Silage Management 101 – The Basics

Limin Kung, Jr., Ph.D.
Department of Animal & Food Sciences
University of Delaware
531 South College Avenue
Newark, Delaware 19716-2150

Introduction

Harvest and storage management can have marked effects on silage quality. The objective of this paper will be to briefly discuss some recommended management practices to make high quality silages.

Evaluating Forage Quality

Much emphasis has been placed on selection of corn hybrids for dairy cattle. A good tool that can help in on farm evaluation is the MILK2006 spreadsheet from the University of Wisconsin at http://www.uwex.edu/ces/crops/uwforage/dec_soft.htm. The MILK2006 program calculates milk/ton and milk/acre for silage hybrids. This latest version allows for input data related to kernel processing score, degree of starch access and in vitro/in situ starch digestibility. This version also allows one to enter data using 24, 30 or 48 h in vitro NDF-digestibility estimates. Depending on your specific situation, most would try to choose hybrids that give high milk/ton and milk/acre. CornPicker is another program for evaluating corn silage hybrids and is available from Michigan State University (http://www.msu.edu/~mdr/cornpicker.html). This program calculates partial budgets and compares net farm income between two corn silage hybrids. The program is more complicated than MILK2006 but unlike that program, CornPicker provides a monetary bottom line between hybrids. Some of the inputs that users can manipulate include the cost of SBM and corn, cost of the seed, planting densities, amount of the hybrid fed to various groups of cows and NDF-digestibility.

For alfalfa, relative feed value (RFV) has now been replaced with relative feed quality (RFQ) estimates (Undersander and Moore, 2002). The later incorporates NDF digestibility into its calculation and better predicts its nutritive value. Values for RFV and RFQ tend to be similar for first cuttings but after that RFQ tends to be the more accurate predictor of feed value.

Forage Maturity and DM

Harvesting forages at optimum maturity is important because it sets the stage for the rest of the year. High forage quality drives intake and in turn, this drives milk production. Not even the best nutritionists in the world can make cows maximize their milk production if they are working with poor quality forages. Corn silage should be harvested when the whole plant is at about 35 ± 2% DM. To monitor whole plant DM, cut representative samples of corn plants from the field and chop them. Collect the chopped material and dry it down with a microwave or Koster moisture tester. Depending on the conditions, corn plants will dry down at a rate of about 0.5 percentage units per day (faster in dry and hot weather). Based on your acres and equipment you may have to start at a lower DM and you may end at a higher DM but the key is to avoid the extremes. Harvesting corn silage that is too wet (typically < 28-30% DM) results in excessive fermentation that often produces high concentrations of total silage acids and may result in excessive seepage losses. Specifically, these wet silages are often characterized by high concentrations of acetic acid produced from "wild" fermentations. A common problem when feeding large quantities of wet corn silages is a reduction in DM intake because of the high acid content. In contrast, extremely dry corn silage (> 40% DM) should be avoided because the low moisture restricts fermentation and this material is more difficult to pack which often leads to poor aerobic stability. In addition, dry corn silage is usually very mature and thus the digestibility of starch digestibility may be low.

Wide Swathing

One of the biggest challenges for making good alfalfa or grass silage is managing the period of wilting to result in maximum conservation of fermentable sugars and obtaining an adequate dry matter level to prevent the growth of clostridia. During prolonged wilts, sugars are metabolized by the plant in the windrow; thus a quick dry down is beneficial. Wet grass and alfalfa silages are highly prone to undergo clostridial fermentations when the dry matter is less than 30-35%. Wilting these crops above this level makes it harder for clostridia to dominate the ensiling process.

There is still considerable interest in drying alfalfa in wide swaths to minimize the time that plants lay in the field and might be subjected to rain and to reduce the loss sugars that can occur during excessive periods of respiration (Kilcer, 2008, Cornell University). In a study on three consecutive cuttings from the same field, we showed an average savings of about 20-24 hr of wilting time to reach 45% DM when comparing alfalfa wilted in 9 ft rows versus 4 ft windrows (Kung et al., 2007). At all cuttings, silage could have been made starting at 35% DM on the same day of mowing in wide swathed alfalfa. Wide swathed alfalfa also had higher sugar content than narrow swathed alfalfa at chopping in our study. Similar findings have been reported by Undersander et al. (2008). However, in our study wide swathing did not have a large impact on the resulting silage fermentation and in fact wide swathing resulted in slightly higher NDF and lower CP, probably because of wheel traffic causing leaf damage to alfalfa in the wide swaths. This problem can probably be overcome depending on the equipment used for mowing. Wide swathing did not improve NDF-D of the resulting silage in our study although it did in the study reported by Cherney and Cherney (2006). A comment often heard from producers that have used the wide swath technique is the fact the DM content of the harvested crop is much more uniform than it is from narrow swathed alfalfa and that this has resulted in a more uniform product at feed out. Producers experimenting with this procedure should use caution during warm weather because wide swathed alfalfa can dry down extremely quickly. In our study, wide swathed alfalfa reached a DM of 45% in about 6 h on a day with temperatures of about 95°F.

Forage Particle Size

Chopping corn silage too fine or too coarse should be avoided. Finely chopped silage reduces the effective fiber and coarsely chopped silage does not pack well and often leads to sorting of the TMR. Recommendations for theoretical chop size usually run between 3/8 to 1/2 inch for unprocessed corn silage and about ¾ inch for processed silage. In diets where corn silage makes up the majority of the forage, 15 to 20% of the particles should be greater than 1.5 inches long. If using a Pennsylvania State Forage Separator with the fourth box (now with top, middle, low screens and bottom pan), about 8 % of the corn silage should be retained on the top screen to ensure optimum levels of effective fiber in the diet. If corn silage is not the major forage in the diet, about 3% of the top screen may be sufficient. For corn silage, the middle screen should have 45 to 65% of the particles after shaking and there should be no more than 5% of particles on the

bottom pan. If corn silage is processed, a higher proportion of particles can be targeted for the top screen. In measurements that we have taken, some baggers decrease the proportion of corn silage particles on the top screen by about 10 to 15 units so this must be taken into consideration when setting chop length. Likewise silage sampled using a corer do not accurately reflect the particle size of the fiber in the silo. Instructions for using the new particle size separator can be found at:
http://www.das.psu.edu/research-extension/dairy/nutrition/pdf/evaluating-particle-size-of-forages.pdf
In general, if faced with drier forages, one can cut shorter to achieve a tighter pack. If feeding long hay, silages may also be cut a bit shorter.

Mechanical Processing

Mechanical processing of whole plant corn has been an accepted method to improve the quality of corn silage (Johnson et al., 1999). Whole plant processing crushes the entire plant through rollers and can be accomplished in the field during harvesting, at the silo but prior to storage, or after ensiling and just prior to feeding. Processing corn silage improves starch digestibility and allows for good packing in silos, even with a longer length of particle chop. Rollers should be set to obtain adequate kernel damage. In drier and more mature corn silage, clearances between rollers will usually need to be tighter. However, care should be taken to monitor the effectiveness of the processing. When large amounts of acreage require harvesting, there may be a tendency to open the rollers more than what is recommended in order to speed up the harvest, reduce energy use and to reduce wears on equipment. As a rule of thumb, adequate processing is occurring if more than 90-95% of the kernels are crushed or cracked and cobs are more than quartered. Many labs currently provide a Corn Silage Processing Score, which is coupled to NIR analyses of corn silage. A dried corn silage sample is sifted through several screens and particles of corn that are greater than ¼ to ½ of a kernel are retained on a screen and considered difficult to digest. The score provides feedback on processing as “optimum”, “average”, or “inadequately processed” (one draw back is that the test takes several days for completion). An improvement in starch digestion is greater when more mature corn silage (e.g., black layer) is processed. However, always target harvest for 32-35% DM (whole plant DM). Corn should probably not be processed if harvesting forage that is less than 30% DM and especially if the corn has not dented. Improvements in fiber digestion due to mechanical processing are inconsistent. A common observation by producers switching to processed corn silage is the reduction in cobs in the feed bunk and a reduction in kernels in the manure.

Keys to Making Good Silage

The keys to making quality silage are to 1) rapidly exclude air from the forage mass, which will result in 2) a rapid production of lactic acid and reduction in silage pH, and 3) to prevent the penetration of air into the silage mass during storage. Excessive air, due to slow silo filling or poor packing (overly dry forage or forage chopped too coarsely) allows the plant to respire for prolonged periods of time. This results in utilization of sugars and excessive degradation of plant protein. Air also encourages the growth of undesirable microbes such as yeasts and molds.

Air can be eliminated by fast filling (but not too fast), even distribution of forage in the storage structure, chopping to a correct length and ensiling at recommended dry matters (DM) for specific storage structures. Bunk and pile silos should be filled as a progressive wedge to minimize exposure to air and packed in 6 to 8 inch layers. The recommended optimal packing density for bunk and pile silos is 14 –16 lbs. of DM per cubic foot (Ruppel et al., 1995). Silage corers can be obtained from several commercial sources to help with obtaining estimates of silage density (extreme care should be taken when coring silos to avoid potential harm from falling silage). An Excel spreadsheet can be downloaded from the University of Wisconsin that helps with bunker silo filling (www.uwex.edu/ces/crops/uwforage/storage.htm). Users can input silo dimensions, tractor weight, forage delivery rate, forage dry matter, and packing time to estimate packing density. In several recent surveys of bag silos, packing densities are more commonly between 9 to 12 lb of DM/cu ft. Silage in bags should be packed tightly by monitoring the stretch marks on the bags. Tunnel extensions on older units can be added to increase pack density. Silo bags should be vented for about 3 days to rid the bags of excess gasses from fermentation.

Under anaerobic conditions (lack of air) the initial stages of silage fermentation is dominated by microbial activity. Fermentation is controlled primarily by a) type of microorganisms that are present, b) available substrate (water soluble carbohydrates) for microbial growth, and c) moisture content of the crop. Lactic acid-producing bacteria utilize water-soluble carbohydrates to produce lactic acid, the primary acid responsible for decreasing the pH in silage. Unlike alfalfa and other grass silages, corn silage rarely undergoes clostridial fermentation. However, because of its high starch content, preventing the proliferation of yeasts that produce alcohol and cause lower DM recovery is a challenge in corn silage.

Microbial Inoculation

Forages can be inoculated with various microorganisms to alter the resulting pattern of fermentation in the silo. Muck (2008) suggested that inoculation can be helpful in three general areas. These include 1) the prevention of clostridial fermentation, 2) the enhancement of aerobic stability, and 3) the capability of making a good fermentation even better.

Bacteria that are classified as homolactic acid bacteria (those that only make lactic acid as an end product) such as *Lactobacillus plantarum* (although now technically classified as a heterolactic acid bacteria)*, Pediococcus acidilactici, P. pentocaceus, and Enterococcus faecium* are the most commonly used in silage inoculants. In particular, use of these types of organisms addresses areas 1 and 3 described by Muck. When compared to untreated silages, silages treated with homolactic acid bacteria are often lower in pH, acetic acid, butyric acid and ammonia-N but higher in lactic acid content and result in better DM recovery (Muck and Kung, 1997). These effects are easier to detect in alfalfa (because of its high buffering capacity) than in corn silage. The rapid drop in pH and attainment of a low silage pH are crucial for preventing the growth of clostridia, which cause undesirable fermentations (excessive protein degradation, energy and DM losses, production of undesirable end products such as butyric acid and amines).

Lactobacillus buchneri (a heterolactic acid bacterium) has been used to improve the stability of silages when they are exposed to air (area 2 described by Muck). This organism alone does not affect the initial process of fermentation as would a classical homolactic acid bacteria. However, under anaerobic conditions, this organism results in a “controlled” fermentation that produces moderately higher concentrations of acetic acid in inoculated silage when compared to untreated silage. Acetic acid helps to limit the growth of yeasts, which initiate the spoilage process when silages are exposed to air.

Use of this organism has been very successful in high moisture corn, corn silage, in silages that are fed during warm weather, in silages that are fed from intermediate feeding piles, and in silages that are moved between silos. Production of moderate amounts of acetic acid by this organism has not been detrimental to intake nor has it lead to excessive amounts of DM loss during ensiling (Kleinschmit and Kung, 2006).

Many silage inoculants contain more than one type of bacterium. For example, the fast growth rate of *Pediococcus* organisms provides a more rapid start to the fermentation than would *Lactobacilli.* However, *Pediococci* are generally less acid tolerant than *Lactobacilli* and thus the later organisms provide staying power to finish the fermentation. Thus, these two types of organisms are sometimes found in silage inoculants. Some strains of *Pediococcus* are more tolerant of high DM conditions than are *Lactobacilli* and have a wider range of optimal temperature and pH for growth (they grow better in cool conditions found in late Fall and early Spring). When choosing the type of inoculant is unclear, *Lactobacillus buchneri* has been combined with traditional homolactic acid bacteria to form “combination inoculants” that can speed up the fermentation process and improve the aerobic stability of silages.

There has been renewed interest on the effects of microbial inoculation on improving fiber digestion in the rumen. Weinberg et al. (2007) ensiled corn and wheat forages with various lactic acid bacteria and reported that in some cases, addition of these organisms improved NDF-D. The direct mechanism of this finding was unknown, but they have speculated that the silage inoculants directly improve the growth and metabolism of rumen bacteria. Recently, Nsereko et al. (2008) reported that several lactic acid bacteria are able to produce ferulic acid esterase in the silo. This enzyme has the potential to improve fiber digestibility. A silage inoculant based on a strain of *L. buchneri* capable of producing this enzyme was recently introduced into the US silage market. To date, improvements in NDF-D from using this inoculant has been inconsistent (Kang et al., 2009, Hofherr et al., 2008) and there is a lack of published and peer-reviewed production data from animals (e.g. milk production or growth) in support of this product. More studies are needed to assess the efficacy of this inoculant.

The location of applying a microbial inoculant onto the forage is important. If silage is to be stored in a bunk, pile or pit silo the inoculants should be applied at the chopper for a more even distribution. Remember that these bugs don’t have legs, nor do they swim! If all the inoculant gets put on in one spot, it will probably stay there (some distribution will occur during tractor movement and packing, but this is not efficient). For silage that will be stored in a bag silo, application at the chopper or bagger will probably not make a difference (in a few instances, forage is chopped and harvested far away from where it is ensiled;under these circumstances, it may be preferable to have the inoculant applied at the chopper so that the microorganisms can begin their work right away). Don’t forget to properly calibrate your applicators to match forage delivery and don’t increase the dilution or reduce the application rate! Also, remember that inoculants in water are stable for about 2 to 3 days but maybe less under very hot temperatures. If for some reason, unused liquid inoculants must be stored, do so in the shade and place a few ice packs into the tank. Do not allow the temperature of water in the applicator tanks to rise above about 100^{o}F as this may decrease the viability of the bacteria (Mulrooney and Kung, 2008). Seal any unused portion of powders tightly to protect from moisture and store in a cool area.

Sealing Silos

After filling silage should be covered with plastic as soon as possible and weighted down with tires (tires should be touching) or gravel bags to exclude air. Split tires are good alternative because they are easier to handle, do not accumulate water (thus less breeding grounds for mosquitoes that could carry the West Nile Virus), and are undesirable for animals to nest in. The return on investment (labor and plastic) is extremely high for covering bunk and pile silos (Bolsen et al., 1993). Oxygen barrier plastics are also now available for use (Borreani et al., 2007) and a two-step process (oxygen barrier plastic closest to the silage with another layer of normal plastic on top of it) has been commonly used. Producers have also had success in covering silage with two layers of normal plastic. Studies are needed to compare the two-step covering system with oxygen barrier plastic to two layers of normal plastic.

Use of plastic to line the side walls of bunker silos has also grown in popularity to prevent the seepage of water into the silo mass. Studies by Muck (2008) and McDonell et al. (2007) have shown silage with markedly higher quality close to the silo wall when using plastic on the side walls. McDonnell et al. (2008) reported that corn silage next to the wall without plastic had an NDF-D of only 42% whereas silage from the crop but next to a wall lined with plastic had an NDF-D of 57%. Plastic draped over the silo wall during silo filling should be protected from rips and holes that could occur as it rubs against the top of the silo wall.

Allow Forages to “Cure” Prior to Feeding

A “fall slump” in milk production is a common occurrence on many dairy farms. It is characterized by some or all of the following: a moderate to large decrease in milk production, a decrease in intake, loose manure, and cycling intakes. Fall slumps are often a result of feeding corn silage that has not had adequate time to complete the fermentation process. Depending on the specific crop and conditions, most silages require 3-6 weeks before the fermentation process is complete. Recent data confirms that starch availability of corn silages and high moisture corn increases with prolonged storage. The fall slump may occur because fresh corn forage contains high levels of fermentable sugars that can put the rumen into sub acute acidosis and because the starch content of the freshly chopped crop is low in rumen availability. The condition occurs most with corn silage because it is usually the highest proportion of forage fed in the diet. Fall slumps are most apparent when cows are switched abruptly from old corn silage to freshly cut corn forage. This occurs frequently on small farms that have only one silo for corn silage.

A fall slump may also occur when switching from one corn silage to another because the new year’s silage may be lower in nutritive value. Not accounting for differences in the dry matter and nutrient content of the new silage when changing silos can certainly cause problems. Several approaches can be taken to minimize the incidences of a fall slump. First, for dairyman that have adequate forage inventory and silos, plan to allow new corn silage to ensile for at least 2 to 3 months before feeding. Next, when switching from one silo to another, try to make the change gradually over a minimum of a 10 to 14 day period. This is obviously very difficult to do if you only have one silo. For this reason, a case could be made to encourage farmers with only one main silo for corn silage to also put up a small bag (or drive over pile) of corn silage every year that can be mixed with new silage and fed out during the fall. Last but not least, new forages should be tested for dry matter and nutrient content and diet formulations should be adjusted accordingly.

Another potential benefit for allowing silages to "cure" prior to feeding is the fact that the acid conditions in the silo appear to result in improvements in starch and fiber digestion with prolonged lengths of storage. Jaeger et al. (2004) reported that digestibility of starch in high moisture corn improved with length of storage and that the effect was more pronounced in corn with a higher (30%) vs. lower (24%) moisture content. Recently, Hallada et al. (2008) reported improvements in starch digestion (+1.63% units per month) in corn silages with increasing lengths of storage.

Silage Feedout

Proper management for removal of silage from silos and management at the feed bunk can help producers to maximize profits and production. Enough silage should be removed from the silo face to minimize aerobic spoilage. Lesser amounts may be removed in areas of the country where ambient temperatures remain cool during the winter months. Removal of silage should be such to minimize loose silage on the ground between feedings. Hot, moldy feeds should not be fed because they are low in nutritive value and digestibility and depress intakes. Feed bunks should be kept full but clean of decaying feed. Face shavers are becoming popular but research is needed on their benefit. Muck and Huhnke (1995) reported that air is able to penetrate into the face of silo as much as 3 ft. even if the packing density was 14 -15 lb DM/cu ft. Face shavers will probably be most beneficial when temperatures are warm and if less than optimal amounts of silage are removed on a daily basis. Extreme care should be taken to prevent air from penetrating the plastic and reaching the silage mass.

Conclusions

Great care should be taken to preserve and maintain the nutritive value of forage crops. Management starts in the field with harvesting crops at the optimum maturity and then following this with a quick wilt (for grasses and alfalfa), by chopping to an adequate particle size, treating with a good microbial inoculant, processing the plant (for corn silage), filling silos quickly and packing them tightly and finally managing the silage in the silo with plastic and weights to minimize exposure to air.

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