDF (%)	pe IL NDF (lb)
Haylage	10	40	4.0	40	1.6
Corn silage	20	45	9.0	50	4.5
Grain mix	20	10	2.0	10	0.2
Totals	50		15.0		6.3

Percent total NDF:	15 lb NDF / 50 lb TMR = 30% (100% DM basis)
Forage NDF:	13 lb forage NDF (4 lb haylage + 9 lb corn silage) /15 lb total NDF = 87% of total NDF
pe IL NDF:	6.3 lb eNDF-Penn / 50 lb TMR = 12.6% (100% DM basis)
pe IL NDF of total NDF:	6.3 lb eNDF-Penn / 15 lb total NDF = 42% (total NDF)

Table 7. Estimated pe IL NDF values for various feeds adjusted for processing.

Baled hay	90 to 95%
Tub ground hay	40 to 65% (Penn Box)
Processed corn silage	50 to 75% (Penn Box)
Unprocessed corn silage	30 to 50% (Penn Box)
By-product feeds	
Ground	5% (such as soy hulls and distillers grain)
Pellets	5% (such as pelleted beet pulp or complete feed)
Coarse	25 to 40% (such as beet pulp, midds, and brewers grain)
Fuzzy cottonseed	75%
Ground grain	10 to 30% (top of flour sifter)

Table 8. Normal milk fat and milk protein relationship for various breeds of dairy cattle in 2002 (adapted from Hoards, 2003).

Breed	Milk fat (%)	True Protein (%)	Ratio (% protein / % fat)
Ayrshire	3.84	3.12	0.81
Brown Swiss	3.97	3.25	0.82
Guernsey	4.47	3.31	0.74
Holstein	3.66	2.98	0.81
Jersey	4.56	3.55	0.78

Table 9. Fecal measurements at various days in milk (DIM), milk yield, dry matter intake (DMI), and feed intake expressed as a percent of body weight (%BW). (Hutjens and Meier, 2003).

Animal cow #	DIM days	Milk lb	DMI lb	DMI % BW	Fecal DM %	Fecal DM[a] grams	Fecal pH[b]	Fecal Starch %
6484	29	76	50.7	3.1	18.1	46	6.4	17.1
6606	28	119	60.7	4.5	16.9	52	6.4	2.3
6696	62	89	na	na	15.8	48	6.6	17.3
6877	25	104	54.6	3.7	18.0	62	6.3	14.3
6881	48	113	57.7	4.1	16.1	60	6.0	21.3
6921	46	103	53.1	3.7	19.2	50	5.9	9.5
6921	53	98	54.1	3.8	16.2	84	6.0	9.7
6921	63	93	na	na	17.9	58	6.3	8.6
7009	35	116	54.4	4.1	11.6	46	6.2	22.4
7063	34	77	56.1	4.4	15.1	50	6.0	6.6
7084	19	99	59.0	4.9	18.1	54	6.2	13.2
7097	25	92	44.3	3.9	16.4	58	6.6	2.8
7144	54	81	47.6	3.4	17.4	56	5.9	11.7
7146	58	78	na	na	18.9	46	5.4	10.4
7158	24	80	47.3	3.9	14.8	54	6.5	10.8

[a]Total fecal DM on all three screens listed as fecal DM.
[b]Fecal pH as fresh and frozen.
na-values were not measured.