

SILAGE: HARVESTING, STORAGE AND FEEDING



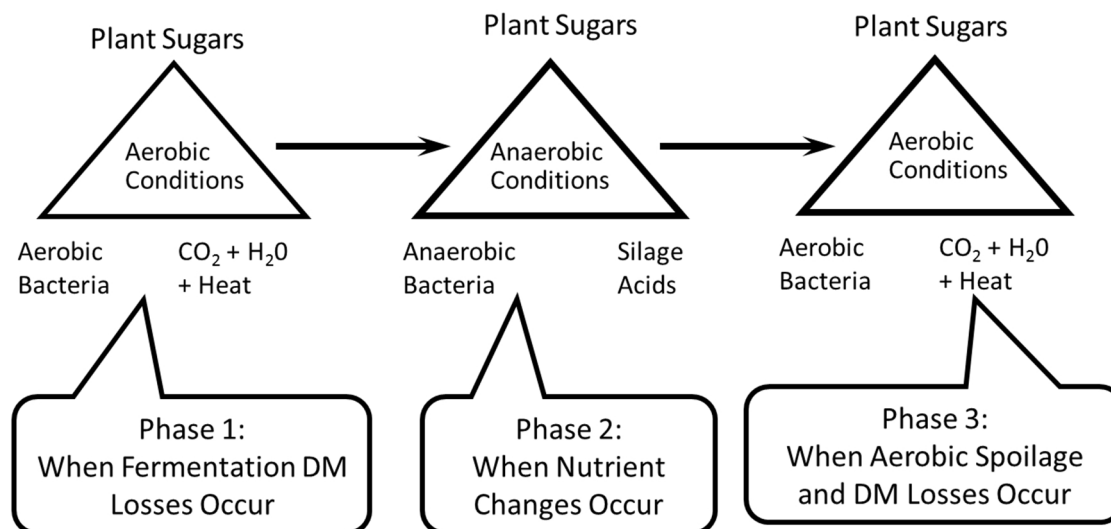
BASICS

OVERVIEW

- The inclusion levels of silages around the world are commonly in excess of 50% of the total dry-matter (DM) in the ration and therefore must have maximum nutrient availability and consistency in rations.
- Implementation of good silage management practices are therefore of utmost importance for maximizing silage quality and profitability from ruminant livestock production.

Fermentation Dynamics

- Silage fermentation is forage preservation by acidification that produces a biosecure feedstuff, prevents spoilage and minimizes DM shrink losses in the silo.
- Silage fermentation can be simplified for discussion purposes into three phases (*Figure 1*).
- Aerobic activity occurs during phase 1 while the silo is being filled where DM loss (shrink) begins with plant cell respiration and aerobic microflora utilizing water soluble carbohydrate (WSC) substrate sources (primarily sugar) thereby producing water, heat and carbon dioxide (CO₂). It is carbon in this gaseous form that is lost to the atmosphere that causes shrink loss. Protease respiratory activity increases soluble protein (SP) during this period. Phase-1 processes will continue until oxygen is depleted within the silage mass.
- Good silo management and bacterial inoculant additive usage during phase-2 maximizes the anaerobic conversion by hetero- and homo-fermentation bacterial strains of WSC to silage acids, thus reducing terminal pH into a 3.8-4.2 range that is inhospitable to spoilage organisms. Additionally, the efficiency of the fermentation process along with time in silo storage increases the starch digestibility (STRD), SP and resulting forage quality in corn silage.
- The re-exposure of silage to aerobic conditions during phase-3 feedout primarily occurs in two areas: 1) top and side exposure, and 2) face exposure. Oxygen from air is re-introduced into the silage mass where yeast, mold, and *Bacillus* activity cause further shrink losses along with heating and spoilage of the silage. Feedout silage management mitigates these losses.



Rules of Silage Management:

1. Sizing of horizontal or vertical storage structures is based on pounds of silage needed/day for feeding ruminants during required feeding periods. Correct silo dimensions must be coordinated with ruminant feeding needs because silage must be fed out fast enough to stay ahead of aerobic deterioration during feedout.
2. Harvest maturity assures adequate WSC and elimination of oxygen to maximize anaerobic fermentation. Corn should be harvested at 1/3 – 2/3 milkline (the corn kernel milk line represents a sudden transition in color difference that separates the solid from the liquid portion of the kernel). As a general rule, when the milk line is 1/2 to 2/3 down from the kernel crown, total plant moisture content is 60-70%.
3. Alfalfa should be harvested at late bud stage. Cereals should be harvested at late boot stage. Advanced maturity causes higher porosity (air holding capacity) of the forage, requiring increased compaction required to eliminate oxygen from the forage mass.
4. Harvest moisture: Silage microbes are most efficient within a 63-68% ensiling moisture range. Legumes and grasses must have proper wilt time between cutting and chopping to permit evaporation of moisture. Wilting concentrates WCS essential for fermentation. Corn forage can be direct-cut because its maturity is negatively correlated with moisture levels. In the case of corn silage, harvesting healthy plants at higher DM will produce higher starch concentrations. Harvest moisture also impacts the degree of forage porosity.
5. Achieve proper chop length and kernel processing. Chopper knives must be sharp and properly adjusted and the shear bar should not be worn to ensure a clean chop and prevent shredding for decreased chances of effluent. The theoretical length of cut (TLC) adjustment (along with moisture and maturity) is critical to maximize forage compaction for efficient fermentation while providing sufficient particle length for proper rumination. The roller mill setting for kernel processing (KP) of corn silage should be 1-3 mm for maximizing STRD; dryer corn requires a more aggressive 1 mm KP setting. Corn TLC should be 9 –16 mm for unprocessed and 9-19 mm for processed corn silage. The TLC for haycrop silages should be 6.5-13 mm. Forages crops with higher dry matter content need to have a shorter TLC.
6. The structure must be filled as rapidly as possible to diminish silage shrink losses. However delivery of forage to the silo shouldn't exceed the ability of packing equipment

to obtain desired packing densities. Bunker silos should be filled from back to front rather than bottom to top; the progressive-wedge method prevents disruption of previously ensiled forage.

7. Adequate silage compaction is required to ensure elimination of oxygen, thus minimizing aerobic activity and maximizing anaerobic fermentation. Factors that impact packing densities (expressed as lbs/ft³) include: porosity based on forage maturity and percent DM, TLC, storage structure, forage delivery rate, packing tractor weight, packing layer thickness, and silo height. Required tractor weight is determined by rate of forage delivery to the silo. A thumb rule for the required tons pack tractor capacity on bunkers and silage piles is to multiply the tons of silage being delivered to the silo per hour by 800. For example, if forage is delivered to the silo at 100 tons per hour, a total of 80,000 lbs. (100 x 800) of tractor capacity is needed per packing hour. On a tonnage basis, this would be a 40 ton tractor (80,000/2,000).
8. The silo surface needs to be properly sealed, where typically plastic tarp is used to cover the entire surface, and a net of tires holds the tarp in place. This technique yields a 4:1 return on investment by eliminating 33% of potential dry-matter losses. Oxygen barrier film (OBF) products have been introduced to the silage market the past several years and show promise in mitigating surface mold and reductions of dry matter losses in the top 3-4 ft. of horizontal silos.
9. Silages require proper feedout rates. Silage feedout must be a minimum of 6 inches/day in winter and 8 inches/day in summer months. Losses resulting from slow removal account for up to 50% of DM losses, which will be in the form of WSC, not fiber. Improper removal creates fissure into the silage mass and allows oxygen to enter and promote aerobic activity. Silages should be removed from bunker and pile faces by shaving the silage face from top to bottom with end-loader buckets or use of silage defacing equipment.
10. Silage additives should only be used if the other eight conditions for producing high-quality silage can be met. Additives are classified as 1) bacterial, 2) enzyme, 3) acid, and 4) nutrient, of which the most common that exist in North America are bacterial inoculant products. Good silage can be made better through the proper use of well researched silage additives; however they will not make poor silage good.

Silage Feeding Considerations:

1. Respect nutritional variations during feedout of silages when making the TMR. Frequent DM determinations during silo feedout will minimize over- or under-feeding nutrients from silages by increased or decreasing as-fed pounds forage in the TMR. In addition, varying crop growing environments will impact nutritional quality being fed out of the silo.
2. Neutral Detergent Fiber digestibility (NDFD) of corn and haycrop silages are greatly influenced by the crop growing environment and quite independent of the respective hybrid or variety genetics planted in the field. Monitoring NDFD between various crops is essential for balancing rations. Most studies indicate NDFD does not improve in the silo.
3. The STRD of corn silage is driven by growing environment of the crop, kernel maturity, degree of KP, and length of storage time in the silo. Genetics of corn hybrids have no impact on STRD at corn silage maturity.
4. Protein level and formulation in the ration should be based around SP levels of silages. The longer silage is stored in silos, the higher will be SP concentrations.

5. Silage particle lengths should be closely monitored using sieving techniques such as the Penn State Separator[®] system to assure the TMR delivers and maintains an adequate fiber mat for rumination and ruminant health.
6. Monitoring of silages and TMR for undigestible NDF (uNDF) provides another indicator of meeting the ruminant's need for rumination and helps determine if dry matter intake (DMI) reduction may be an issue; a rough rule is > 5 DM lbs uNDF in the TMR may start limiting DMI.



MISCELLANEOUS

ABBREVIATIONS

- CO₂ = Carbon Dioxide
- DM = Dry Matter
- DMI = Dry Matter Intake
- KP = Kernel Processing
- NDFD = Neutral Detergent Fiber Digestion
- OBF = Oxygen Barrier Film
- SP = Soluble Protein
- STRD = Starch Digestibility
- TLC = Theoretical Length of Chop
- TMR = Total Mixed Ration
- uNDF = Undigestible Neutral Detergent Fiber
- WSC = Water Soluble Carbohydrate

Suggested Reading

Dairyland Laboratories: <https://www.dairylandlabs.net/resources/feed-and-forage/articles-papers-and-presentations>

Penn State Extension: <http://extension.psu.edu/plants/crops/forages/hay-and-silage>

Pioneer.com-The Silage Zone[®]: <https://www.pioneer.com/home/site/us/livestock-feed-nutrition/>

USDA-DFRC: <http://www.ars.usda.gov/services/services.htm?modecode=50-90-15-00&locpubs=yes>

UW Forage Extension: <http://www.uwex.edu/ces/crops/uwforage/storage.htm>.

UMN Forage Extension: <http://www.extension.umn.edu/agriculture/dairy/forages/>

McDonald, P: The Biochemistry of Silage. 1991. John Wiley & Sons, Chacombe Publications, 13 Highwoods Drive, Marlow Bottom, Bucks SL7 3PU.

Mahanna, W.C., Seglar, W.J., Dennis, S. 2013. Pioneer Silage Zone[®] Manual.

DuPont Pioneer Global Forages, 7100 N.W. 62nd Ave. Johnston, IA 50131.

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