SILAGE QUICK FACTS

HANDBOOK

A resource to help you maximize the value of your forage

LALLEMAND ANIMAL NUTRITION
Tel: 1 (800) 541-5598 Email: LAN_NA@lallemand.com
www.lallemandanimalnutrition.com

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CONTENTS

INTRODUCTION

Evolving industry and market dynamics provide constant pressure for producers to increase efficiency to maintain profitability. One way to improve efficiency is by producing high-quality preserved feedstuffs and increasing their proportion in the ration. The ensiling process converts perishable forages into stable silages so that they can be stored and fed throughout the year. Ensiling involves acidifying, or pickling, the crop, either by direct addition of acid or by fermentation. The ensiling fermentation is an anaerobic process involving the conversion of sugars into organic acids such as lactic, acetic and propionic. These organic acids are produced by bacteria, either present naturally on the crop or added by the use of an inoculant.

The purpose of this handbook is to help producers obtain the best quality feeds from their own forages. The appendices also provide troubleshooting advice for some common silage problems and storage capacity charts for horizontal and upright silos.

Some factors that can affect forage quality cannot be fully controlled, for example, weather and equipment breakdowns. Key areas to focus on that can be controlled include:

- Harvesting at optimum maturity and dry matter (DM)
- Optimizing chop length
- Correctly using inoculants relevant to the challenges presented
- Packing the silage effectively to get air out
- Covering and sealing to keep air out
- Managing feedout properly

Further information on factors affecting silage quality is available at www.qualitysilage.com


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MATURITY & DRY MATTER CONTENT

Achieving the proper dry matter (DM) content for specific forage at harvest is important for maximizing nutrient preservation and feed intake by the animal. Forages harvested below 30% DM are at risk from effluent loss and clostridial fermentation, while forages harvested at over 35% DM are more prone to losses due to aerobic spoilage.

Alfalfa is optimally harvested when the crop is at 38% NDF and should be wilted to between 35% and 45% DM, though this varies somewhat depending on storage structure (Table 1). Grass crops should be harvested at the boot stage and also wilted to 35% to 45% DM. Corn is optimally harvested between 32% and 38% DM: corn harvested for silage at greater than 30% DM will benefit from using a kernel processor or shredder processor at the time of harvest. High-moisture corn or cereal grains are harvested at 65% to 75% DM (Table 1).

Alfalfa and Grass

Yield and quality are major factors to consider when harvesting alfalfa or grass. Yield increases and quality decreases with increasing maturity. The harvest schedule during the first two cuttings should be optimized to maintain reasonable yields while maximizing quality of forage. Alfalfa should be harvested between bud and one-tenth bloom, while grass should be harvested prior to the boot stage.

Table 1: Optimum harvest stage and moisture

CROP	HARVEST STAGE	DM LEVEL %
Corn Silage	1/2 - 2/3 milkline	32-38%
HMC/Cereals		65-75%
Cereals	boot or dough	35-45%
Grasses	boot	35-45%
Alfalfa:		
Bunker or Bag	bud - 1/10 bloom	35-45%
Stave	bud - 1/10 bloom	40-55%
Harvestore	bud - 1/10 bloom	50-65%

Corn

Maturity can be monitored by kernel milkline development, as kernels mature from blister to physiological maturity (black-line). To maximize quality, corn should be harvested for silage when the kernels are between one-half and two-thirds milkline (Figure 1). Between these stages, starch content is increasing and fiber digestibility is in an optimum range.

Figure 1: Development of milkline in corn kernels (left); Milkline in corn ready for harvest for silage (right)

Small grain silages

All of the common small grain (cereal) crops including oats, barley, wheat, rye and triticale are commonly ensiled. Small grain-Canadian field pea mixtures are popular on dairy farms in some parts of the U.S., typically producing a feed intermediate between a small grain and alfalfa in quality.

It is especially important to wilt small grain crops to at least 30% DM and preferably >35% following mowing, to minimize the potential for clostridial (butyric) silages. Adding field peas to a cereal often makes the forage slower to dry, so spreading the windrow to at least 2/3 mowed width is critical. In some areas, cereal silages are grown as an energy crop, as an alternative to corn silage. The crop is harvested at a more advanced stage with more grain fill and, hence, higher starch levels, and direct cut at a higher DM. Typically, this has been done with wheat, oats or barley, harvested around the soft cheddar stage at a DM level around 40%.

CUTTING HEIGHT & CHOP LENGTH

Mowing/cutting decisions often involve a trade-off between yield and quality. Increasing cutting height of corn has a more pronounced effect on quality than does the mowing height of alfalfa and grass. Grass mowing height should be about 4 inches: unlike alfalfa, the nutrients for the following crop of grass is in the bottom few inches of the above-ground portion of the plant. Alfalfa regrows from the crown buds and can be mowed at 2 inches with no impact on regrowth or plant health. However, mowing should be high enough to avoid scalping the field, to avoid contamination with soil, manure residues and crop debris. Increasing the chop height of corn from the normal 4 to 8 inches to 12 to 18 inches decreases yield but increases energy concentration, with lesser effects on fiber digestibility. Immature corn, as well as BMR and other high fiber digestibility corn hybrids, should not be chopped higher than about 8 inches. Summer annual crops that experience drought conditions can contain high levels of nitrates which can have detrimental effects on feeding. Nitrates accumulate in the bottom portion of the plant so raising the cutter bar to leave about the bottom one-third of the plant in the field can be effective in reducing nitrate levels in the resulting silage.

CHOP LENGTH AND PROCESSING:

Chop length affects both ensiling characteristics and forage quality. A short chop length minimizes air infiltration into the silo, while a longer chop length increases effective fiber in the diet.

The correct chop length for corn depends on whether the crop is harvested conventionally, with or without a kernel processor (KP), or with a shredding processor. Much of the advantage of processing corn silage is due to better kernel breakage and, therefore, higher kernel processing scores (KPS). Kernel processed corn should be chopped at ¾ inches (19mm) theoretical length of cut (TLC), while a TLC of 1 inch (30mm) is recommended for shredding processors. Corn that isn't processed or shredded should be chopped at a TLC of ¼ inch to ½ inch (6 to 13 mm). For KP silage, the roll clearance should usually be set at 1 to 3 mm, depending on both the equipment and the maturity and variety of the crop. Increasingly, some farmers and custom operators are setting roll clearance to 1 to 2 mm (instead of 3 mm) in an effort to improve KPS, especially with hard (vitreous) kernel varieties. Processor maintenance is critical since worn rolls can result in many unbroken kernels. Properly processed, all the kernels should be broken, nicked or damaged, and there should be no cob fragments larger than ¼ inch. One suggested rule of thumb is that in a quart of KP corn silage, there should be no more than one whole or two half kernels.

The use of shredding processors has been increasing, particularly on dairy farms feeding high levels of corn silage. The processor shreds the corn stalk into longer pieces than with KP, providing more physically effective fiber, while the chop length is longer (26 to 30 mm at 30% to 35% DM) and the processing rolls are set a bit closer (1.75 to 2.25 mm) to better crush the corn kernels. To date, research on shredded corm silage has been limited but current results suggest that compared with KP corn silage it may increase milk production by about 2 pounds per cow. However, in these trials, KPS was somewhat higher for shredlage than for KP corn silage: results may have been different if both crops were at the same KPS.

For most other forage crops, chop length can vary from ¼ inch to 3/8 inch (6 to 10 mm) depending on how much of the ration consists of silage. To maintain good rumen function with all-silage rations, 3/8 inch TLC is generally preferred to shorter chop lengths.

INOCULANTS

Forage inoculants are used for two primary reasons: (1) to stimulate or ensure a rapid fermentation (fermentation aids) and (2) to inhibit aerobic deterioration (spoilage inhibitors).

Fermentation aids generally contain efficient (homofermentative) lactic-acid-producing bacteria (LAB) and are mainly used on low dry matter (DM) forage crops that have low concentrations of fermentable carbohydrates and high buffering capacity.

Spoilage inhibitors include specific LAB and propionic-acid-producing bacteria. These products are designed for use on materials more prone to aerobic spoilage such as drier haylages (more than 35% DM), corn and cereal silages, high moisture corn and cereal grains and baleage.

Things to consider when comparing silage inoculants include:

- Is there ample data for the specific product formulation in the target crop from trials conducted at independent research facilities, such as universities, verifying their claims at the application rate on the product label? Without data to validate specific product claims, let the buyer beware!
- Remember that not all bacteria are the same, even if they have the same name. Companies have unique strains that have been tested and developed under rigorous conditions. Look for strain identification numbers and make sure they match up with those used in trials.
- Is the product manufactured to quality control standards and does the manufacturer have accreditation to show that manufacturing procedures are independently reviewed?
- Is the product packaged appropriately? Inoculants contain dry viable microbes: the three enemies of these live products are heat, moisture and air. To prevent exposure to heat follow recommended storage instructions, which should be stated clearly on the label (Figure 3). Packaging must prevent exposure of the contents to moisture and air, e.g by using high barrier foils or sealed tubs. Manufacturers should also flush with an inert gas (e.g. nitrogen) during packaging to minimize residual oxygen and include specific preservation agents, e.g. moisture scavengers, in the product formulation.

- Read and understand the label (Figure 3):
  - Number of bacteria, application rate and weight: Does data supplied by the company validate the recommended application rate? (Calculations may have to be done to determine the application rate of bacteria on forage [Table 2].) It is generally accepted that fermentation aids, containing homolactic LAB, should be applied at a minimum of 100,000 colony forming units (CFU)/g forage. Rates for organisms in spoilage inhibitors vary: the FDA has allowed products containing ***L. buchneri*** 40788 to claim improvement in aerobic stability in silages and HMC stored for 60 days, provided the product is applied at a minimum of 400,000 CFU/g for silage or 600,000 CFU/g for HMC. In the U.S., for microorganisms to be legally included in products, they must be on the direct-fed microorganisms list approved by the Association of American Feed Control Officials (AFFCO) (Table 3). Microorganisms that are not on this list are not approved for use in the animal feeding in the United States.

Figure 3: Example of a forage inoculant label

Acme Sile

Water Soluble Concentrate — **product form**

A concentrate of selected viable lactic acid producing organisms to aid in the fermentation of all silages.

GUARANTEED MICROBIAL ANALYSIS
Total Lactic Acid Producing
Microorganisms.................................45.4 billion CFU/g — **number of bacteria**
(*Lactobacillus plantarum* AB12. ***Pediococcus acidiactici* CD34**) — **type of bacteria, (blue = microbial genus; green - microbial species; red = strain designation)**
Xylanase 2,500 U/g Alpha-amylase 2,000 U/g
One unit is the enzyme activity required to liberate on mg of glucose per g per minute

INGREDIENTS
Sucrose, dehydrated *Lactobacillus plantarum* and *Pediococcus acidlactici* cultures, dehydrated *Trichodema reesii* and *Aspergillus niger* fermentation products, and sodium silcoaluminate.

DIRECTIONS FOR USE — **application rate**
Mix one pouch (100 grams) of Acme Sile with 25 gallons of water. Apply resulting liquid to chopped forage at the rate of 1/2 gallon per ton of forage and 1 gallon for high-moisture grain. When used at a rate of 1/2 gallon per ton, the resulting product will inoculate at a rate of 100,000 CFU/g of forage. This pouch will treat 50 tons.

RECOMMENDED STORAGE IS IN A FREEZER OR REPRIGERATOR AT OR BELOW 40F. USE WHOLE PACKETS AT ONE TIME. SHELF LIFE IS 18 MONTHS WHEN STORED AS RECOMMENDED. — **storage instructions**

NET WEIGHT: 3.5 OZ (100g) — **weight**

Manufactured for Acme, City, State 01234

- Levels of enzymes: If the product claims to include enzymes, guaranteed levels should be declared, and they should be the same as those used in trials to validate product efficacy. If no guarantee levels are given for enzymes, it's best to consider that they are not present. Like microorganisms, there is a list of enzymes and sources approved by AFFCO. Again, anything not on this list is not approved for use in animal feeding in the United States.

- Shelf life and storage conditions should be stated clearly on the product label, read, understood and followed. The shelf life of the inoculants is linked to the recommended storage conditions. Improperly storing the product could significantly reduce its shelf life and efficacy.

- Do not use expired inoculant: check the expiration date! If you have a stock of product that is beyond the expiration date, it may be worth a check to see if the manufacturer can get the product tested for you. This should be conducted by an independent laboratory.

Table 2: Calculations for the number of bacteria per pack of inoculant and product application rate (CFU/g forage)

bacteria/gram x grams = bacteria in package *example:* 45.4 billion CFU/g x 100 g = 4.54 trillion CFU/package
bacteria in package/(tons treated x 1 ton/908,000 g) = Application Rate *example:* 4.54 trillion CFU/(50 tons x 1/908,000) = 100,000 CFU/g forage

Table 3: Organisms approved by AAFCO for use in animal feed products in the US

Aspergillus niger	*Lactobacillus farciminis (swine only)*
Aspergillus oryzae	*Lactobacillus fermentum*
Bacillus coagulans	*Lactobacillus helveticus*
Bacillus lentus	*Lactobacillus lactis*
Bacillus licheniformis	*Lactobacillus plantarum*
Bacillus pumilus	*Lactobacillus reuteri*
Bacillus subtilis	*Leuconostoc mesenteroides*
Bacteroides amylophilus	*Megasphaera elsdenii (cattle only)*
Bacteroides capillosus	*Pediococcus acidilactici*
Bacteroides ruminocola	*Pediococcus cerevisiae (damnosus)*
Bacteroides suis	*Pediococcus pentosaceus*
Bifidobacterium adolescentis	*Propionibacterium acidipropionici (cattle only)*
Bifidobacterium animalis	*Propionibacterium freudenreichii*
Bifidobacterium bifidum	*Propionibacterium shermanii*
Bifidobacterium infantis	*Rhodopseudomonas Palustris (broiler chickens only*
Biflidobacterium longum	*Saccharomyces cerevisiae*
Bifidobacterium thermophilum	**Enterococcus cremoris*
Lactobacillus acidolphilus	**Enterococcus diacetylactis*
Lactobacillus brevis	**Enterococcus faecium*
Lactobacillus buchneri (cattle only)	**Enterococcus intermedius*
Lactobacillus bulgaricus	**Enterococcus lactis*
Lactobacillus casei	**Enterococcus therniophilus*
Lactobacillus cellobiosus	*Yeast (as defined elsewhere)*
Lactobacillus curvatus	**Formerly classified as Streptococcus.*
Lactobacillus delbruekii	

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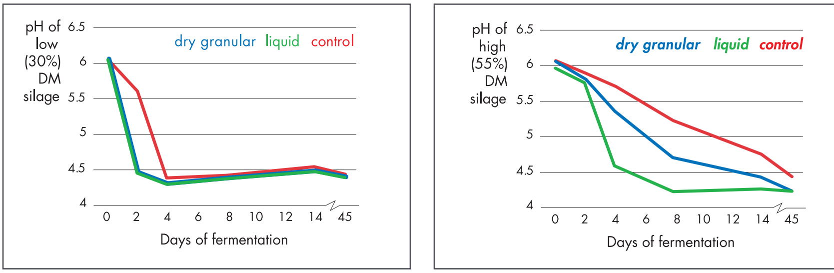
- Suitability of product form. Dry granular application may be easier but is less effective than liquid application as crop DM increases (Figure 4). Granular inoculants should not be used in crops with DM levels above 40% (less than 60% moisture). Also be aware that the stability of granular inoculants is subject to the same stresses as noted above: heat, moisture and oxygen. It is also more difficult to store granular products under optimal temperature conditions.

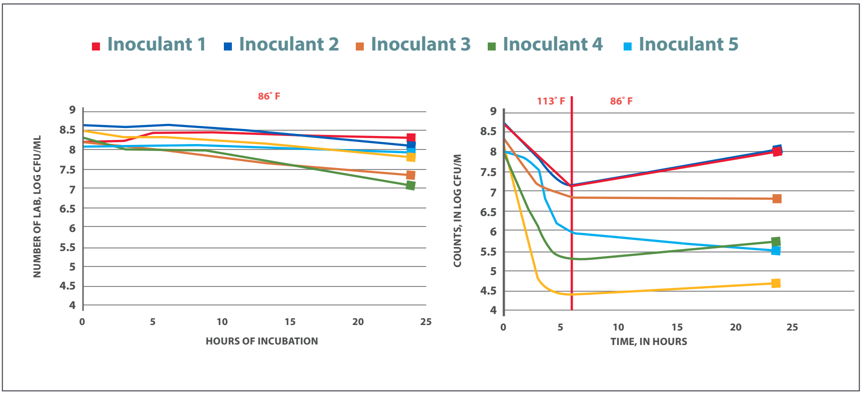
Figure 4: Effect of inoculant form on rate of pH drop in alfalfa silage



- Product stability in the application tank or hopper. The bacteria in liquid applied inoculants can die off quickly following rehydration if not kept cool (Figure 5). Do not allow water with bacterial inoculants to reach temperatures above 95 to 100 F during use: keep product cool by adding ice packs to the applicator tank. Ask to see the rehydration stability data for any product you are considering. If liquid applied product becomes slimy, it should be discarded (this indicates that bacteria have died, releasing their DNA and causing the sliminess). Granular, dry applied inoculants also die off in the hopper (Figure 6) and are more likely to be at ambient temperature, and exposed to air (oxygen) during the harvest. Be sure at the very least to keep product out of direct sunlight. Product flow characteristics may also suffer due to the absorption of moisture. Granular inoculant left over in the hopper at the end of the day should be discarded to ensure optimum product performance.

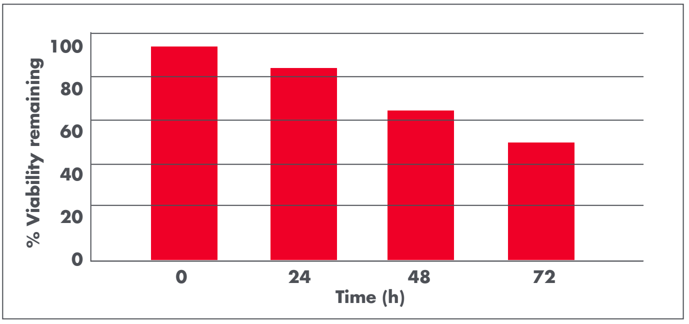
- Does the type of product match your expectations? Do you need a fermentation aid, a spoilage inhibitor or both? Is there independent data to show that the product can do what you are looking for?

Figure 5: The effect of temperature on the stability of liquid applied inoculants after rehydration.



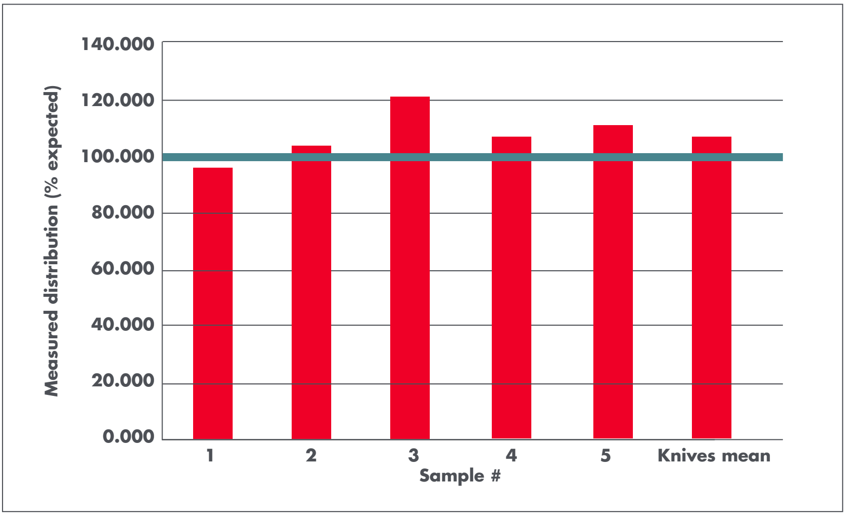
Mulrooney, C.N., and L. Kung Jr. 2008. Short communication:
The effect of water temperature no the viability of silage inoculants. J. Dairy Sci. 91:236-240

Figure 6: Stability of granular silage inoculant in the applicator hopper



- Calibrate your application rates for liquid and dry-applied inoculants. Application rates should be checked several times a day. Even distribution of the inoculants is a key factor in their ability to help the fermentation process. Products are best applied at the chopper box or accelerator on the harvester. The DE-1008.5/1010 (Dohrmann Enterprises, Inc.) are low-volume liquid applicators (1.28 oz. per ton/ 40 ml/ton), which have been validated as achieving even distribution (Figure 7). The product reservoir on this system is a 10-gallon insulated tank, which helps keep the product cool to maintain viability. Ice blocks can be added to the product in the tank to maintain viability, based on recommendations for the specific product from the manufacturer.

Figure 7: Consistency of Product Application Rate Using Dohrmann Low Volume Liquid Applicator (red bar shows actual application rates; blue line shows theoretical perfect application)



PACKING

It is vital to properly pack silage to achieve an anaerobic environment rapidly after harvesting and to reduce DM loss. Silage porosity is determined by pack density and DM content, and it determines the rate that air can infiltrate the silo. This in turn affects the amount of spoilage that can occur during storage and feedout.

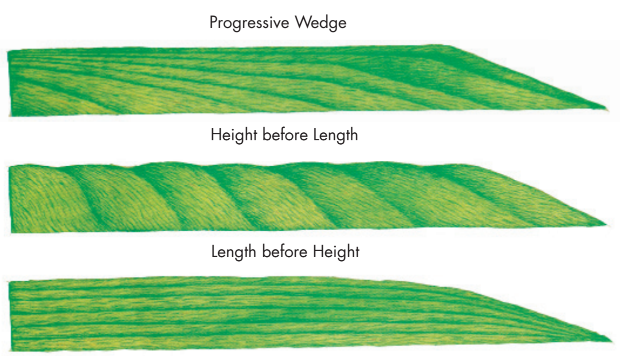
The effort put into packing has a greater effect on silage density than initial NDF content or particle length. The minimum recommended pack density is 47 pounds per cubic foot on a fresh weight basis at 30% DM. Figure 8 gives equations to calculate requirements to achieve this minimum target level for bunker silos and piles. A web-based spreadsheet developed by the University of Wisconsin for calculation of packing density can be accessed at: **fyi.uwex.edu/forage/harvest/#inventory**

Figure 8: Calculations for packing tractor weight/filling rate to achieve minimum target packing density (47lb./fresh weight at 30% DM cu ft.) in trench and bunker silos

Optimum packing vehicle weight (lbs) = filling rate (tons/hr) x 800
Optimum filling rate (tons/hr) = vehicle weight (lbs)/800

Bunker silos should be filled using the progressive wedge technique (Figure 9) to minimize the surface exposed to air and to maximize packing efficiency. Slopes should not be greater than 4:1 (length: height) both for safety and to allow effective packing and filling should be done in layes of 6" or less.

Figure 9: The Progressive Wedge



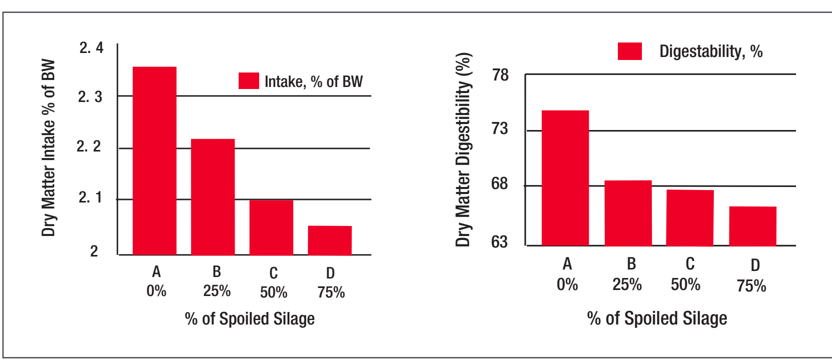
The progressive wedge method is the best way to fill a bunker silo. There is less silage respiration with the progressive method than when bunkers are filled length before height or height before length.

COVERING & SEALING

Dry matter losses in horizontal silos (bunkers and piles) are reduced greatly by covering effectively with suitable plastic weighted down with with tires or gravel-filled bags (Figure 10). Sealing and covering a 40-foot by 100-foot bunker returns approximately $2,000 - $4,000 in improved silage DM recovery when filled with corn or alfalfa silage, respectively. Covering also improves the quality of the silage fermentation and reduces the production of undesirable compounds in the top layer. The improvement in yield and quality translates into improved digestibility of nutrients when fed. Figure 11 shows the effect of feeding spoiled silage on DM intake and DM digestibility of the total ration. As silage from the spoiled top layer is mixed into the ration, it reduces both intake and digestibility of the whole ration.

Figure 10: Use of gravel filled bags (left) and tires (right) to weigh down plastic covering

Figure 11: The effect of feeding spoiled silage on dry matter intake and total ration dry matter digestibility



Whitlock, L.A., M. K. Siefers, R. V. Pope, B. E. Brent, and K. K. Bolsen 2000.
Effect of level of surface-spoiled silage on the nutritive value of corn silage-based rations.
Kansas Agric. Exp. Sta. Rpt. of Prog. 861: 36.

FEEDOUT

FEED OUT MANAGEMENT

The key steps are to:

- Remove all spoiled silage
- Keep the silage face vertical and tight
- Remove enough silage to avoid any heating and do not pile silage ahead of feeding, as this can result in composting
- Premix the silage that has been obtained from the entire face with the loader bucket or mixer wagon prior to feeding
- Strive to have as little loose silage at the end of feeding as possible
- Keep the leading edge of plastic sufficiently weighted down to prevent air infiltration beneath the plastic
- Remove plastic at least twice weekly, or as often as necessary, so that top spoilage does not occur prior to feeding

Spoilage silage from along the top and sides of the silo, also balls or chunks in the main body of the silo, should be discarded.

Ideally remove silage using a bunk defacer (Figure 12). Defacers have a lot of benefits: they do not cause fracture lines that allow air into the silo; they mix the silage from across the height of the silo, reducing ration variability; they break up haylage clumps, which can reduce mixing time; they leave a very straight face, which does not catch water; and they can cause less damage to the silo equipment used to remove silage from the bunker. If using a loader buckets to remove silage, preferably shave across the width of the silo.

Figure 12: Bunk defacer

Silage should be removed at the rate of at least 6 inches during the summer and 3 inches during the winter to stay ahead of spoilage. The rate necessary will vary, due primarily to the packing density, crop ensiled and inoculant type used. Silage inoculated with ***L. bucherni*** 40788 will not have to be fed as quickly since the elevated levels of acetate reduces growth of yeasts and molds and improves feed stability.

Be an alert, organized silo manager. Remember that details matter. Remove plastic and tires in a timely manner, ideally on a daily basis but certainly no more than three days ahead of feeding. Keep the leading edge of plastic completely weighted down. Carefully observe and smell layers of silage within the bunker. Watch for layers of silage that went through clostridial or abnormal fermentations and selectivly remove these layers for discard or feeding to nonlactating animals. Premix forages obtained from the entire bunker face prior to preparing loads of feed. Test the DM of the silage being added to the ration and make adjustments as necessary.

Face management is also a safety concern. Maintaining a flat bunker face avoids dangerous silage overhangs that can fall at any time and cause serious injury.

For more information on working safety around silage, check out our Silage Safety Handbook, available from your Lallemand forage inoculants supplier or contact: www.qualitysilage.com .

APPENDIX I

SILAGE TROBULESHOOTING: PROBLEMS, CAUSES, AND SOLUTIONS

PROBLEM	CAUSES	MANAGEMENT AND FUTURE AVOIDANCE
High pH silage (see Figure 3)	A number of possible causes: ▪ Slow fermentation: smell and look at VFA profile for indicators (butyric etc.) ▪ Yeast growth: look for indicators in smell (no smell or slightly alcoholic), VFA profile and microbial analyses. ▪ *Bacillus* growth: earthy smell, may be heating.	Management is largely down to what else is going on. If silage is not heating, feed rate needs to be high and/or a TMR treatment used. If silage is butyric, feed rate must be carefully controlled. Performance is likely to be compromised due to energy lost from silage. Avoidance: Total management approach -harvest stage, chop length, speed of fill, pack rate, plus use a good additive.
Silage heating or heated	▪ Yeast growth (main initiators of heating). ▪ *Bacillus* growth. ▪ *Acetobacter* growth: mainly seen in cereal silages.	Managing needs high feed rate, good face management, maybe also use of a TMR treatment. Avoidance: Focus on management—packing, speed of fill, chop length, etc., plus use an aerobic spoilage inhibitor on the silage.
Moldy silage	All mold comes in from the field and grows in silage because air is present. Air can be due to poor packing (e.g., balls or lumps of mold in silage mass), delays during filling (e.g., bands of mold in silage: fill lines), poor sealing (mold at top and/or sides) or slow feedout (mold across face). Large diseased areas in the field at harvest.	Be very careful! If any doubt, throw away moldy silage: by the time it's moldy it has lost most of its available energy. See also LAN Mold Guide. Avoidance: Exclude air in the silage, use fungicides properly in the crop in in the field, and use a proven aerobic spoilage inhibitor on the silage.
Silage pH too low	This usually results from the activity of "wild" lactobacilli naturally present in the silage and often results after a slow initial fermentation (usually a fast fermentation will prevent the wild lactobacilli becoming established).	May need to be careful what is fed to avoid acidosis, etc. Avoidance: Largely management (fill rate, packing, etc.) and use an inoculant with a good homolactic LAB.
High ammonia	Some lactic bacteria (e.g. *Enterococcus/ Streptococcus faecium*) break down protein, so can cause a higher ammonia level in an otherwise well-preserved silage. High ammonia can also result from a clostridial silage (strong fecal smell) or from enterobacteria. High ammonia can result from over-application of fertilizers (total crude protein will be unrealistically high).	Requires care when feeding. If silage is butyric, be careful with rate of inclusion in ration. Spread out to aerate and reduce butyric acid levels. If not butyric, be careful with level of NPN in ration. Avoidance: If fertilizer problem,man fertilization better. If clostridia, avoid soil inclusion (ash <8%), harvest drier (30% DM), and use a homolactic LAB inoculant.

APPENDIX II

GLOSSARY OF SILAGE SMELLS

SMELL	PROBABLE CAUSE	MANAGEMENT ISSUE
Sweet Acid	Probable strong fermentation: check pH, could be too low	Could have stability problems when fed out. Check yeast and mold levels.
Acetic/ Vinegar	Elevated acetic acid level: check VFAs etc. 1) High lactate, acetate and propionate: good stable silage, feeds well. 2) Lower acetate, some ethanol, maybe some butyric, iso-butyric (messy VFA profile), also some ammonia. Classic slow fermentation: may or may not be stable, intakes not ideal, lower performance.	Type 1: Excellent silage, feeds well, animals perform well. Type 2: Silage may not be stable, potential palatability problems, animals do not perform ideally.
Fecal/ putrid/ decaying	Clostridial silage: slow fermentation and?or contamination (ash>8%) has resulted in clostridia dominating the fermentation and producing butyric acid (classic smell is mouse droppings), ammonia, amines (e.g. putrescine, cadaverine). Silage will be wet, pH may be elevated or may be low.	Silage will be very stable but intakes will be low. Forcing high intakes can cause health and fertility problems. Spread out to aerate and reduce butyric acid levels. Feed as low proportion of ration, mask with suitable flavor (e.g. butterscotch, caramel). Do not feed to pregnant cows, transition cows or cows in first 100 days of lactation.

GLOSSARY OF SILAGE SMELLS

SMELL	PROBABLE CAUSE	MANAGEMENT ISSUE
Earthy	*Bacillus* growth: pH will be high.	Silage will eat and may also go moldy. Must be fed quickly, removing moldy material. Consider treating TMR.
No smell to alcoholic or fruity/ yeasty/ bread odor	Yeast growth, consumption of VFAs. pH will be elevated, may be some alcohol on analysis. Micro will probably show high yeast levels.	Silage very likely to be warm, hot or likely to heat. May also be or go moldy. Feed carefully as above.
Tobacco/ burnt odor	Silage has undergone excessive heating due to yeast and/or *Bacillus* growth. May also be moldy. Analysis shows little or no VFAs or other volatiles. May have a high level of bound/heat damaged protein (ADIN): this indicates temperatures have been in excess of 100F.	May have reasonable/high intake (cows like the taste) but will not perform well since most of the energy has already gone.
Musty/ moldy	Molds are growing in the silage, probably visibly. Silage as already heated due to yeast growth with losses of dry matter and nutrients.	Remove and discard moldy silage.

APPENDIX III

ESTIMATED FRESH WEIGHT FORAGE CAPACITIES

1. Bunkers and trenches:
(All weights and capacities are in tons fresh weight)

Wall height	Avg width	Corn Silage, 65% (15 lb DM/cu ft) Wall lenght			Haylage, 60% (14 lb DM/cu ft) Wall lenght			HMC, 30% (45 lb DM/cu ft) Wall lenght			Earlage, 38% (35 lb DM/ cu ft) Wall lenght		Snaplage, 42% (30 lb DM/cu ft) Wall lenght	
		60	80	100	60	80	100	60	80	100	60	100	60	100
8	20	169	250	331	138	204	270	253	375	497	222	436	203	400
	30	252	373	494	206	305	404	378	560	742	332	651	304	597
12	36	353	571	789	288	466	644	529	856	1183	465	1039	426	952
	60	587	949	1311	480	775	1071	881	1424	1967	774	1727	709	1582
16	36	NA	619	898	NA	505	734	NA	928	1347	NA	1183	NA	1084
	60	NA	1030	1495	NA	841	1221	NA	1545	2242	NA	1969	NA	1804

Note: Calculated using the spreadsheet available at fyi.uwex.edu/forage/harvest/#inventory and assuming:
Top width = avg width (measured at half wall height) + 2 ft
2 ft of dome height above the wall when avg width ≤30 ft
3 ft of dome height above the wall when avg width ≥36 ft
4:1 (lenght:height) filling ramp - included in the wall lenght for calculations
Packing density assumptions as shown on the table in lb DM/cu. ft.

2. Upright silo capactiy (tons fresh weight):

		Haylage		Corn Silage		HMC (ground)		Earlage	Snaplage
Dia (ft)	Hght (ft)	50%	60%	60%	65%	25%	30%	35%	40%
16	60	186	247	227	259	317	356	316	343
16	65	204	270	248	284	345	387	345	374
18	60	244	323	293	335	404	454	406	439
18	70	291	387	349	398	475	533	478	518
20	60	310	410	369	420	503	564	506	548
20	80	434	575	511	580	679	763	685	743
24	70	563	743	650	735	860	965	849	971
24	90	760	1001	862	970	1115	1254	1135	1231

Source: Savoie, Philippe, and Jan C. Jofriet. "Silage Storage." Silage Science and Technology. Vol. 42. Madison: American Society of Agronomy, 2003. 419. Print. Agronomy.

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