High Quality Forages – More Milk, Less Grain

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Summary

Feed costs are the single greatest cost of producing milk, and forages typically make up the greatest percentage of the diet. Cows produce more milk when fed more digestible forages than forages of the same NDF level but lower digestibility. Additionally, improvements in forage management will also assist you in bunker and feed bunk management. Producers need to carefully evaluate all aspects of their forage production program in an effort to increase the likelihood of the dairy having adequate quantities of highly digestible feedstuffs. A forage management meeting involving all personnel active in the forage production program can dramatically enhance a dairy's forage quality. The meeting should review all critical factors influencing forage quality, the dairy's performance in each of these areas, and a discussion of ways to increase quality in areas where improvement is needed.

Introduction

Forages make up a greater portion of the dairy ration than any other single ingredient. Unfortunately, their quality can also vary more than any other ration component. One of the essential components of achieving high production and still having healthy cows is to feed forages that are highly digestible, underwent an appropriate fermentation, and are stored and removed from the silo appropriately. This discussion will focus on ensiled as compared to dry forages.

Life as a dairy producer isn't easy – especially right now. Much of the stress that is felt is related to the financial status of the dairy. Feed costs are the single greatest cost of milk production. Since forage quality influences both total feed costs and level of production, it is a key component influencing the profitability of the dairy.

I think that the best way to improve overall forage quality is to have a farm-specific forage meeting. All individuals involved with the cropping program should be involved. In some situations it may be only the nutritionist, the agronomist, and the producer. At other times it may also involve multiple owners, the crops crew, seed company representatives, and custom operators. Many individuals that are part of the crops crew do not attend as many meetings as their herdsperson counterparts, especially a meeting that specifically addresses the results of all of their efforts and discusses methods for improvement. They will be very attentive, interactive, and helpful.

Forage Management Meetings

Forage management meetings should address all key areas that can influence forage quality, including the following areas:

- Goals – quality and inventory
- 1st cutting start date
- Windrow width
- Dry matter at harvest
- Fermentation basics
- Chop length
- Inoculants
- Packing
- Covering
- Cutting intervals
- Feed out

It is helpful to evaluate the previous one or two years of performance in each of these areas, considering with everyone the reason for the results, and ways they can be improved.

Seed selection is another important consideration. Yield, fiber digestibility, starch characteristics, and maturity time are all important considerations in corn silage variety selection. Although alfalfa varieties do vary in digestibility, generally maturity has a much greater influence on digestibility and that is where most of the emphasis should be placed. Grass species vary by heading date in the spring, and their relative abilities to grow on various soils and during the warmer, drier summer months.

Two excellent examples of the affect that forage quality can have on production are seen in Kawas et al. (1991) and Stone et al. (2008). Kawas et al., (1991) used sixteen Holstein cows in a 4 x 4 Latin Square design to determine the effect on production of alfalfa hay harvested at four different maturities (pre-bloom, 40.5% NDF; early-bloom, 42% NDF; mid-bloom, 52.5% NDF; and full-bloom, 59.5% NDF). Cows were fed diets where the varying qualities of alfalfa hay were the sole forage fed and composed 29, 46, 63, and 80% of the ration; the concentrate mixture was corn and soybean meal. The percentage of soybean meal was varied to provide isonitrogenous diets. Across forage levels, production averaged 82.1, 71.7, 63.5, and 63.1 lbs. for cows fed pre, early, mid, or full-bloom alfalfa hay, respectively. At the same level of dietary NDF, an advance in alfalfa maturity adversely affected yield of 4% FCM. With each day of alfalfa maturity beyond the harvest time for the prebloom alfalfa hay, NDF increased 0.86 percentage units per day, while production of 4% FCM decreased by 0.86 lbs. per day.

Stone et al. (2008) fed 66 Holstein cows either conventional (a mixture of varieties) corn silage (CS) or brown midrib corn silage (BMR) from 3 wks prefreshening to 3.5 wks postfreshening. All cows were fed a separate ration containing only conventional CS as the CS source from wk 4 to 15. Milk weights (3X/d) and DMI were recorded daily and milk composition was measured weekly. Diets were formulated to keep all parameters the same with the exception of NDF digestibility. The NDF-d (30 h) for BMR and conventional silages averaged 73.8 and 56.8, respectively. Cows fed BMR had higher DMI during the 2 wk period before calving (31.5 vs. 29.1 lbs./d, $P < 0.03$) and 3 wk period postcalving (44.6 vs. 40.1 lbs./d, $P < 0.001$). Yields of fat-corrected milk (106.1 vs. 99.5 lbs./d, $P = 0.067$) and solids (12.5 vs. 11.7 lbs/d, $P < 0.02$) were increased for the first 15 wk of lactation for cows fed rations containing BMR. Feeding BMR CS during the transition period resulted in increased peripartal DMI and increased milk and milk solids yield during the first 15 wk of lactation.

Forage quality goals are important. Individuals involved with the cropping system need to know what they are striving to achieve, and the best way to accomplish it. Since nearly all producers have the same production goals (more!), the quality goals are often very similar across dairies (Table 1).

Table 1. Characteristics of quality silage

		Type of Silage		
		Alfalfa	Grass	Corn
Neutral Detergent Fiber, %		38 - 42	48 - 55	38 - 42
Dry matter, %	Bunker	34 - ~ 41	32 - 38	33 - ~ 36
	Upright (stave)	34 - 41	34 - 41	33 - 38
	Bag	34 - 41	32 - 40	33 - 36
Odor	Little or none at a distance; slightly sharp, pleasant up close			
Lactic acid	Wet (< 35% DM) 6-8%, Wilted (>40% DM) 3-4%			
Acetic acid	< 1-2%; ratio of at least 2.5:1 lactic:acetic (when using *L. buchneri* as an inoculant the ratio will be lower)			
Butyric acid	< .1%			
Total VFA	< 10%			
Particle length		~ 8-15% of TMR on coarse screen; > 55% on top two		
Iron		< 200 ppm (varies by region, ash could also be used)		

Most of the forage goals are self-explanatory. Due to lower lignin levels, grasses have similar milk-production capabilities at a higher NDF level than alfalfa. Ratios of lactate:acetate will be reduced when *L. buchneri* is used as an inoculant. Iron can be used as a proxy for soil contamination. Soil typically harbors bacteria that are more likely to produce an undesirable fermentation. Iron levels of less than 200 ppm indicate very little soil contamination, although this baseline can vary with the iron levels for a given geographical region.

First Cutting Start Date

Since first cutting typically accounts for approximately half of total haylage yields, and second cutting is usually relatively lower in fiber digestibility (Van Soest, 1994), it is very important that first cutting is harvested at the appropriate stage of maturity. Three methods have been evaluated for use in predicting the best time to start with the first cutting alfalfa harvest. These methods are growing degree days, PEAQ (predictive equations of alfalfa quality), and actual wet chemistry NDF measurements (Cherney and Sulk, 1997). In summary, alfalfa will be at approximately 40% NDF after 700 GDD (41º F base for five days), and when it is 29 – 32" tall. The GDD method works reasonably well for predicting first cutting alfalfa NDF levels in the midwest and northeast. The PEAQ system works reasonably well for any cutting. The GDD method is most useful when used in conjunction with both the PEAQ and "scissors cut" methods.

My preference is to have a pretty good idea of crop maturity based on GDD, and then go to several fields to measure alfalfa height for the PEAQ system and to clip representative samples at cutter bar height for wet chemistry NDF measurement. The predictions from the GDD approach can be improved by determining the NDF level from representative samples in early May, and then using the average slope of GDD per unit change in NDF for a given region across several years (Cherney and Sulk, 1997). Grasses should be harvested for lactating cows while still in the boot (Cherney and Cherney, 1993). The PEAQ approach can also be used on alfalfa to predict when fields of varying percentages of grasses should be harvested (http://alfalfa.50webs.com/quality.html; Parsons et al., 2006).

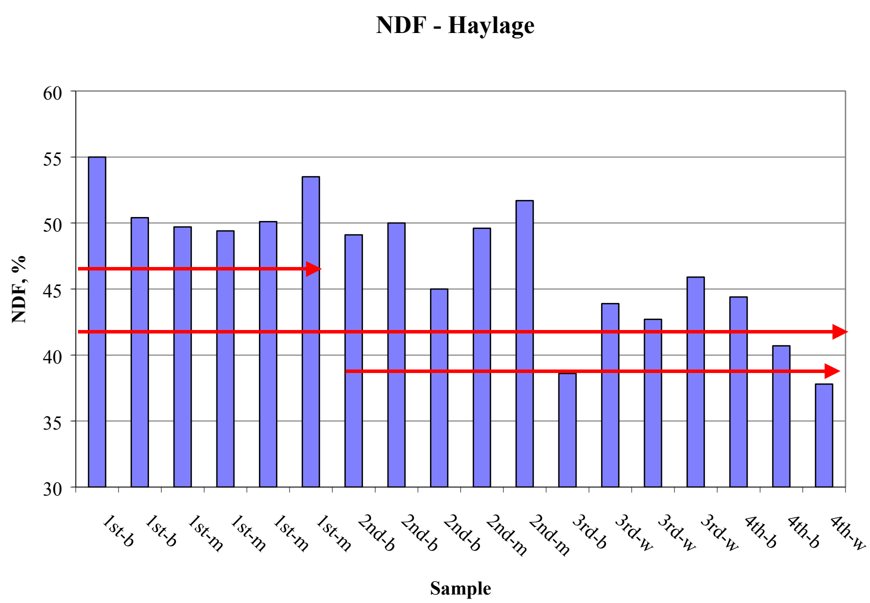


Figure 2. Haylage maturity levels from each cutting from a NY dairy. NDF goals are slightly higher for first cutting because of additional grasses present. Most samples are higher in fiber than optimal for lactating cows. This dairy had two main problems: too large of a harvest window required for first cutting, and too long of a harvest interval between cuttings.

The Silage Fermentation Process

It is important that people involved with the cropping system have a good understanding of what goes on inside the silo. This knowledge leads to an understanding of why they are asked to perform various management tasks.

Figure 4 depicts the various phases of the ensiling process.

Aerobic phase: Microorganisms and possibly plant respiration use oxygen entrapped in silage.

Events:

Depletion of crop sugars continues, pH decreases little. Yeast and mold populations increase. Plant enzymes convert true protein into soluble protein and ammonia. Microbes produce relatively more of the weaker acetic acid.

Goal: Complete the aerobic phase as quickly as possible.

1. Pack continuously and tightly.

2. Harvest at the appropriate DM. Oxygen is more difficult to remove from drier silage.
3. Monitor particle length. Longer particles are good for rumen health, but not if the longer chop jeopardizes packing and the fermentation.
4. Prevent air re-introduction into forage. Don't disrupt packed surfaces.
5. Minimize the length of time surface is exposed to air. Use progressive wedge filling technique, cover top surface when shut-downs occur.

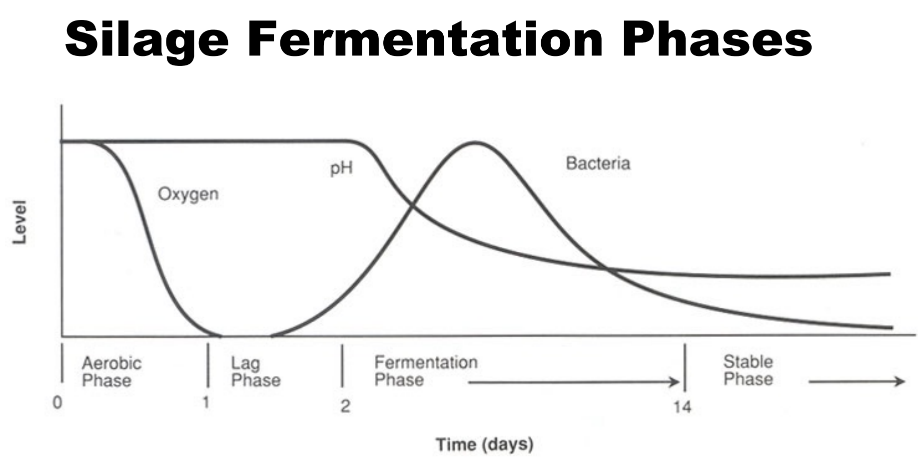
Lag Phase: The rupturing of plant membranes releases nutrients for lactobacillus growth.

Fermentation Phase: The growth rate of lactic acid producing bacteria (LAB) accelerates as pH nears 5.

Events: Sugars are converted into acids that preserve silage.

Goals: Optimize fermentation through:
1. Rapid dry-down to conserve crop sugar levels.
2. Harvest at the appropriate DM to balance silage compaction with the sugar levels necessary at that DM level.
3. Consider including some grasses in legume fields.
4. A research proven inoculant increases the likelihood of a favorable fermentation.
5. Cover quickly to minimize oxygen infiltration.

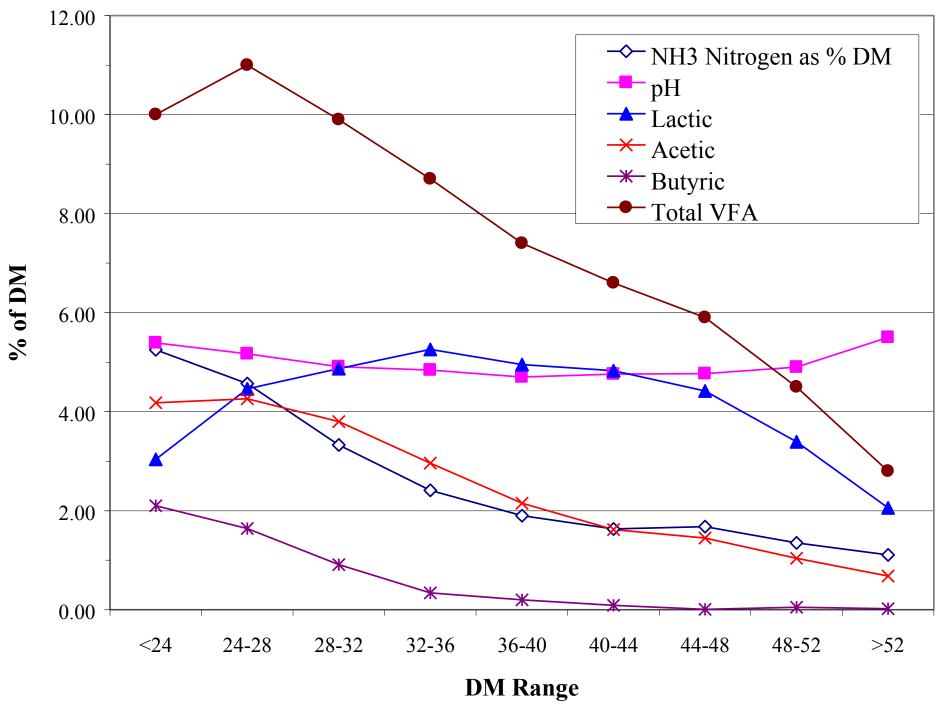
Figure 4. The silage fermentation process.



Pitt, 1990. NRAES, Silage and Hay Preservation

The legume fermentation summary in Figure 5 is very useful in describing how the fermentation varies with changes in crop DM. Notice the rise in butyric acid and drop in lactic acid as DM levels drop below 34%. Clostridial fermentations are likely to occur when alfalfa is harvested at < ~32% DM, and slightly less than this in grasses. Clostridia bacteria ferment lactic acid, causing an increase in silage pH. They also break down amino acids, resulting in the production of noxious amines. Clostridial fermentations vary, primarily because there are at least 60 Clostridia species that can be found in silage. Different species of Clostridia utilize different substrates, and produce different end-products (Stone and Chase, 2004)

Figure 5. The effect of DM on legume silage fermentations



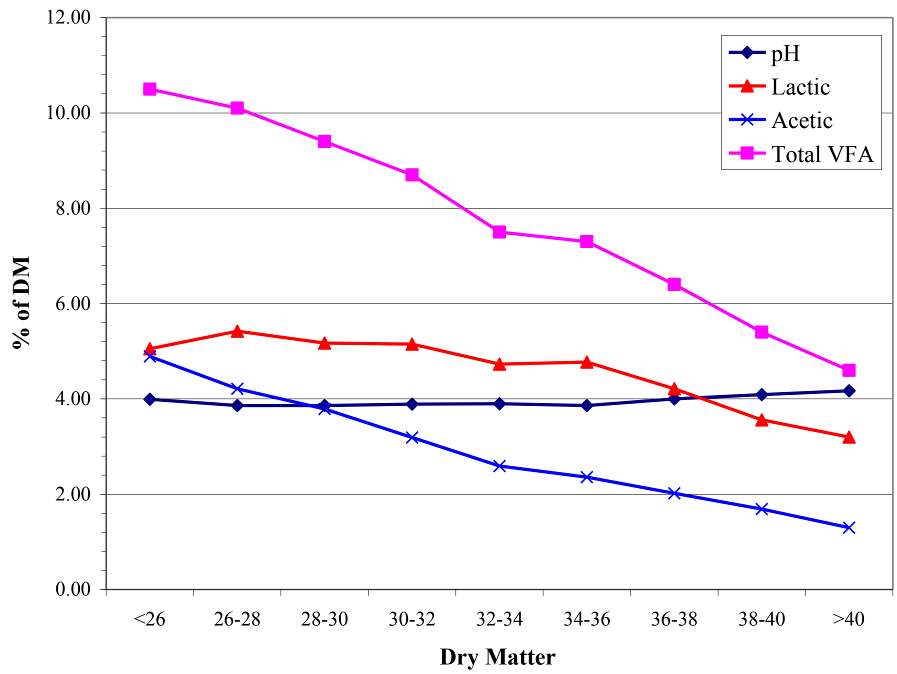
Data courtesy of Cumberland Valley Analytical Services, Hagerstown, MD.

Clostridial fermentations vary, probably due to the wide array of Clostridia organisms that may overwhelm the desired fermentation process. This, of course, may result in varying affects on animal performance (ketosis or indigestion) when the silage is fed.

Lingass and Tveit (1992) ruminally infused cows with butyrate. Blood acetoacetate levels significantly increased in both early and late lactation cows. Acetoacetate levels rose higher, and remained elevated for a longer period of time, in early lactation as compared to later lactation cows. It would require the consumption of 2.85 kg DM of 7% butyric acid haylage (a level commonly found in severe Clostridial fermentations; Stone and Chase, 2004) to equal the quantity of infused butyrate.

Lingass and Tveit (1992) also ruminally intubated cows with putrescine (100 g in 1 dose) for three consecutive days. The putrescine infusate resulted in significant decreases in feed intake and milk yield, with marked individual variation in response. For example, one of the cows consumed very little feed on the last experimental day, although she recovered completely after the experimental period. The quantity of putrescine infused was much greater than cows would normally consume, even if the feeds had undergone a clostridial fermentation. For example, it would take approximately 100 kg DM of haylage that had undergone a severe Clostridial fermentations (Stone and Chase, 2004) to provide 100 g of putrescine, or approximately 20 kg DM of this type of silage to provide 100 g of all of the measured amines. Lingass and Tveit (1992) recognized this, noting that the effect of the amines when fed in combination and for a longer time period, as when feeding silage, may well be different than when infusing only one amine for a relatively short time period.

Figure 5b. The Effect of DM on Corn Silage Fermentations



Data courtesy of Cumberland Valley Analytical Services, Hagerstown, MD.

The pH of corn silage is very constant across the range of dry matter because corn silage essentially always has enough carbohydrate to complete the fermentation. Acetate increases as DM decreases because the wetter feed is more conducive to the growth of heterofermentative bacteria (Figure 5b).

Windrow width and type of haybine

We've made great strides in New York in improving forage quality by simply spreading the windrows out as wide as possible. Wide swathed haylage dries much faster than narrow swaths, reducing the risk of rain damage and resulting in a crop that is a consistent and appropriate DM rather than a correct average made up of forage that was too wet (bottom of the windrow) and too dry (top of the windrow). Some producers are spreading their haylage out to 100% of cutterbar width – and chopping the same day or within about 24 hours. Spread yours as wide as your equipment will allow, and then think about how you could spread it out even wider. Windrows should be made as wide as possible to enhance dry down and minimize plant respiration and proteolysis. Higher sugar levels at ensiling will help to ensure a great fermentation (Kilcer, 2006). Some dairies have purchased smaller haybines so that there is less material in a windrow and drying is enhanced.

Figure 6. Haylage dries faster the wider it is spread out. Conditioned haylage was put into windrows that varied from 40 to 83% of cutterbar width, or were cut by a sickle bar mower at 94% of cutterbar width.

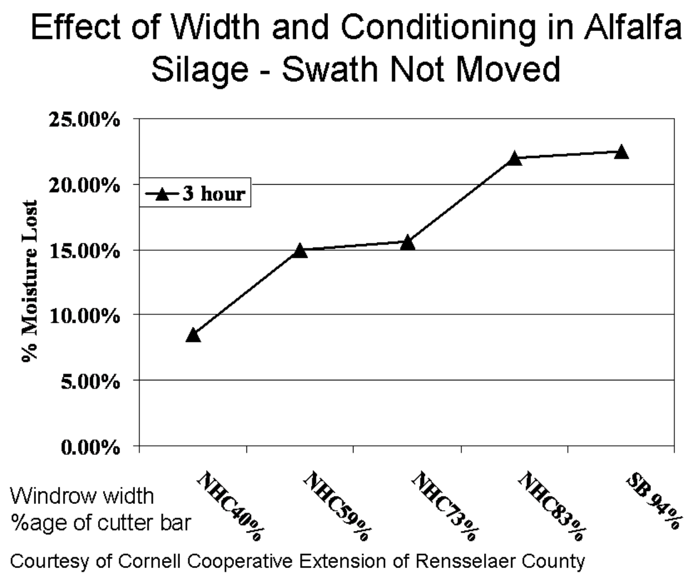


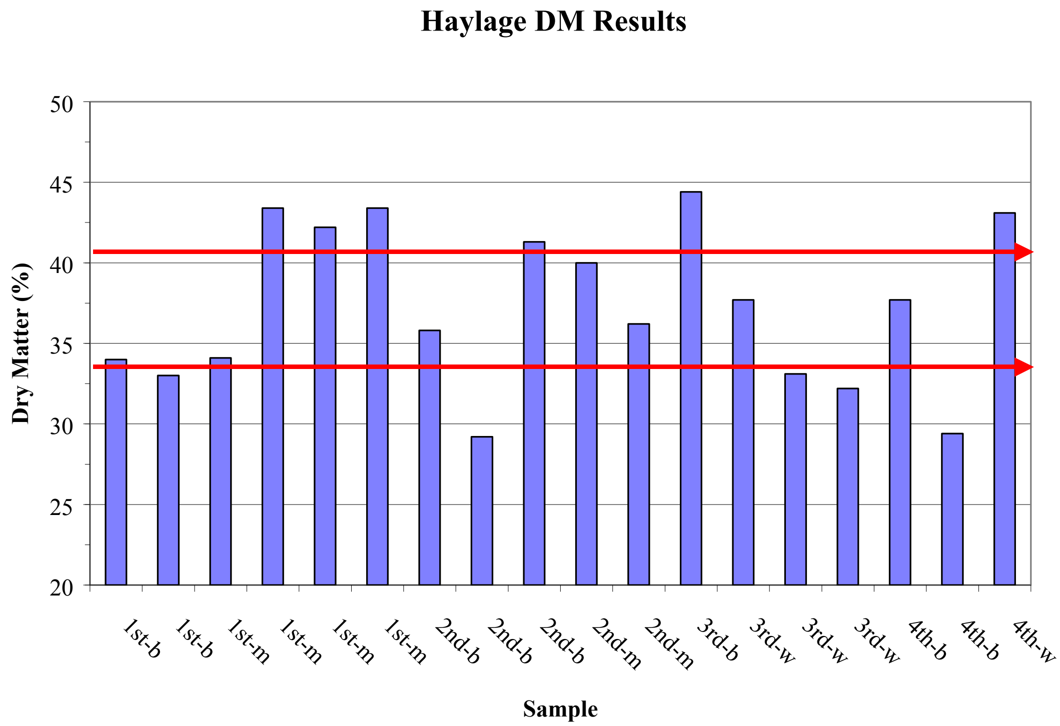
Figure 7. This dairy removed their conditioning rollers from their sickle bar haybines, and then had to cut away some metal so that the haybine would not plug. Haylage is now spread out 100%. Conditioning doesn't appear to influence drying rate nearly as much as windrow width. We are doing some additional comparisons of dry down rates in conditioned versus non-conditioned haylage in wide-swathed windrows.

Disc bines are faster and don't succumb to broken parts as easily as sicklebar mowers. However, they can significantly increase ash levels in very loose soils.

Dry Matter at Harvest

Dry matters for various cuttings of haylage (Figure 8) are graphed at our farm meeting to show the crew how they have done and to help think through possible management changes necessary to achieve the DM goals. The DM goals for forage stored in bunker silos are approximately 34 – 40% for haylage, and 33 – 36% for corn silage. Haylage harvested wetter than 34% DM is more prone to a Clostridial fermentation, while haylage harvested at DM much above the low 40's are more prone to heating, particularly at feedout. Corn less than 33% DM usually has not adequately matured – give it some more time and allow for additional ear fill. Effluent seepage becomes an issue as DM drops below approximately 32%. Additionally, these wetter corn silages almost always have a sour, acetic acid smell, and cows usually do not perform as well on them. Corn harvested at DM in the upper 30's can result in more of a packing challenge. Additionally, kernel processing becomes imperative. Ruminal starch digestibility increases with the length of time that the crop has been ensiled, but the rate of increase is slower with drier corn.

Figure 8. Haylage DM from a dairy.



Particle length

Although recommendations certainly vary, my preference is that the TMR contain about 7-15% of particles on the top screen of the Penn State Particle separator, and over 55% on the top two screens. If hay is not fed, then a 50% forage ration will need forages with 16-30% on the top screen to achieve this TMR goal. A variety of factors influence chop length, including DM, species, tonnage, knife sharpness, and shear bar setting. Additional blowing, packing, and/or unloading equipment needed for upright silos and bags can easily reduce particle size, and needs to be considered in chopper setting.

Review historical forage and TMR particle length, cow health, production, components, TMR sorting, and fermentation quality when deciding on a chop length. Too long can compromise fermentation quality, probably both from increased silage oxygen levels and an extended lag time due to slower sugar availability. Chop longer if necessary and management has been successful with it; chop shorter if fermentation challenges have existed and management can't correct it. However, additional sources of effective fiber will probably be needed.

Inoculants

Muck (2008) conducted a recent review on the use of inoculants. He suggests a goal-orientated approach when choosing an inoculant, with the potential goals being a) the avoidance of a clostridial fermentation, b) improved aerobic stability, and c) making a good silage even better. The main management approach in avoiding a clostridial fermentation is to harvest when the crop is at least 34% DM. A homofermentative inoculant can also help by slightly reducing the final pH. Aerobic stability is usually less of a problem with alfalfa silage than corn silage. When alfalfa is harvested at DM less than 40%, Muck recommends the use of a homofermentative inoculant to hopefully improve stability, DM recovery, and performance, while in alfalfa harvested above 40% DM may benefit more from a combination inoculant which includes *Lactobacillus buchneri*. *L. buchneri*, a "back-end" inoculant, grows later in the fermentation, converting some of the lactate to acetate and propionate; both of these acids are much more potent mold and yeast inhibitors than lactate. Use an inoculant containing *L. buchneri* if your goal is to extend bunk life. Alternatively, mixtures of propionic and acetic acid applied during ensiling will also extend bunk life, and may assist with the overall fermentation.

The use of *L. buchneri* would be the first choice to improve stability in corn silage. A homofermentative inoculant would provide the greatest likelihood of making a good silage even better. Finally, Muck (2008) states that in the northern US the routine use of an inoculant is profitable even though it will not be beneficial every time it is used.

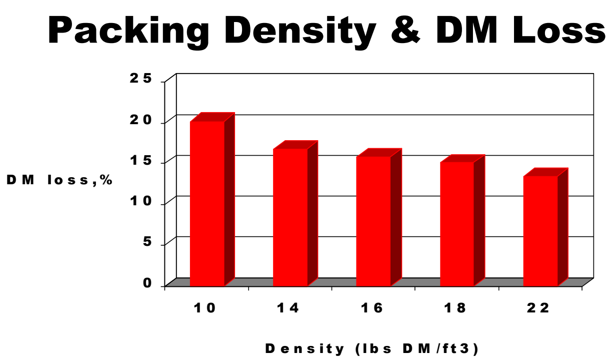
The inoculant should be applied in liquid form if the crop DM is > 40%, and either liquid or granular for DM < 40%. It is best to apply at the chopper, bagger, or blower to ensure proper distribution. It should come from a reputable company that has unbiased research demonstrating the efficacy of the product. The producer must do his part as well, since proper handling is essential in keeping the microbes alive and not contaminating the inoculant reservoir. Lastly, inoculants don't guarantee fermentation success, but they do shift the odds in our favor.

Packing

Bunker silos should be packed constantly while filling. Care should be taken by the operator of the tractor with the blade to ensure that the layer being packed is as thin as possible (maximum of 6" thick), and that the blade does not disrupt layers already packed. The progressive wedge filling technique should be employed. Do not have the slope too steep, or tires will dig into and disrupt packed silage throughout filling. Operations with large choppers or those utilizing custom operators must have multiple tractors packing. Often there is not adequate room to do this with the traditional progressive wedge. In this situation try flattening the slope of the wedge, making more of a platform. This makes for more room for multiple tractors to be packing at the same time. The bunker density calculator at the University of Wisconsin website is very useful to review possible packing scenarios with producers.
http://www.uwex.edu/ces/crops/uwforage/dec_soft.htm

Dry matter recovery (Figure 9) and silage density (Figure 10) and hence silo inventory vary tremendously. Packing vehicle weight, time per ton, layer thickness, dry matter and particle length are the variables most influencing silage density. Higher silage densities improve dry matter recovery; you should have about a percentage point of additional silage available to you for every pound that silage density is increased. For example, increasing silage density from 14 to 18 lbs. DM per cubic foot will give you 4% more silage to feed. Some farms are achieving densities of 20 pounds throughout the silo. Higher densities will also reduce oxygen infiltration, which will help to improve bunk life.

Figure 9.



Ruppel, 1992

Figure 10.

Bunker Silo Densities

- Hay crop silage (87 silos)
- Average = 14.8 lbs/cu ft (6.6 - 27.1)
- Corn silage (81 silos)
- Average = 14.5 lbs/cu ft (7.8 - 23.6)

Holmes, 1999

Covering

Cover bunkers immediately upon completion of filling. Should you cover the silo during filling if a rain delay is expected? Well, how much is it going to rain and how long will the delay be? Put a quick cover over the bunker when rain is coming, because you don't know if the shutdown is for a few hours or an entire week. You can't have top production and an 8" layer of slime in the silo. Final covering should involve tires placed in contact with each other to minimize air infiltration, and to keep the cover in place. Oxygen limiting plastic (Silo-Stop, for example) (Muck, 2008) is a relatively new cover material that is 1/20th as permeable to oxygen as polyethylene. Muck (2008) compared 8 mil white plastic weighted down with tires to the Silo-Stop product placed along the walls and over the silage. A tarp was placed over the plastic to provide UV and additional protection; the tarp was weighted down with tube bags of sand. There were large improvements in DM recovery along the wall in the Silo-Stop silos (1% DM loss as compared to 19% with white plastic), but very similar losses between products at 6" depths across the main surface. However, silage fermentation was consistently and slightly better when stored under the Silostop product. My preference is to use the "two-step" (oxygen limiting membrane covered with plastic) as opposed to the "one-step" products because I have seen better results with the two-step process. If using traditional polyethylene, thickness likely important. Muck has found approximately a five percentage point reduction in surface spoilage in 8 mil as compared to 6 mil plastic. If you can't find 8 mil plastic, then consider using two sheets of 6 mil. Lining the bunker walls with plastic, and extending this plastic onto the silage yet beneath the top cover will also markedly reduce spoilage.

Feedout

Face management and silage removal rate is critical in minimizing the growth of yeast and molds. Silo faces should be kept as straight as possible; silage defacers can certainly help to accomplish this goal. Scraping across the width of the bunk works well with corn silage. Time and care are necessary for straight faces with haylage bunkers. The amount of silage that must be removed to keep ahead of any spoilage varies terrifically, probably from 1" to 1.5'. The reasons for this large discrepancy in removal rates are variation in bunker densities (more dense silage allows less oxygen infiltration), fermentation profiles (acetate, propionate, and butyrate are more effective yeast and mold inhibitors than lactate), and silage mold and yeast counts. Inoculation with *Lactobacillus buchneri* extends bunk life by increasing the levels of acetic acid (Ranjit and Kung, 2000). Buffered propionic acid applied at ensiling accomplishes the same purpose, although to a much lesser extent (Ranjit and Kung, 2000). These products should be used if the bunk is oversized or spoilage has been a problem in the past.

Spoiled silage can adversely affect intake and digestibility. Make it a goal to keep rotten feed away from all animals, but especially prefresh, fresh, and high cows. At the start of the day, any loose feed from the previous day should be scraped into a separate pile, and either fed to bred heifers or dry cows, or disposed of if truly spoiled.

Cutting intervals

Lastly, don't let up the intensity throughout the harvest season. Grass and alfalfa should have harvest intervals of approximately 31-34 days to optimize forage digestibility, fiber levels, and yield. The intervals can vary somewhat more than this in extreme conditions (ideal growing conditions or drought, for example).

Summary

Top-notch forages are an essential component in achieving high production and in having healthy cows. The silage process is complex, with many steps necessarily being done correctly to increase the odds of having super feed. Forage managers have some control over most variables, with the notable exception of the weather. Strive to have a forage management meeting with all individuals involved with a farms cropping enterprise. The results will be very positive.

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