Nuts and Bolts of Corn Silage Quality

Dr. Hugo A. Ramírez Ramírez
Dairy Extension Specialist

IOWA STATE UNIVERSITY
Extension and Outreach

Healthy People. Environments. Economies.

Outline

Basics of Silage Fermentation

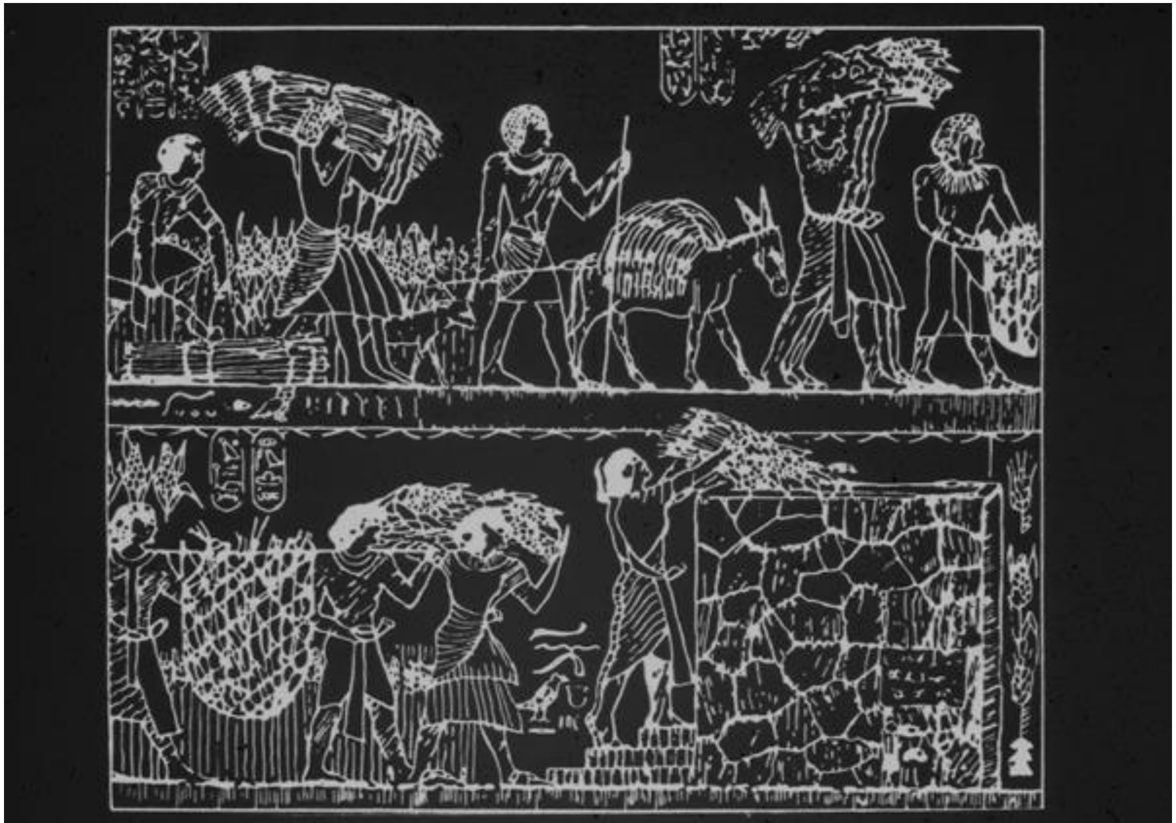
Factors affecting corn silage quality

Animal response to improved corn silage quality

Take home messages

Making corn silage

- Same old process but new discoveries?



Egypt, A. copy of a mural showing that whole-crop cereals were ensiled 1000-1500 BC.

Advancements in Silage Management

Silage Management = Risk Management

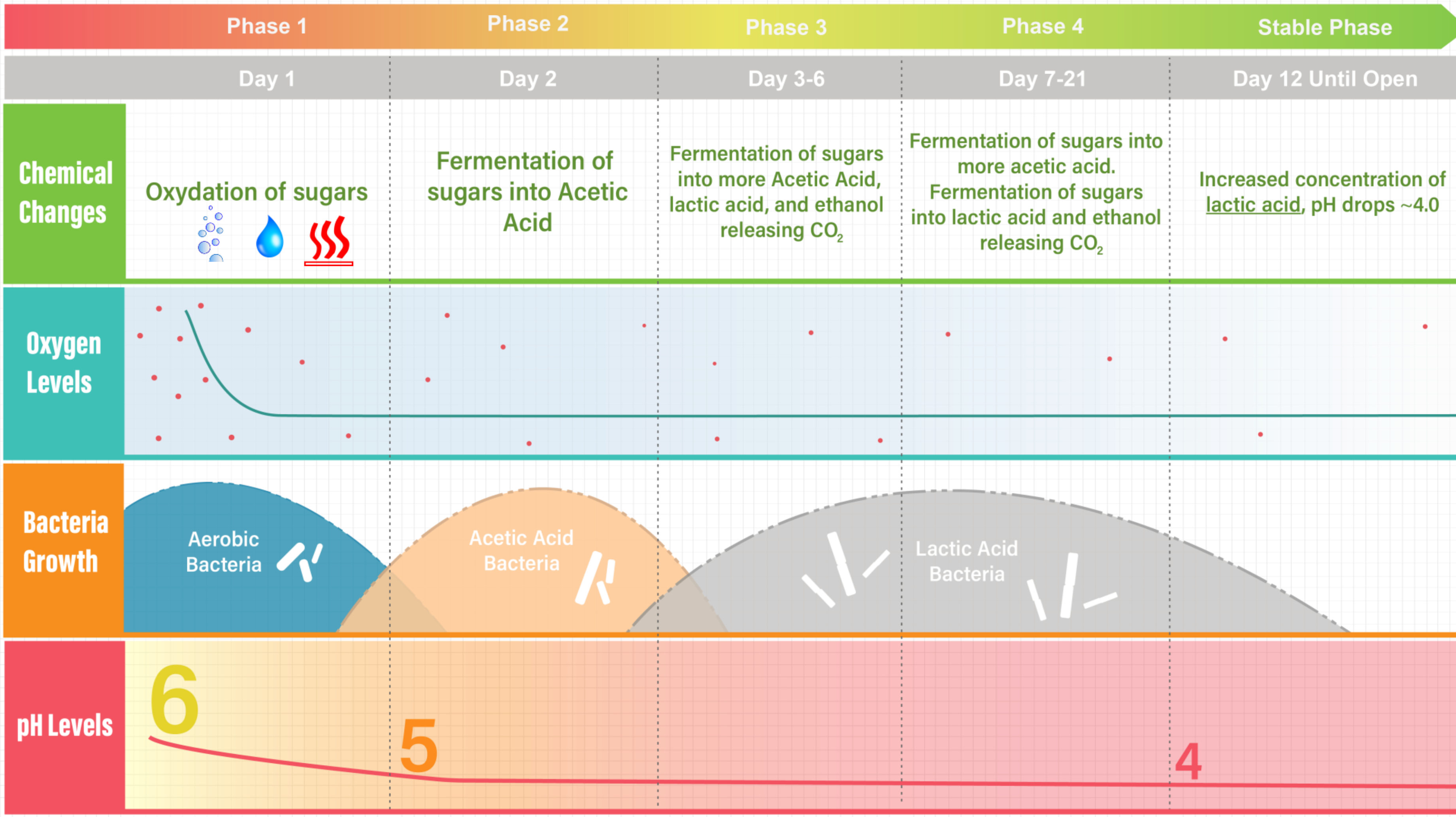
Fermenting forages: big picture process

- Plants contain sugars and also naturally present bacteria
- Some bacteria convert sugars into organic acids under anaerobic conditions

  Propionic Acetic Lactic

- Enclosed system leads to acid accumulation, low pH and ultimately inhibition of microbial action = pickling forage

Phases of Corn Silage Fermentation



Growing corn for silage

- Is it a silage specific hybrid?
  - Yes: high quality forage, making silage is the only reasonable option
  - No: more flexibility to harvest as forage, grain, or in-between!
- Regardless of type of hybrid, the objectives are the same:

1. *Grow forages to optimize yield*
2. *Harvest nutrients* at an optimal stage for digestion
3. Promote *efficient utilization* of the harvested nutrients

Location, shape and size


Leveled ground and clear outlines


Preparing the bunker: lined walls prevent spoilage in the edges of the bunker

Preparing the bunker

Lined walls

Storing conditions: lining bunkers

- Bunker with no lined walls
- Hard to pack close to the walls
- ↑ Risk for water seepage along the walls

- Silage spoilage on edges
- Much lower quality than what was harvested
- ↑ Discarded feed
- Ultimate decision based on $

Variations in dry matter = variation in nutrient supply

Forage production program

- Decisions will have long term consequences
- Lots of effort into growing – make the best out of it for the subsequent phases

Corn silage is highly valuable, managing the different processes protects your investment

Harvesting corn for silage

- Deciding when to harvest
  - Best test is whole plant dry matter

Recommendations, rule of thumb 35% DM

Conventional corn: 32 – 35% DM

BMR corn: 30 – 34% DM (Mycogen recommendation)

Harvesting corn for silage: maturity

- Deciding when to harvest
- Milk like is another indicator

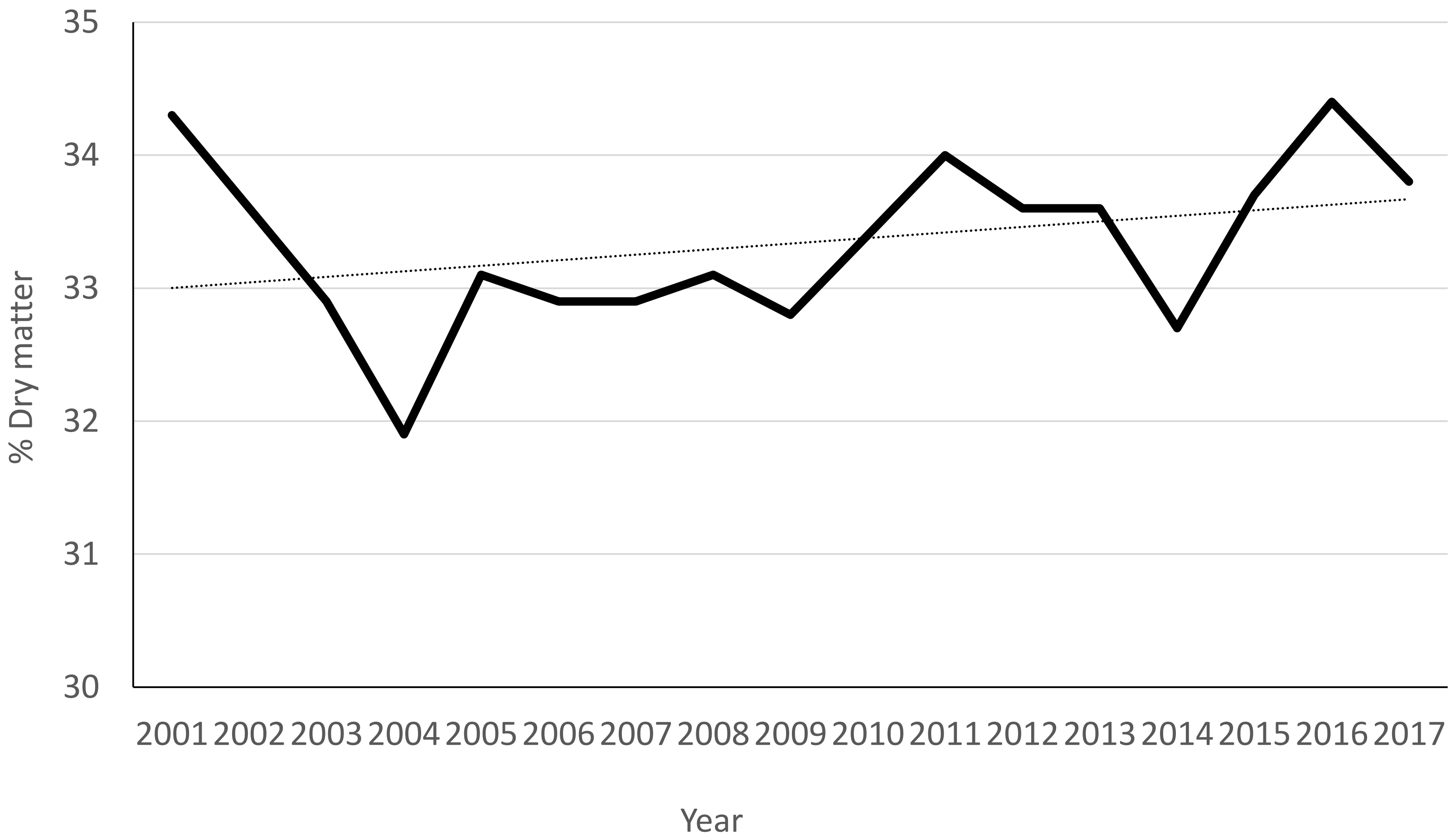
Increasing maturity, less moisture, more starch deposition

Milk line

Starch content increases as milk line progresses towards the cob

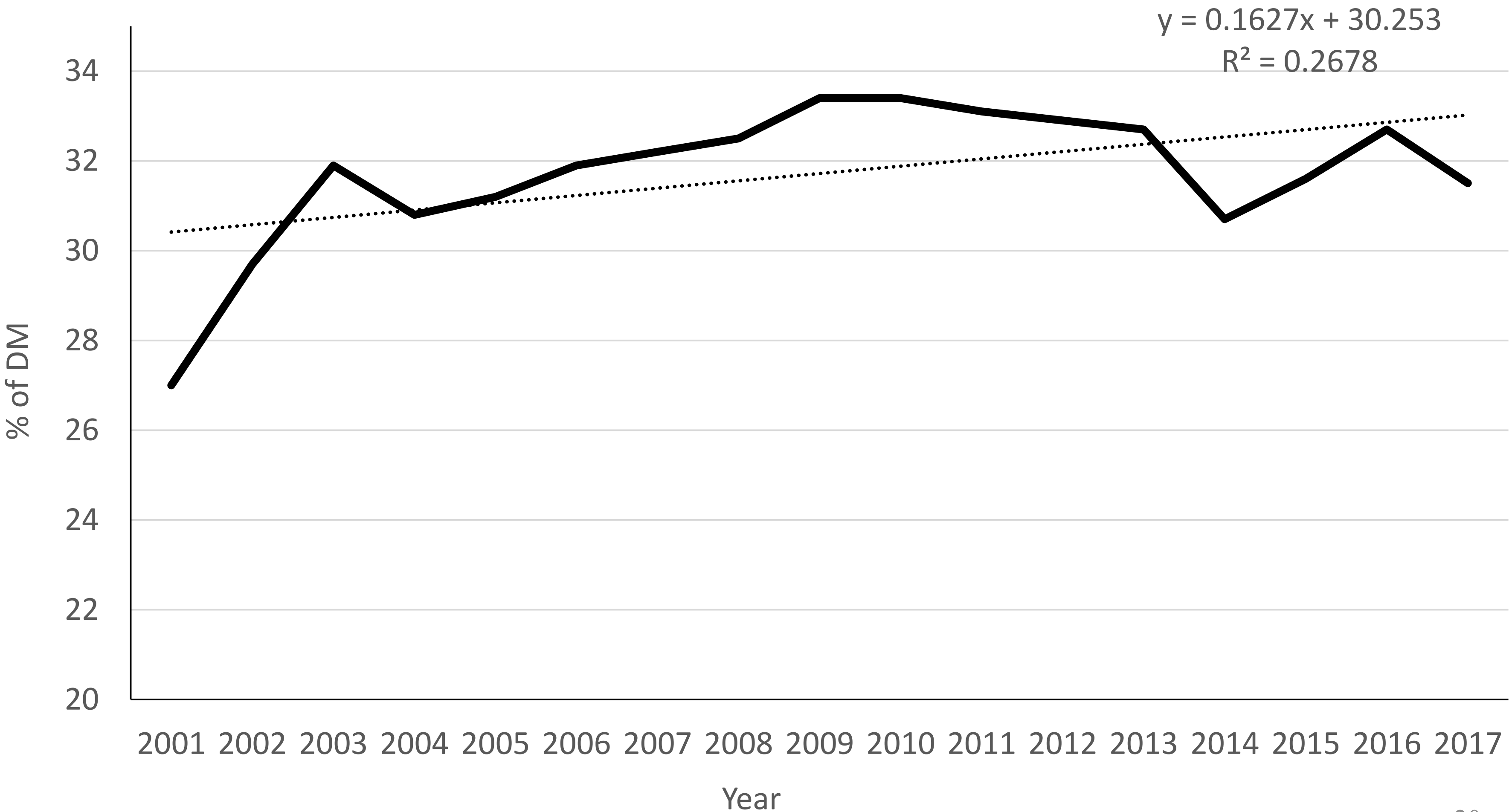
Recommendations 2/3 to 3/4 milk line

Dry Matter



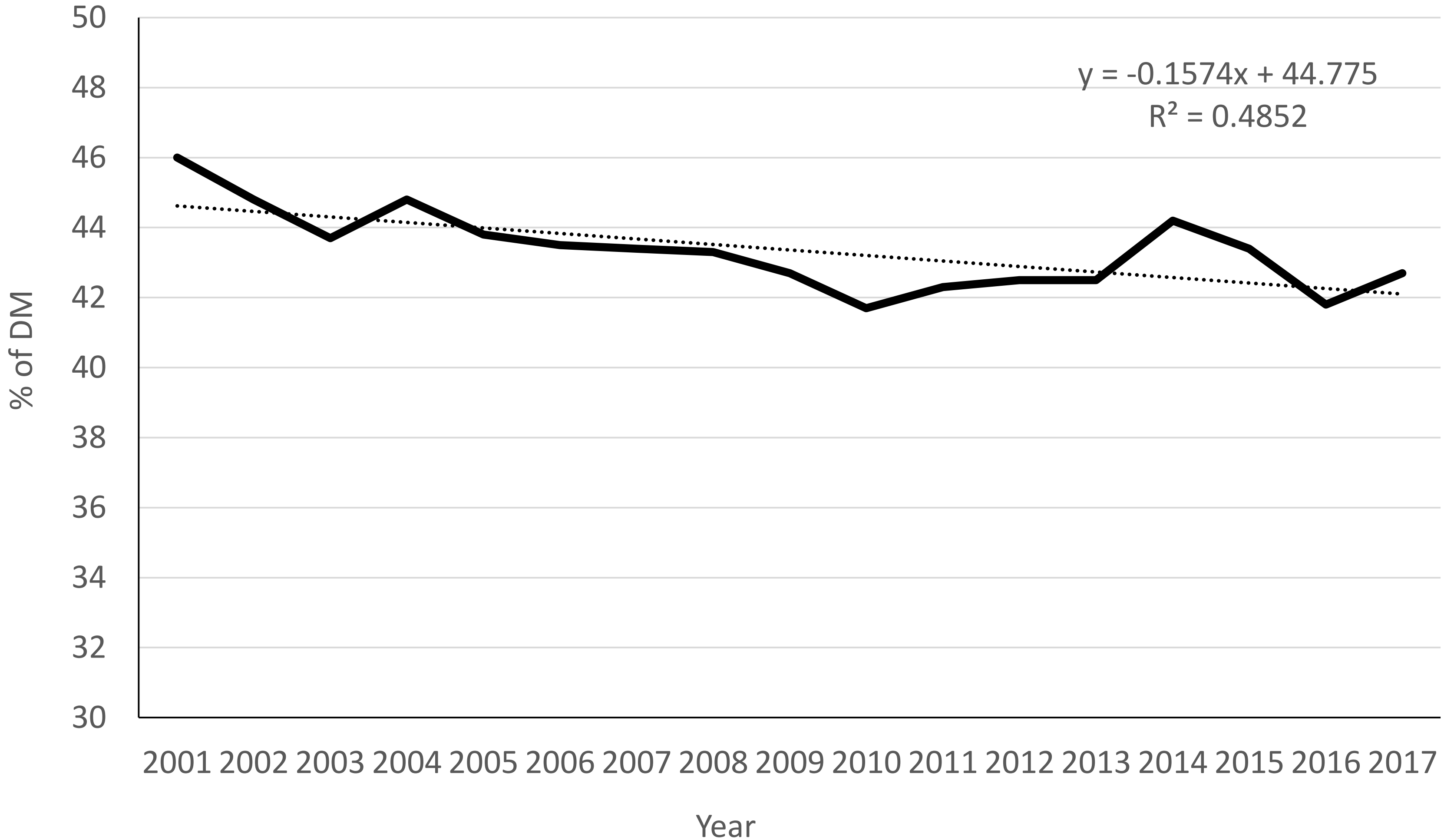
Feed Composition Library – Dairy One

Starch



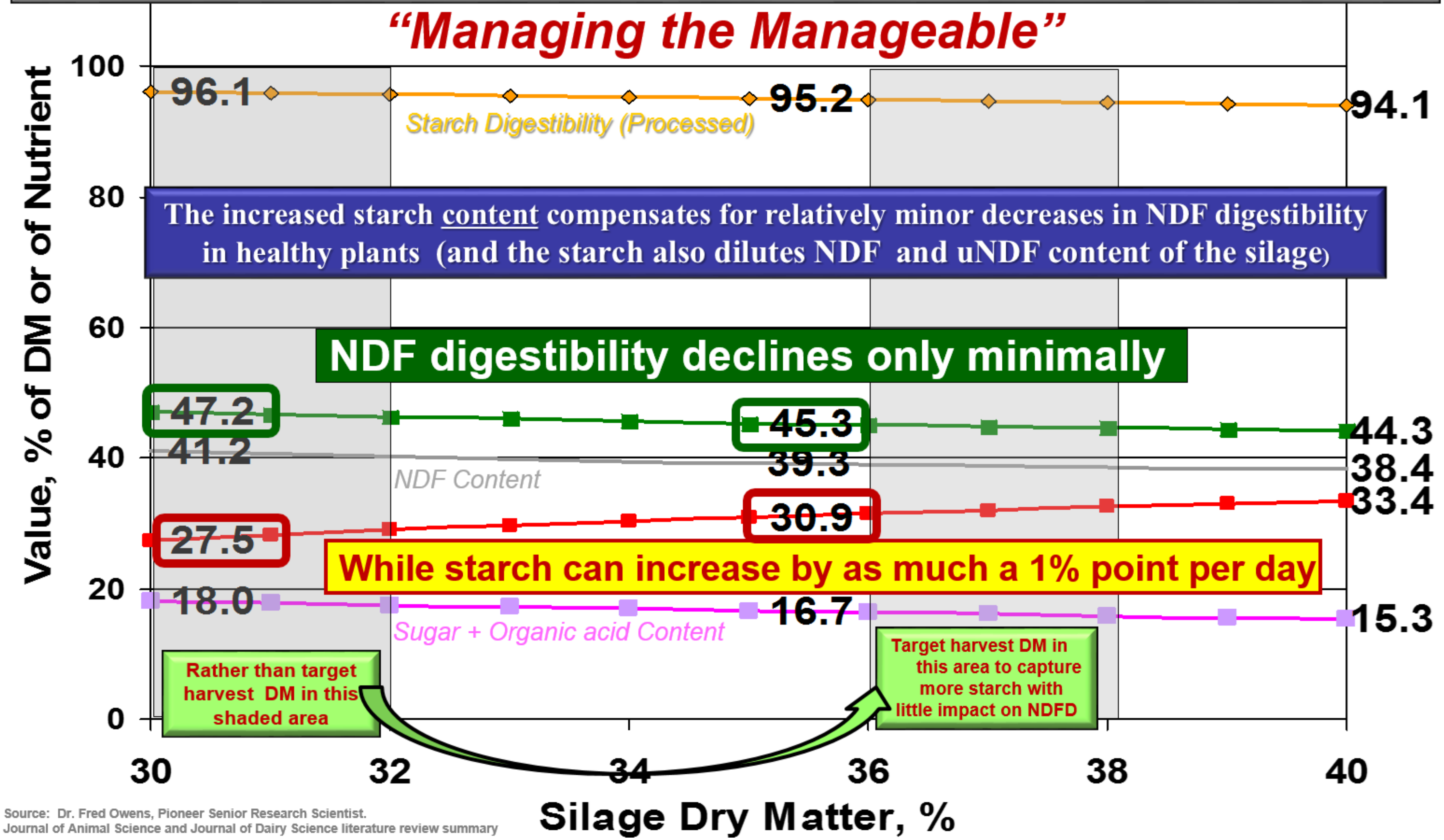
Feed Composition Library – Dairy One

Neutral Detergent Fiber



Feed Composition Library – Dairy One

Harvesting at Closer to ¾ Milk Line to Capture More Starch Does Not Significantly Reduce Fiber Digestibility in Healthy Plants



Source: Dr. Fred Owens, Pioneer Senior Research Scientist.
Journal of Animal Science and Journal of Dairy Science literature review summary

Slide courtesy of Dr. Bill Mahanna (DuPont Pioneer)

Deciding when to harvest

Consider a 0.5 to 1% dry-down rate to estimate when the target DM would be expected:
Example:
Target DM = 38%
Current DM = 33%
Difference: 5%
(5%) / (0.5%/d) = 10 days until harvest

Determining dry matter % prior to harvest

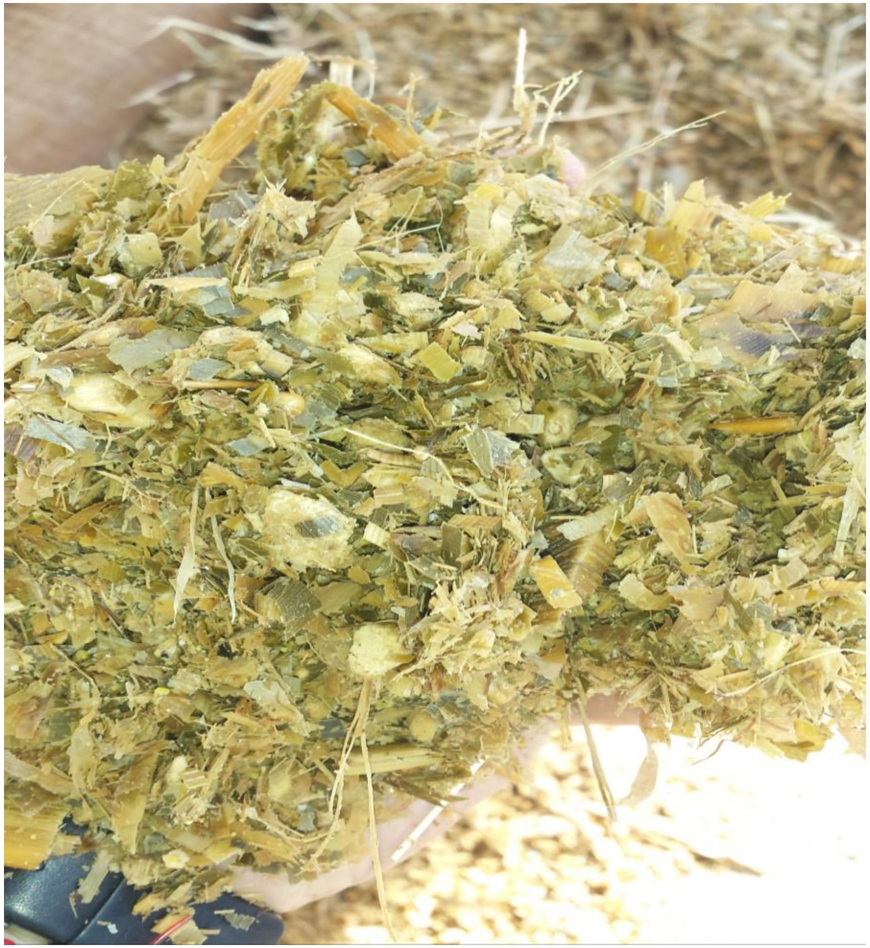
3/4 milk line (36 -38% DM) captures more starch but plant is dryer which requires excellent packing and kernel processing

Harvesting corn for silage: chop length

- Non processed corn silage:
  ¼ to ½ inch
- Processed corn silage:
  ¾ inch (19 mm)
- Shredlage: 1 inch to 1.2 inches (26 to 30 mm)

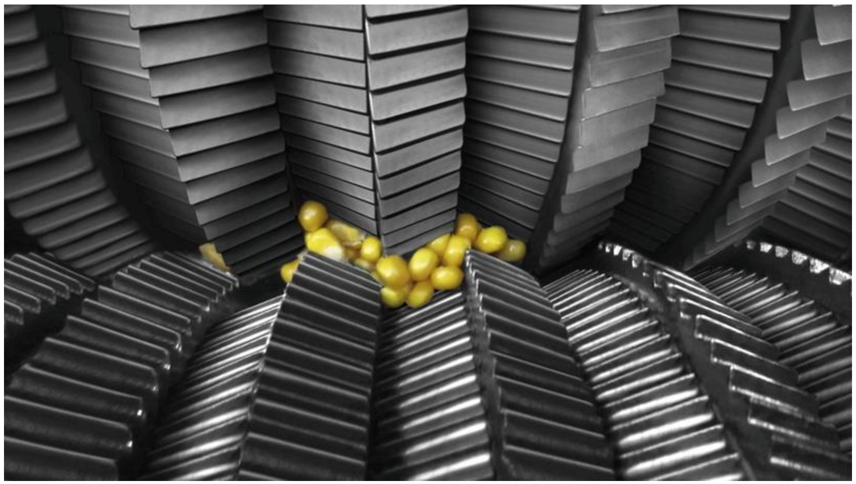
http://www.claasofamerica.com

Examples of particle that is too short



Kernel processing

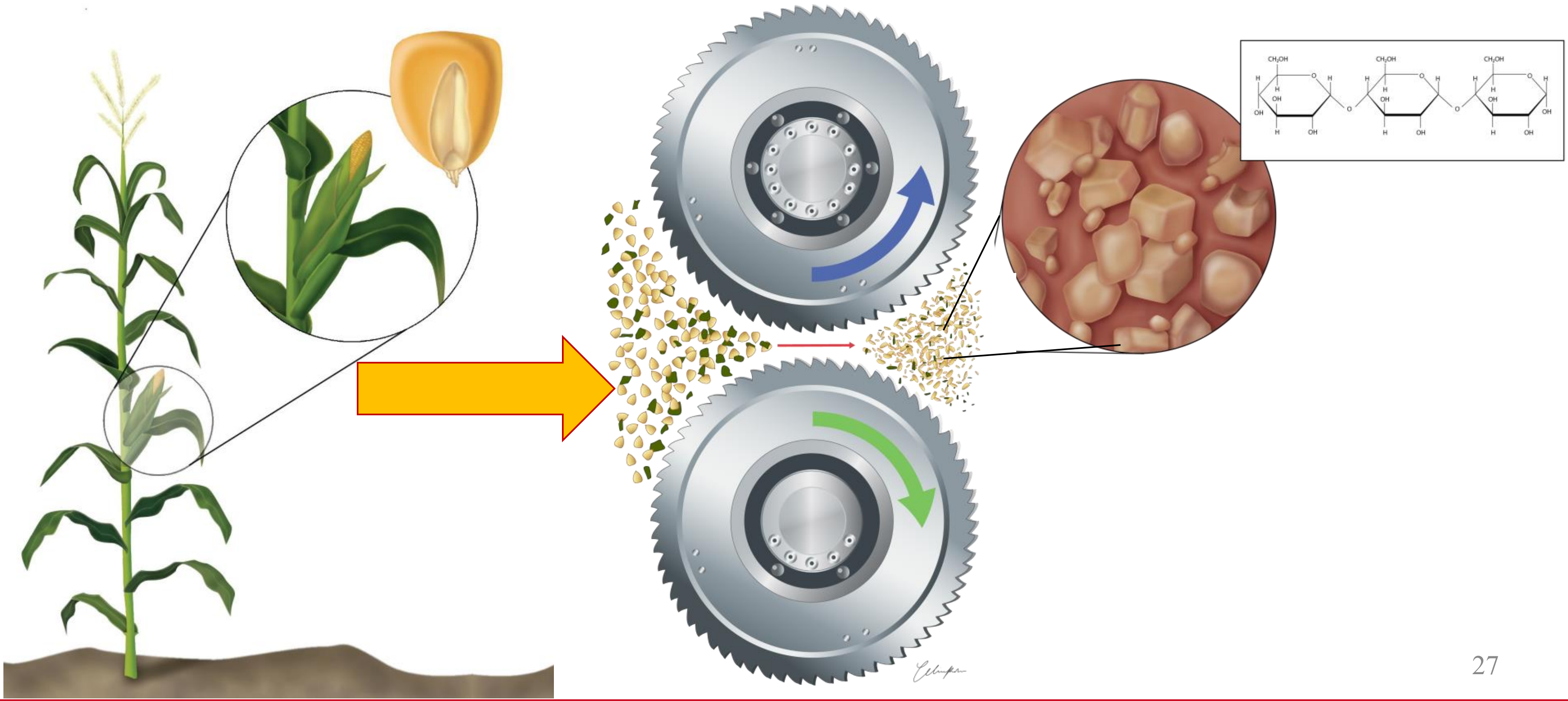
- Kernel processing is the equivalent of **smashing** an eggshell



- Exposing starch for microbial fermentation
- When microbes have access to starch they may be better prepared to digest fiber and produce microbial protein

Kernel processing

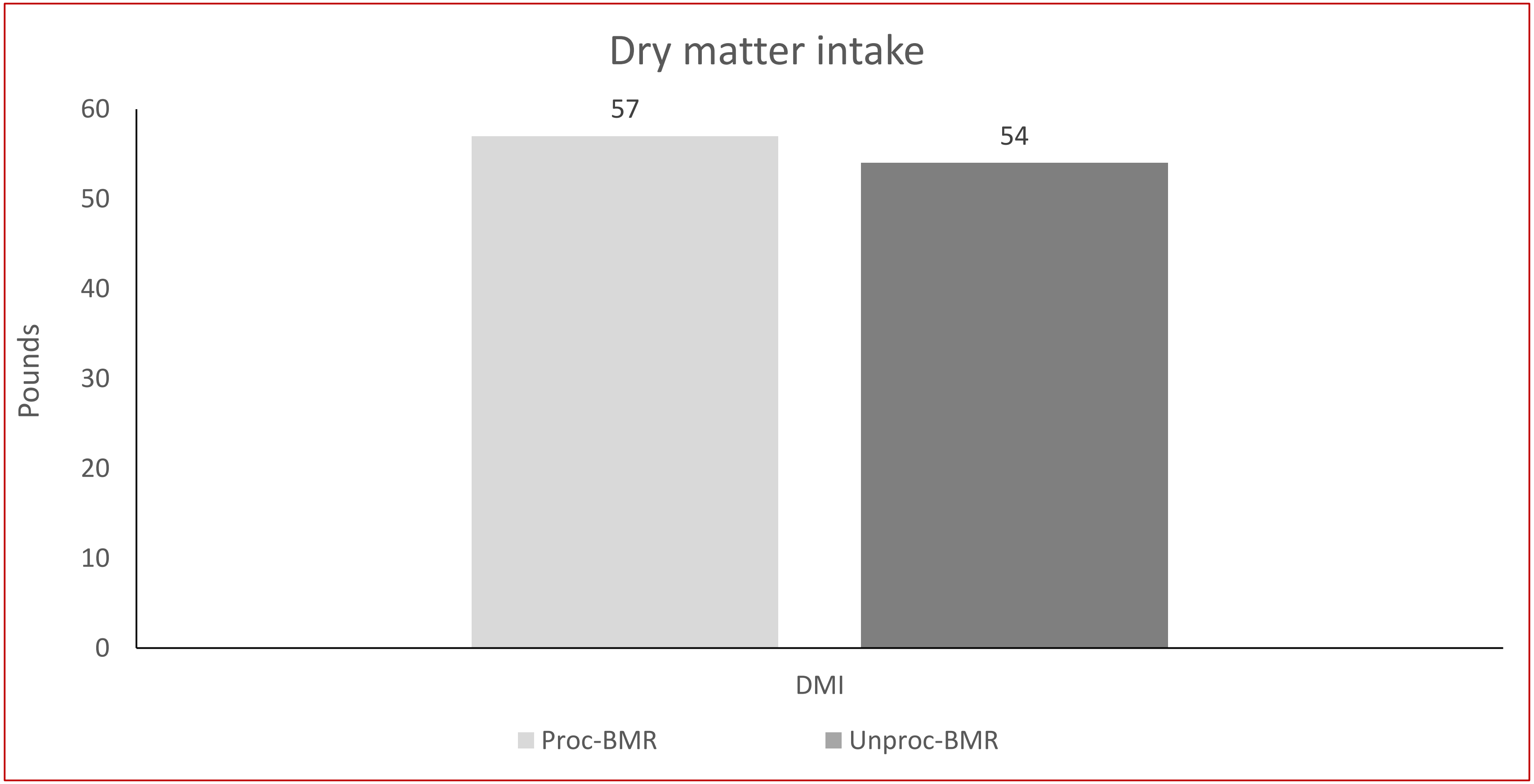
- Roller gap 1 to 3 mm = crushing action
- Differential speed = shearing action



Only a few whole kernels

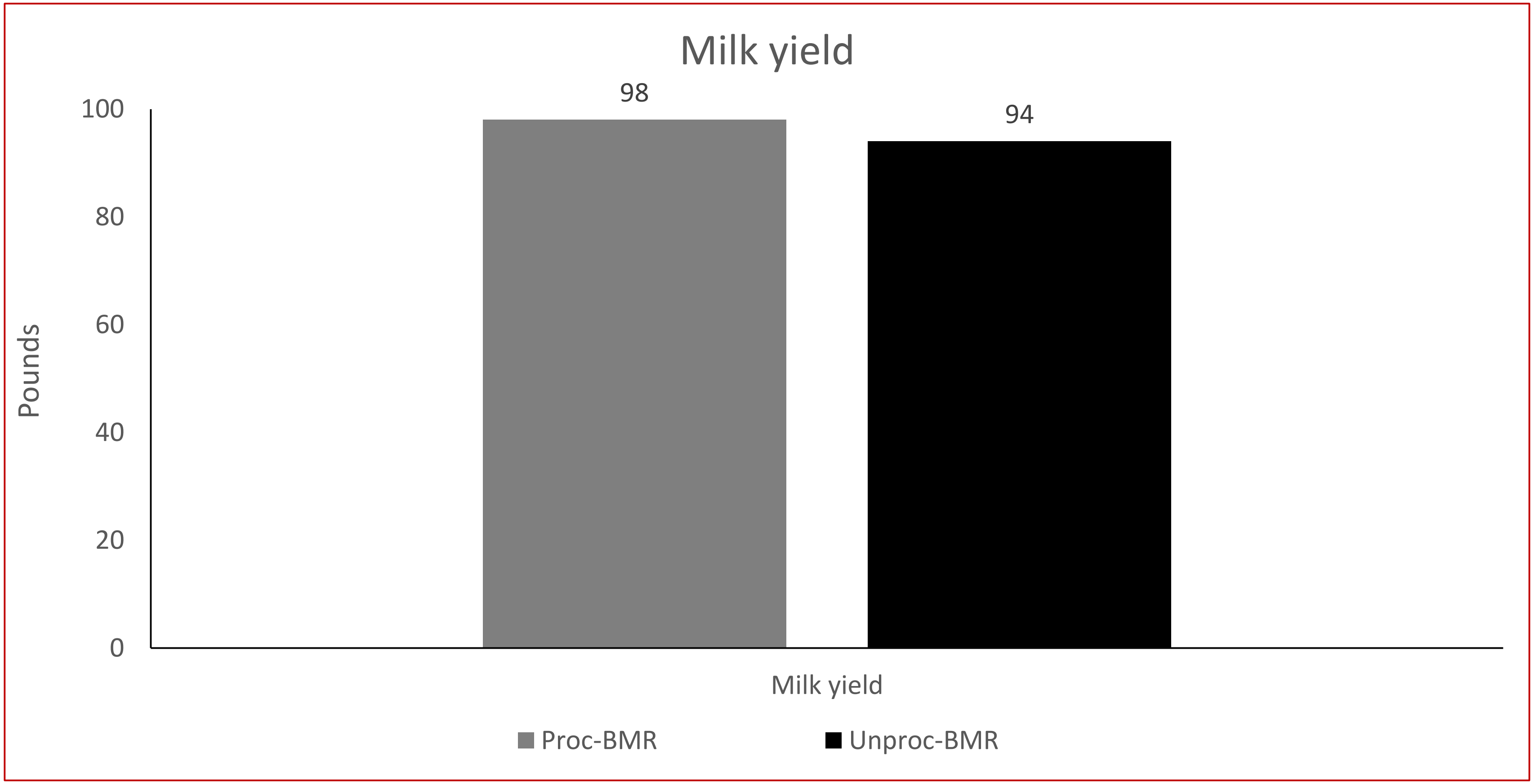
Most corn kernels are fractured to less than ½ their original size, mostly fragments and smashed kernels

What's the impact of processing?



Adapted from Ebling and Kung (2004)

What's the impact of processing?



Adapted from Ebling and Kung (2004)

Beef cattle response to kernel processing corn (Univ. Nebraska, 2018)

	Treatment		SEM	*P* - value
	Unprocessed	Processed		
Initial BW, lbs	882	882	9.6	0.99
Final BW, lbs	1,337	1,338	11.2	0.96
DMI, lbs/d	32.6	31.8	0.27	0.04
ADG, lbs	4.38	4.38	0.047	0.93

Feed to gain reduced by 2.68% with kernel processing when feeding CS at 40% of finishing ration

Hilscher et al. (2018)

Evaluating kernel processing

- During harvest: manage it, **adjustment in real time**.
  - 32-oz cup
  - Spread sample
  - Sift and count halves and whole kernels
  - Goal is to have less than 2 half to whole kernels

These trade names are only provided as examples. This does not constitute endorsement of any particular product.

Evaluating kernel processing

- During harvest: **manage it, make adjustment in real time.**
  - Floating test
    - Fill a dish pan or 5-gallon bucket with water about ½ full
    - Collect 2 to 3 handfuls of chopped material into the bucket
    - Stir the content (less than 1 min is enough)
    - Remove the floating stover
    - Carefully drain the water
    - Pour the kernels onto a flat surface and visually inspect them
    - Good processing should result in almost no half or whole kernels.

From Univ. of WI Extension: http://fyi.uwex.edu/forage/files/2014/01/KernelProcessing-FOF.pdf

Evaluating kernel processing

- After harvest and storage, objective test:
  - Kernel Processing Score (KPS) or Corn Silage Processing Score (CSPS)
  - A sample of corn is sifted through 9 screen on a Ro-Tap shaker
  - Percentage of starch that passes through the 4.75 mm screen

Less than 50%	50 to 69%	More than 70%
Inadequately processed	**Adequately processed**	**Optimally processed**

CUST: Iowa State Universit # 3560 (5)   CLIENT: Hugo - ISU
Hugo A. Ramirez
Ames , IA 50011   DESC: MF silage

Moisture	59.1%
Dry Matter	40.9%
Starch (dry basis)	40.5%

Particle Size Dry Matter Distribution
prior to grinding

Coarse Screen (greater than 4.75 mm)	32%
Medium Screen	53%
Fine screen (less than 1.18 mm)	15%

Percentage of starch passing through the coarse screen.	83%

CUMBERLAND VALLEY ANALYTICAL SERVICES

Laboratory services for agriculture ... from the field to the feed bunk.

Farm:
Desc: **BUNKER 2**
Submitter: **RAMIREZ, HUGO A.**
Account:

Copies to:

Lab ID: **21267 069**
Sampled: **12/22/2016**
Arrived: **01/05/2017**
Completed: **01/11/2017**
Reported: **01/11/2017**

Corn Silage Processing Score

% of starch passing a 4.75mm screen **61.9**

The Corn Silage Processing Score (CSPS) was developed by Dr. Dave Mertens formerly of the USDA Forage Research Center as a tool to define the adequacy of kernel processing by forage harvesters. In addition, the CSPS is a tool that defines starch particle size and can be used to make inference on ruminal and total tract digestibility of corn silage starch. Approximately 600 ml of dried corn silage is sieved in a Ro-Tap Shaker for 10 minutes. This unit oscillates 278 timer per minute and "taps" the top of the sieves 150 times per minute to create an aggressive shaking action. Material that passes through the 4.75 mm sieve is collected and analyzed for starch content. The percentage of starch that passes through the screen becomes the "Processing Score".

Guidelines:

- Greater than 70% .... Optimally Processed
- Between 50% and 70% .... Adequately Processed
- Less than 50% .... Inadequately Processed

DAIRYLAND LABORATORIES, INC.
Arcadia, WI 54612
Telephone 608-323-2123

DATE: 1/ 6/2017
SAMPLE: 001-1701-092278

CUST:

CLIENT: Hugo Ramirez

DESC: CS bunker 2

Moisture	71.6%
Dry Matter	28.4%
Starch (dry basis)	28.2%

Particle Size Dry Matter Distribution
prior to grinding

Coarse Screen (greater than 4.75 mm)	43%
Medium Screen	47%
Fine screen (less than 1.18 mm)	10%

Percentage of starch passing through the coarse screen.	60%

CS-17

SAMPLE INFORMATION

Lab ID:	23271 163	Series:	
Crop Year:	2017	Version:	2.0
Cutting#:			
Feed Type:	CORN SILAGE		

CHEMISTRY ANALYSIS RESULTS

Moisture	57.5

CUMBERLAND VALLEY ANALYTICAL SERVICES

Laboratory services for agriculture ... from the field to the feed bunk.

Farm: [redacted]
Desc: CS-17
Submitter: RAMIREZ, HUGO A.
Account: IOWA STATE UNIVERSITY

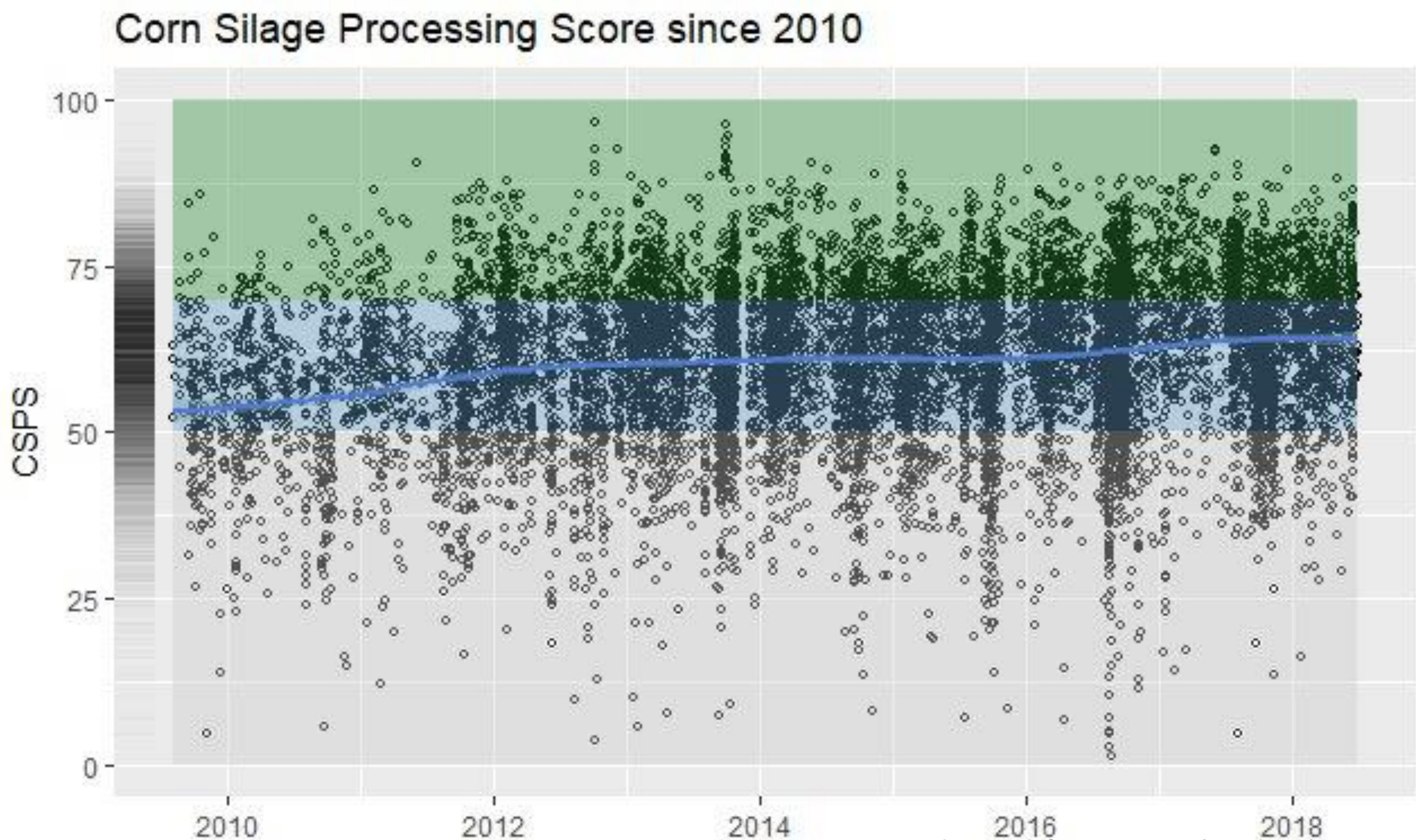
Copies to:

Lab ID:	**23271 163**
Sampled:	**11/27/2017**
Arrived:	**12/14/2017**
Completed:	**12/18/2017**
Reported:	**03/26/2018**

Corn Silage Processing Score

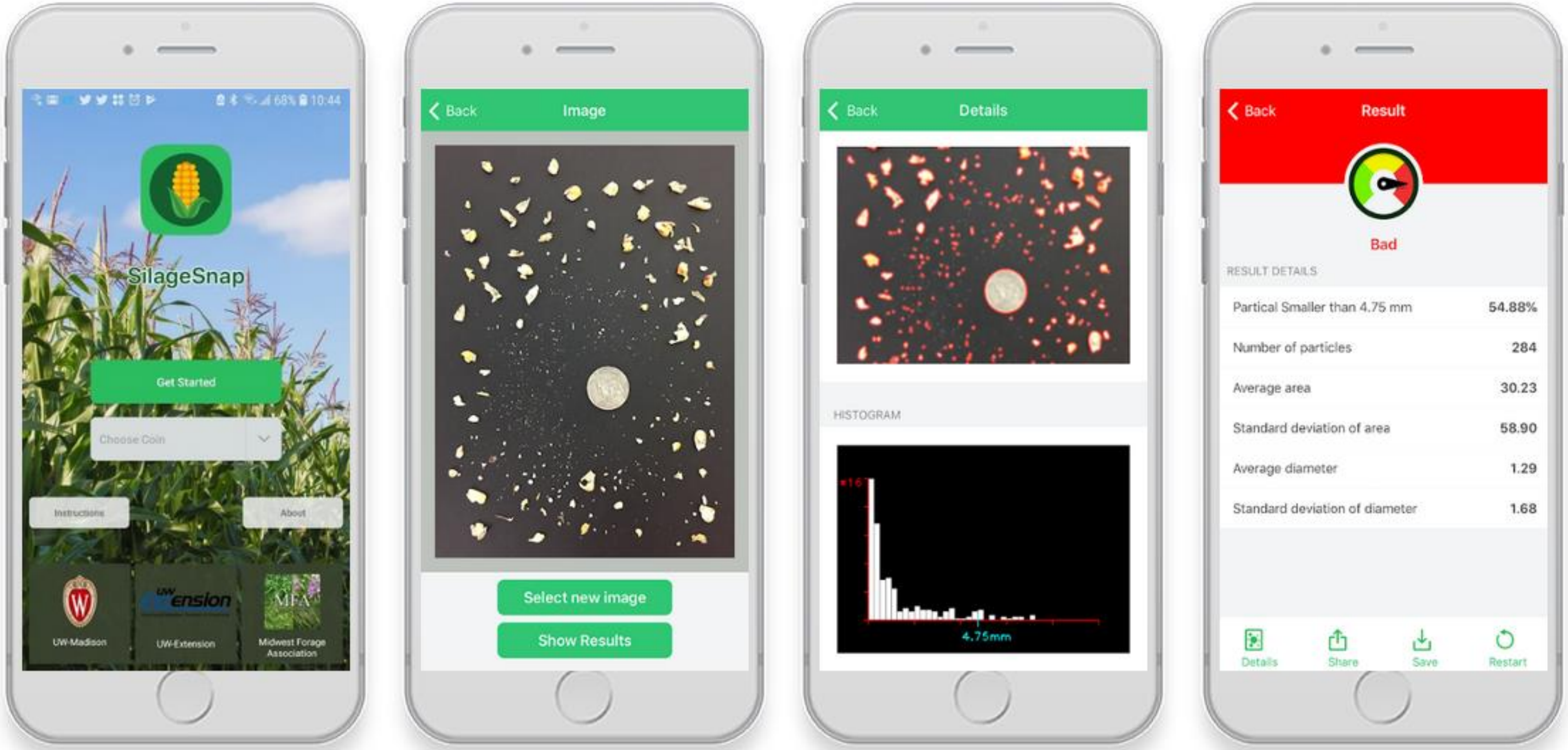
% of starch passing a 4.75mm screen **23.6**

On our way from common to standard



Adapted from Dairyland Laboratories, Inc.

Silage Snap



SilageSnap
Get Started
Choose Coin
Instructions
About
UW-Madison
UW-Extension
Midwest Forage Association
Back
Image
Select new image
Show Results
Back
Details
HISTOGRAM
4.75mm
Back
Result
Bad
RESULT DETAILS
Partical Smaller than 4.75 mm 54.88%
Number of particles 284
Average area 30.23
Standard deviation of area 58.90
Average diameter 1.29
Standard deviation of diameter 1.68
Details
Share
Save
Restart

Results

Good

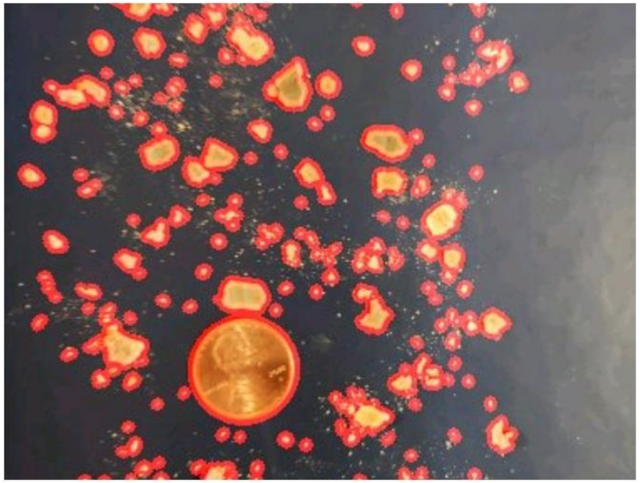
RESULT DETAILS

Particle Smaller than 4.75 mm	**89.39%**
Number of Particles	**245**
Average Area	**15.10 mm²**
Standard Deviation of Area	**32.93 mm²**
Average Diameter	**0.92 mm**
Standard Deviation of Diameter	**1.14 mm**

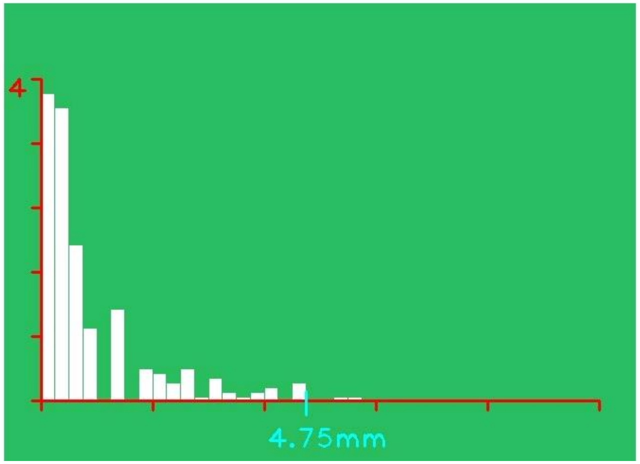
Details Share Save Restart

Details

PARTICLES DETECTED



HISTOGRAM



Kernel processing …gone wrong

Piece of cob with kernels still attached to it!!!

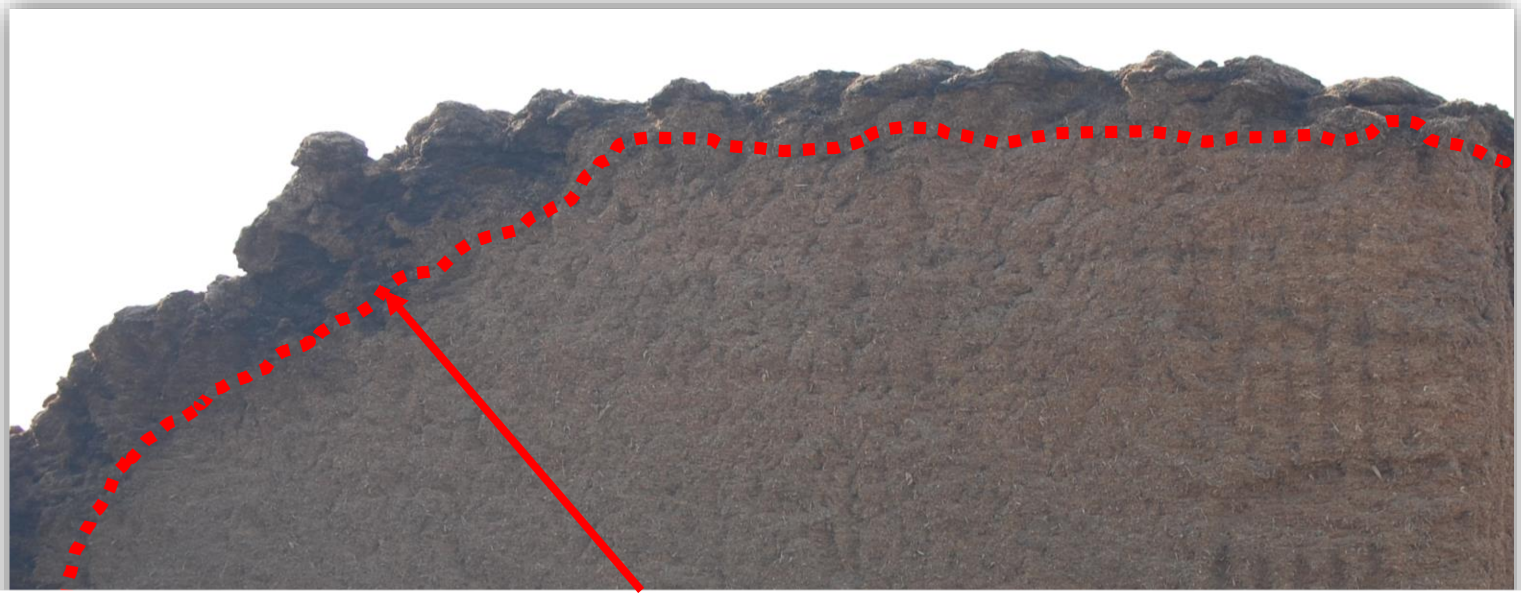
Starch is already there, let's make sure we make it available!!!

Many whole kernels, starch is encased and not readily available!!!

Bringing the forage to the storage structure: density is key = packing is a critical point

Shape – maintain slope of 3 to 1, or 4 to 1

Too steep and too high = Spoiled material on top



This material is already paid for
Not efficient use of resources
More labor to remove rotten material and high risk!!!
Significant shrink!!!
    If preserved properly, one can feed more cows or the same number cows for longer

Filling rate

Weight of tractor / 800 = tons per hour

Or

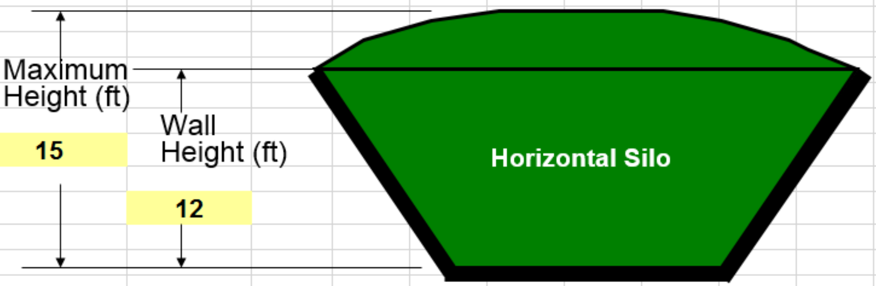
Tons per hour * 800 = weight needed

Layers of 4 to 5 inches thick to ensure good packing

Spreadsheet to Calculate Average Silage Density in a Bunker Silo(English Units)

Brian Holmes(1) and Richard Muck(2)
(1) Biological Systems Engineering Dept. and
(2) US Dairy Forage Research Center
University of Wisconsin-Madison
23-Aug-07

Bunker Silo Wall Height (feet) =	12	
Bunker Silo Maximum Silage Height (feet) =	15	Values in yellow cells are user changeable
Silage Delivery Rate to Bunker (T AF/Hr) =	150	Typical values 15-200 T AF/hr
Silage Dry Matter Content (decimal ie 0.35) =	0.35	Recommended range of DM content = 0.3-0.4
Silage Packing Layer Thickness (inches) =	8	Recommended value is 6 inches or less



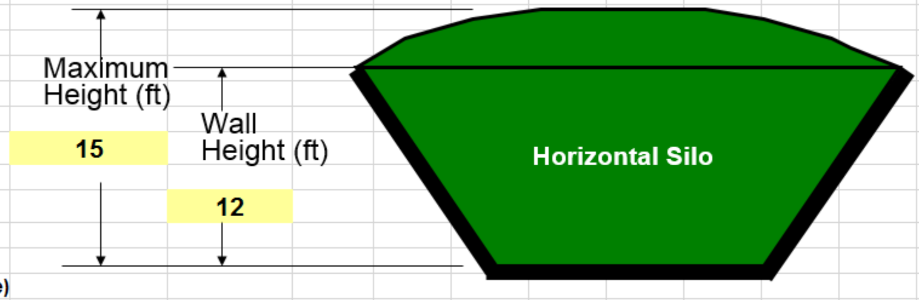
Packing Tractor - Each Tractor		Tractor Weight (lbs)	Tractor Packing Time (% of Filling Time)
Tractor # 1	Typical tractor weight is 10,000-60,000 lbs	40,000	100
Tractor # 2	Typical tractor weight is 10,000-60,000 lbs	40,000	100
Tractor # 3	Typical tractor weight is 10,000-60,000 lbs	0	0
Tractor # 4	Typical tractor weight is 10,000-60,000 lbs	0	0
Proportioned Total Tractor Weight (lbs) =		80,000	
Average Silage Height (feet) =		13.5	Green cells are intermediate calculated values

Packing Factor =	341.6	Values in pink cells are results of calculations
Est. Average Wet Density = Bulk Density (lbs AF/cu ft) =	39.5	Wet Density greater than 44 lbs AF/cu ft is recommended
Maximum Achievable Bulk Density (lbs AF/cu ft)=	73.3	Wet Density greater than Max. Wet Density is unrealistic
Gas Filled Porosity =	0.46	Gas Filled Porosity less than 0.40 is recommended
Est. Average Dry Matter Density (lbs DM/cu ft) =	13.8	Density greater than 15 lbs DM/cu ft is recommended
Maximum Achievable DM Density (lbs DM/cu ft)=	25.7	DM Density greater than Max. Achievable is unrealistic

Spreadsheet to Calculate Average
Silage Density in a Bunker Silo(English Units)

Brian Holmes(1) and Richard Muck(2)
(1) Biological Systems Engineering Dept. and
(2) US Dairy Forage Research Center
University of Wisconsin-Madison

Bunker Silo Wall Height (feet) =	12	23-Aug-07
Bunker Silo Maximum Silage Height (feet) =	15	Values in yellow cells are user changeable
Silage Delivery Rate to Bunker (T AF/Hr) =	150	Typical values 15-200 T AF/hr
Silage Dry Matter Content (decimal ie 0.35) =	0.35	Recommended range of DM content = 0.3-0.4
Silage Packing Layer Thickness (inches) =	6	Recommended value is 6 inches or less



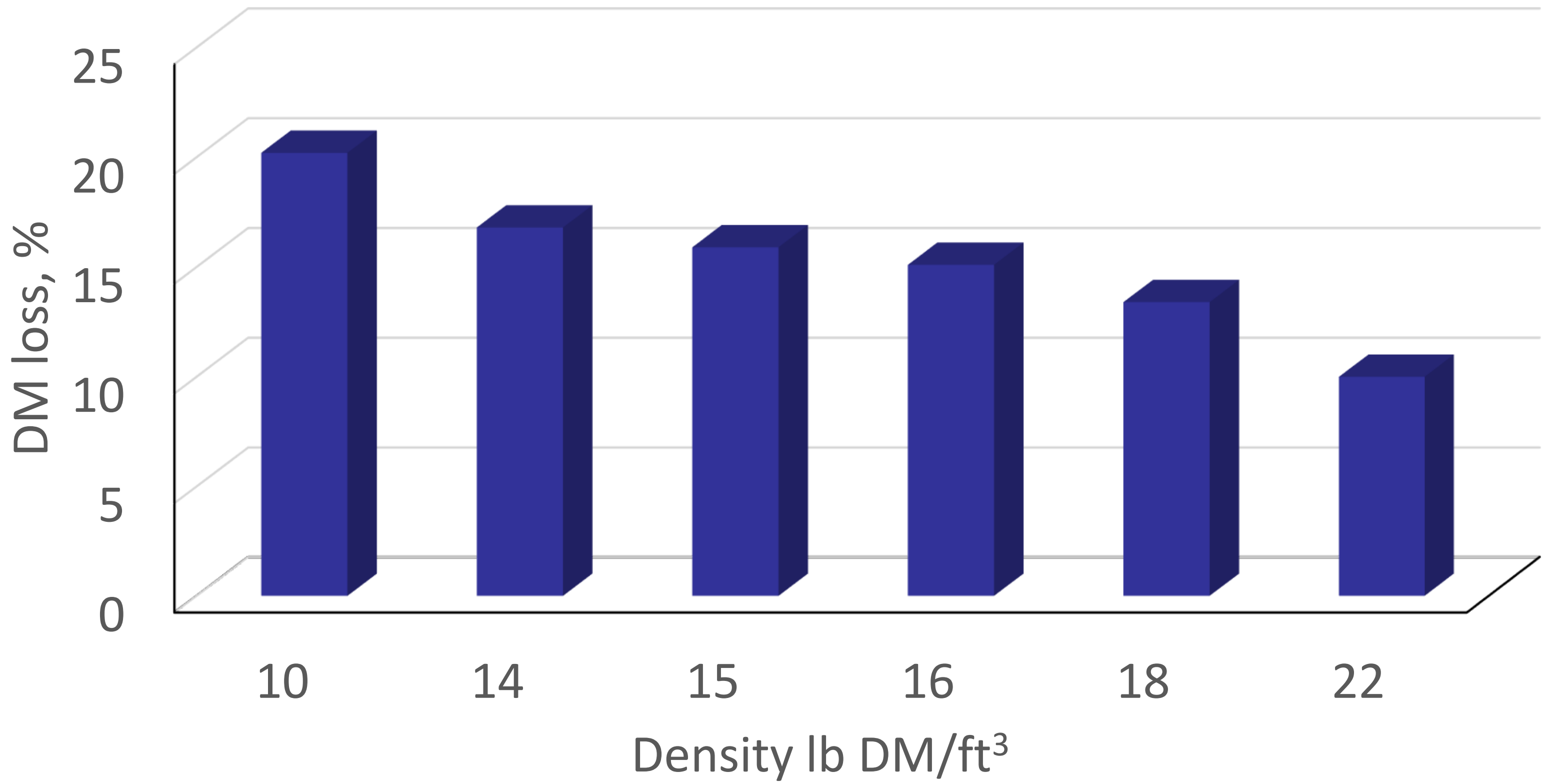
Packing Tractor - Each Tractor		Tractor Weight (lbs)	Tractor Packing Time (% of Filling Time)
Tractor # 1	Typical tractor weight is 10,000-60,000 lbs	40,000	100
Tractor # 2	Typical tractor weight is 10,000-60,000 lbs	40,000	100
Tractor # 3	Typical tractor weight is 10,000-60,000 lbs	0	0
Tractor # 4	Typical tractor weight is 10,000-60,000 lbs	0	0
Proportioned Total Tractor Weight (lbs) =		80,000	
Average Silage Height (feet) =		13.5	Green cells are intermediate calculated values

Packing Factor =	455.4	Values in pink cells are results of calculations
Est. Average Wet Density = Bulk Density (lbs AF/cu ft) =	44.5	Wet Density greater than 44 lbs AF/cu ft is recommended
Maximum Achievable Bulk Density (lbs AF/cu ft)=	73.3	Wet Density greater than Max. Wet Density is unrealistic
Gas Filled Porosity =	0.39	Gas Filled Porosity less than 0.40 is recommended
Est. Average Dry Matter Density (lbs DM/cu ft) =	15.6	Density greater than 15 lbs DM/cu ft is recommended
Maximum Achievable DM Density (lbs DM/cu ft)=	25.7	DM Density greater than Max. Achievable is unrealistic

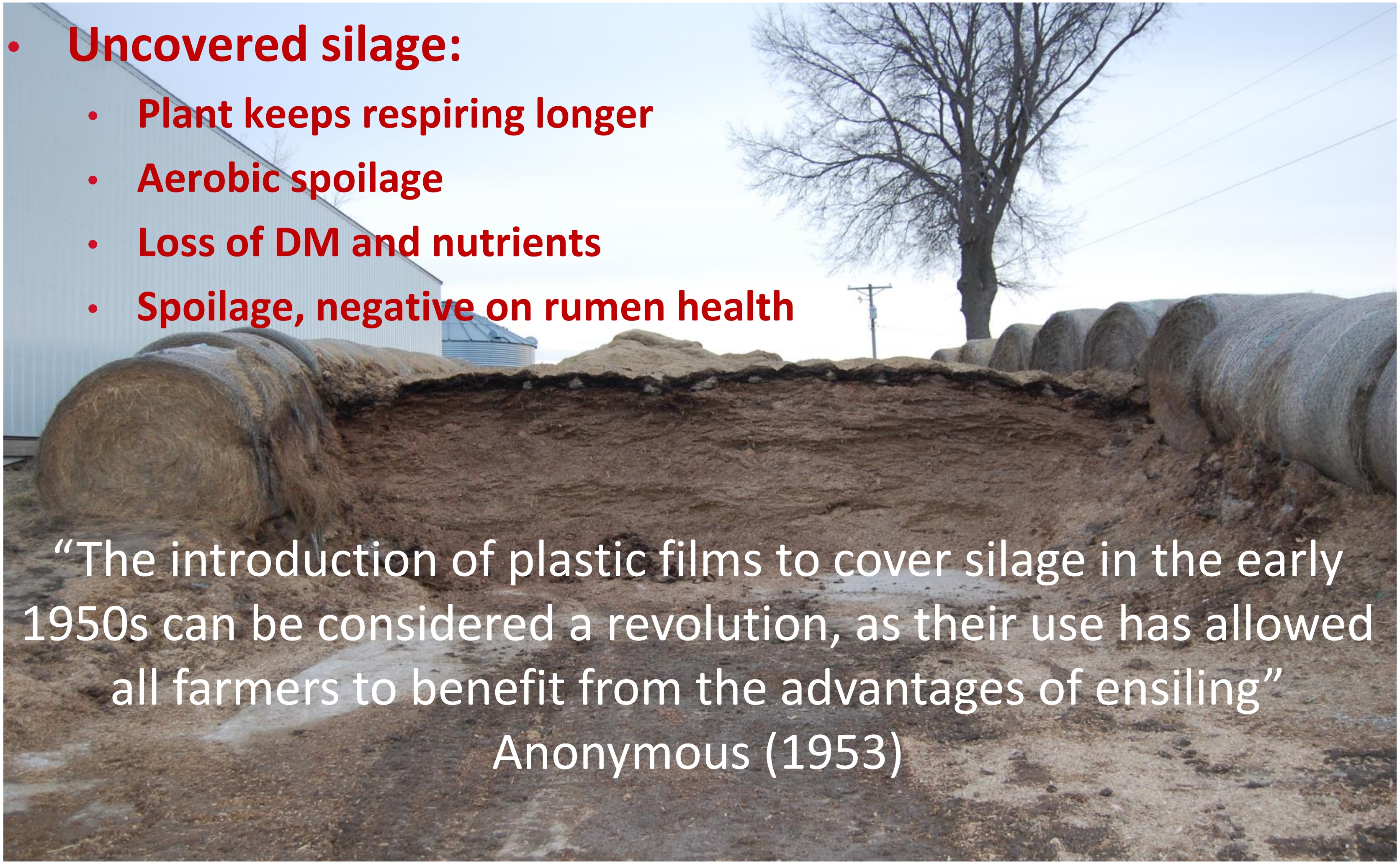
Compaction - packing

Packing, packing, packing!

Loose silage is lost silage!



Covering Practices



- **Uncovered silage:**
  - **Plant keeps respiring longer**
  - **Aerobic spoilage**
  - **Loss of DM and nutrients**
  - **Spoilage, negative on rumen health**

"The introduction of plastic films to cover silage in the early 1950s can be considered a revolution, as their use has allowed all farmers to benefit from the advantages of ensiling"
Anonymous (1953)

Spoilage…only the top layer. Not big deal?

- Bunker dimensions
  - 40 ft × 100 ft × 12 ft
- Density 16 lbs DM/ft^3
- Storage appr. 1,000 ton with approximately **25% of the total material is stored in the top 3 ft**

- Uncovered OM losses
  - 47% top 1.5 ft
  - 11% next 1.5 ft below
- Covered
  - 20% top 1.5 ft
  - 5% next 1.5 ft below (Bolsen, 1997)

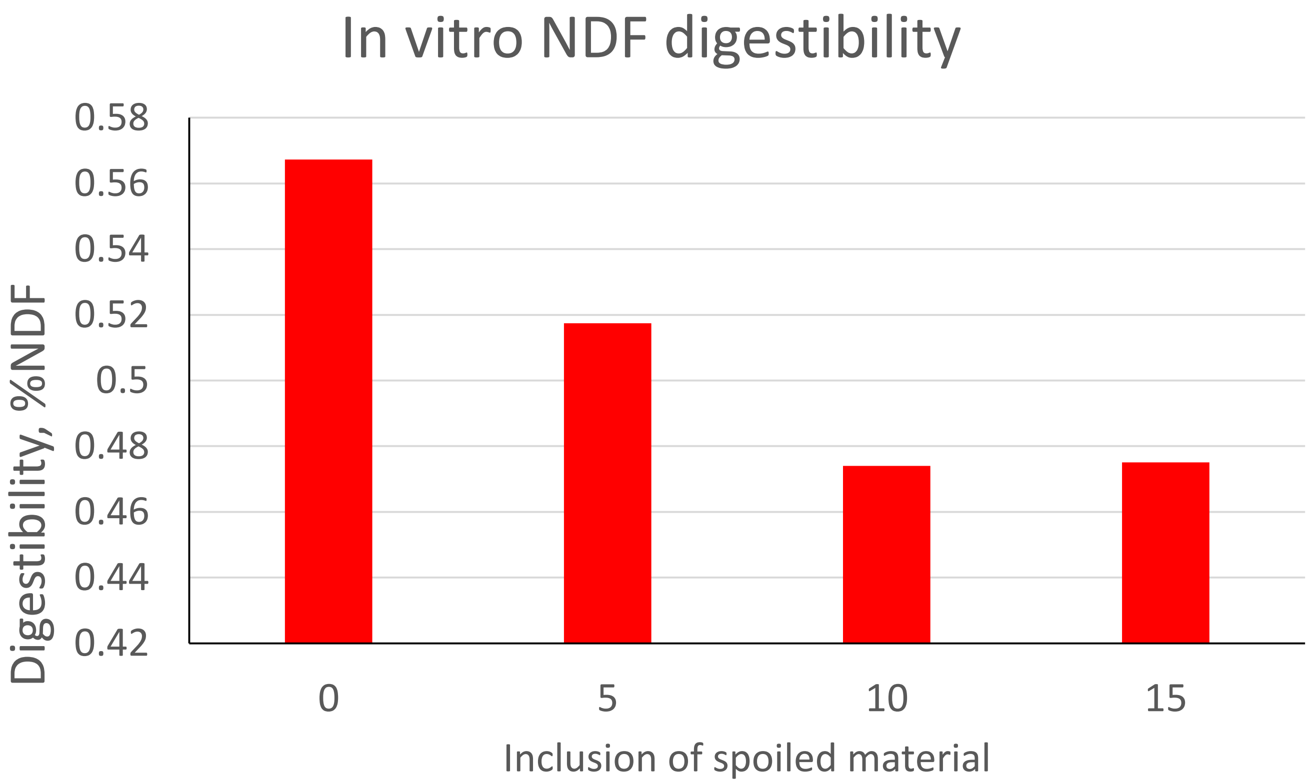
Farm conditions, DM losses in the 3 ft layer immediately below the plastic film can be > 30% of the original ensiled crop. (Borreani et al., 2007; Holmes and Bolsen, 2009).

Storing conditions: uncovered vs bags

- Uncovered silage, plant keeps respiring longer
- Aerobic spoilage
- Loss of DM and nutrients
- ↑ Risk for mycotoxins development

- Ag bags offer good anaerobic environment
- Flexibility in management, location
- Better recovery of DM and nutrients
- ↓ Risk for mycotoxin development

Effect of including Surface-spoiled corn silage with non-spoiled corn silage



Carroll et al., (2019)

Not covered silage is a problem, covering should fix it…as long as it is well covered!!!

Slope is too steep, tires do not stay in place
Safety risk!

Excellent coverage with tires touching each other

Covering and sealing

Oxygen barrier film underneath

Black and white plastic on top

Covering done right!

Chopped right, packed tight and well covered!!!

Oxygen barrier films

- Approx. 40% reduction of DM loss in the upper 60 cm of silage piles (Wilkinson and Fenlon, 2014)

- Top surface inedible silage (Wilkinson and Fenlon, 2014)
  - 10.7% for standard film
  - 2.96% for and OB film systems

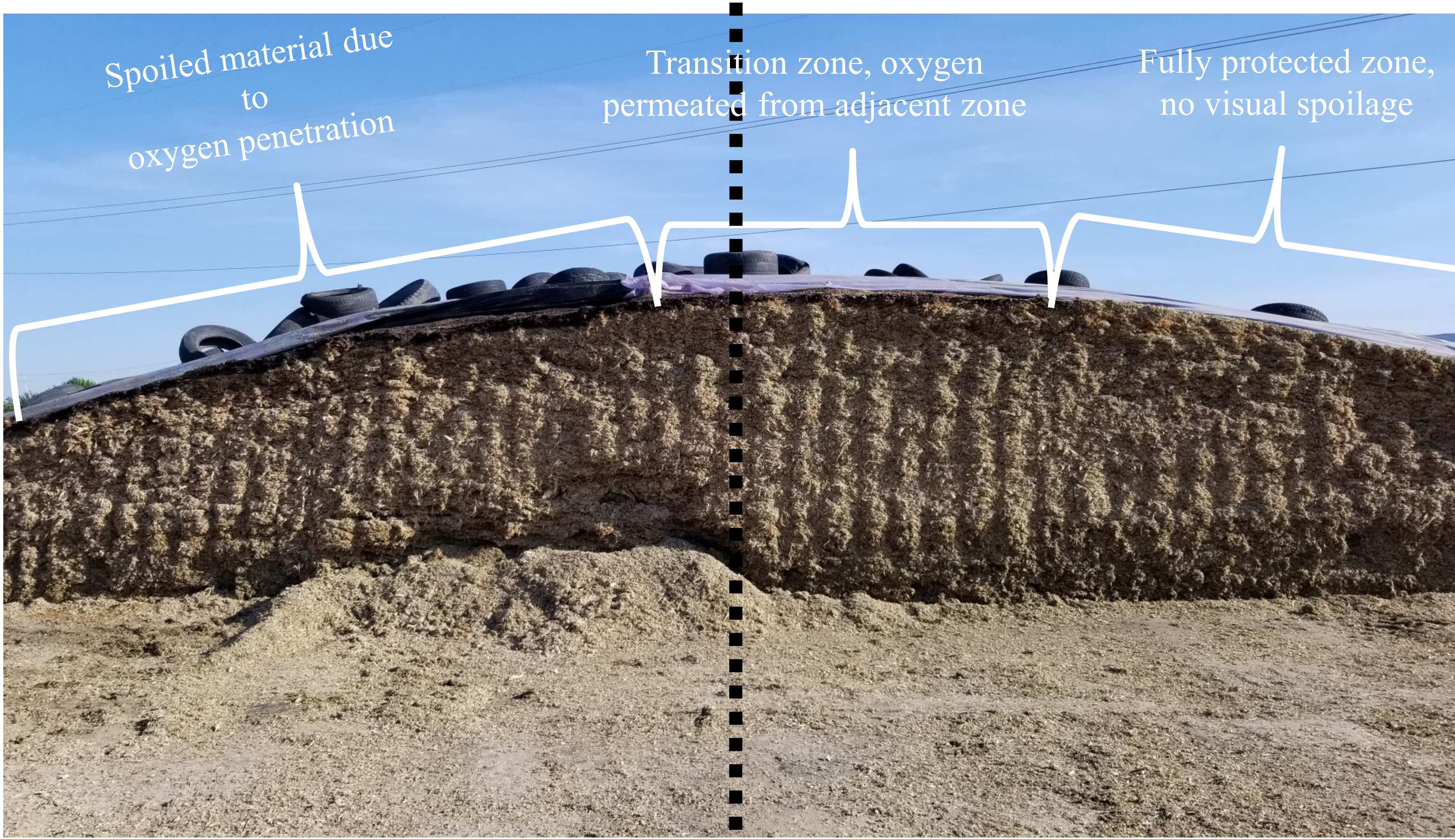
- Economic return compared to conventional films for every ton of fresh forage
  - $1 .13 (Borreani and Tabacco, 2014)
  - $5.80 (Bolsen et al., 2012)

Visual appraisal of the effect of oxygen barriers on top region of a silage pile

½ sealed without oxygen barrier

Same pile

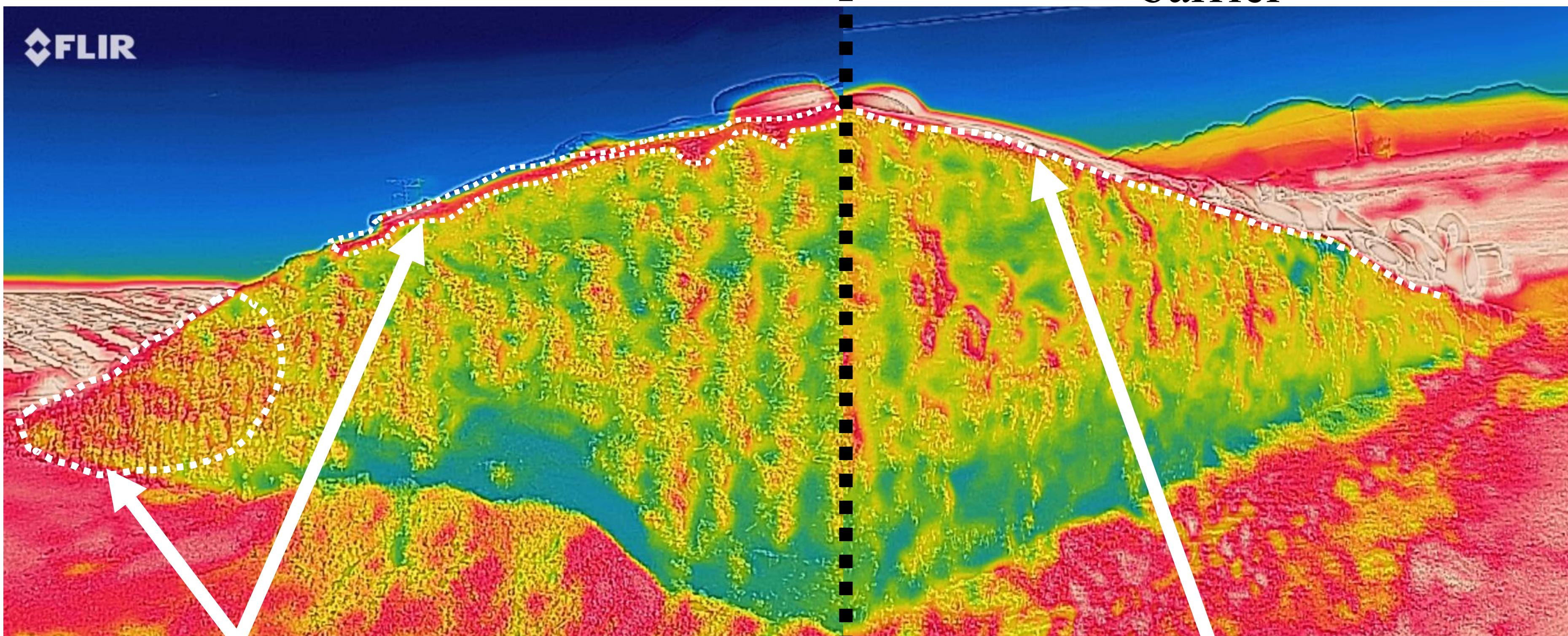
½ sealed with oxygen barrier



Same pile

½ sealed without oxygen barrier

½ sealed with oxygen barrier



Outline of regions with spoilage and heating due to oxygen penetration + sun radiation

No visible spoilage and minimal heating from sun radiation

Reduction in DM losses by oxygen barrier films

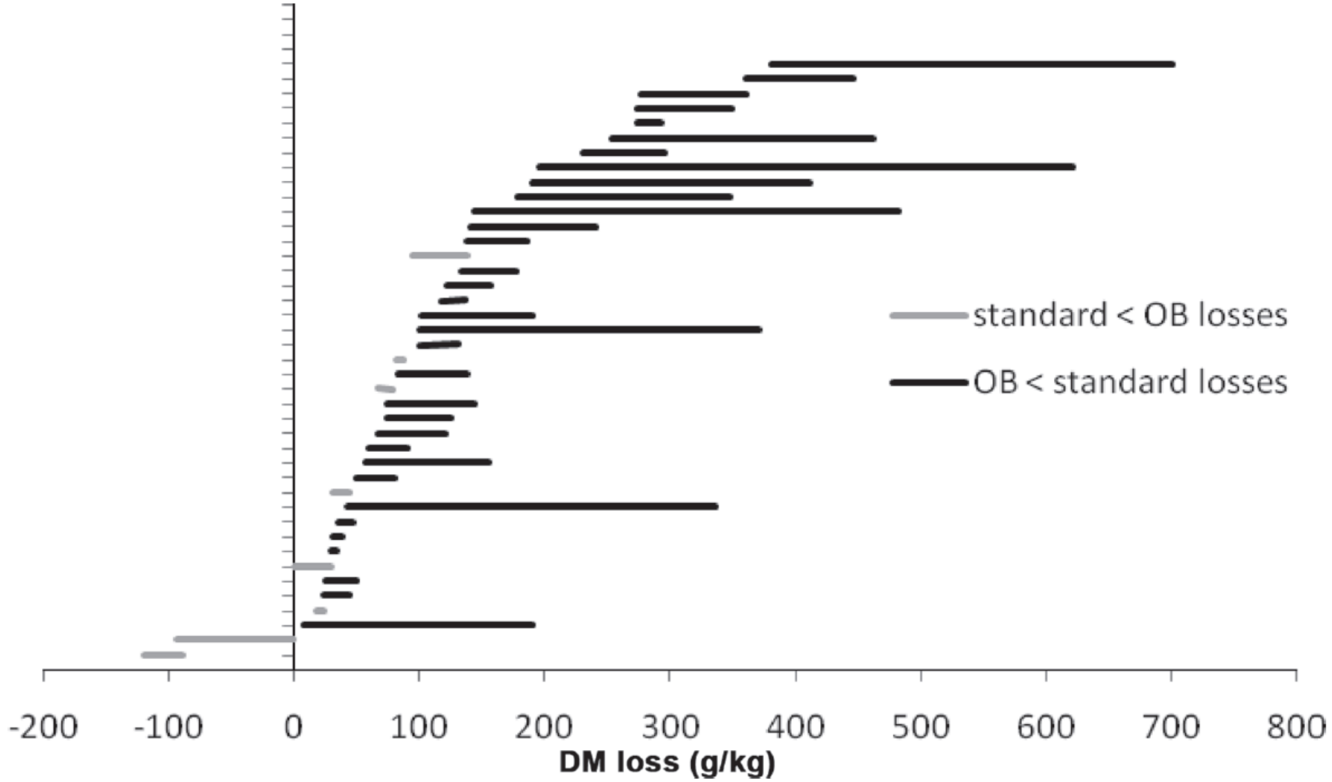
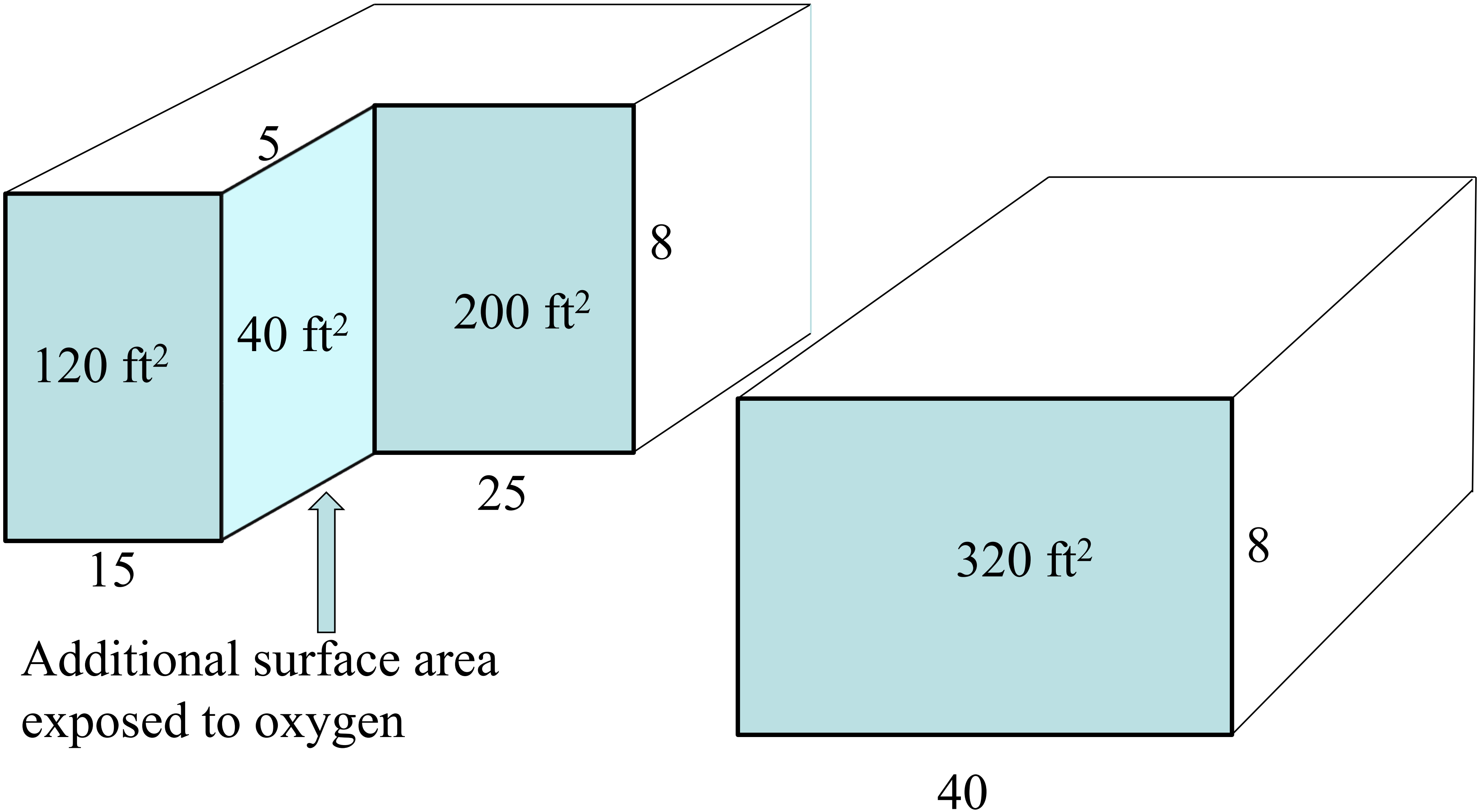


Figure 12. Horizontal silo comparison-differences [standard polyethylene (PE) vs. oxygen barrier (OB) film losses of DM] ordered by OB loss (from Wilkinson and Fenlon, 2014).

Little to no spoilage

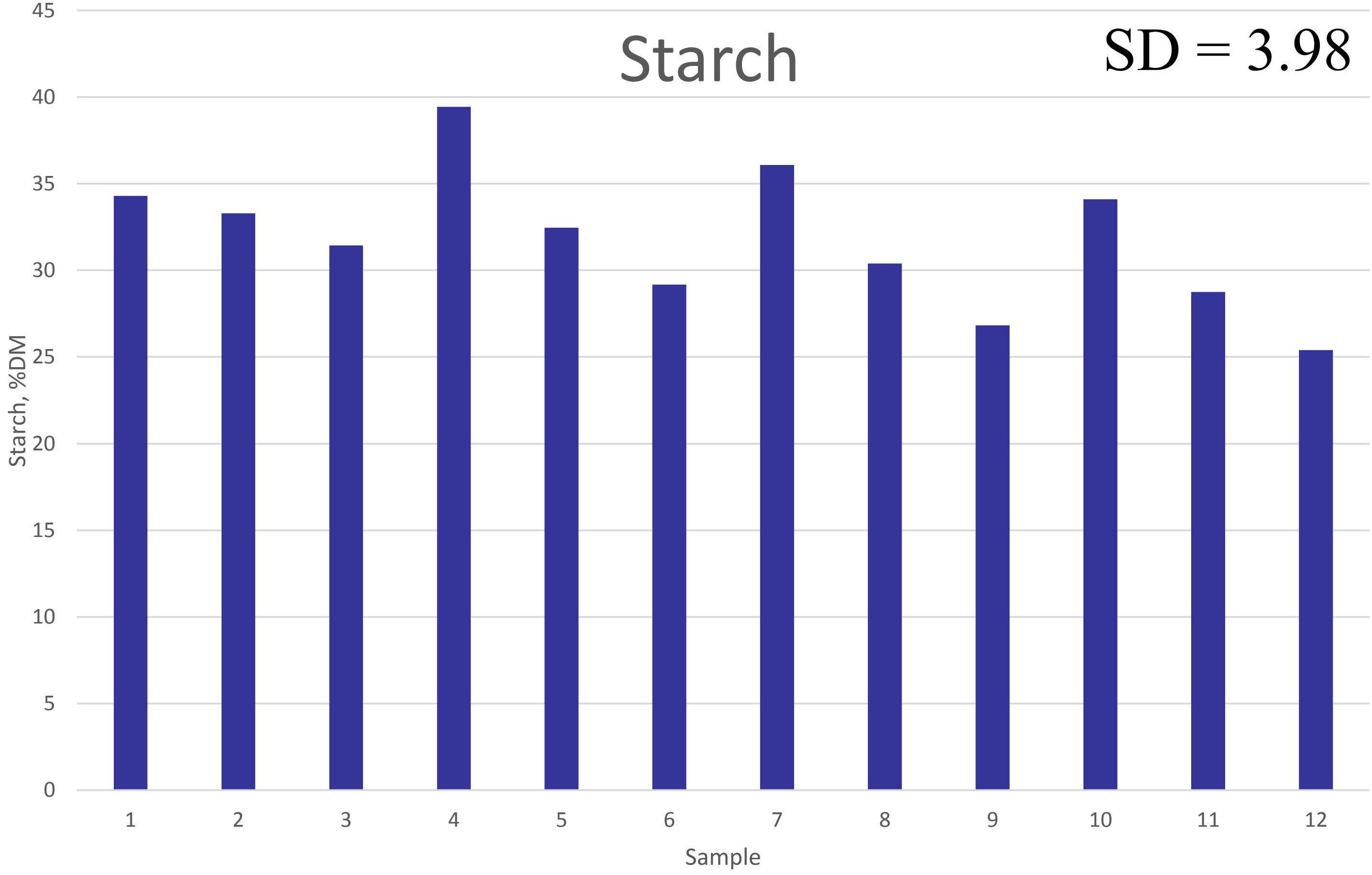
Importance of face management

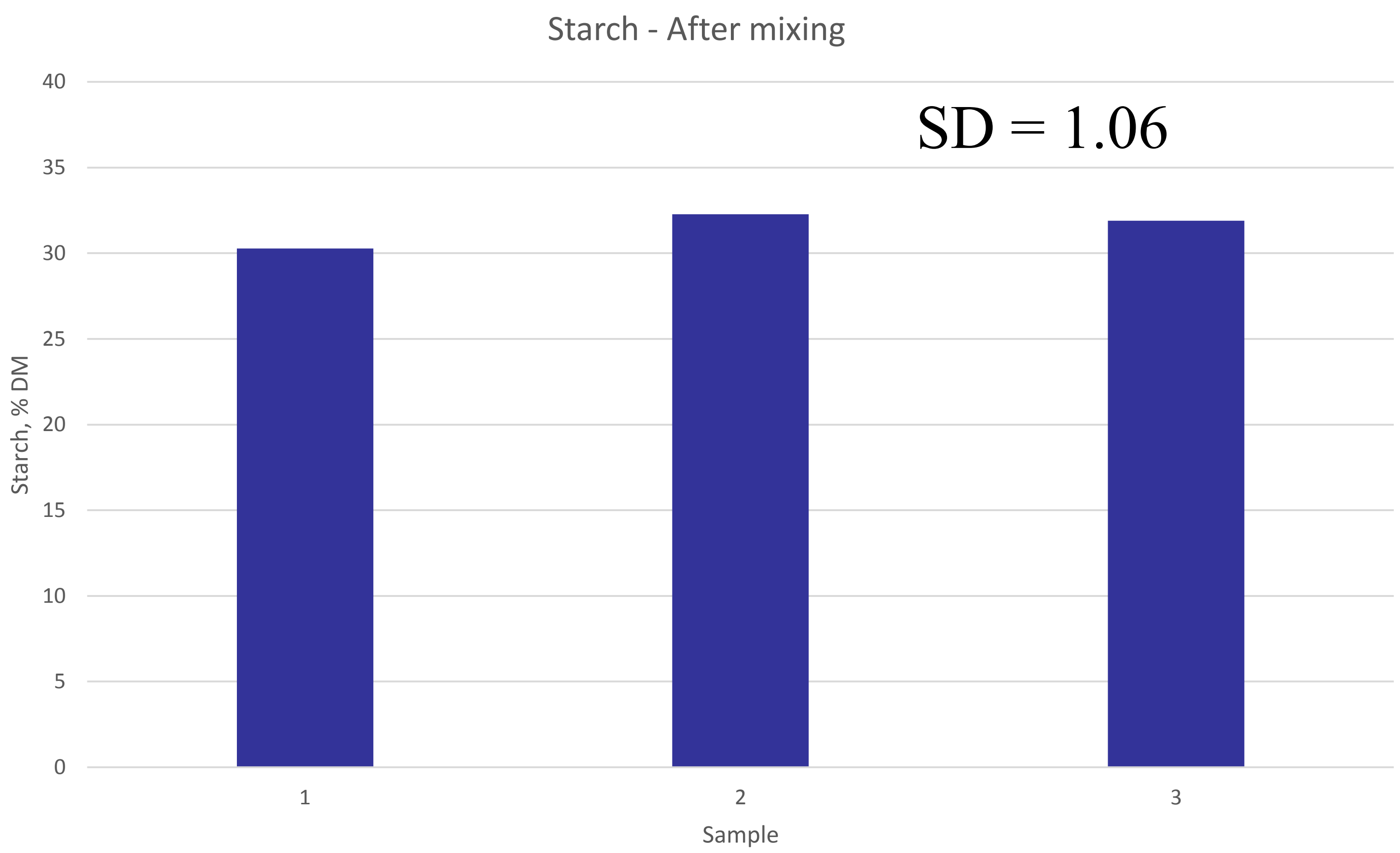


Additional surface area exposed to oxygen

Managing variation

Mixing reduces variability


Starch
SD = 3.98
45
40
35
30
25
20
15
10
5
0
Starch, %DM
1
2
3
4
5
6
7
8
9
10
11
12
Sample


Starch - After mixing
SD = 1.06
40
35
30
25
20
15
10
5
0
Starch, % DM
1
2
3
Sample

The five C's of Corn Silage Quality

1. Content of dry matter – maturity
    - Aim for 32-35% DM (2/3 to 3/4 milk line)
2. Chop length and kernel processing
    - 19 mm or ¾ inch chop length, kernel processor 2 mm or tighter
3. Compaction, packing
    - Goal is at lest 15 lbs DM per cubic foot
4. Covering and sealing
    - Seal as soon as possible, oxygen barrier and black and white plastic
5. Care and management at feed-out

Thanks for your attention

Dr. Hugo A. Ramírez Ramírez
Dairy Nutrition & Management
Department of Animal Science
hramirez@iastate.edu
515-294-5517

IOWA STATE UNIVERSITY
Extension and Outreach