Corn Silage Management in California and Air Quality

Green Acres Blue Skye - June, 2010

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VOC Sources in Dairies

Cows

There are various VOC sources in dairy operations: cows

VOC Sources in Dairies

Commodities

Commodities, especially, when exposed to the elements (sun, rain, wind)

VOC Sources in Dairies

Silage

Silages

VOC Sources in Dairies

Feedbunk

Feedbunk

VOC Sources in Dairies

Farm Equipment

Farm Equipment

VOC Sources in Dairies

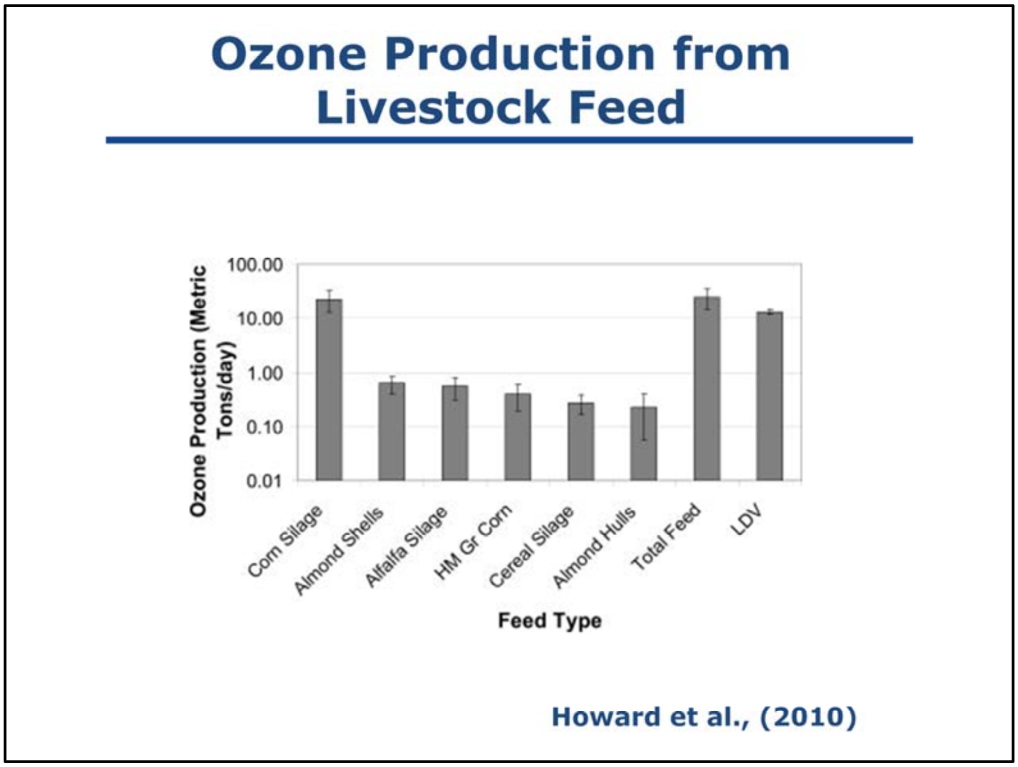
Manure Ponds

Manure Ponds

VOC Sources in Dairies

Farm Land

Farm Land



In a recent scientific publication, corn silage was estimated to be the major feed source of VOC in dairies.
In this figure, the x axis shows the different types of feed studied and the y axis indicates the ozone production in metric tons per day in a log scale.

Corn Silage

Corn silage is a commodity found in most California dairy operations. Silage is a way to preserve and store forage based on a low ph, below 4, and anaerobiosis.

Corn Silage

Silage making starts when fresh forage is chopped (left picture) and stored (right picture). The forage standing in the field is not sterile. There are bacteria and fungal groups mostly in bottom leaves and stems.

Typical populations of bacterial and fungal groups on plants prior to ensiling.

Group	Population (cfu g-1 crop)
Total aerobic bacteria	>10 000 000
Lactic acid bacteria	10-1 000 000
Enterobacteria	1000-1 000 000
Yeasts and yeast-like fungi	1000-100 000
Molds	1000-10 000
Clostridia (endospores)	100-1000
Bacilli (endospores)	100-1000
Acetic acid bacteria	100-1000
Propionic acid bacteria	10-100

Pahlow et al., (2003)

This table shows the different bacteria and fungal groups, and the range of colony forming units that can be found in plants prior to ensiling. It is important to notice that within each group we have different strains with different metabolic pathways, so there is a large diversity of microorganisms in silage.

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Pahlow et al., (2003)

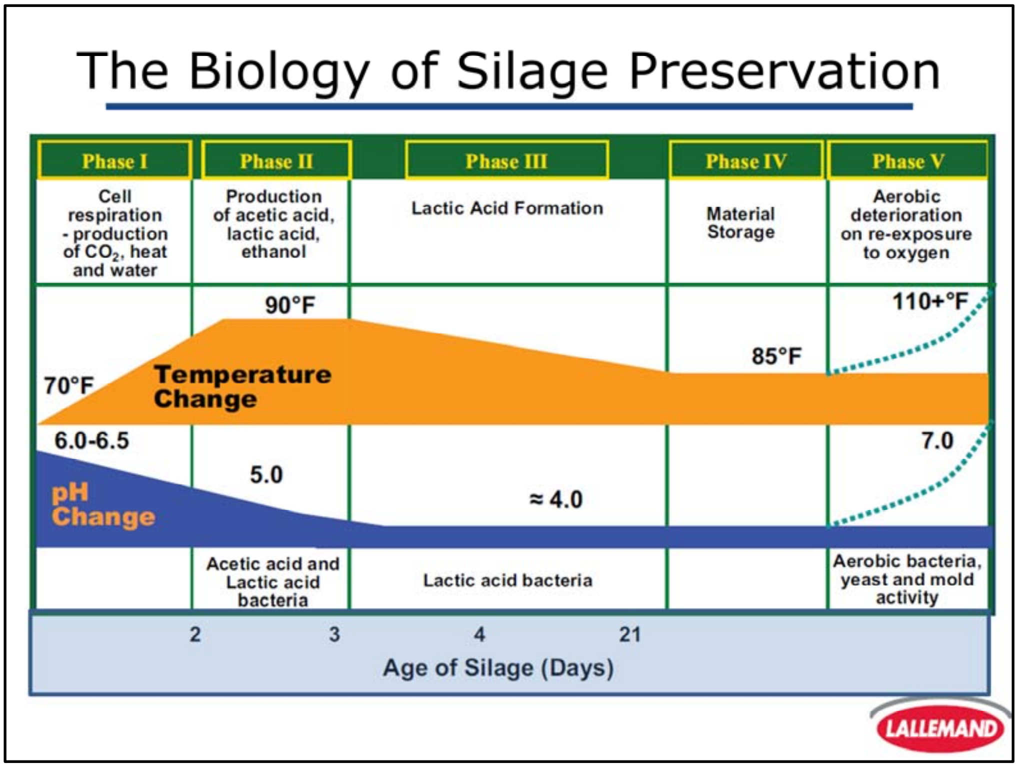
The group we are most interested in is the Lactic Acid Bacteria (LAB), in particular the homolactic ones. This group of bacteria can use carbohydrates to produce lactic acid, a strong acid that decreases the pH.

Corn Silage

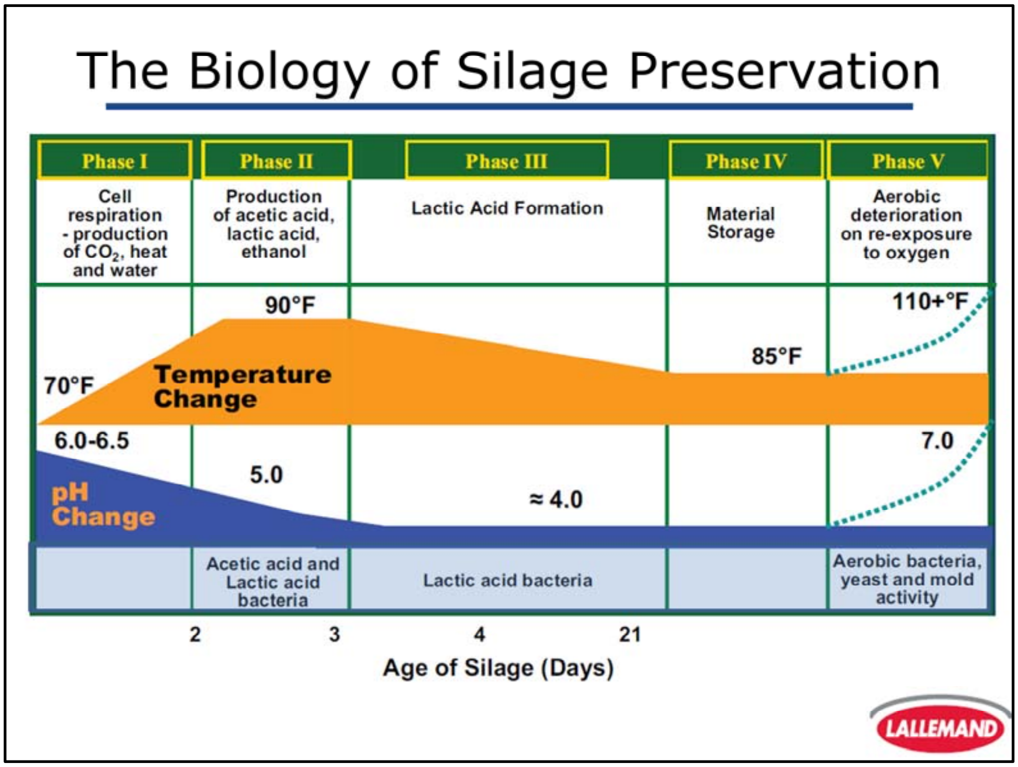
No Oxygen + Lactic Acid Bacteria & Carbohydrates =

Lactic Acid -> Low pH

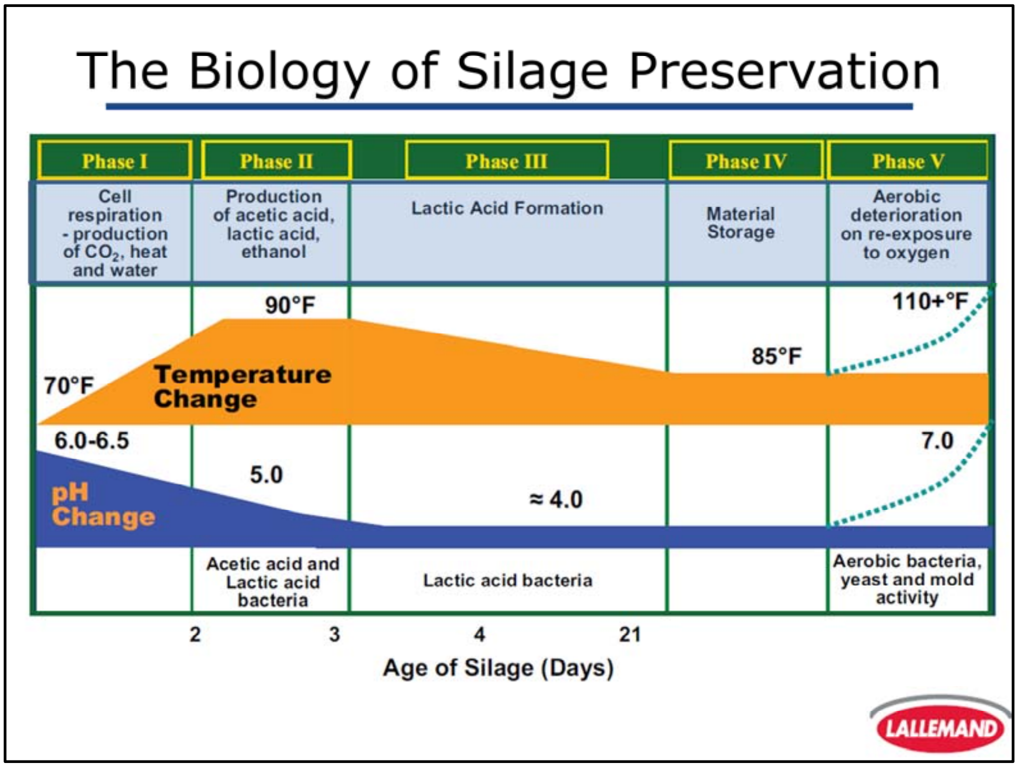
Silage making is based on elimination of oxygen from the forage mass so the LAB can produce lactic acid and the pH decreases.



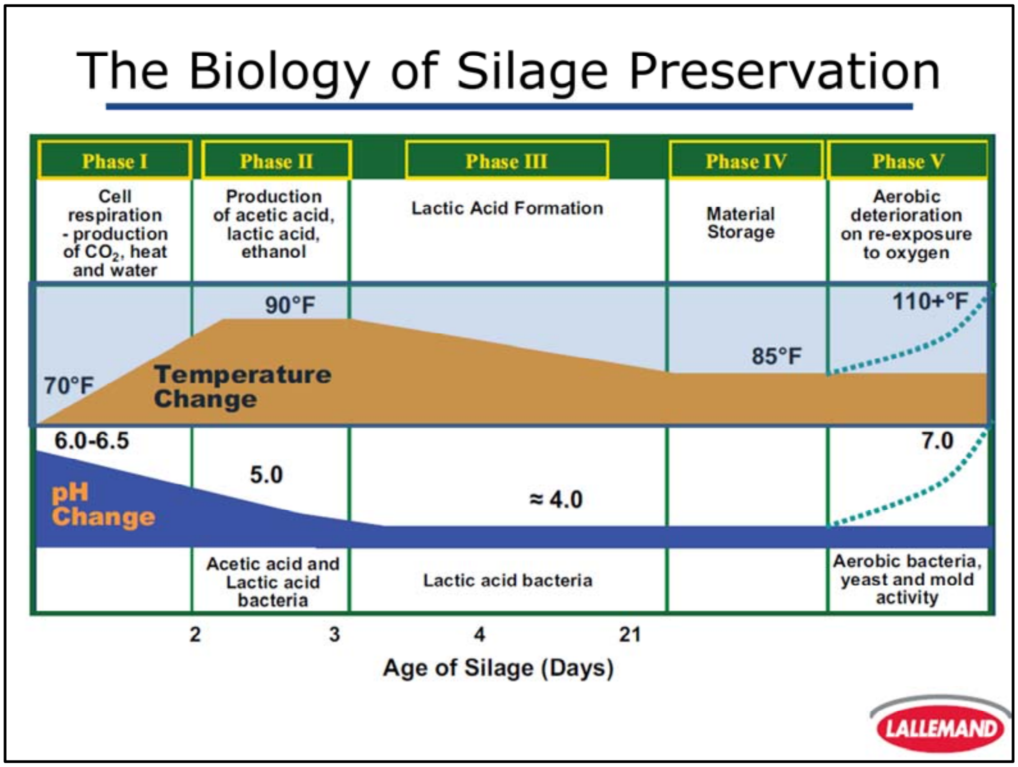
This figure represents the biology of silage preservation. On the X axis we have the age of silage. Over time, we can differentiate 5 different phases.



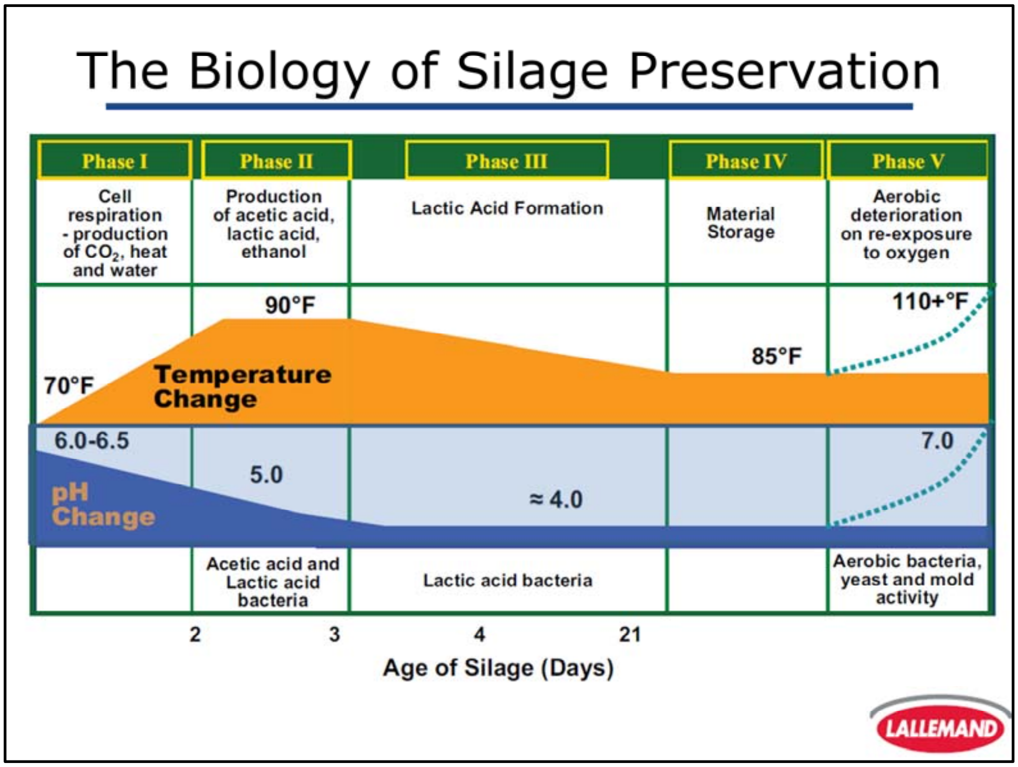
Different groups of silage microorganisms will thrive in the different phases and will be responsible for:



the various end products formed, some of which are VOC,



changes in temperature,

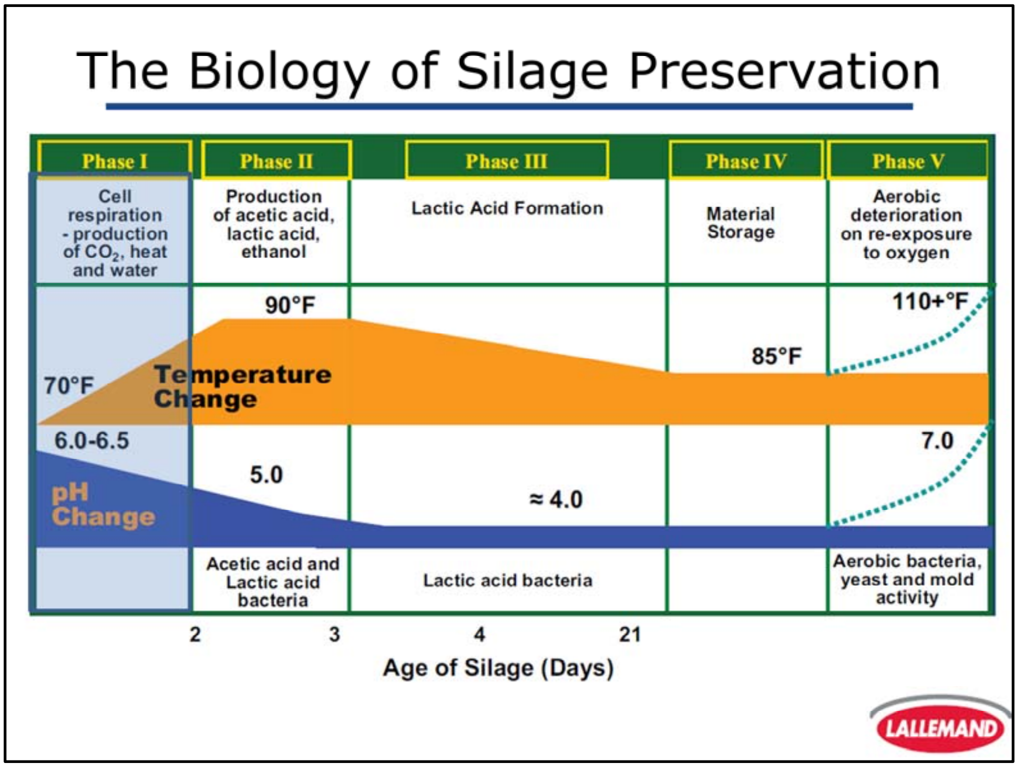


and changes in pH.

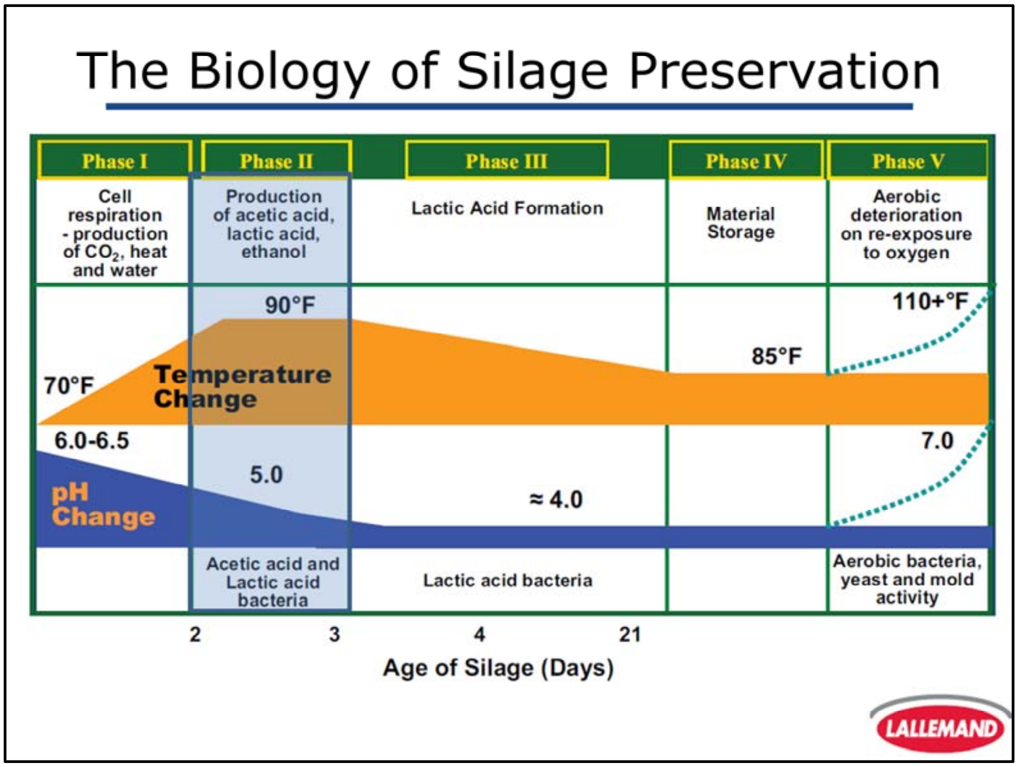
Factors Affecting Microbial Activity

- Temperature
- pH
- Oxygen
- Available Substrate
- Fermentation Products

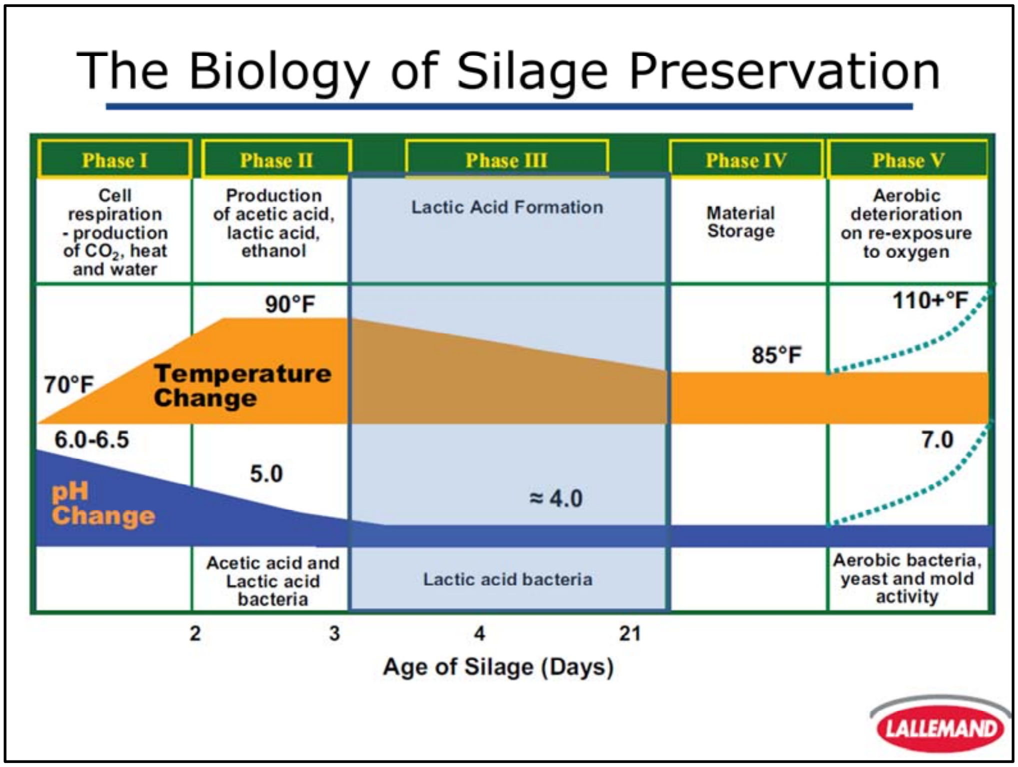
It is important to remember that the microbial activity is affected by temperature, pH, oxygen, available substrate and fermentation products. Different microorganisms will thrive under different conditions.



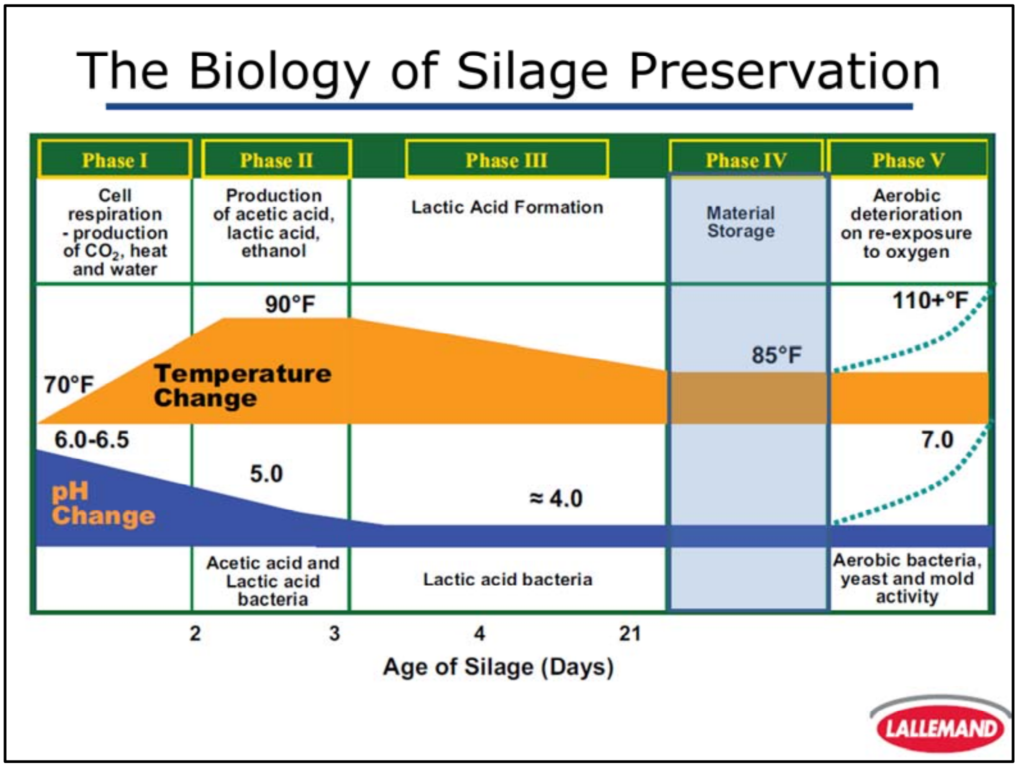
Phase I: the Aerobic phase. The oxygen trapped within the forage matrix maintains the respiration of plants and microorganisms.



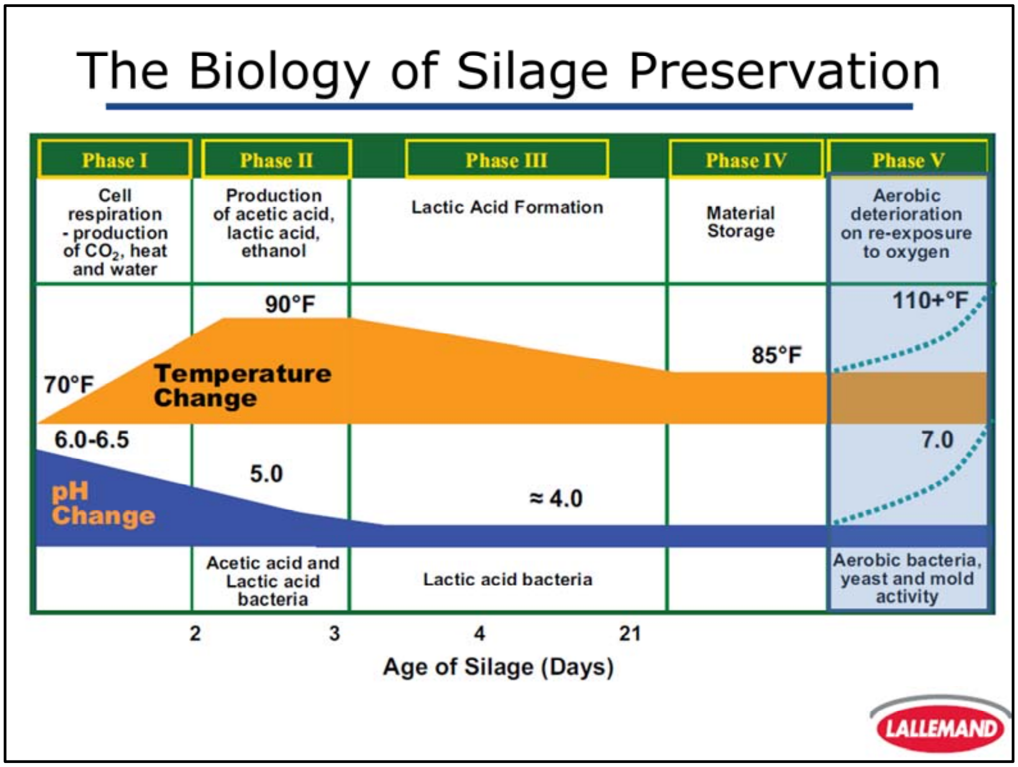
Phase II: Oxygen has been depleted but pH is still relatively high. Spoiling microorganisms can grow. But as LAB proliferate and produce lactic acid, pH decreases below the critical point, inhibiting or killing spoiling organisms.



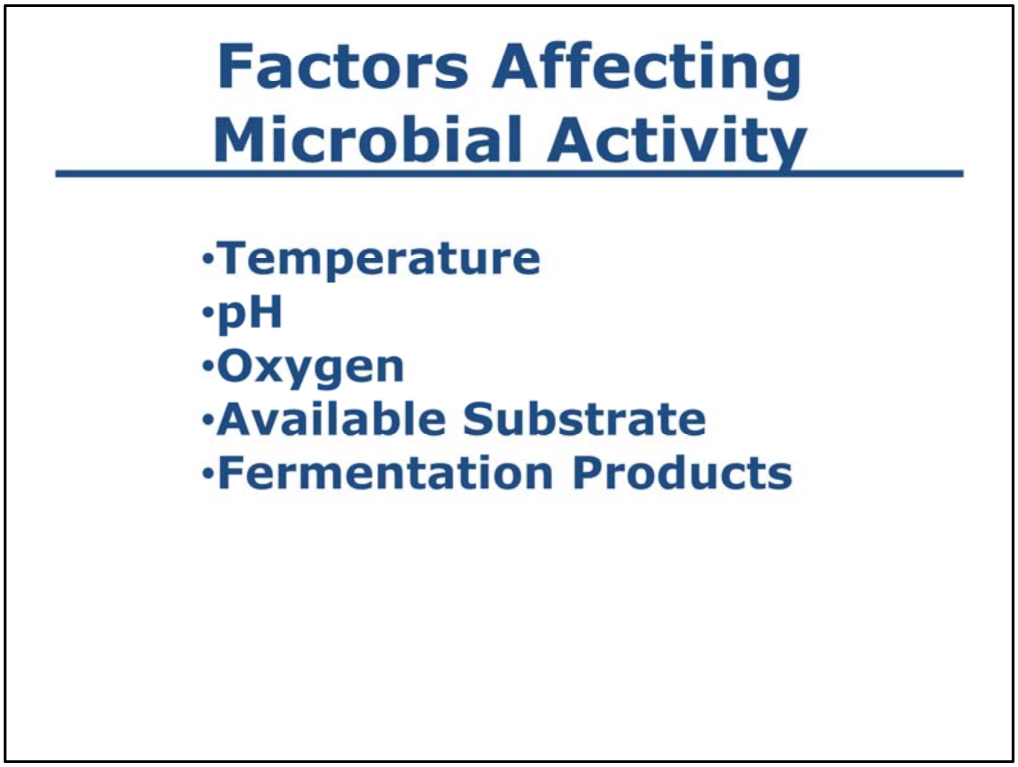
Phase III: Rapid Lactic Acid Production. Lactic acid bacteria are dominant and lactic acid becomes the predominant product formed. Lactic acid is the most effective of the organic acids produced in silages to decrease pH.



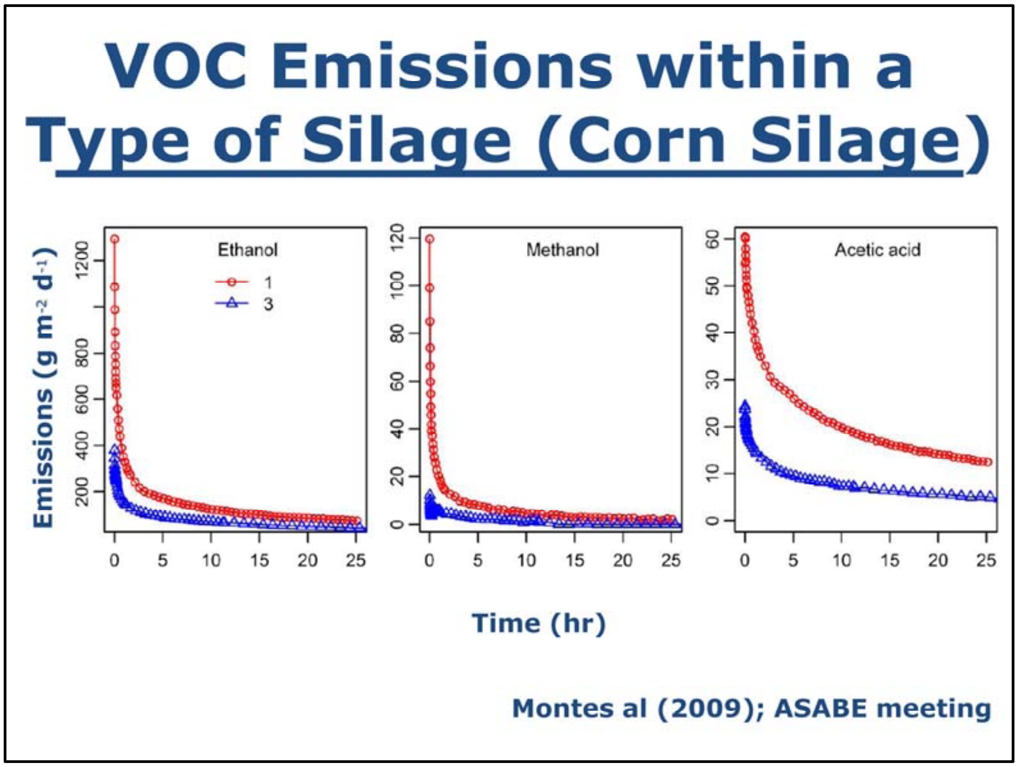
Phase IV: Stable phase. Little microbial activity will take place during this phase, but air may ingress into the silage, for example, through the top and sides of bunkers and pits.



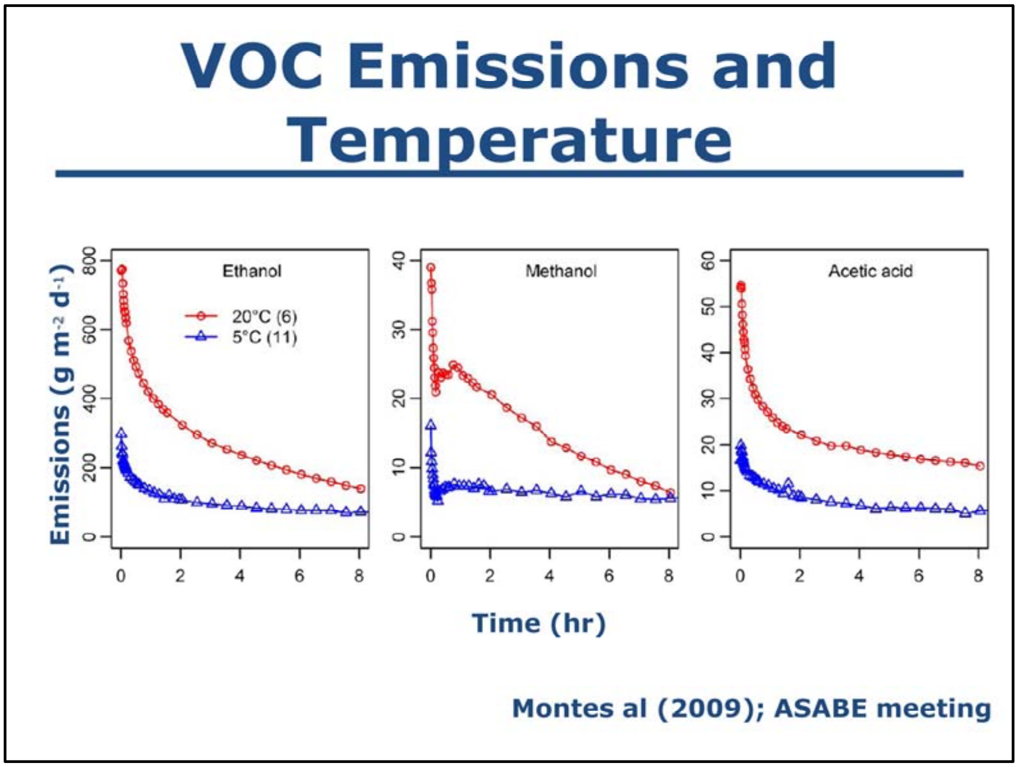
Phase V: Feedout. As the silage begins to be fed, it is again exposed to air. Oxygen can infiltrate at least 3 feet into the face. Aerobic organisms that survived the ensiling process, e.g. bacilli, yeasts and molds, can grow.



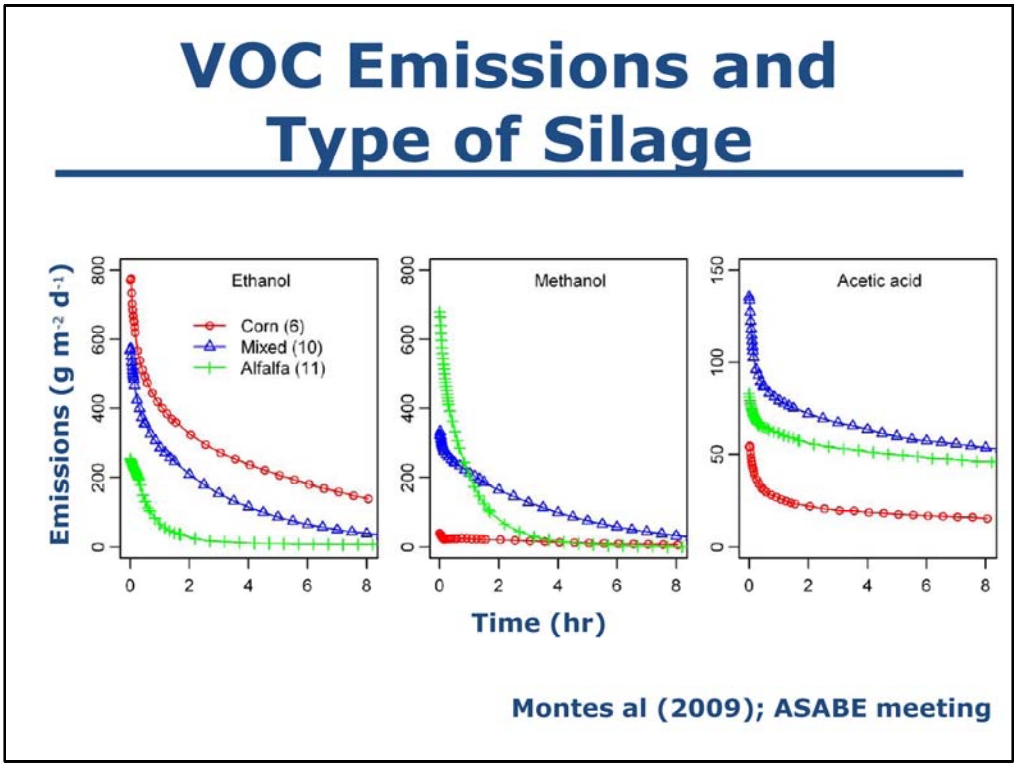
As previously mentioned, microbial activity is affected by temperature, pH, oxygen, available substrate and fermentation products. Different microorganisms will thrive under different conditions, and fermentation products and VOC production will differ.



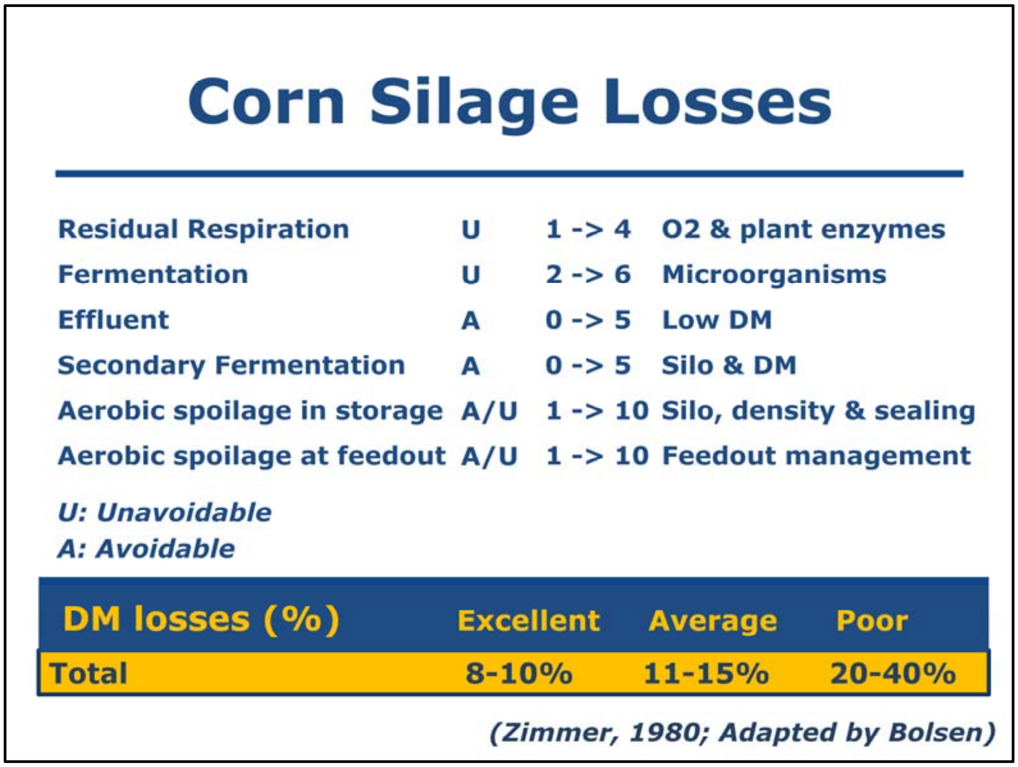
Montes et al., measured emissions from two different corn silages stored in bunkers. On the x axis, we have time in hours and on the y axis, the emissions in $g/m^2/d$. Differences in corn genetics and management practices at growing, harvesting, storing and feeding out will affect the microbial population activity in the silage, and, therefore, VOC emissions. Two corn silage samples will have different nutritional components and fermentation profile.



Corn silage samples stored in bags had different emissions of ethanol, methanol and acetic acid when exposed at different temperatures. The red line shows samples exposed at 20C, and the blue line at 5 C.



VOC emissions of ethanol, methanol and acetic acid were different for different forages. This is not a surprise considering that microorganisms are exposed to different nutrients and growth conditions across forages.



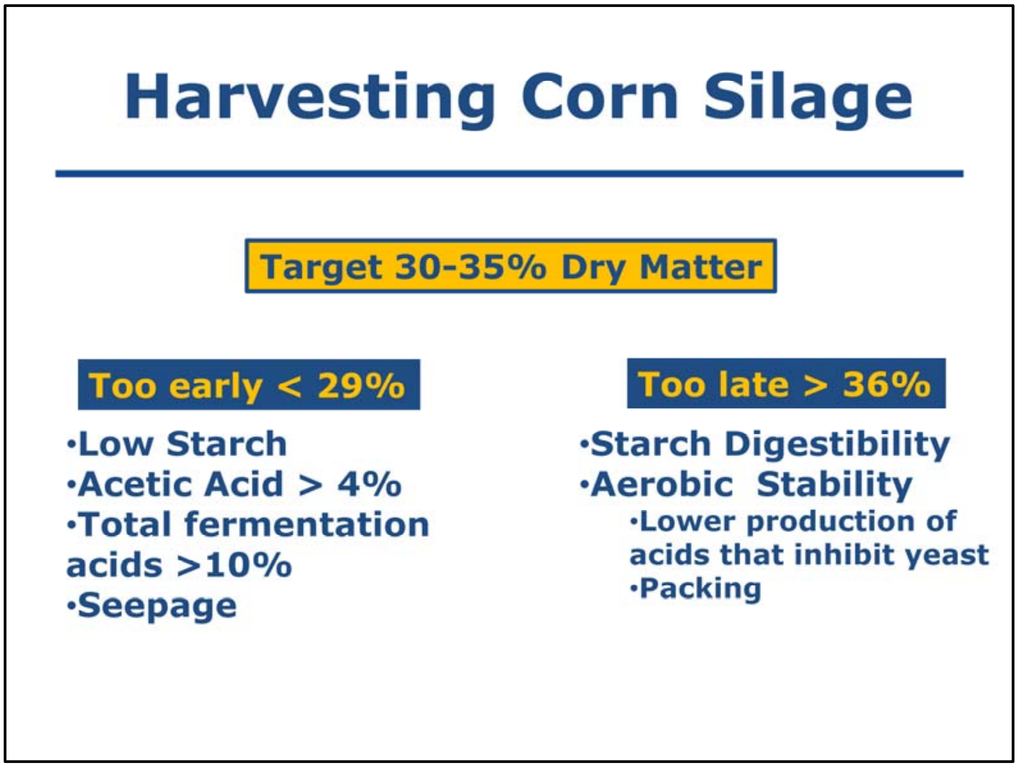
This slide shows avoidable and unavoidable dry matter losses at the different phases of the ensiling process. Well managed silages experience less than 10% DM losses, while poorly managed silages can potentially lose between 20 and 40%. The dry matter is lost to the environment as a leachate, air emissions or spoiled feed.

Best Management Practices: Corn Silage

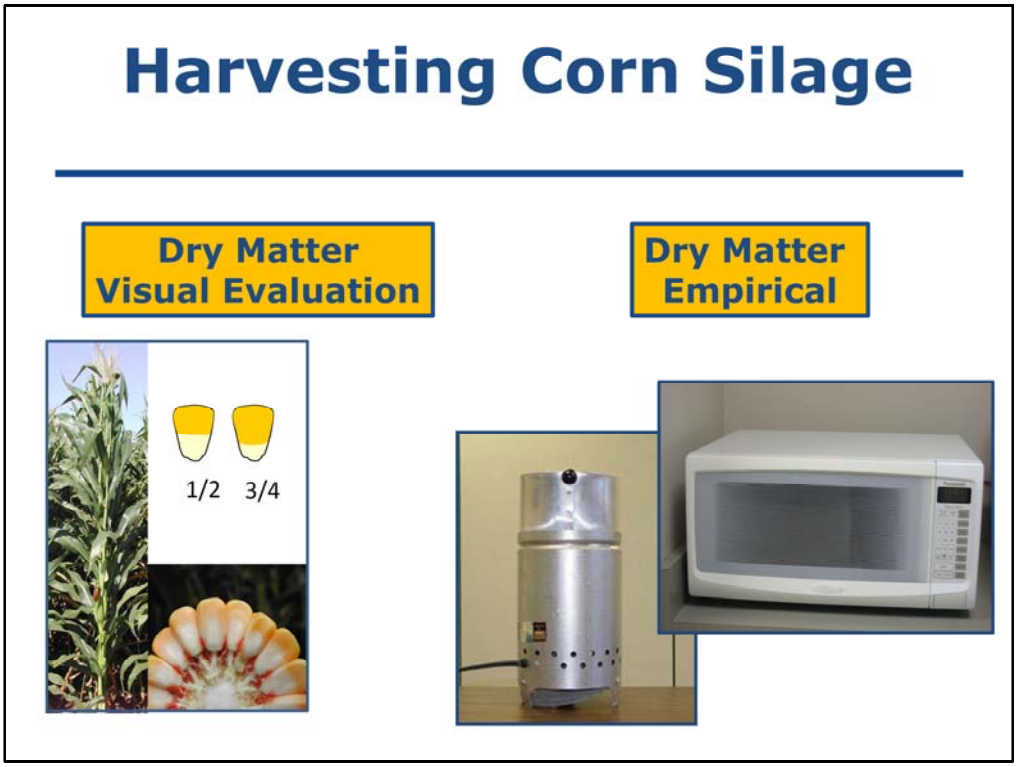
Harvesting Corn Silage

When is it Time to Harvest?

The first decision in silage making is when to harvest.



The target is to harvest the corn crop when it is at 30-35% of dry matter.
If we harvest corn too early, the crop will be lower in starch. There would be greater production of acetic acid and other fermentation acids that are not as effective as lactic acid in decreasing pH. Also, we will observe greater losses as a run-off.
If we harvest too late, the starch digestibility would be compromised as well as the aerobic stability during feed out. The aerobic stability is compromised because there would be less production of acids that inhibit yeast (i.e. acetic), and packing is more difficult.



We can estimate dry matter by visual evaluation of the stalk and the kernel. But if we want to be more accurate, it is better to chop some corn plants and determine dry matter using a microwave or a koster tester.

There are several challenges that producers need to face before deciding when to harvest. It is not uncommon that producers plant several hybrids, and maturity might be reached at different times.

Producers may plant several hundred of acres, and harvesting all fields may take several days. During the heat of the summer, dry matter may change 0.5 to 1% dry matter units.

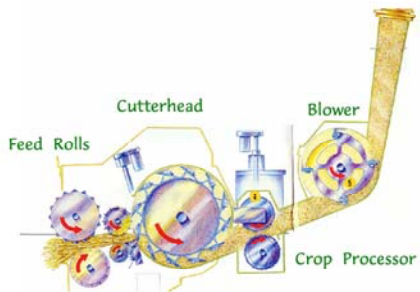
Most producers hire external labor to custom harvest for them. Custom harvesters have a tight schedule during the harvesting season, and producers need to communicate with them early to schedule their services.

Harvesting Corn Silage

Harvesting

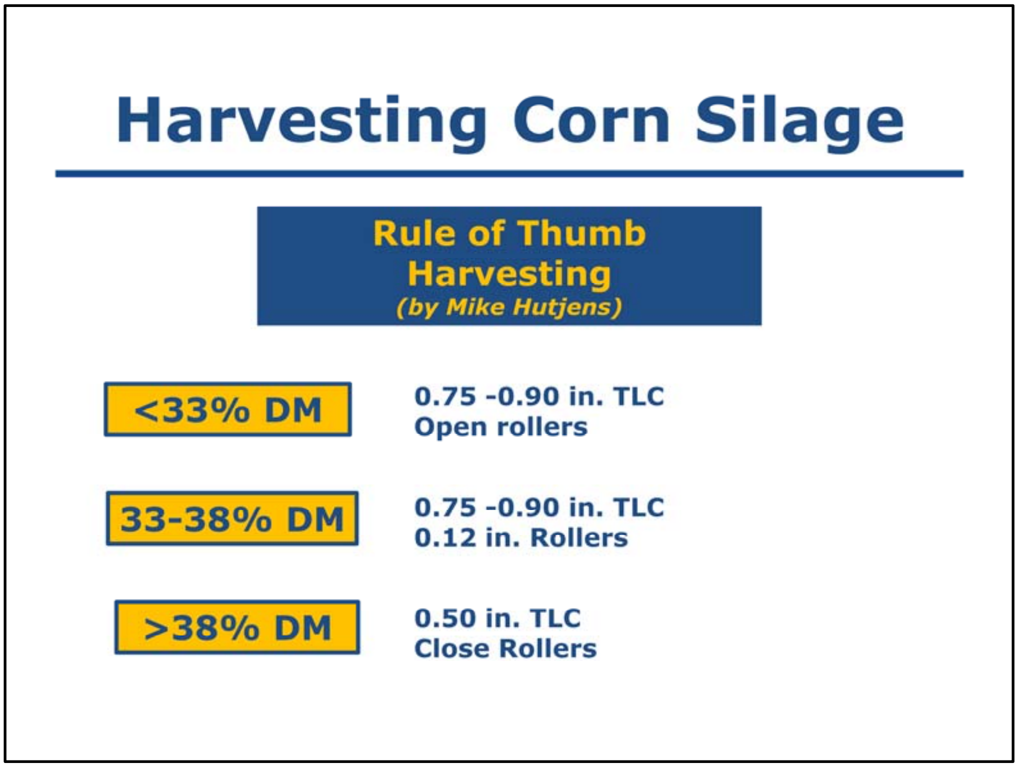
Harvesting Corn Silage

Cutterhead



Rollers

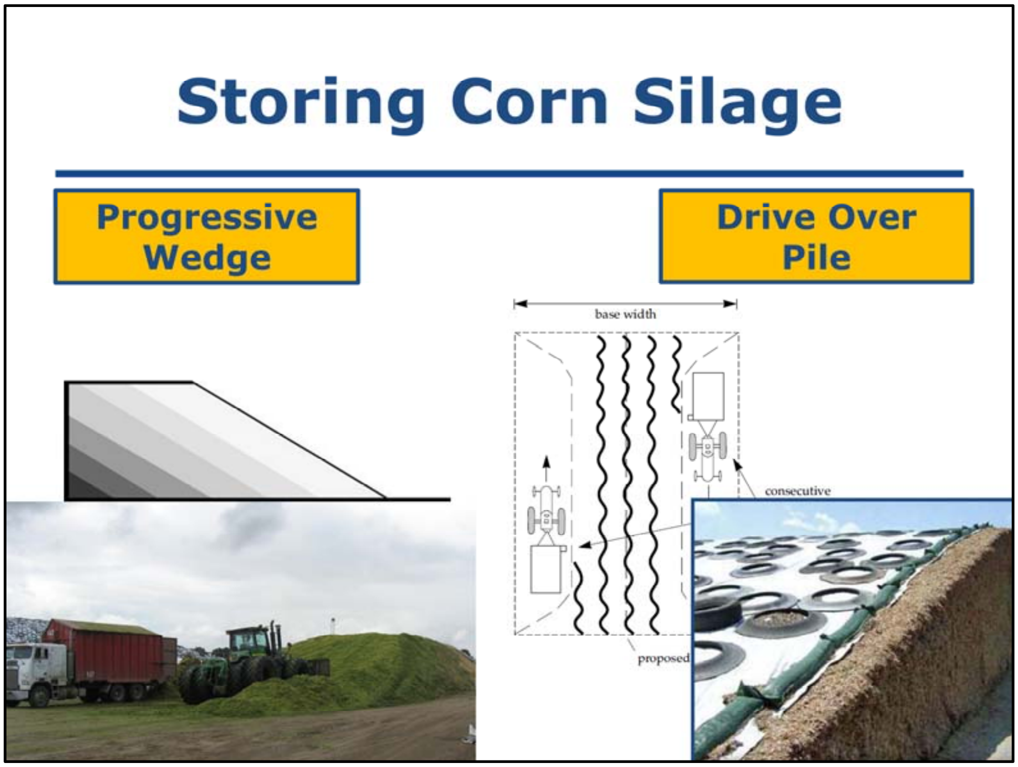
Harvesters are equipped with knives and rollers. The figure in the middle represents a harvester. First the forage enters the harvester (left) and goes through the cutterhead and the crop processor (right). The theoretical length of cut "TLC" of the cutterhead and the opening of the rollers should be adjusted based on dry matter.



Here we have some guidelines from the University of Illinois. The more mature or drier the plant is, the more aggressive we need to be at harvesting, with shorter chopping and closer rolls. On the other hand, the lower the DM, the rolls can be more open and the chopping length can be longer.

Producers may face different challenges at harvesting.
Different fields may have different dry matters, and the rollers and the TLC should be adjusted based on dry matter. Therefore, it may be necessary to change settings from field to field.
Producers should monitor the green forage harvested to ensure proper chopping and processing. The forage should not be too coarse or too fine.
The knives of the cutter head should be sharpened frequently to be effective.

In California, most silage is stored in piles and bunkers. Bags are not nearly as popular, and they are used in combination with one of the other storage types.



Most piles are built as a progressive wedge. The forage is pushed up in layers that should be no thicker than 6 inches.
There are a few silage pits that are drive-over piles. They have a larger fingerprint, as they take more space from the commodity area. Not every producer has the space to build this silage structure. They are no taller than 8 to 10 feet. They have the advantage that packing tractors can drive across the pile ensuring better packing.

Storing Corn Silage

Challenges at Packing: Delivery Rate

There are several challenges at packing. One of them is when the delivery rate of fresh chopped forage into the silage pit is too fast to achieve proper packing.
Before new fresh chopped forage is pushed up, the silage surface should look like the bottom picture. The tractor tracks are obvious and no loose material is observed.

We could increase the number of packing tractors to cope with a fast delivery rate. Here three tractors are packing a single silage structure.

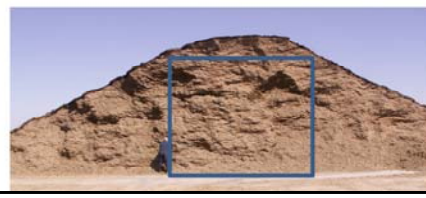
Storing Corn Silage

Challenges at Packing

Driving a packing tractor requires skills. To pack the edges, difficult maneuvers are required. It is difficult to pack silage built this size (bottom picture).

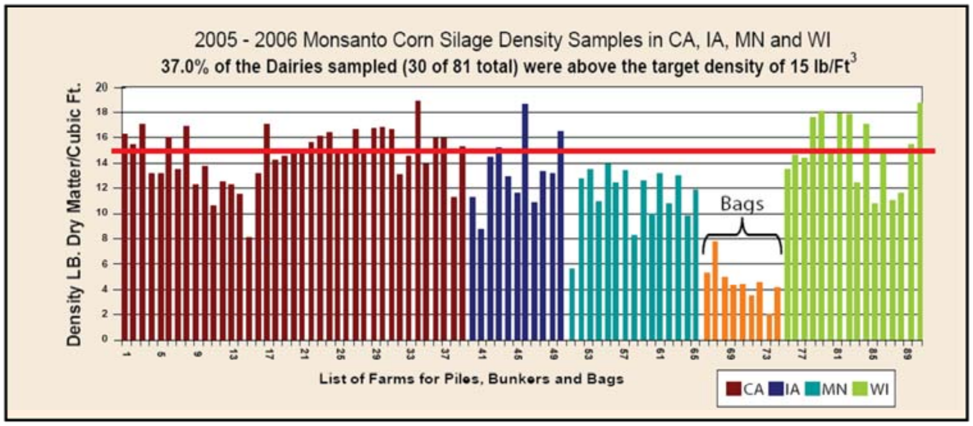
Storing Corn Silage

Challenges at Packing



So what affects packing density, and how can we increase it on the farm? Most of the items on the list are within your control to change: harvesting at proper DM, size of tractor or number of tractors used, how long the tractor is packing the silage, and how much forage is being packed per pass.

Packing Density –Data



To monitor if packing is properly done, we can monitor packing density. This figure shows packing density in California, Iowa, Minnesota and Wisconsin. As you can see, packing density is not just a California problem. Only 37% of dairies met the minimum recommended packing density.

Covering Corn Silage

Covering

Covering should be done immediately after the silage is put up. There are enterprises providing this service to dairies.
Here we have some people placing tires. Tires are used to maintain a close contact between plastic and silage.

Here we have more pictures of people covering silages. Silage should be sealed on the edges with sand, gravel bags or other materials.

Covering Corn Silage

Challenges at Covering

This silage (left picture) was temporarily covered until another field reached the proper dry matter/ maturity. After a week, the silage was reopened and the new field was added to the silage pile (right picture).

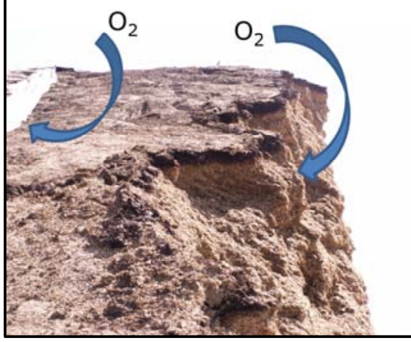
Covering Corn Silage

Tulare County, May 2010

There is an opportunity to prevent dry matter losses by covering silages.

Corn Silage Feedout

Feedout Losses: 1 to 10 % of DM



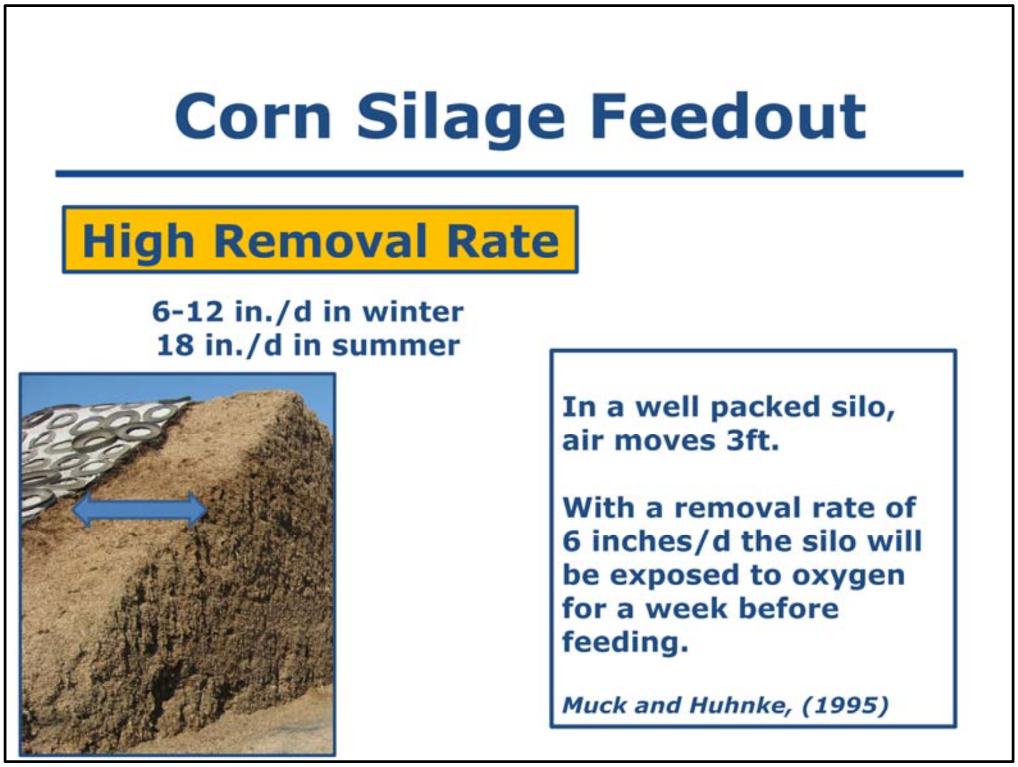
-Silo is exposed to oxygen

- Yeast metabolizes lactic acid

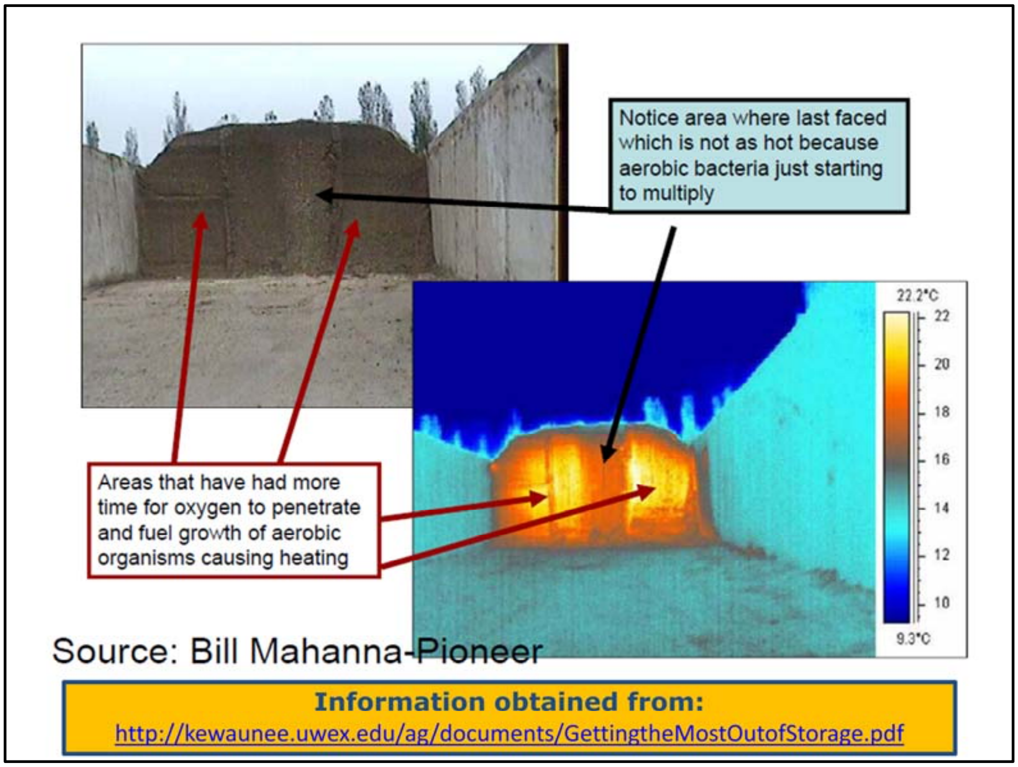
- Silage pH increases.

- Undesirable bacteria are able to grow and further spoil the silo.

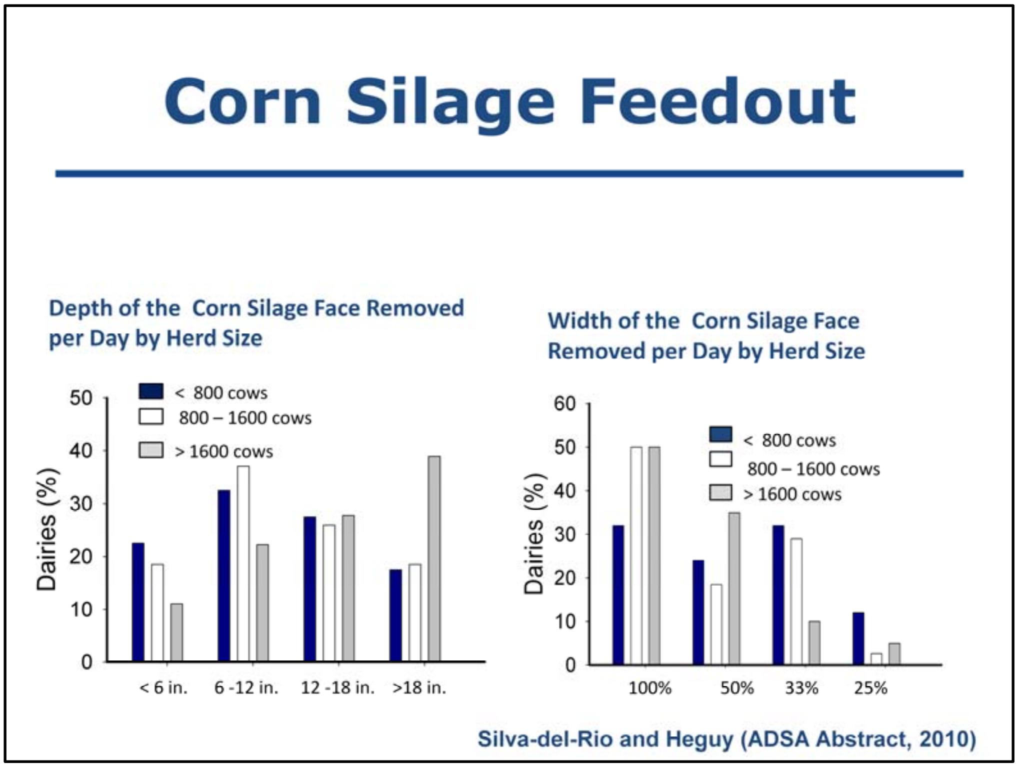
During feedout, losses can be up to 10% of DM. When silos are exposed to oxygen, yeast can metabolize lactic acid. The pH increases and other undesirable bacteria are able to grow and further spoil the silage. We are going to review face management practices that can help to minimize feedout losses.



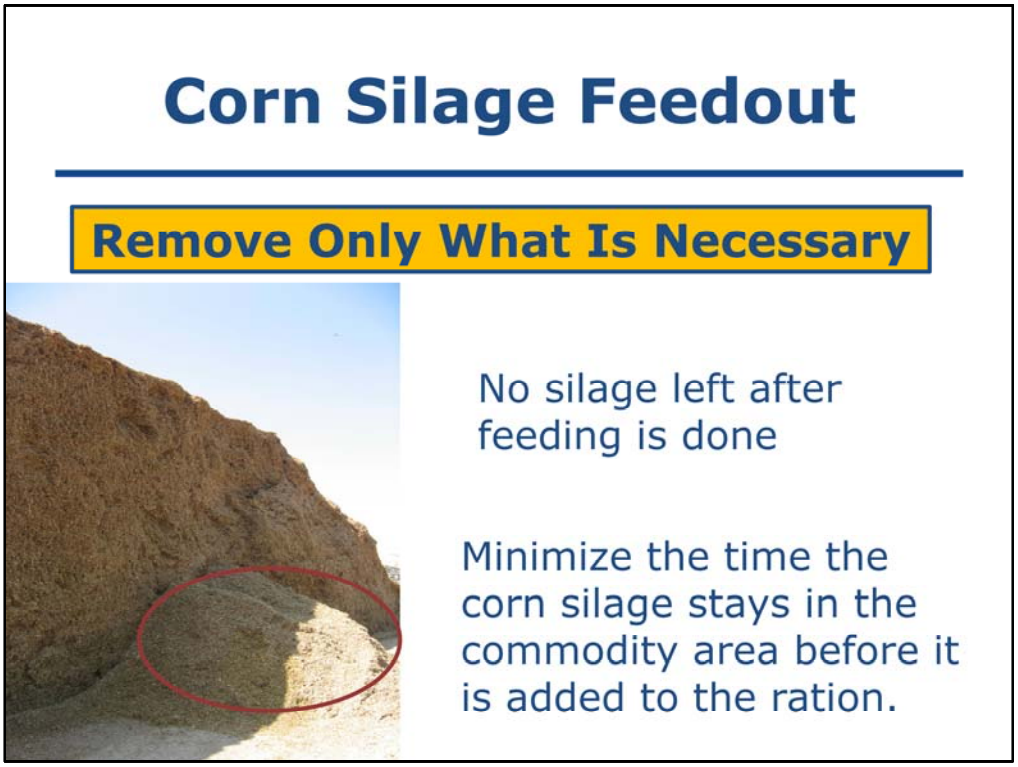
It is very important to maintain a rapid progression through the face. The rule of thumb is to take between 6-12 in/d in cold weather and 18 inches in warm weather, but is that enough? In a study from 1995, Muck and Huhnke evaluated how far the air moves into a well packed silo. They found that air moves into the silo 3 ft. Therefore, with a removal rate of 6 inches per day, the silo will be exposed to oxygen for a week before feeding. So, we can only achieve a good removal rate if we properly size the silo!!!



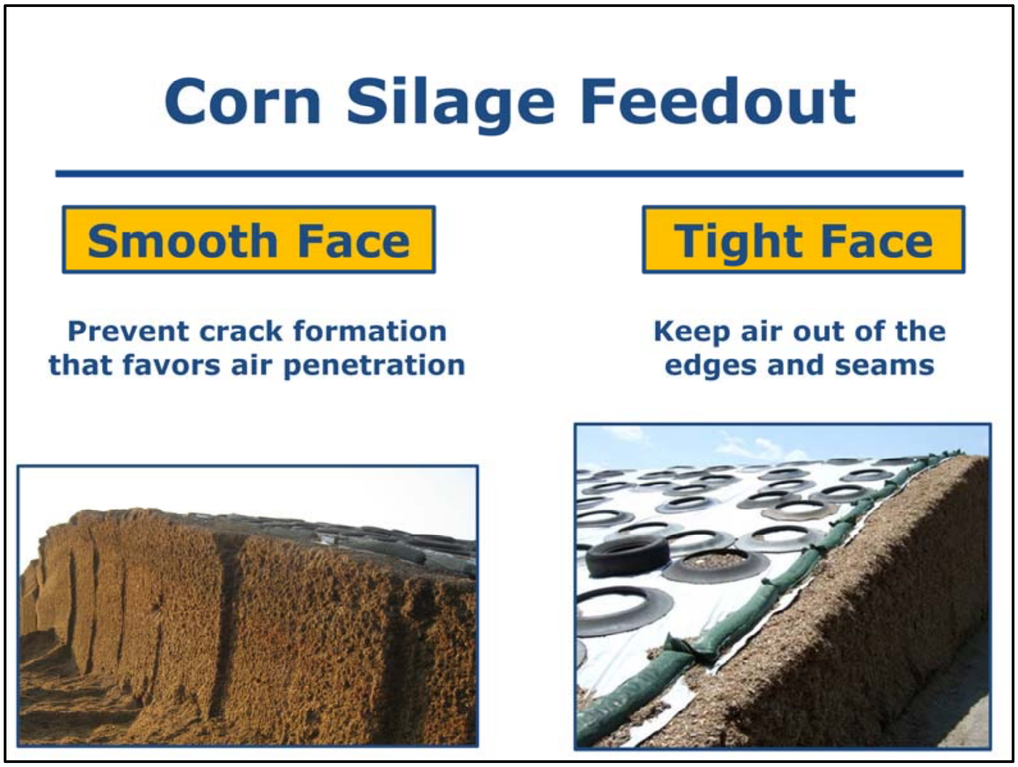
The middle section of the corn silage was shaved and the infrared picture shows that that area is cooler because aerobic bacteria are just starting to multiply. This slide has been extracted from Dr. Brian Holmes' Extension Presentation. For more information go to: http://kewaunee.uwex.edu/ag/documents/GettingtheMostOutofStorage.pdf



In Summer 2009, a feed management survey was mailed to dairy producers in Tulare, Stanislaus, and San Joaquin, the first, third and seventh largest dairy counties in California. Response rate was 16.9% (120/710). Herd size ranged from 160 to 6,600 cows (median=950). These figures represent current face management practices, width and depth of face removed, in California dairies by herd size. There is an opportunity to size piles properly so the whole width of the face is removed every day at a proper depth.



It is important to minimize the time the corn silage stays in the commodity area before it is added to the ration. It may be necessary to remove silage from a bunker or pile and move it to the commodity area two times per day. There should be little or no silage left at the base of the face after feeding is finished for the day.



The feedout face should be a smooth surface that is perpendicular to the floor and sides in bunker or pile. It is important to prevent crack formation that favors air penetration. Keep the air out of the edges and seams. One solution is to put weight on the plastic at the leading face.

This feeder is removing silage from the face upwards. This increases the air infiltration into the forage mass.


DEERE


DEERE


DEERE


DEERE


Dairy 1
DEERE

This dairy is able to face a smooth surface using a front loader by shaving side to side.


Dairy 2

This dairy uses a defacer. Research from the University of Wisconsin estimated that dry matter losses could be minimized by 3% using these types of devices.

Some Current Management Issues with California Corn Silages

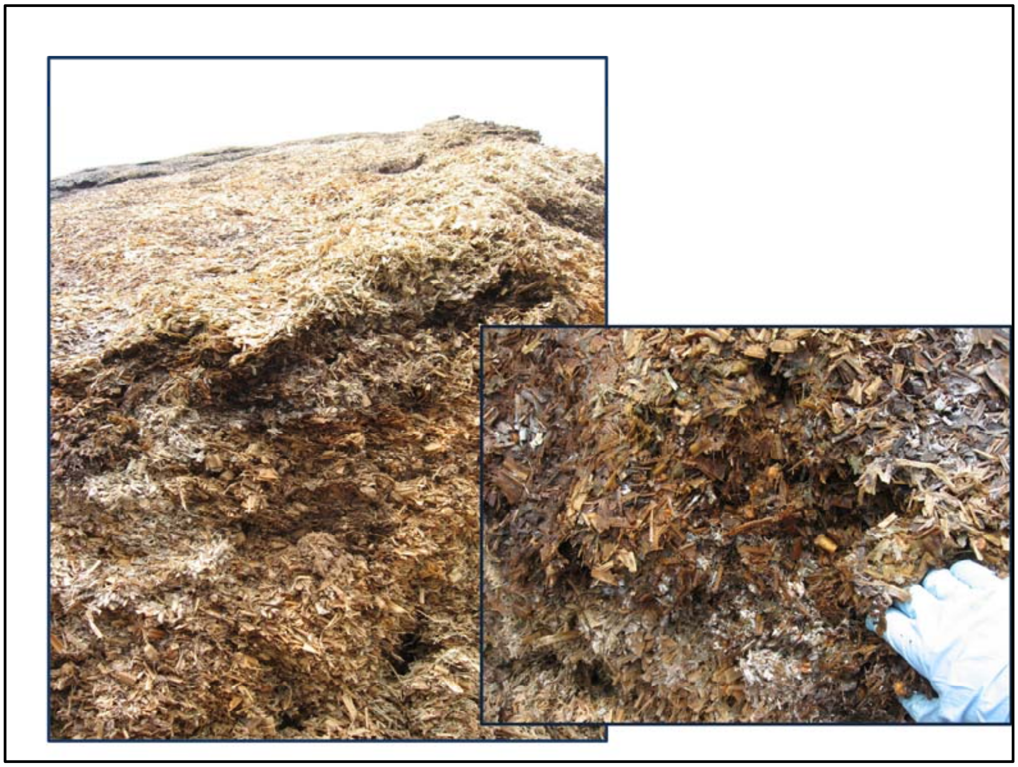
This picture shows an inactive face. Due to space issues, the producer was forced to close one end of the face and put in new silage. The other end of the silage pit is now an active face.

Tires should touch to ensure proper contact of plastic with forage mass.

This picture shows how poorly compacted the forage mass is. We can see the imprinting of tires halves, which are light in weight, on the surface.

The “U” shaped face is not desirable. It results in an increased surface of feeding area.

This picture shows the side of a silage pit, while it was being built as a progressive wedge. Just by walking on the side we can see how poorly compacted the sides are in a progressive wedge silage pile.



This picture represents the growth of aerobic microorganisms on the top and sides of the silage due to oxygen exposure.

Spoiled forage on the top and the side of the pile needs to be removed, creating hard, extra work.

THANKS