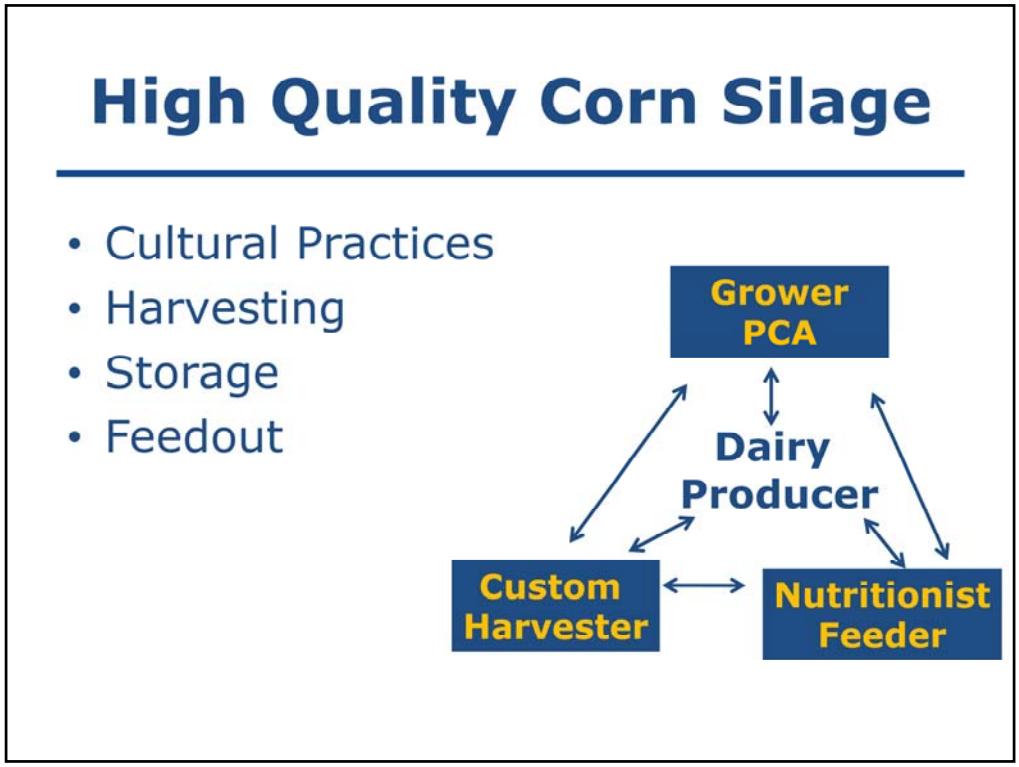
In this talk, opportunities to improve silage quality in California through management will be discussed.

Corn silage is a commodity found in most California dairy operations.



To maximize crop yield and minimize ensiling losses, we need to excel in the following management practices:
Cultural Practices, Harvesting, Storage, Feedout.
To achieve this goal, dairy producers need to trust the services of growers, pest control advisors, custom harvesters and nutritionists. The dairy producer should ensure an efficient communication with the different members of the silage team. Otherwise, poor communication may have a direct impact on the quality and quantity of the ensiled forage.

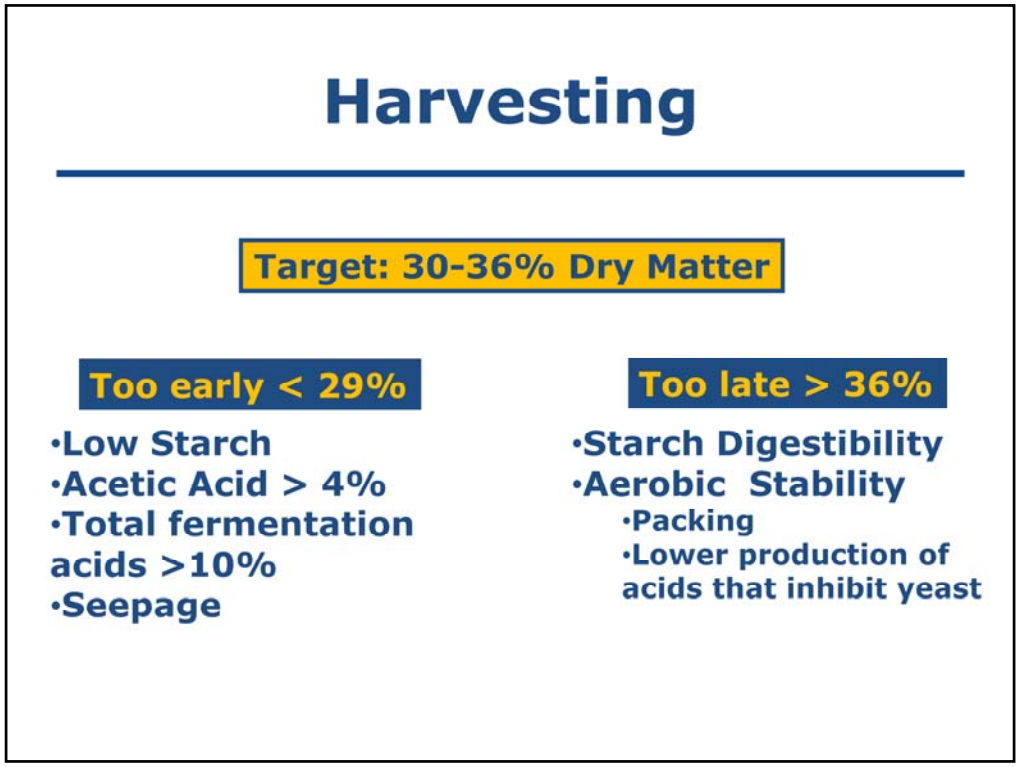
Outline

- Harvest
  - Targeting proper dry matter
  - Kernel processing and theoretical length of cut
- Storage
  - Packing density
- Feedout
  - Face management

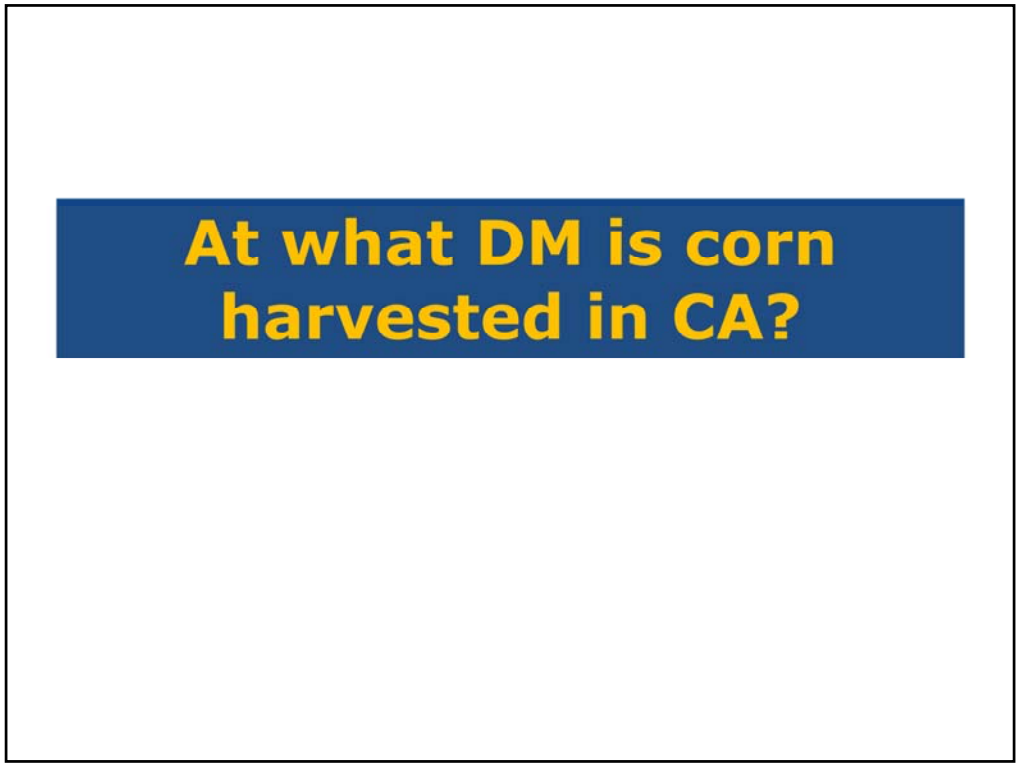
The outline for this presentation is as follow:
Harvest: the focus would be on targeting the proper DM, Kernel process and TLC.
Storage: how well are the silages packed.
Feedout: proper face management.

When is the corn ready for harvesting? One of the greatest challenges in corn silage production is to decide when to harvest to achieve the proper moisture. The interactions between forage yield and quality, genetics and environment make it difficult to properly time harvest. In addition, we have to take into account the following considerations in California:

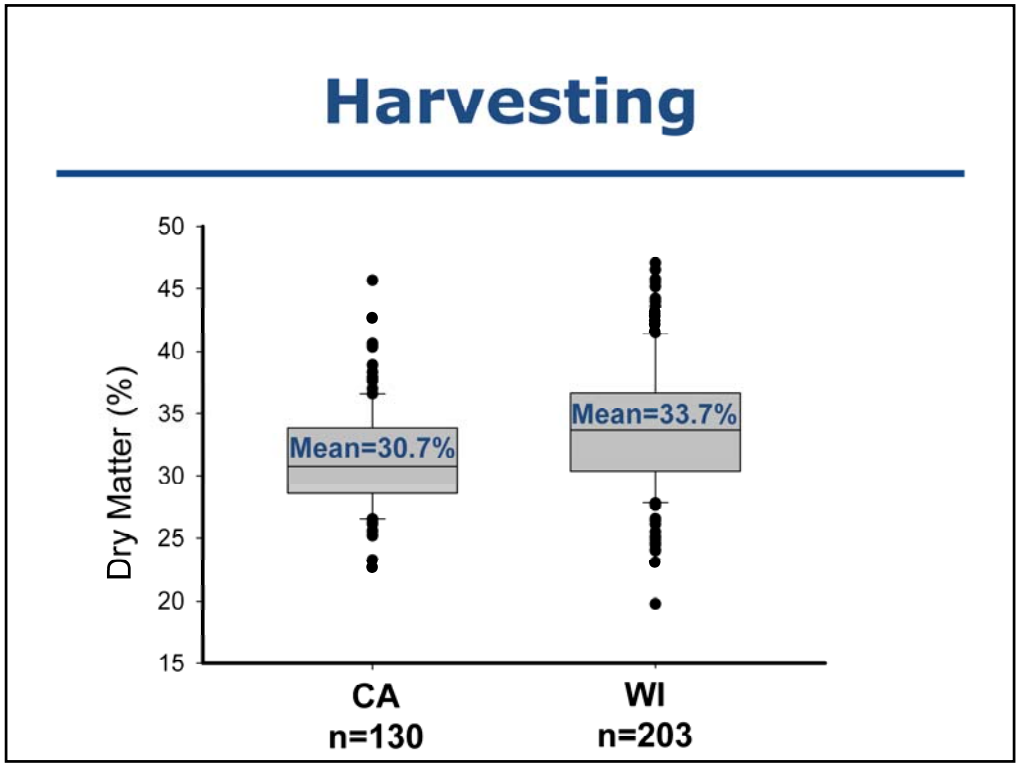
1. It is likely that growers have planted different hybrids maturing at different times.
2. The large scale of California farms implies that harvesting one field may take several days, and during the heat of the summer, dry matter may change 0.5 to 1.0% dry matter units.
3. Timing the last irrigation may be challenging. It can take 10-20 days after the last irrigation before the harvesting equipment may enter the field.



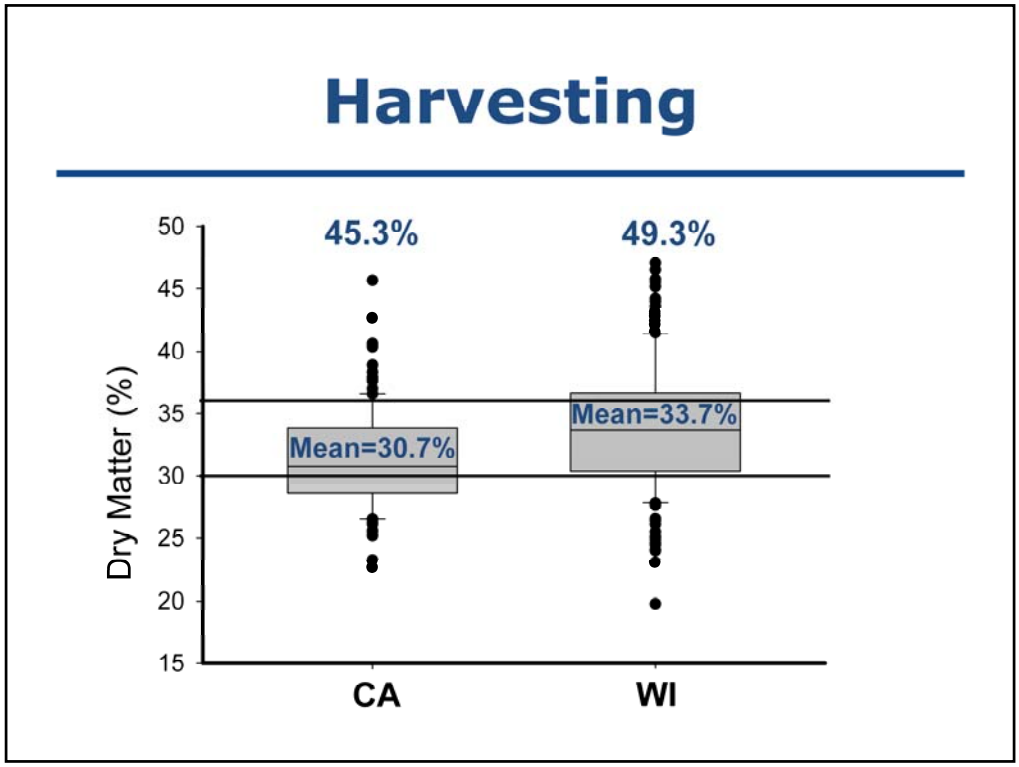
It is recommended that corn be harvested when DM is somewhere between 30% to 36%.
If we harvest corn silage too early (lower DM), starch will be low; whereas, acetic acid and total fermentation acids will be high. Also, there would be higher run-off or seepage.
If we harvest corn too late (higher DM), the starch digestibility would be compromised. Also, the aerobic stability may be affected, as drier forage is harder to pack and there is less production of acids that inhibit yeast (such as acetic acid).



At what DM is corn harvested in CA?



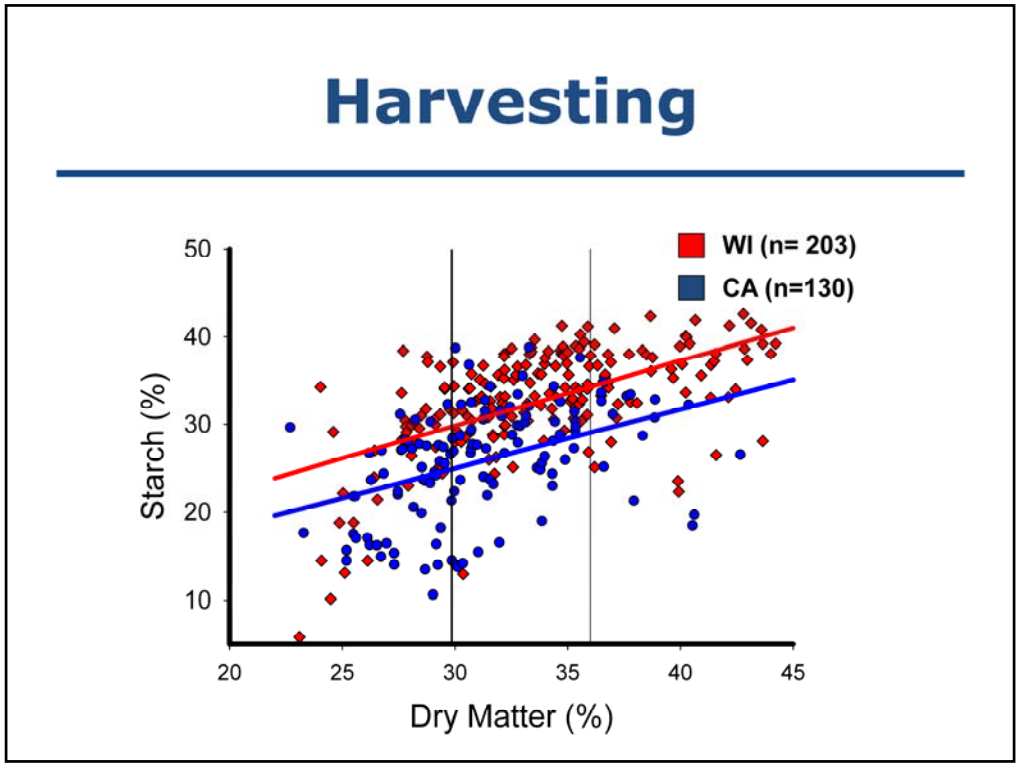
To answer that question, a data set provided by the allied industry is presented. The 2009 data set counts with 130 corn samples from CA and 203 from WI. The rectangular box represents 50% of the data. The dots represent 10% of the extreme observation on the top and 10% of the extreme observation on the bottom. The mean or central value was 30.7% for CA and 33.7% in WI.



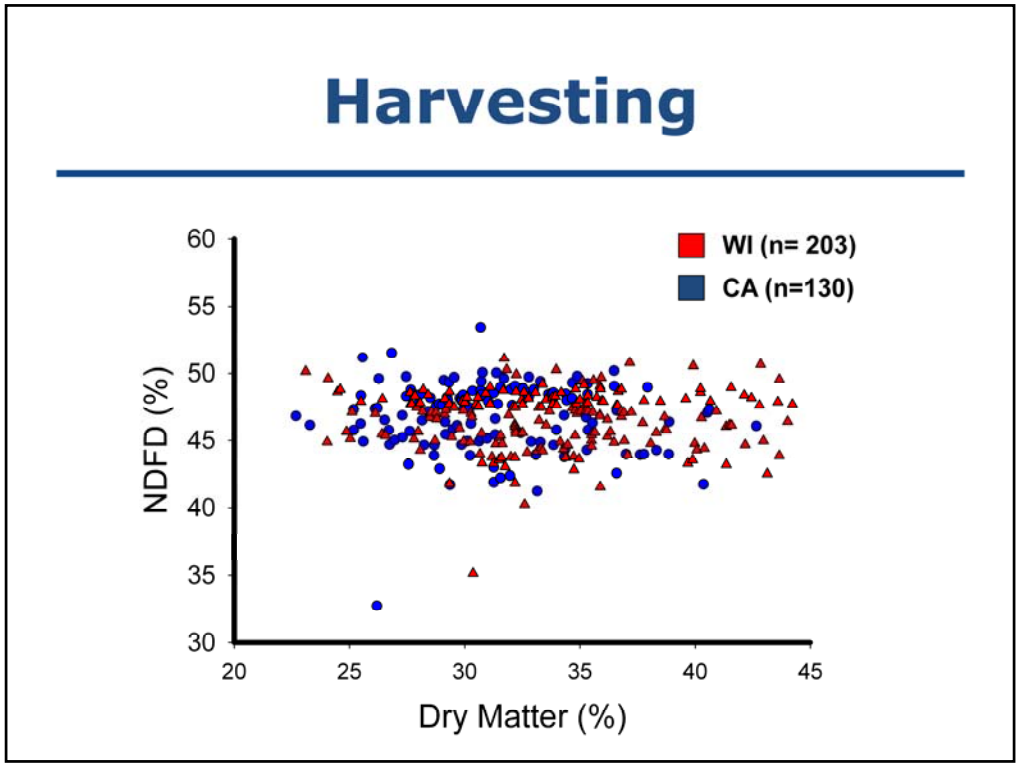
Forty-five percent of the silage samples from CA fell within the desired DM range, whereas samples collected in WI were 49.3%.

There is a lot of discussion in the field among the different silage team members on what the desired DM should be. As a norm, custom harvesters are inclined to harvest on the wet side, whereas nutritionists like to target on the drier side.

What are the implications on silage quality of harvesting at different DM?

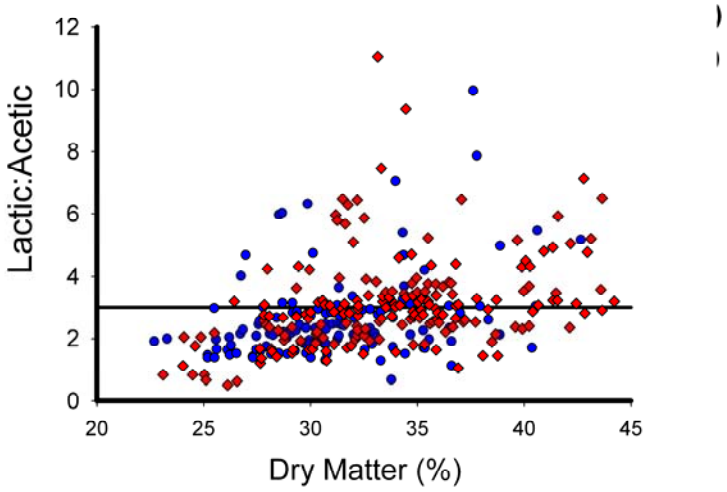


To answer that question, here is a plot with the Starch% in y axis, DM% in X axis. The lines represent the best fit of the data but the R-square are very poor. However, for the purpose of this presentation we are going to infer from the regression lines. The starch level increases with DM, and at any DM, corn silage harvested in CA has approximately 4% less starch than in WI. Based on best estimates calculated for this data set, harvesting at 30% of DM in CA will result in starch level of 25% and at 36% of DM will result in 29% of starch.

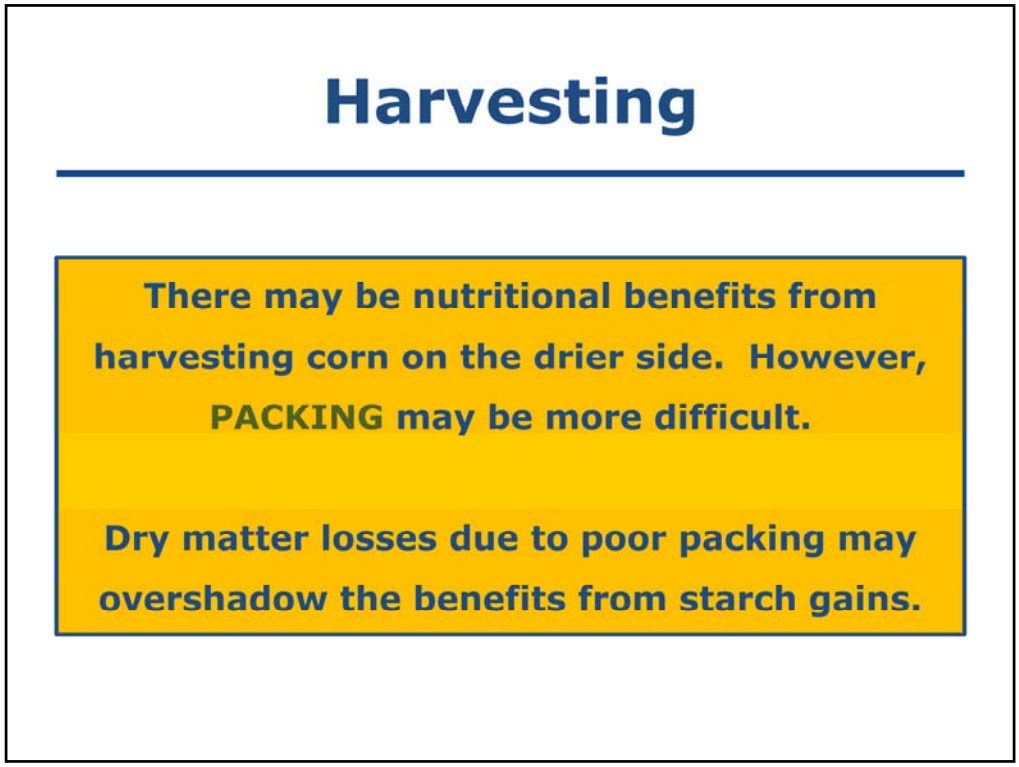


There were no differences in NDF digestibility with DM.

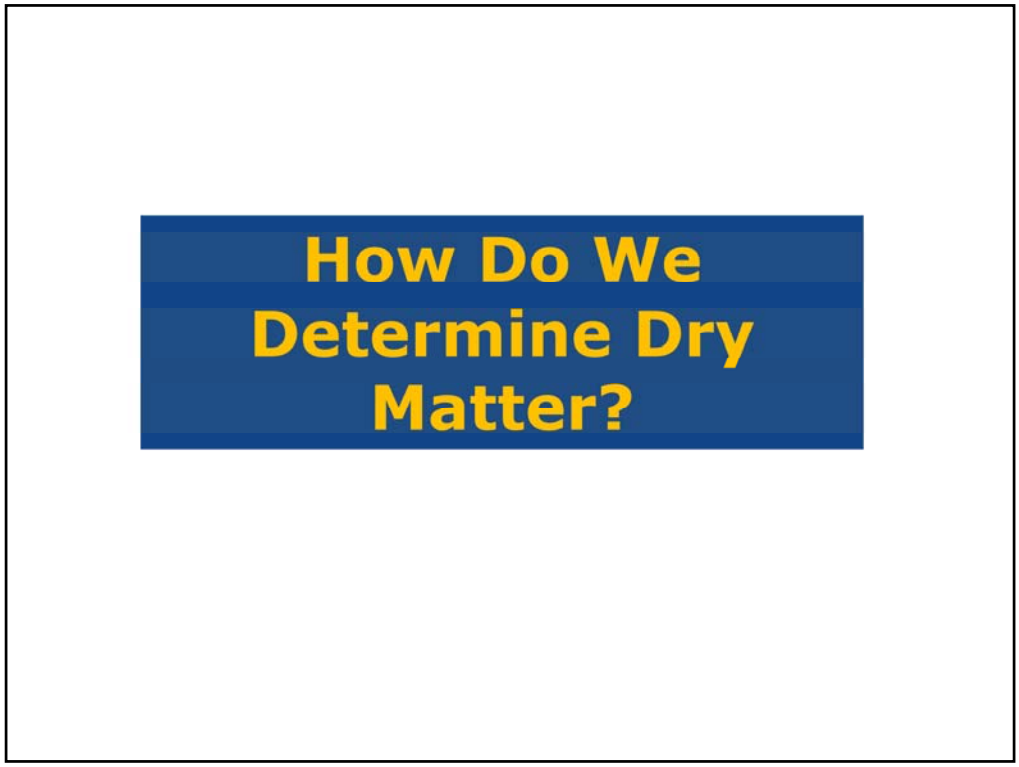
Harvesting



When looking at the fermentation profile, lactic:acetic acid ratio, it was positively correlated with DM.



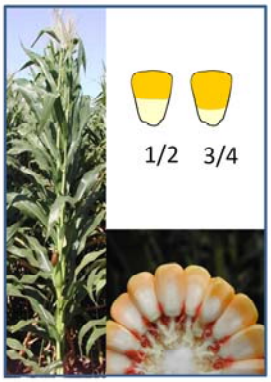
There may be nutritional benefits from harvesting corn on the drier side. However, packing is more difficult.
Dry matter losses due to poor packing may overshadow the benefits from starch gains.



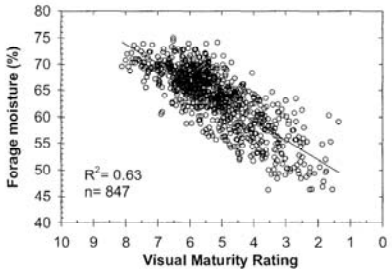
Once the silage team agrees on the targeted DM, how do we determine dry matter of the crop standing in the field?

Harvesting

Dry Matter Estimation
Visual Evaluation



Milk Line (2/3)
Stover Maturity



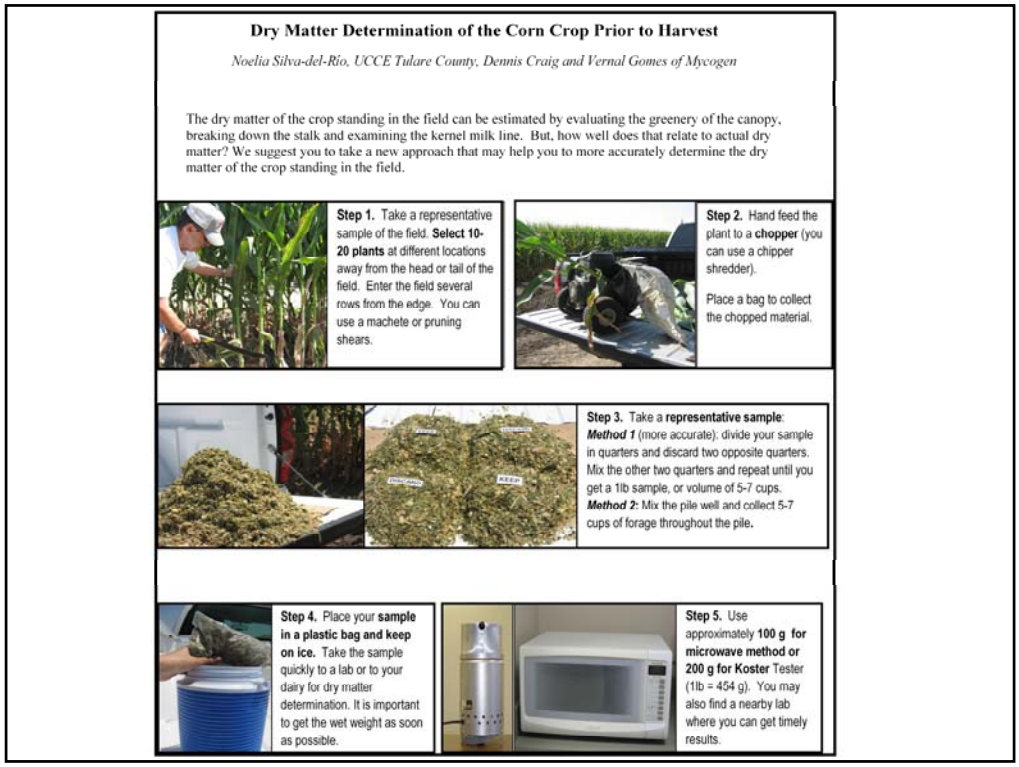
(Lauer, 2006)

We can estimate dry matter by visual evaluation. We could look at the canopy and the kernel milk line. But how well does that related to dry matter? In 2004 and 2005, all the corn variety trials in WI were rated for Visual Maturity rate that combined Kernel and Stover Maturity Rate. The figure on the bottom right represents the data and the regression line. On the X axis we have visual maturity rating, and in the y axis we have forage moisture. The R-square was 0.63, so the data did not explain very well the regression line.

Harvesting Corn Silage

Dry Matter Determination
Empirical

We can also determine dry matter instead of estimating it. We could use a koster tester and a microwave oven.



Dry Matter Determination of the Corn Crop Prior to Harvest

Noelia Silva-del-Río, UCCE Tulare County, Dennis Craig and Vernal Gomes of Mycogen

The dry matter of the crop standing in the field can be estimated by evaluating the greenery of the canopy, breaking down the stalk and examining the kernel milk line. But, how well does that relate to actual dry matter? We suggest you to take a new approach that may help you to more accurately determine the dry matter of the crop standing in the field.

Step 1. Take a representative sample of the field. **Select 10-20 plants** at different locations away from the head or tail of the field. Enter the field several rows from the edge. You can use a machete or pruning shears.

Step 2. Hand feed the plant to a **chopper** (you can use a chipper shredder).

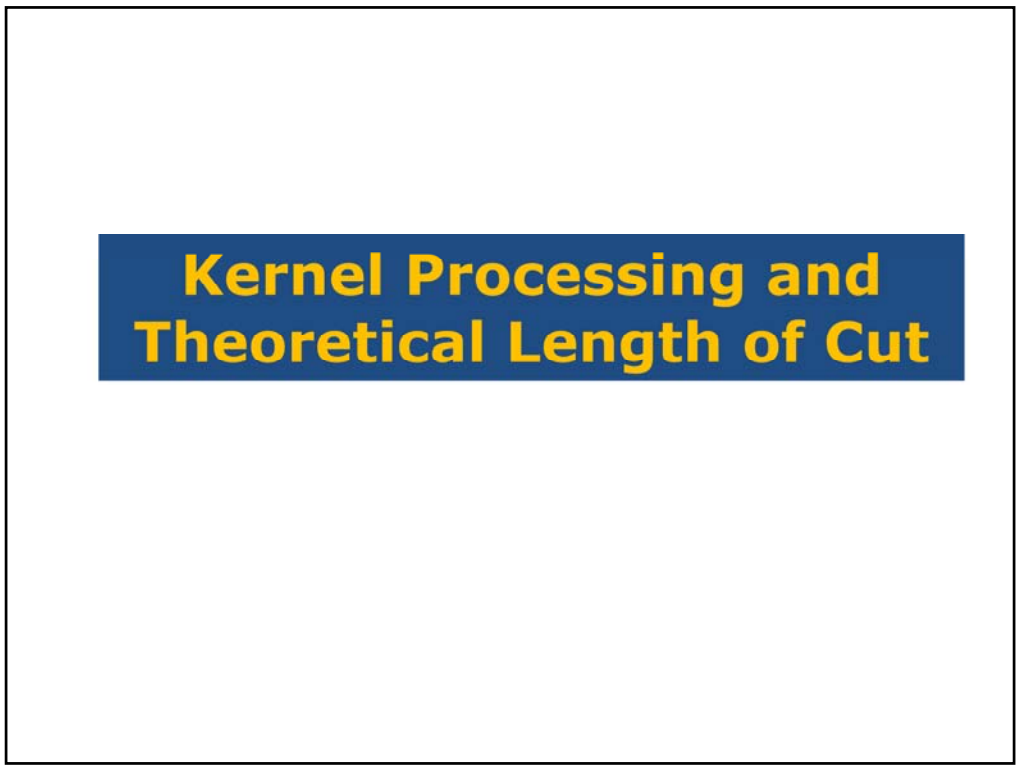
Place a bag to collect the chopped material.

Step 3. Take a **representative sample**:
Method 1 (more accurate): divide your sample in quarters and discard two opposite quarters. Mix the other two quarters and repeat until you get a 1lb sample, or volume of 5-7 cups.
Method 2: Mix the pile well and collect 5-7 cups of forage throughout the pile.

Step 4. Place your **sample in a plastic bag and keep on ice.** Take the sample quickly to a lab or to your dairy for dry matter determination. It is important to get the wet weight as soon as possible.

Step 5. Use approximately **100 g for microwave method or 200 g for Koster** Tester (1lb = 454 g). You may also find a nearby lab where you can get timely results.

The guidelines for DM determination prior to harvest are described in Appendix I, at the end of the proceedings of the 2010 Alfalfa and Forage Symposium. In the last talk of this session, Carol Collar will present the results of a custom harvesters survey that we have recently conducted. Interestingly, only one out the nine custom harvesters determined DM before harvesting using this procedure. He had positive comments about the value of including this task in his routine work.



Kernel processing and theoretical length of cut.

Harvesting

Kernel Processing Improves:

- Handling and Packing
- Starch Digestion
- Fiber Utilization
- Feed Intake
- Reduces Feed Sorting

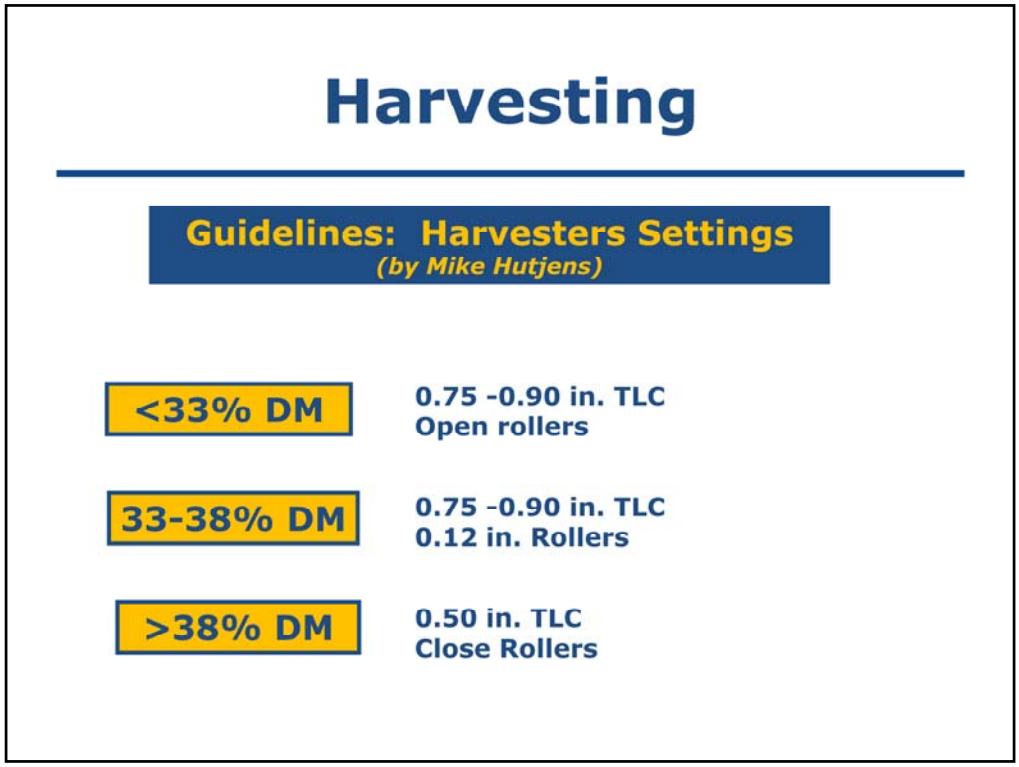
Too Much Processing:

- Decreases effective fiber
- Favors rapid fermentation -> rumen acidosis

Too Little Processing:

- Kernels lost in feces
- Difficult Packing
- Sorting increased

Kernel processing improves handling and packing, reduces feed sorting, and improves starch digestion, fiber utilization and feed intake. However, too much processing can have a negative impact when feeding cows. It can decrease effective fiber and favor rapid fermentation in the rumen that causes acidosis. By contrast, too little processing increases sorting and kernels that are lost in feces, and the silage is difficult to pack.



Here we have some guidelines from Mike Hutjens from the University of Illinois on harvesters settings. The TLC and roll opening must be adjusted depending on DM.

Harvesting

Evaluate the Broken Kernels

Picture Courtesy of Dr. Limin Kung Jr.

Separate kernels in a bucket of water

Guidelines:

- **90 - 95% cracked**
- **70% smaller than ¼ of a kernel**

Nicking and Crushing is not enough

(Mertens, 2005)

During ensiling, we should always evaluate the physical form of the material we are getting at the silage pit. To assess kernel process, we can separate the kernels by using a bucket of water where the kernels would sink. 90 t0 95% of kernels should be cracked, 70% smaller than ¼. It is not enough that they are just nicked or crushed.

Harvesting

Evaluate Forage Particle Length

	3/4 TLC Processed	3/8 TLC Unprocessed
Top	5-15	3-8
Second	>50	45-60
Third	<30	30-40
Bottom	<5	<5

To determine if the TLC is properly processed, we can use a tape measurement at the silage to and randomly select several particles and check the length. We also could use the particle size separator from NASCO. The particle length guidelines for processed and unprocessed corn are presented in the table.

Custom Harvesters

	Low	High
Target DM	28-30%	30-32%
Roller Opening	0.02 to 0.04 inches	0.12 inches
TLC Corn	0.43 to 0.67 inches	0.67 to 0.83 inches

This table illustrates that the preferred settings for the harvesting equipment varies across custom harvesters (n=9). On the left (LOW) we have the preferred settings for custom harvesters on the low end, and on the right the preferred settings on the high end.

Packing Density

Packing Density

- **Dry matter**
- Delivery rate
- Tractor weight
- Tractor time
- Theoretical length of cut
- Packing layer thickness

There are several factors that impact packing density:
Dry matter at harvest,

Packing Density

- Dry matter
- **Delivery rate**
- Tractor weight
- Tractor time
- Theoretical length of cut
- Packing layer thickness

Delivery rate – In the picture we see a truck delivering forage while another truck is approaching the silage pit,

Packing Density

- Dry matter
- Delivery rate
- **Tractor weight**
- Tractor time
- Theoretical length of cut
- Packing layer thickness

Tractor weight,

Packing Density

- Dry matter
- Delivery rate
- Tractor weight
- **Tractor time**
- Theoretical length of cut
- Packing layer thickness

Tractor time – In this picture we see three tractors packing the face,

Packing Density

- Dry matter
- Delivery rate
- Tractor weight
- Tractor time
- **Theoretical length of cut**
- Packing layer thickness

Theoretical length of cut and processing – the shorter the particle length, the easier it is to pack.

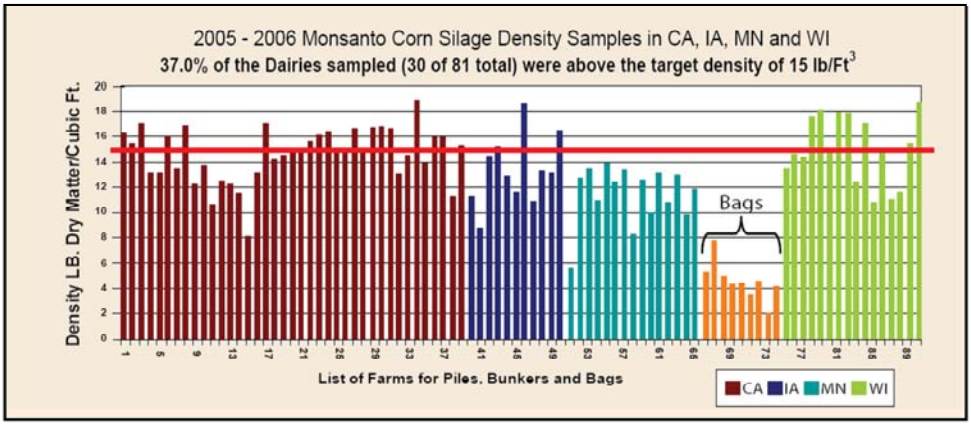
Packing Density

- Dry matter
- Delivery rate
- Tractor weight
- Tractor time
- Theoretical length of cut
- **Packing layer thickness**

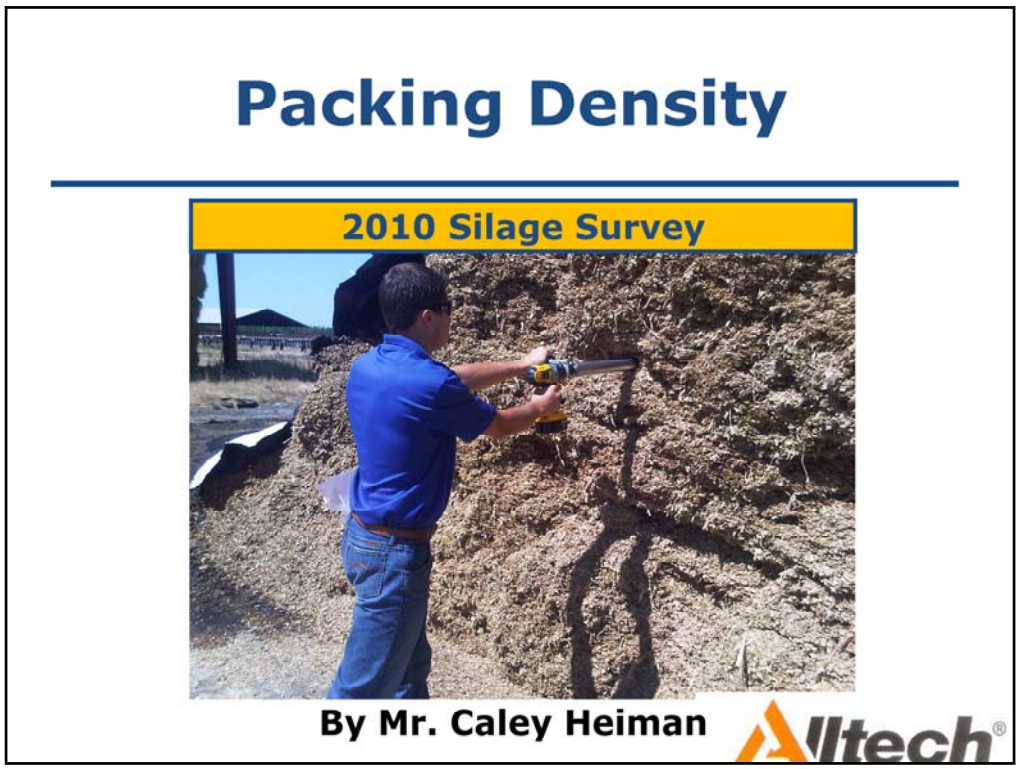
Packing layer thickness.

Packing density in California silage structures

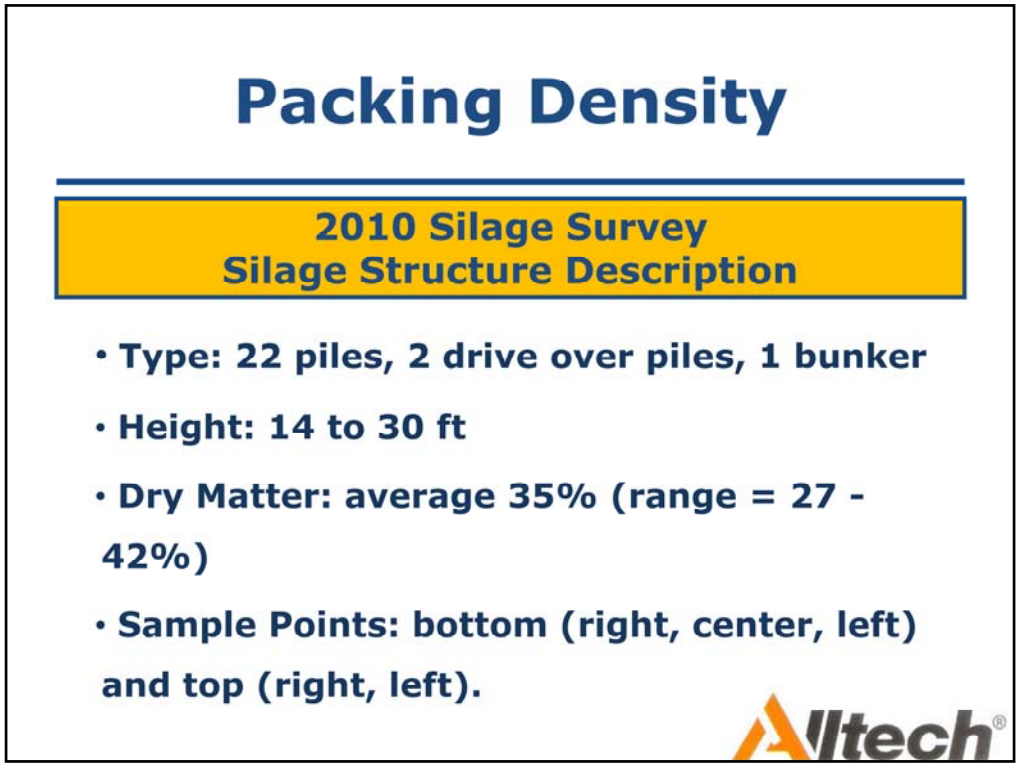
Packing Density



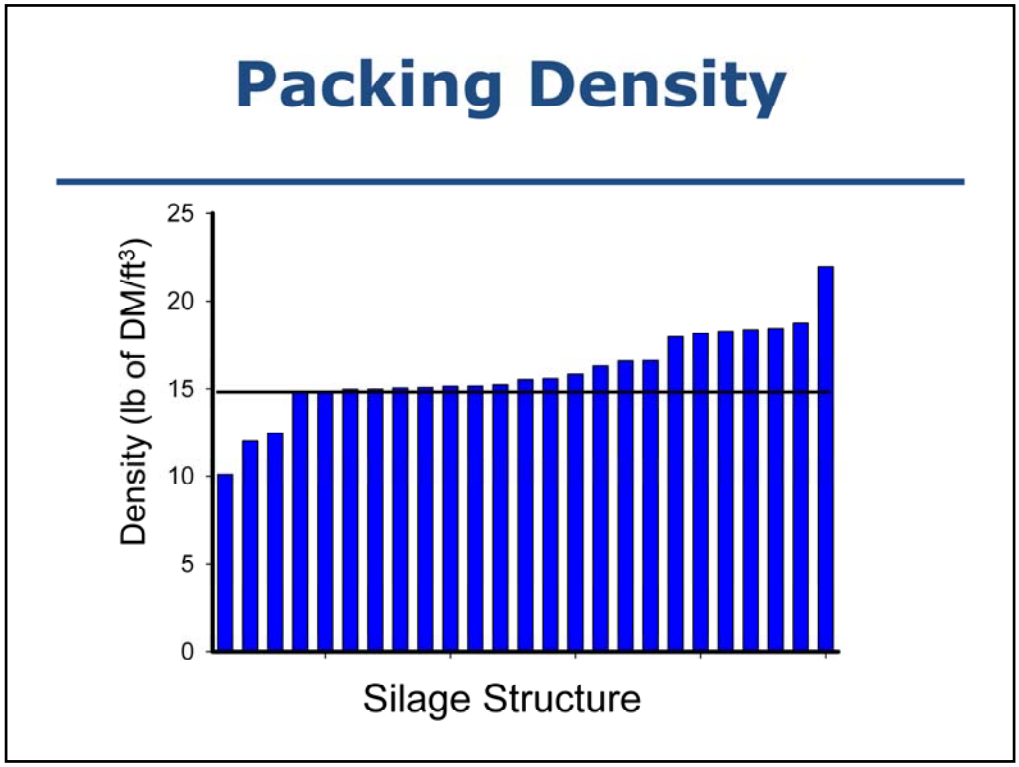
To asses whether packing is properly done, we can monitor packing density. This figure shows packing density in California, Iowa, Minnesota and Wisconsin. Overall, only 37% of dairies met the minimum recommended packing density. However, in this study, 56.4% of the silage structures in California meet the desired benchmark.



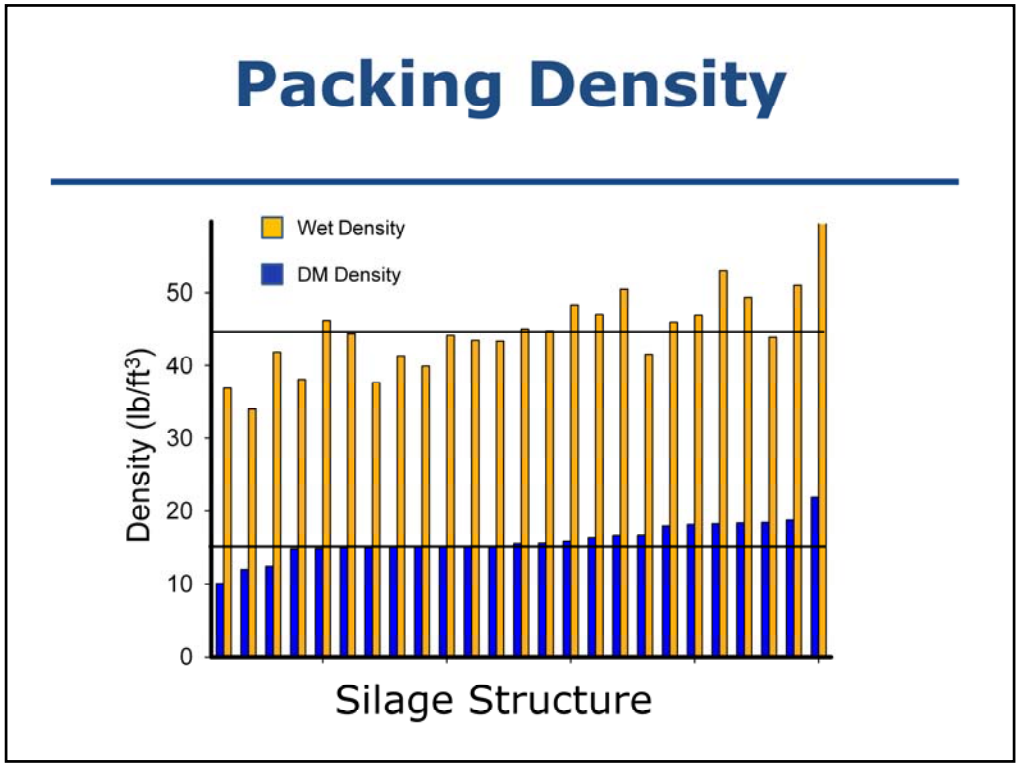
However, we have more recent data. Caley Heiman with Alltech conducted a silage survey in 2010 . He did all the data collection, and my part was just to summarize and plot the information given to me.



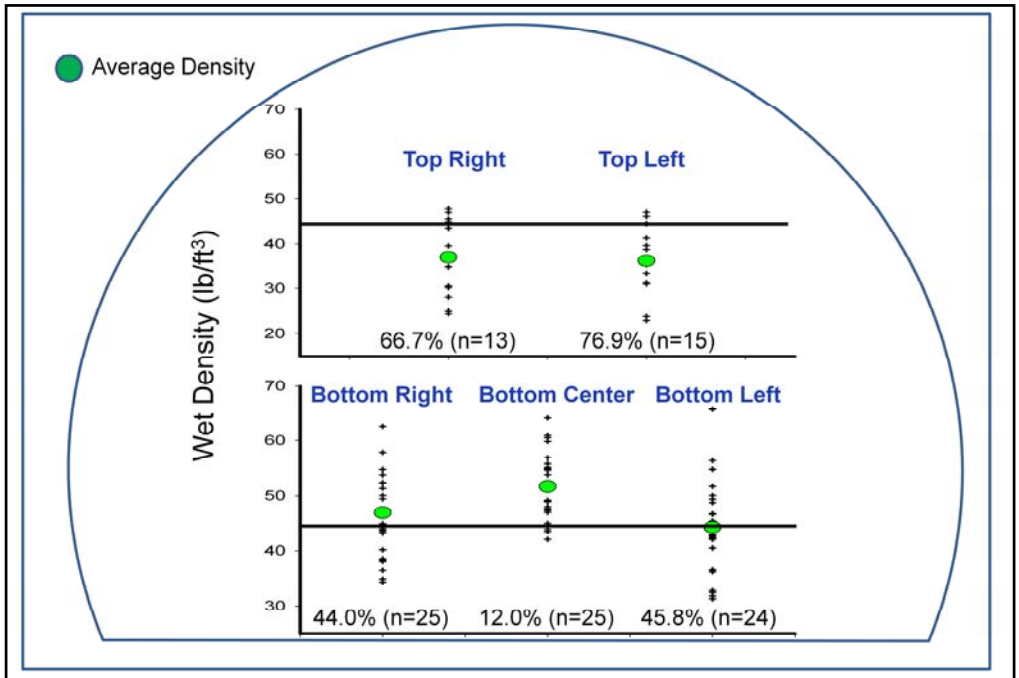
Twenty-five silage structures were studied and:
22 were piles, 2 were drive over piles, 1 was a bunker.
The height ranged from 14 to 30 ft.
Dry matter averaged 35% and ranged from 27 to 42%.
Samples were taken at the bottom (right, center, left) and at the top (right and left).



Results from this survey indicated that when density was expressed in lb/ft3, only 3 silage structures did not meet the benchmark.

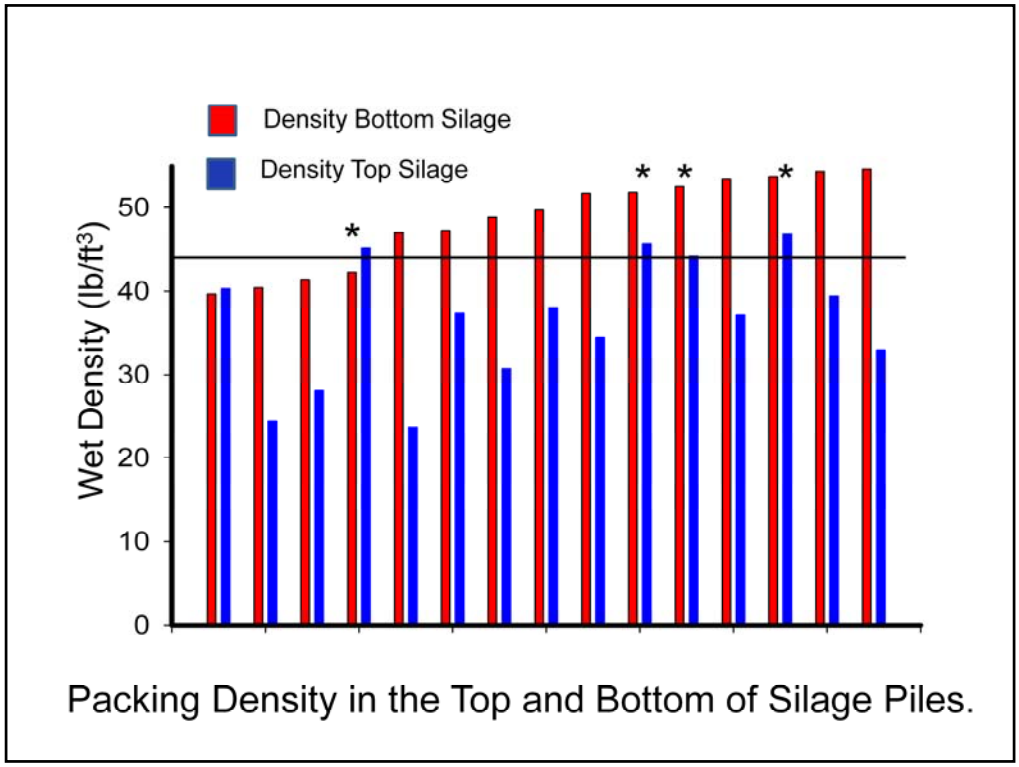


Wet density reflects porosity, which is the pore space relative to the volume occupied by the forage mass. Therefore, to account for porosity, we will report results based on wet density. Furthermore, regulatory agencies are setting compliance with density at 44 lb/ft3.
However, when the results were expressed in wet density (yellow bars) 11 silage structures did not meet the desired benchmark of 44 lb/ft3.



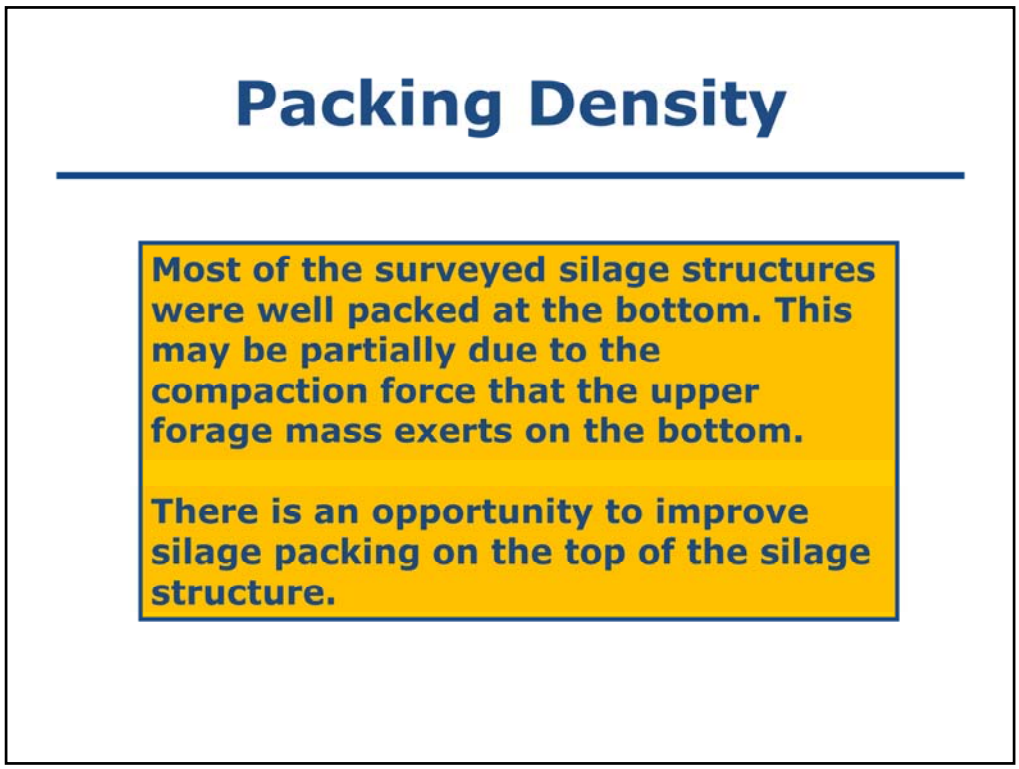
Percentage of wet density samples below 44lb/ft^3 for each of the sample locations.

This figure shows the percentage of samples below the benchmark of 44 lb/ft^3 in each of the different sample locations.

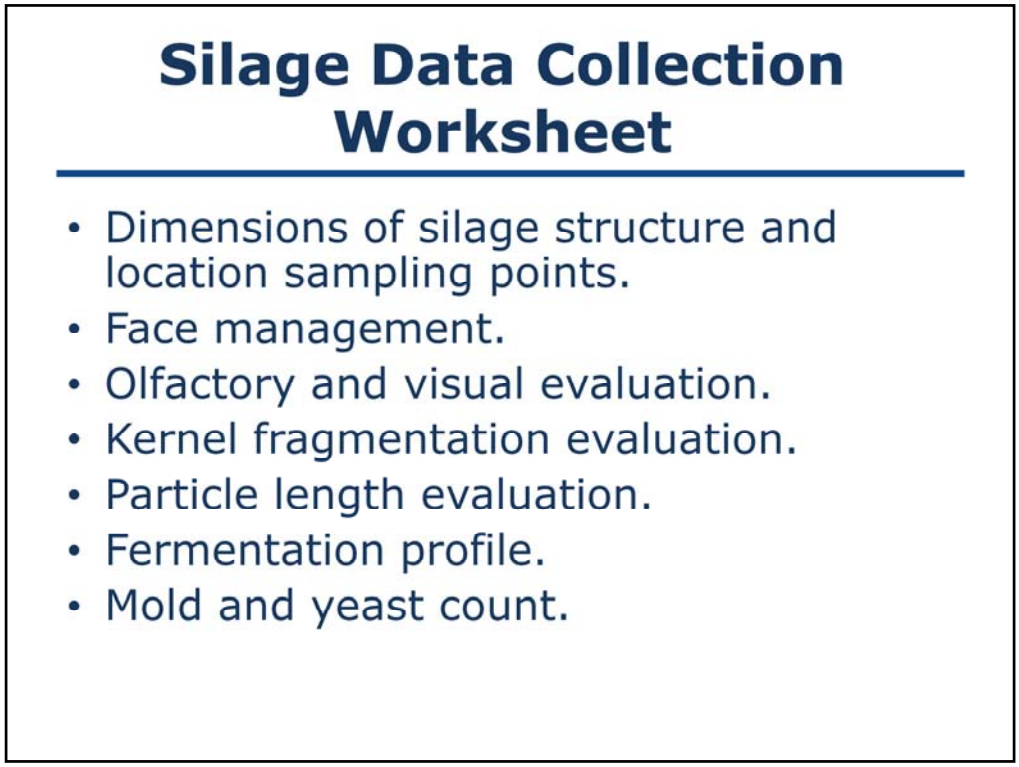


Packing Density in the Top and Bottom of Silage Piles.

A total of 15 silage structures were sampled at both locations: bottom and top. The average wet silage density by location (top and bottom) is summarized in this figure. Only four silages meet the benchmark for both top and bottom samples.



Packing density is critical to prevent dry matter losses associated with aerobic spoilage. Most of the surveyed silage structures were well packed at the bottom. This may be partially due to the compaction force that the upper forage mass exerts on the bottom. However, there is an opportunity to improve silage on the top of the silage structure.

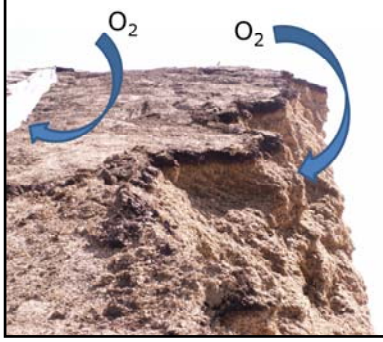


I am currently developing a data collection worksheet for industry people conducting silage surveys. The following information will be included:
Dimensions of silage structure and location sampling points.
Face management.
Olfactory and visual evaluation.
Kernel fragmentation evaluation.
Particle length evaluation.
Fermentation profile.
Mold and yeast count.

Face Management

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 silage.

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.

Feedout

High Removal Rate

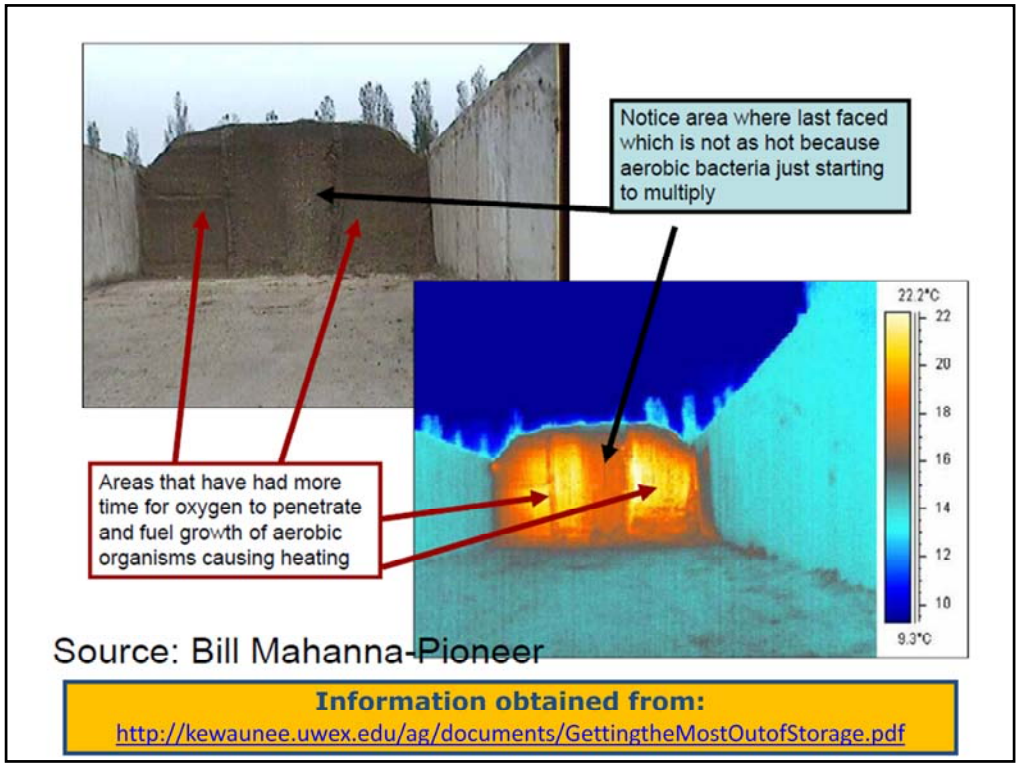
6-12 in./d in winter
18 in./d in summer

In a well packed silo, air moves 3ft.

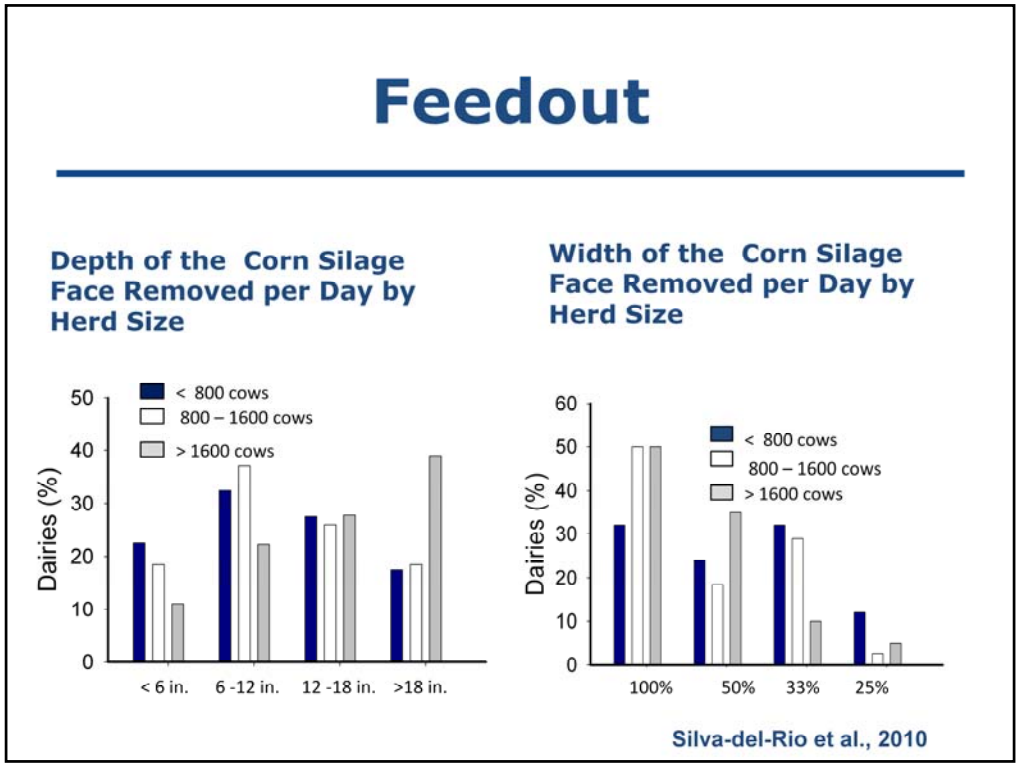
With a removal rate of 6 inches/d the silo will be exposed to oxygen for a week before feeding.

Muck and Huhnke, (1995)

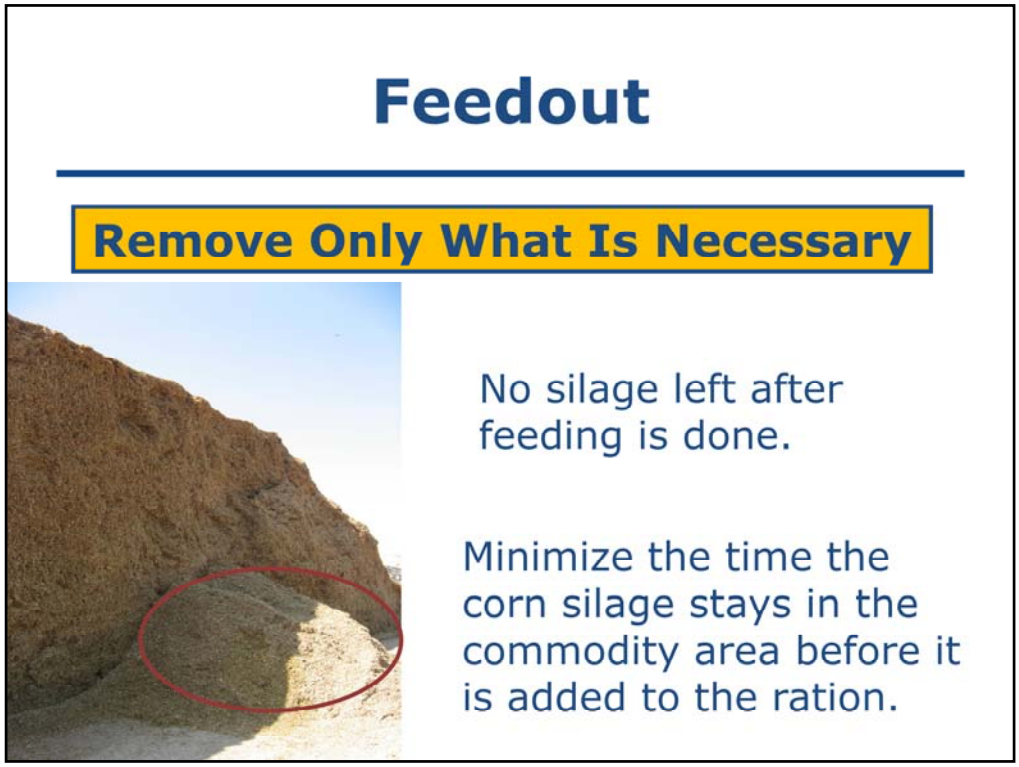
It is very important to maintain a rapid progression through the face. The rule of thumb is to take between 6-12 in/d in cold weather and 18 inches in warm weather, but is that enough? In a study from 1995, Muck and Huhnke evaluated how far the air moves into a well packed silo. They found that air moves into the silo a depth of 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!!!



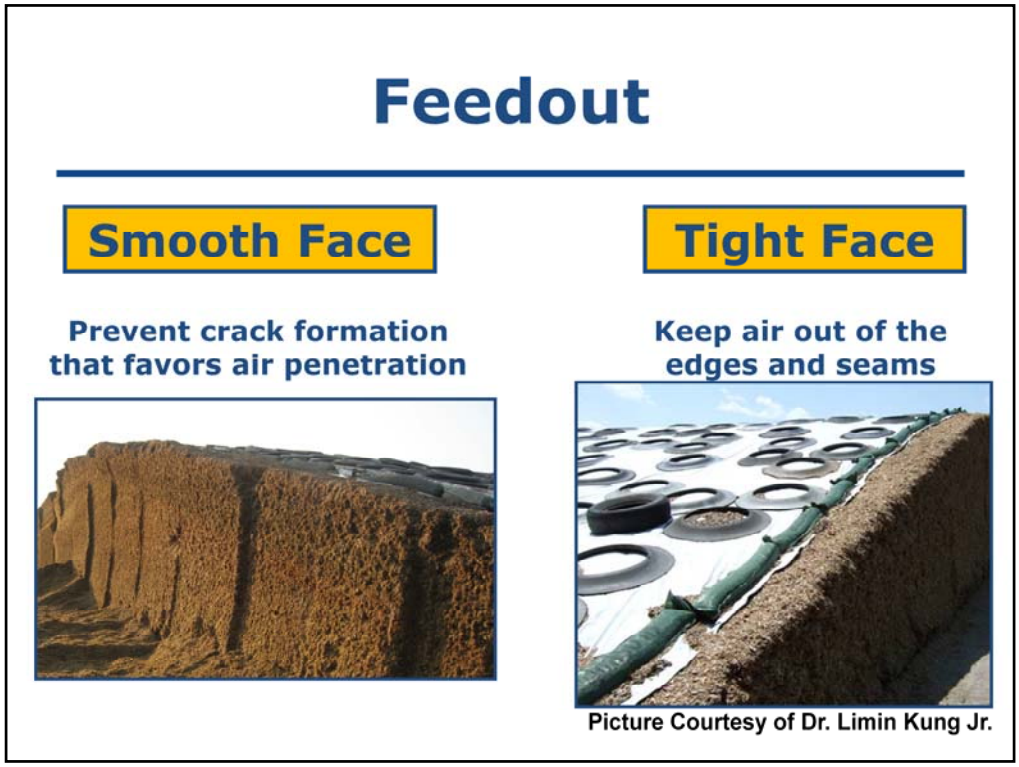
The middle section of the corn silage was shaved, and the infrared picture shows that the area is cooler because aerobic bacteria are just starting to multiply. This slide has been extracted from Dr. Brian Holmes' Extension Presentation. For more information go to: http://kewaunee.uwex.edu/ag/documents/GettingtheMostOutofStorage.pdf



In Summer 2009, a feed management survey was mailed to dairy producers in Tulare, Stanislaus, and San Joaquin counties, 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 removal rate.



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.



Smooth Face: 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.
Tight Face: Keep the air out of the edges and seams. One solution is to put weight on the plastic at the leading face.

The following pictures show different silage removal strategies in California dairies. In this dairy, the feeder is removing silage from the face upwards. This increases the air infiltration into the forage mass.

DEERE

DEERE

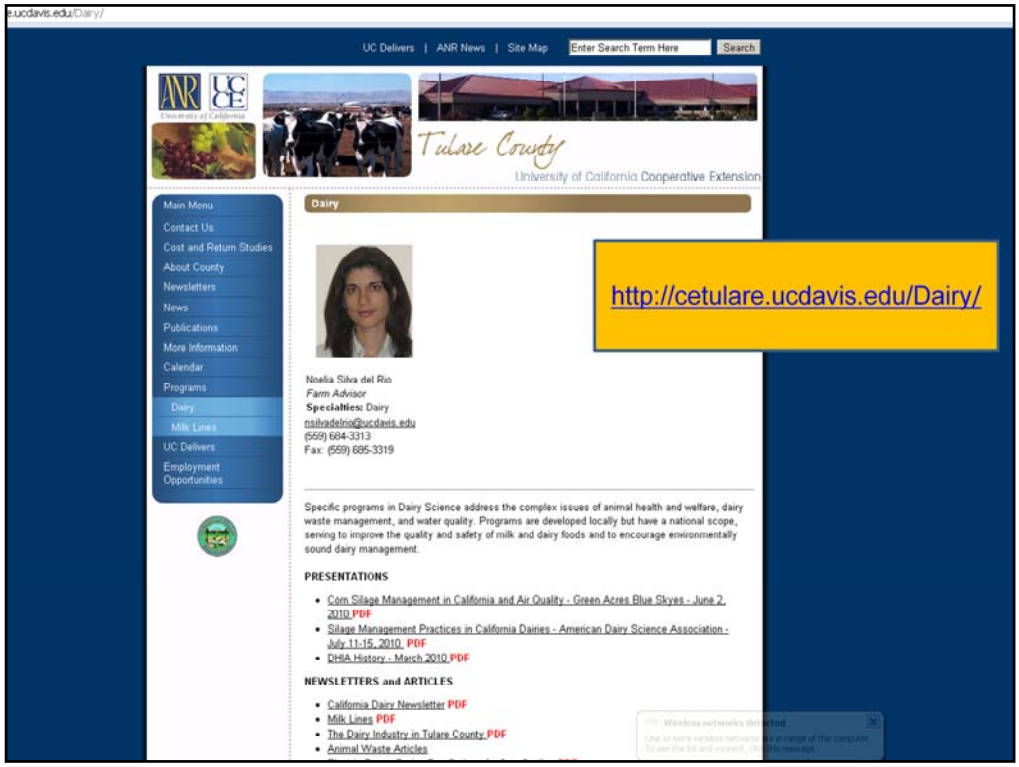
Dairy 1
DEERE

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

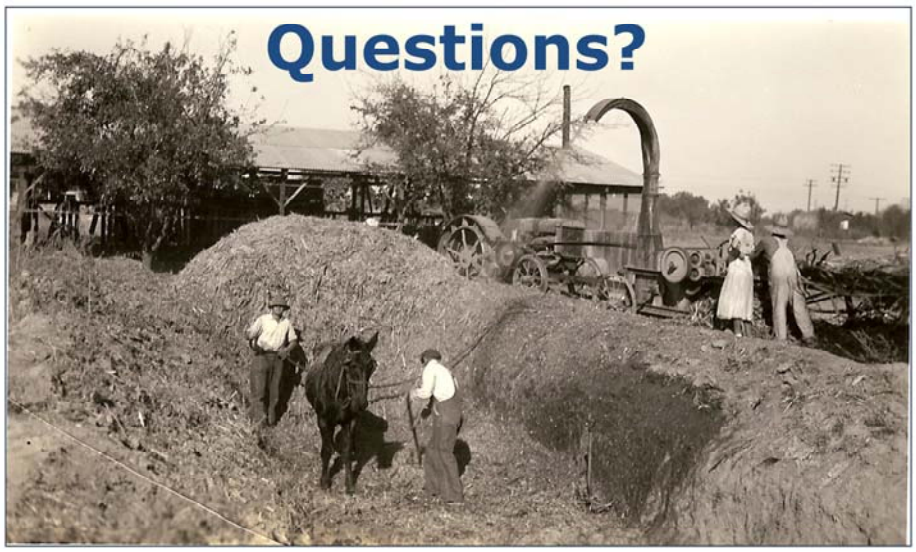
VOLVO

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.



This presentation will be posted on line.



Silage pit in the Central Valley (late 1930's)
Photo Courtesy of Alan George, retired UCCE Farm Advisor in Tulare County

Over the past 70 to 80 years, some progress has been made on silage management in California.
Questions?