The Importance of Silo Management and Aerobic Stability of Silages/TMR

Limin Kung, Jr. (lksilage@udel.edu)

Dairy Nutrition & Silage Fermentation Lab

Department of Animal & Food Sciences

Cooperative Extension

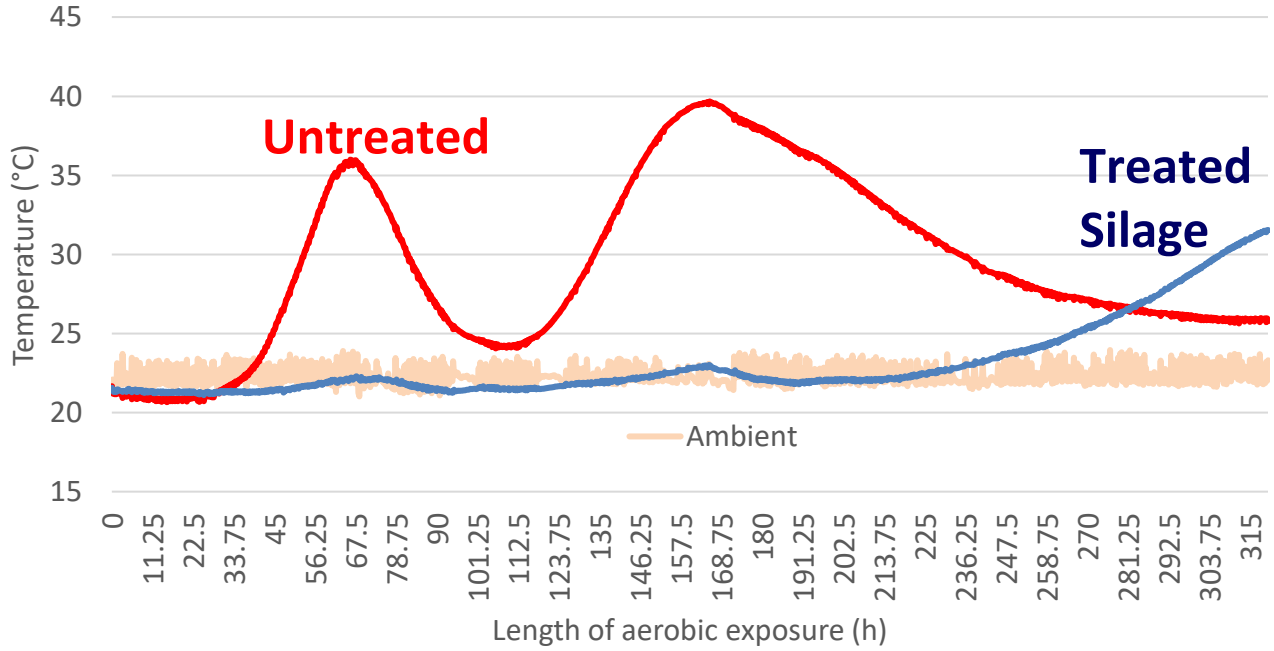
University of Delaware, Newark

Presentation Topics

- Definition of “aerobic stability”
- Silage fermentation and goals
- Yeasts in silages and aerobic stability
- Undesirable effects of feeding spoiling silage to ruminants
- Methods to maximize aerobic stability

Definition of "Aerobic Stability"

- The amount of time that a silage or TMR with silage remains "fresh" and unspoiled after exposure to air
- Aerobic stability can be measured in a variety of ways
- The simplest and most widely used method is to measure the the increase in silage temperature increases (indicates spoilage) when exposed to air



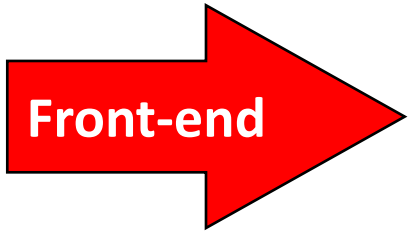
Importance of “Aerobic Stability”

- Unstable or spoiling silages cause:
  - Loss of DM and energy
  - Poor animal performance
    - decreased intake
    - decreased production
    - various health issues

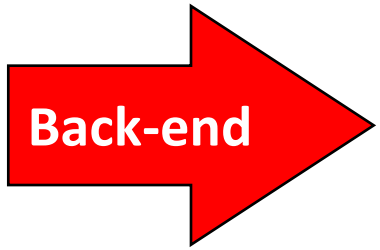
Dry Matter Losses From Good and Poor Silo Management

Losses From	Good Management	Poor Management
Respiration	0-4%	5-15%
Fermentation	4-6%	10-20%
Seepage	0-1%	5-10%
Aerobic instability during storage/feeding	5-7%	10-20%
Total	10-15%	20-30%

The Goals of Making Silage



Rapid preservation of high quality forage for maximum recovery of nutrients



Continued preservation of nutrients and excellent “aerobic stability” during storage and feedout

Silage Quality at Feedout is a Result of:

1) The quality you start with at harvest

2) How you manage the forage during ensiling, storage, and feedout

Starting Right vs. Starting Wrong

	Right	Wrong
Alfalfa -	35-40 NDF	> 50% bloom, >50% NDF
	35-42%DM	<30% DM, >50% DM
Grasses,	boot	> headed out
Sm grains, etc.	30-35%DM	<30% DM, >40% DM
Corn silage	~35% DM	<30% DM, >40% DM

(Values may vary based on individual farm conditions, needs and target animals)

Help With Silage

- Avoid soil contamination
- Minimize wilting time
- Maximize dry down hours during daylight
- Wilt to proper DM, avoid excessive DM
- Use a proven additive
- Follow best silo management practices

Consequences of Extreme DM on Grass and Alfalfa Silages

Too Wet	Too Dry
- Wild acetic fermentations	- Hard to pack
- Clostridial fermentations	- Heats rapidly
- Low intakes	- Low intakes
- Seepage	- Heat damaged protein

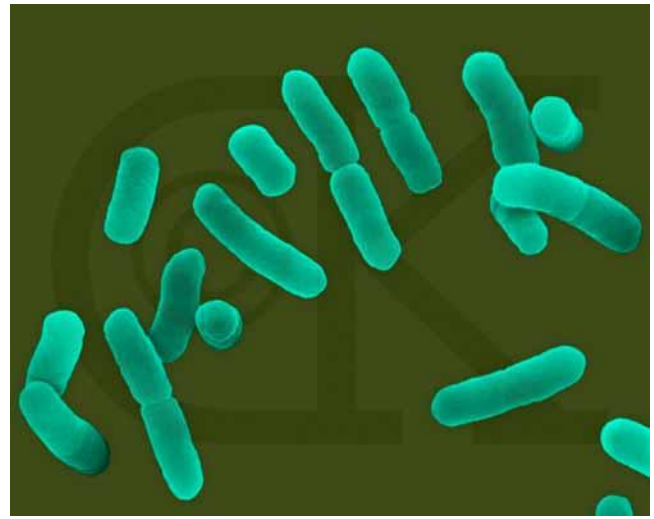
Once you have these issues there is not much you can do to fix them!

What are the Keys to a Successful Silage Fermentation?

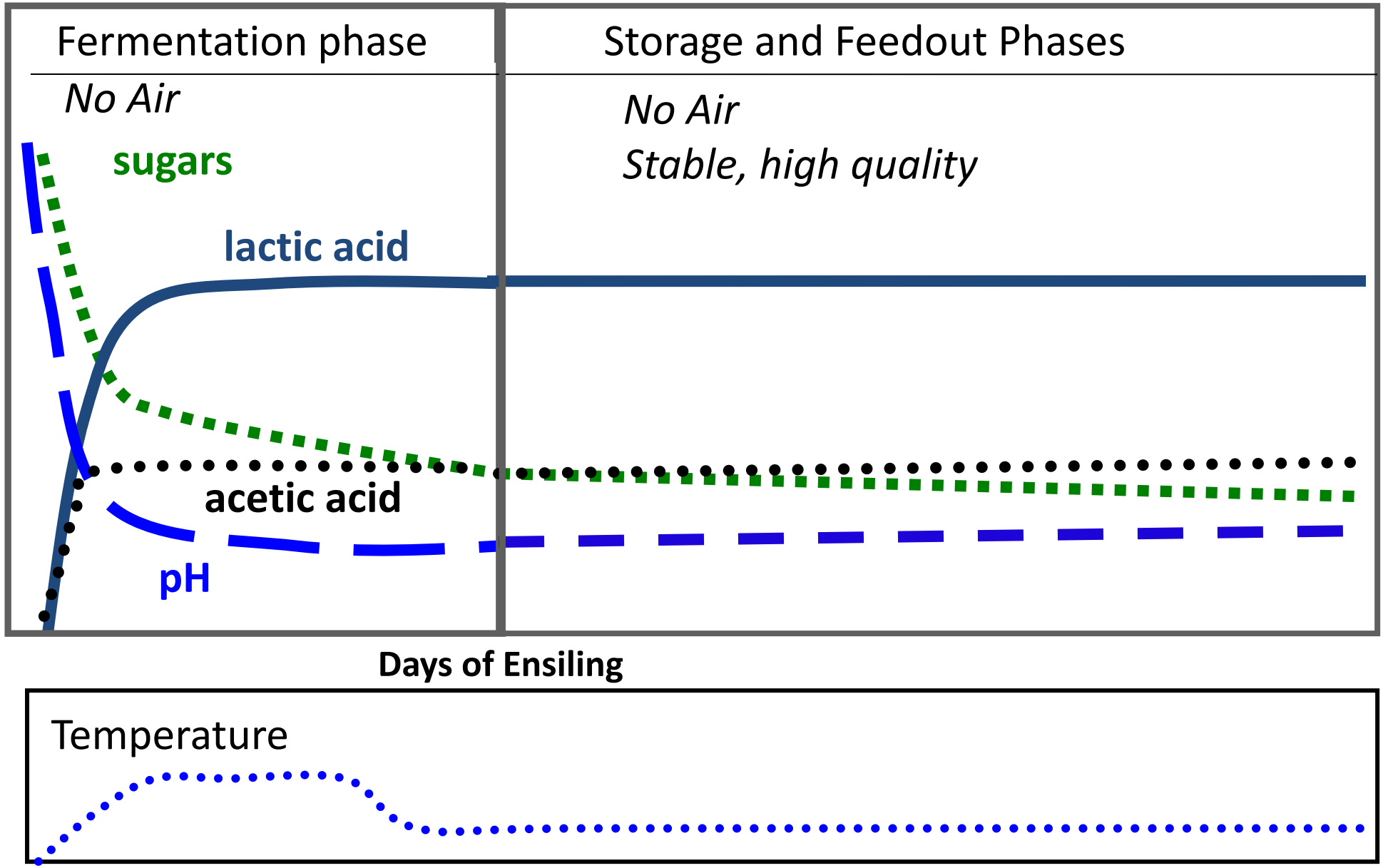
- ✓ Fast pH drop
- ✓ Low pH
- ✓ Keeping air out of the forage/silage mass

Microbes at work in silage – *silage making is like a war – good bugs must win!*

- "Good bugs"
  - Lactic acid bacteria
    - heterofermentative
    - homofermentative



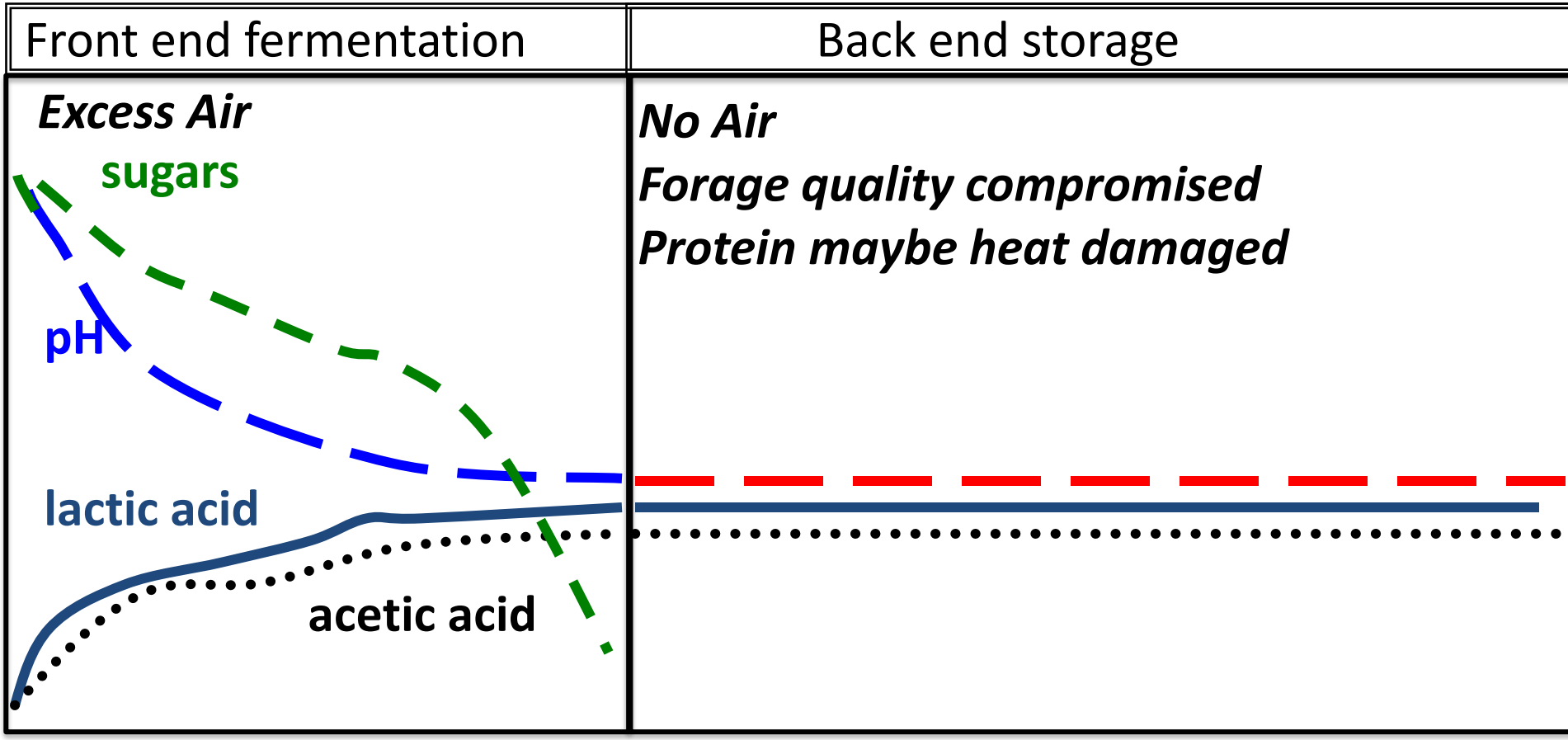
Ideal Fermentation and Good Storage Conditions



Air is the Worst Enemy of Silage

- Delays fermentation, ***encourages growth of yeasts***
- Uses nutrients
- During storage and feed out
  - Stimulates growth of spoilage microbes
  - Reduces aerobic stability
  - Resulting in nutrient and DM losses

Excess Air at the Start of Fermentation



Microbes at work in silage – *silage making is like a war – good bugs must win!*

- "Bad bugs"
  - Aerobic bacteria
  - Yeasts
  - Molds
  - Clostridia
  - Enterobacteria

Metabolism of 2 Major Categories of Wild Yeasts in Silage that are Undesirable

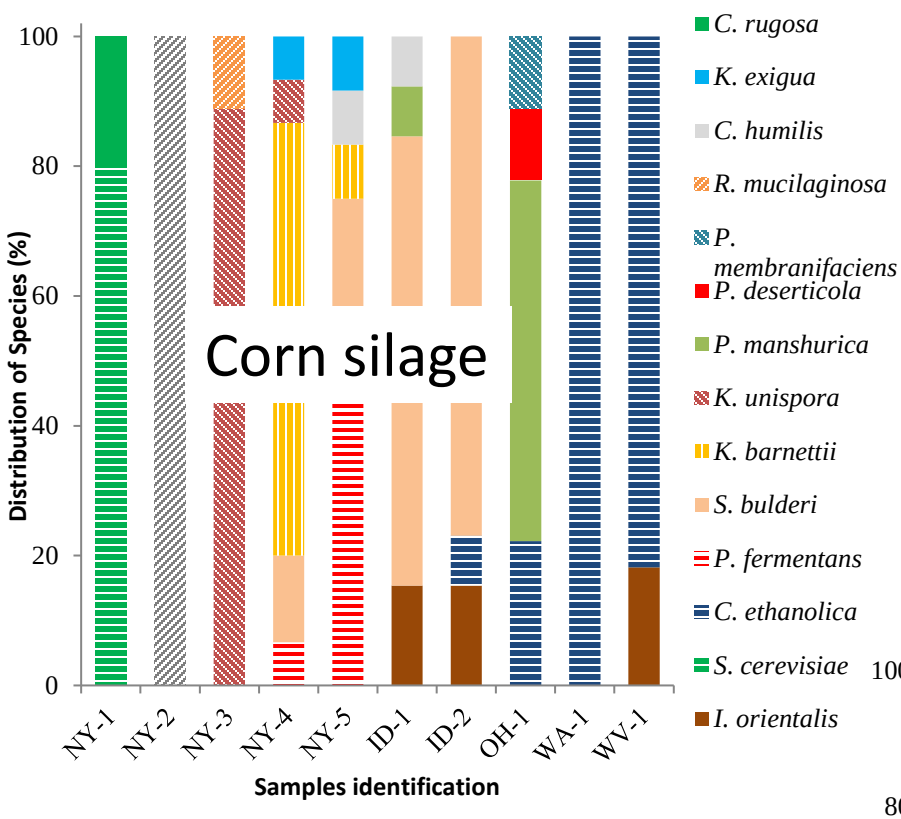
- Anaerobic conditions – 1. *Fermenting yeasts* convert sugars to ethanol, CO_2, and H_20

  Result: Large loss of dry matter

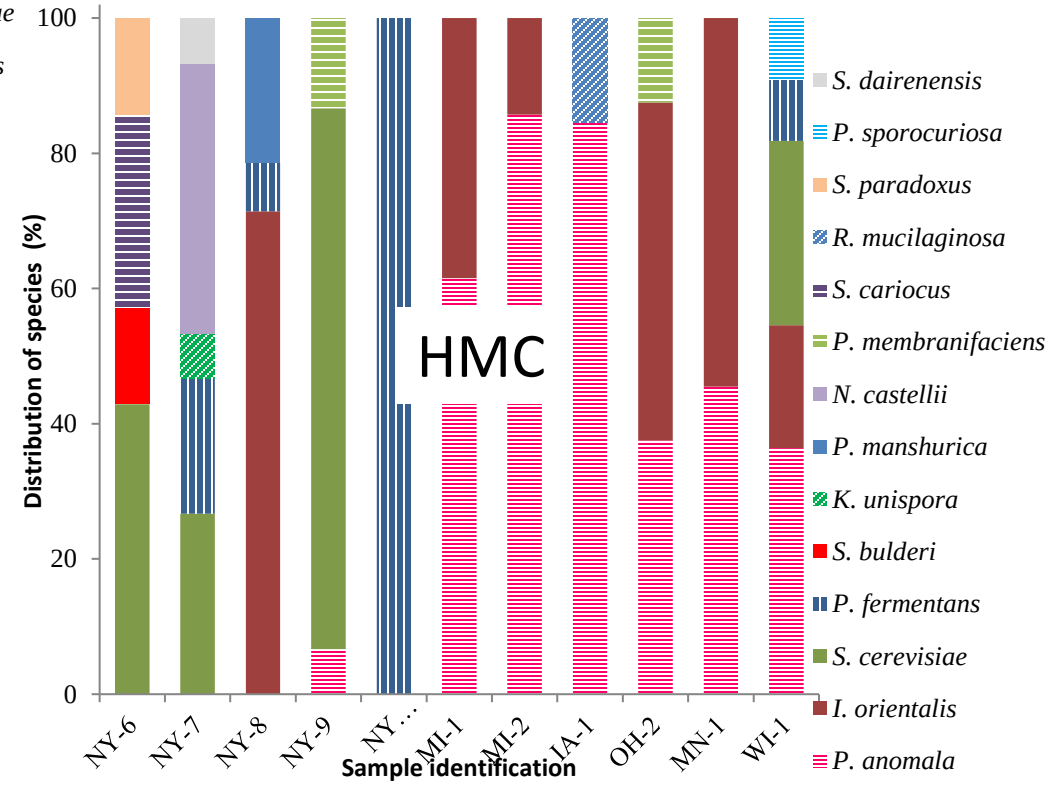
- Aerobic conditions – 2. *Lactating utilizing yeasts* (primary initiators of aerobic spoilage) oxidize lactic acid to CO_2 and H_20

  Result: Spoilage -> loss of matter and energy

Diversity of Yeasts in Silages



(Santos et al., 2011)



-Several predominant species

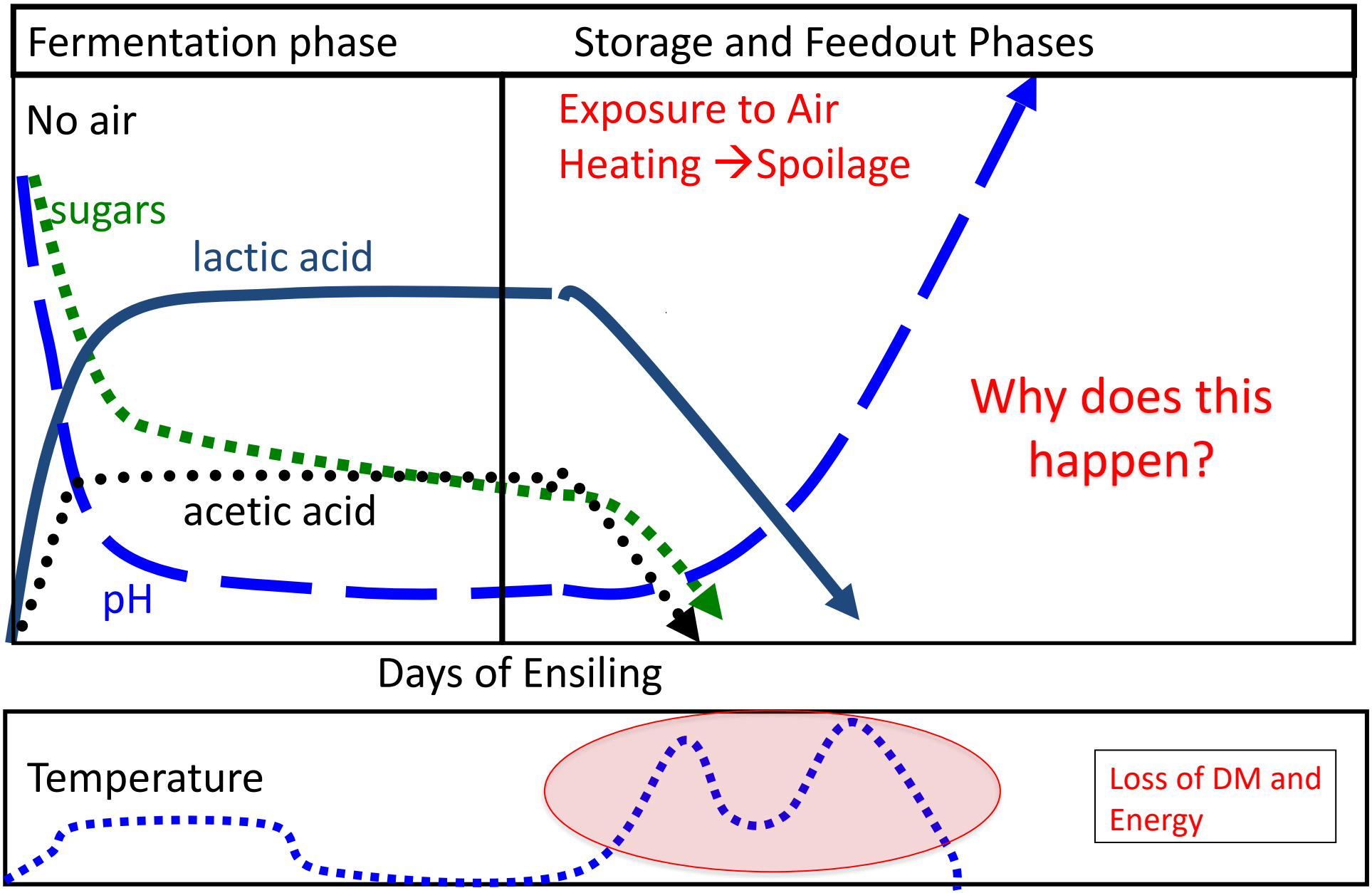
- Species variable by feed and farm

Potential Negative Effects of Yeasts in Silages and TMR

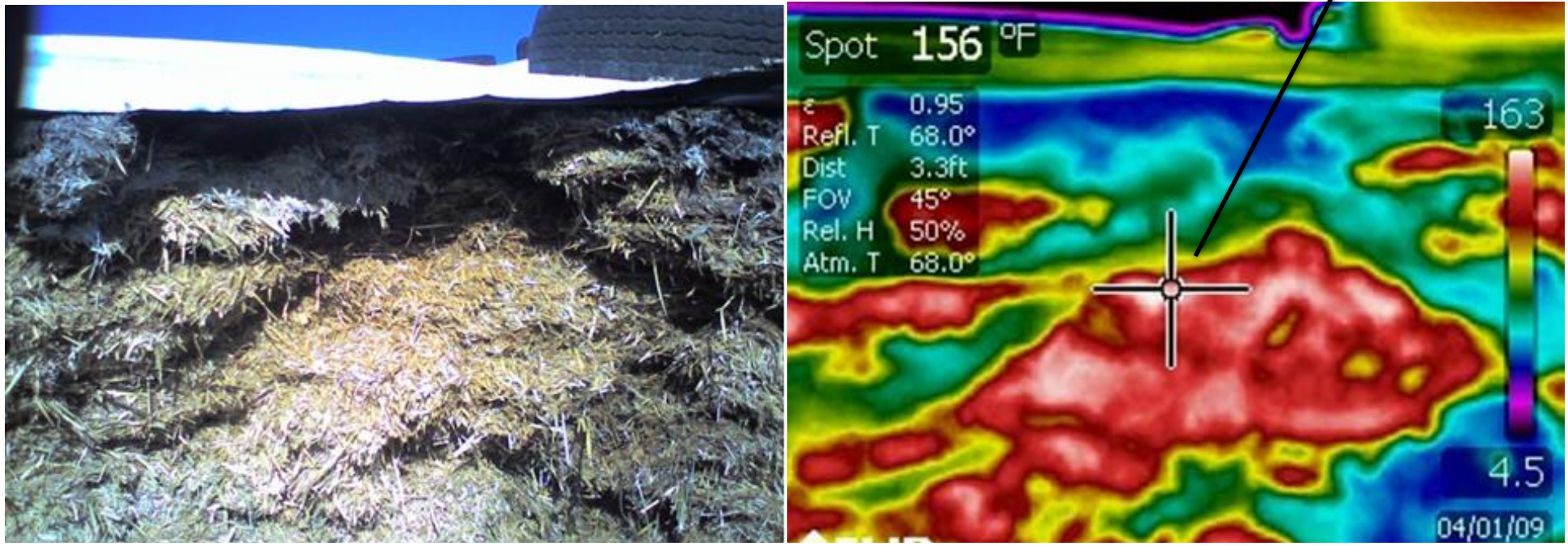
- Heating silage in the silo and feed bunk (reduced aerobic stability)
- Reduced intakes
- Acidosis like conditions
- Milk production and fat depressions

It is a misconception that “molds” cause aerobic instability

Excess Air During Storage or Feedout



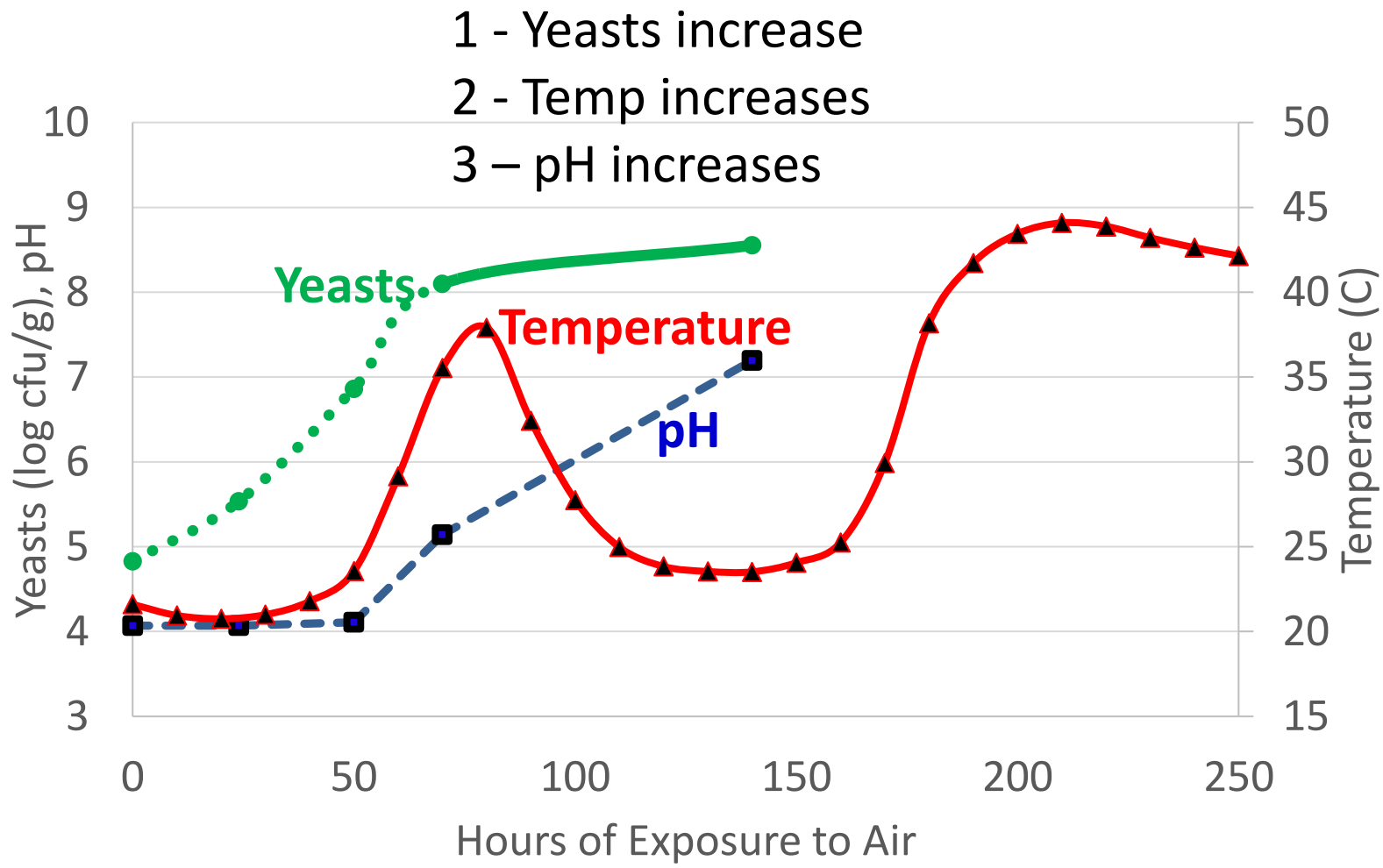
Aerobically Spoiling Silage Becomes Very Hot –> Loss of DM and Energy



The “Domino Effect” of Air and Wild Yeast on Spoilage in Silages

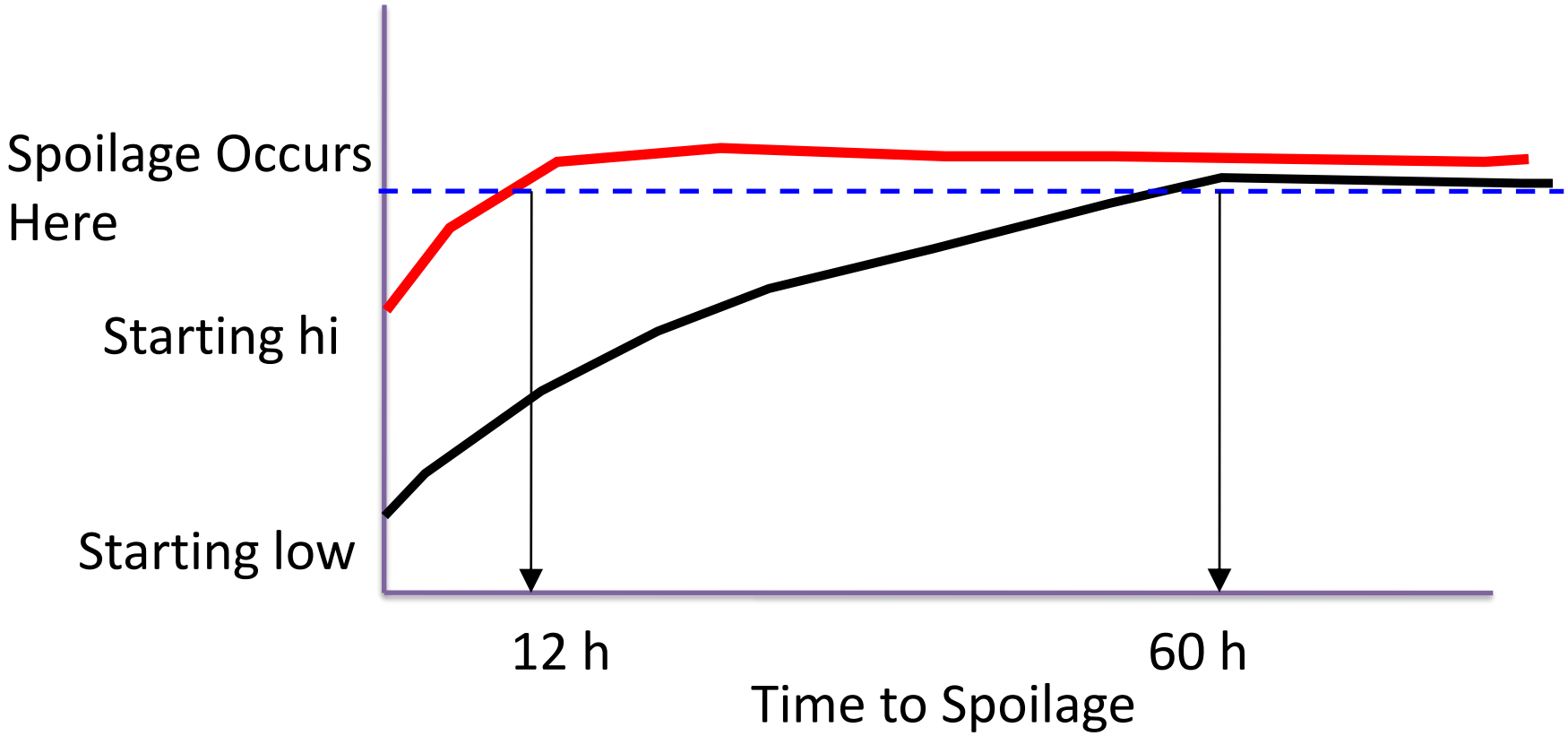
- Silage is exposed to air
  - Yeasts ‘wake up’ and degrade lactic acid
    - Numbers of yeasts increase
      - Highly degradable nutrients are destroyed
        - Heat is produced
          - pH increases
            - Molds/bacteria ‘wake up’ causing further spoilage
              - More heating
                - Massive spoilage

Changes in Yeasts, pH and Temperature of Aerobically Spoiling High Moisture Corn



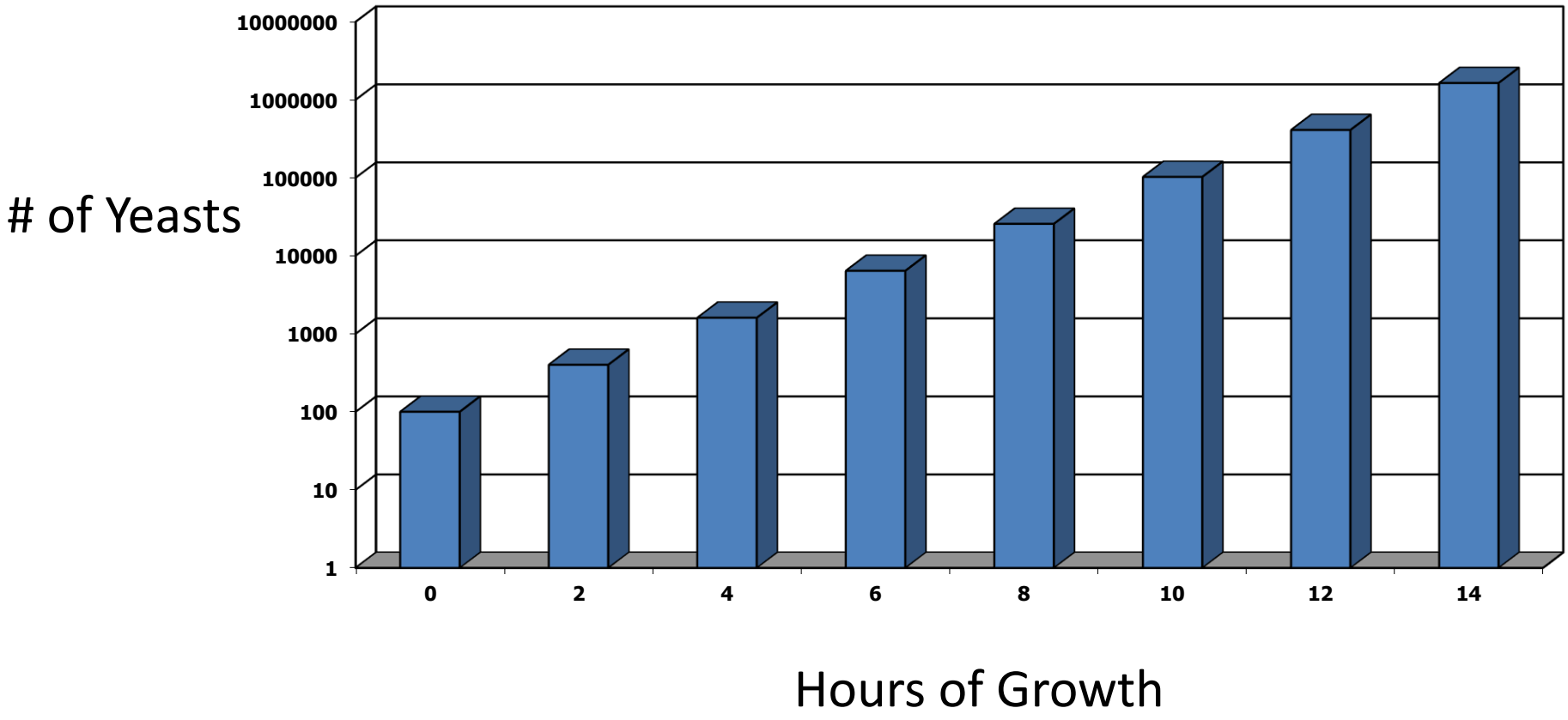
Kung et al., University of Delaware

How do initial populations of yeasts affect time to spoilage?

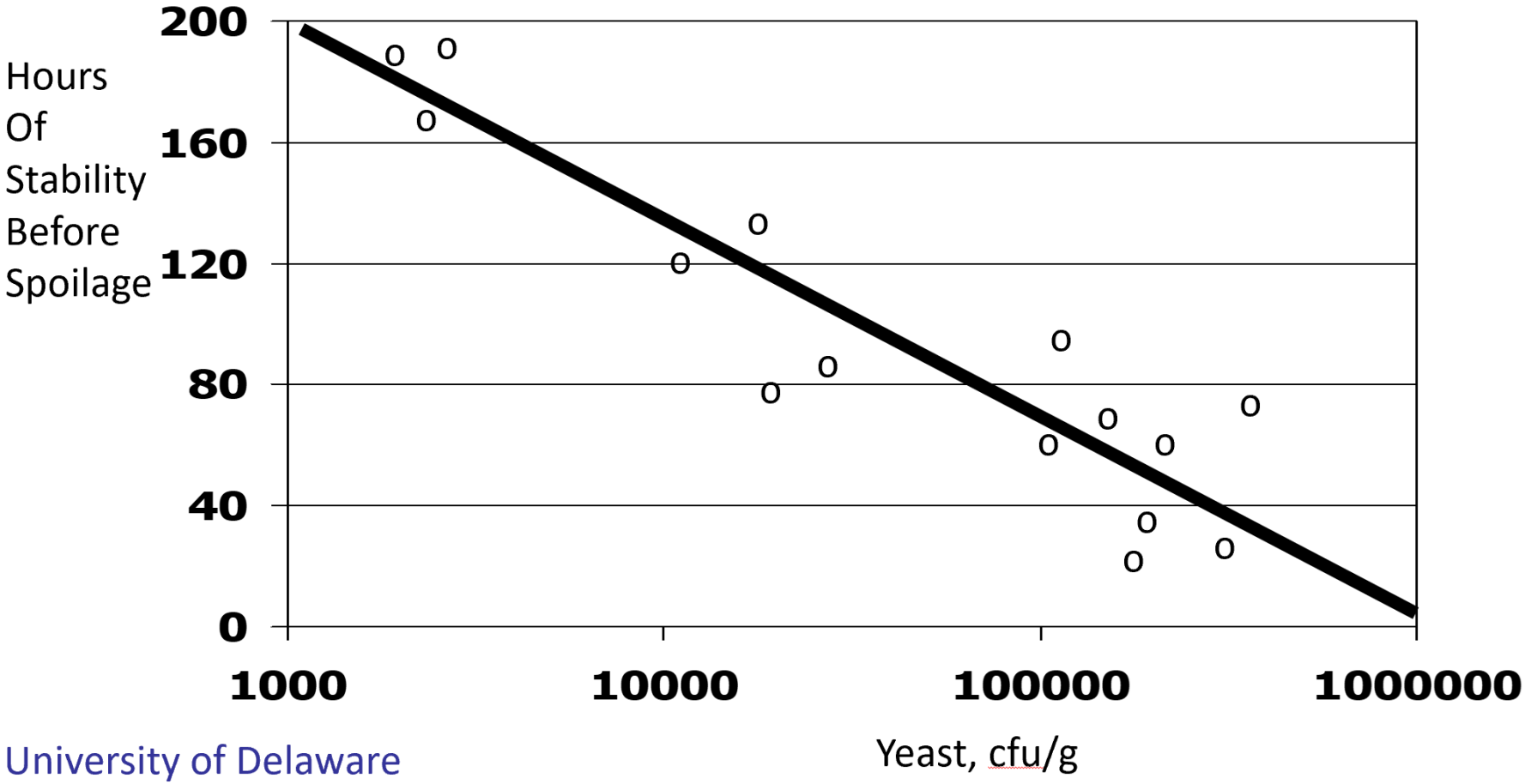


Theoretical Growth of Yeasts if Doubling Time = 1-2 h

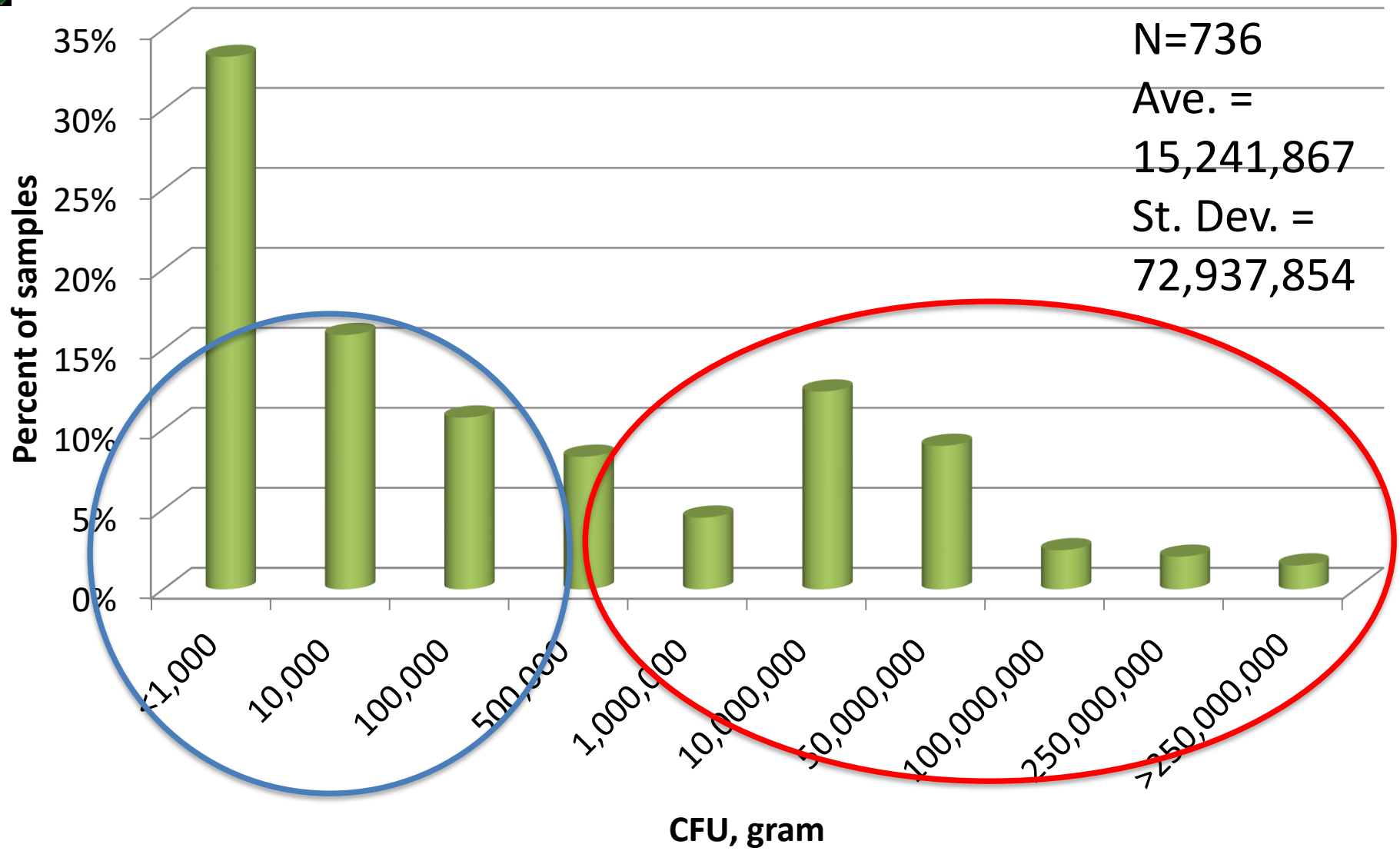
➢1.6 million cfu/g



The Negative Relationship Between Number of Yeasts and Aerobic Stability



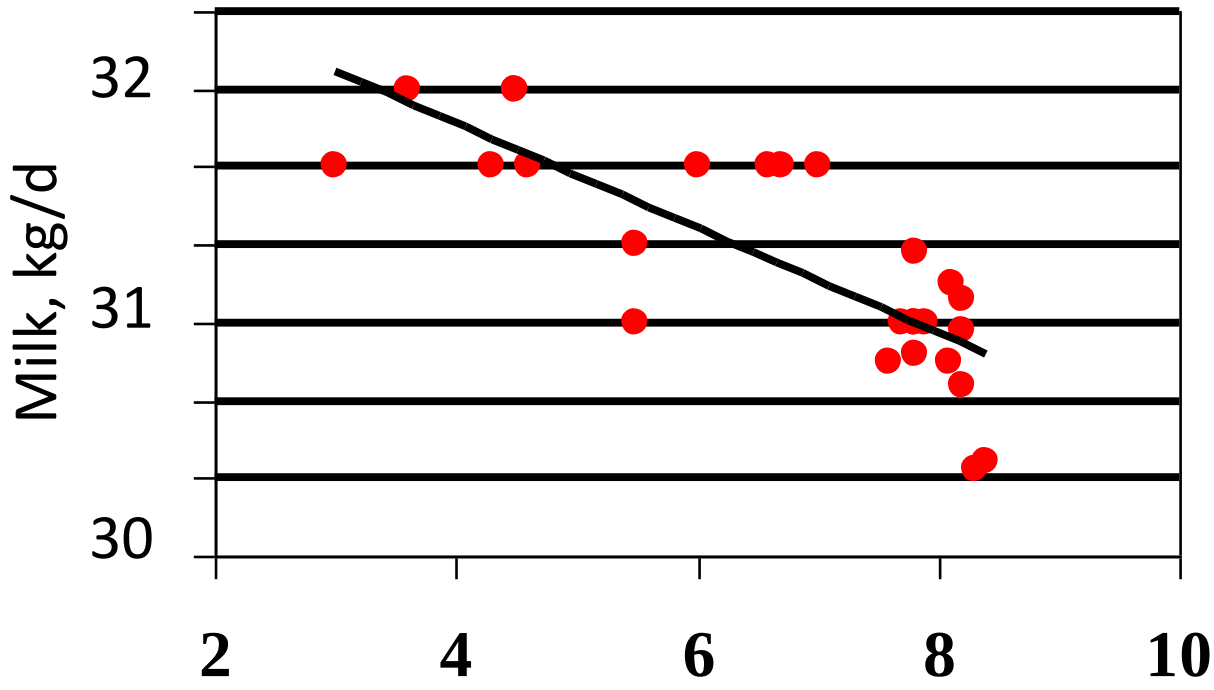
Distribution of Yeast Counts in Corn Silage CVAS



Effects of Feeding Aerobically Spoiled Silage on the Animal

Feeding Spoiled TMR with Molds Decreases Milk Production

- Hoffman et al 1995
- Moldy HMC fed to lactating cows for 14 d
- Fed to Lactating Cows 14 d



Feeding Aerobically Spoiled Silages Depresses Intakes and Reduces Digestion in Steers

	-Spoiled Silage*, % of DM-			
Item	0	5.4	10.7	16
DMI, kg/d	7.98	7.39	7.00	6.67
NDF dig., %	63.2	56.0	52.5	52.3

* “crust layer” from bunker silo.

Whitlock and Bolsen, 2001 KSU

The Effect of Feeding a Spoiling TMR to Heifers

- Treatments:
  - Fresh TMR
  - Spoiling TMR: Fresh TMR was placed in bins (with holes) in a heated room for 2 – 5 d prior to feeding.
  - ***When the spoiled TMR was fed to heifers, it was between 90 – 130^{0}F***

2013 Windle and Kung

Fermentation Analysis and Numbers of Yeasts in TMRs Fed to Heifers

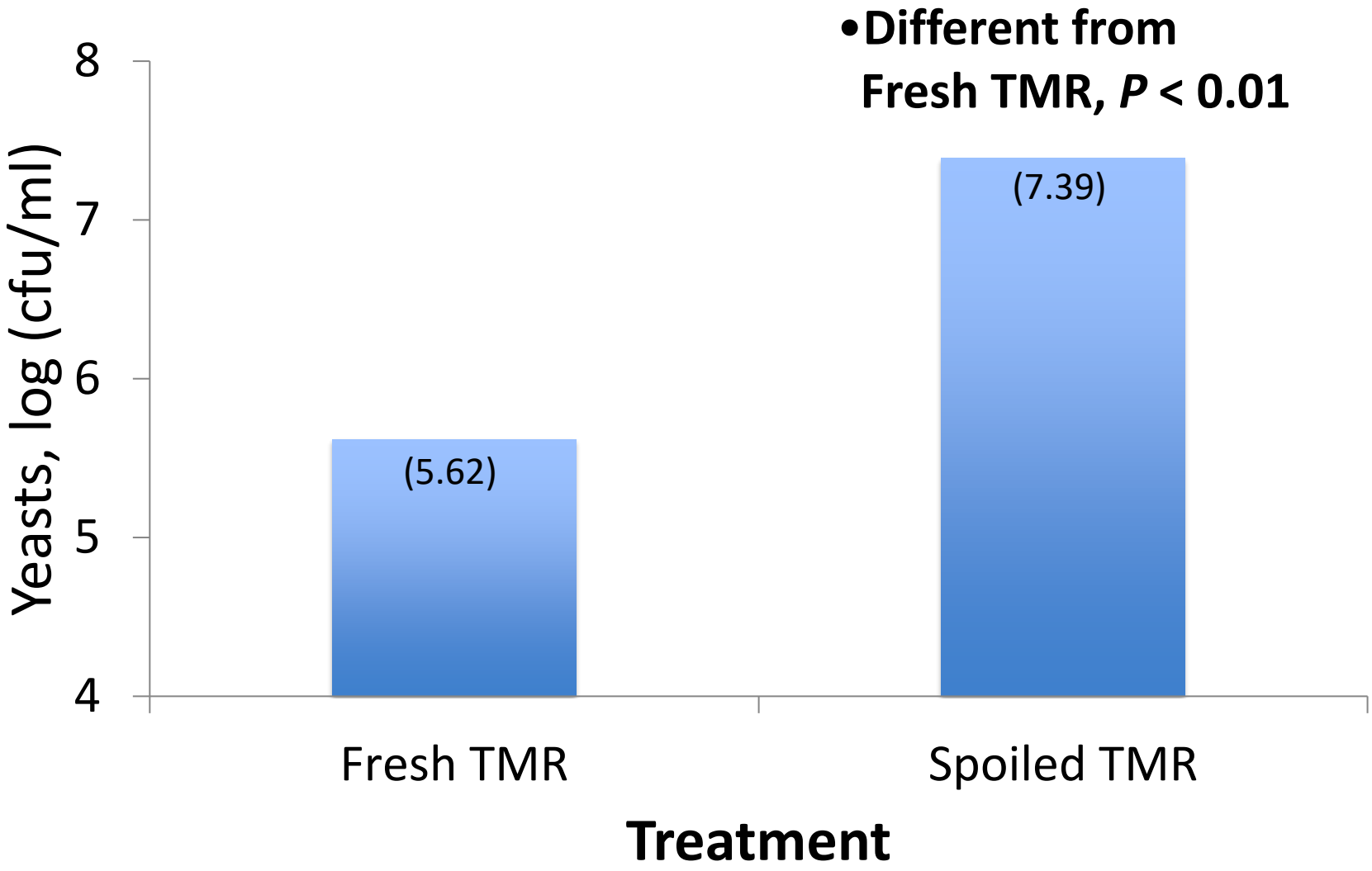
Item	Fresh TMR	Spoiling TMR	*P*-Value
pH	4.16	5.17	<0.01
WSC, %	2.46	1.85	<0.01
Lactic acid, %	4.17	2.59	<0.01
Acetic acid, %	0.97	0.64	<0.01
Ethanol, %	5.82	6.07	<0.01
Yeasts, log_{10} cfu/g	5.03	7.82	<0.01

2013 Windle and Kung

107,151 yeasts/g

66,069,345 yeasts/g

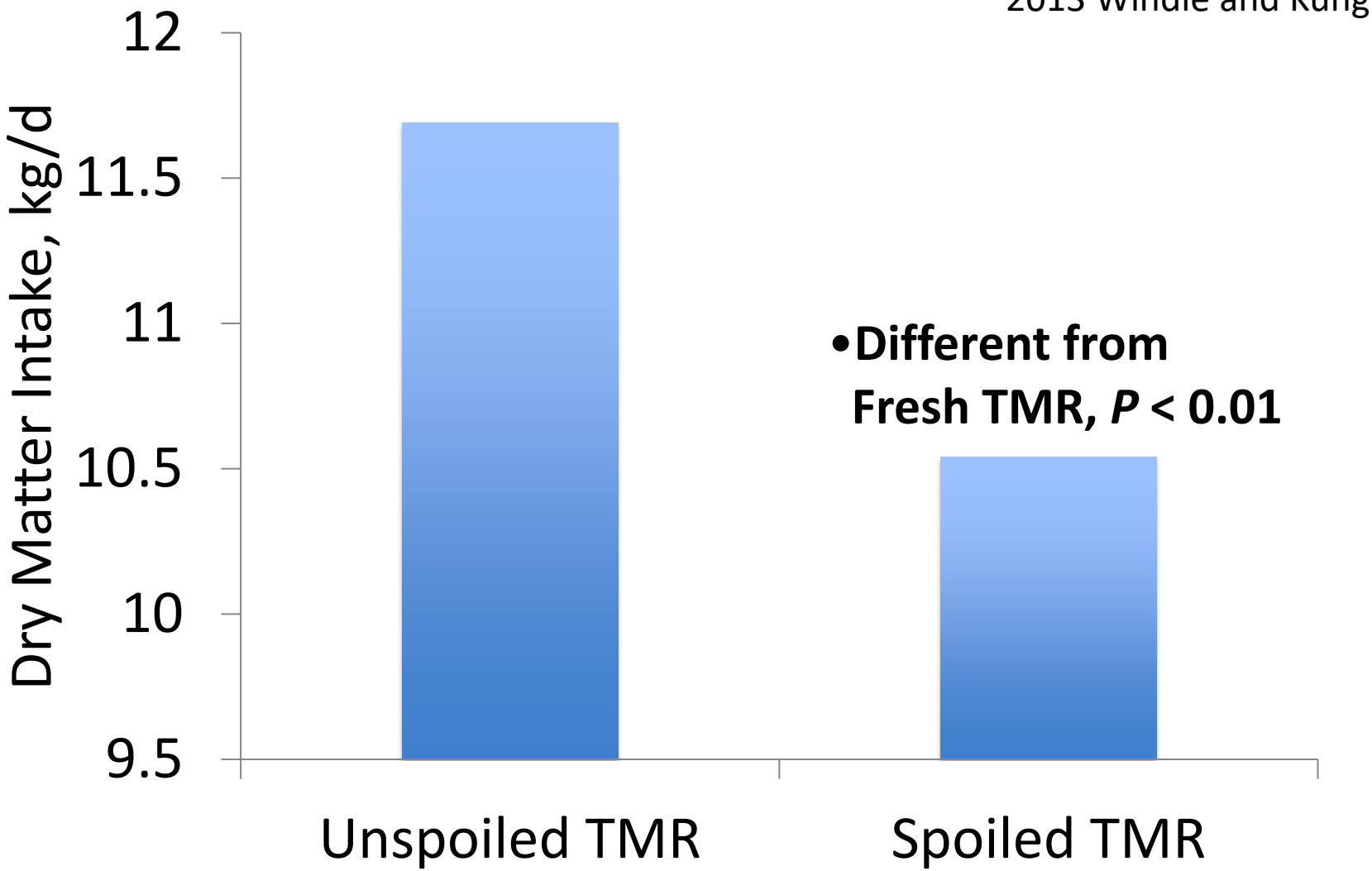
Numbers of Yeasts in Rumen Fluid



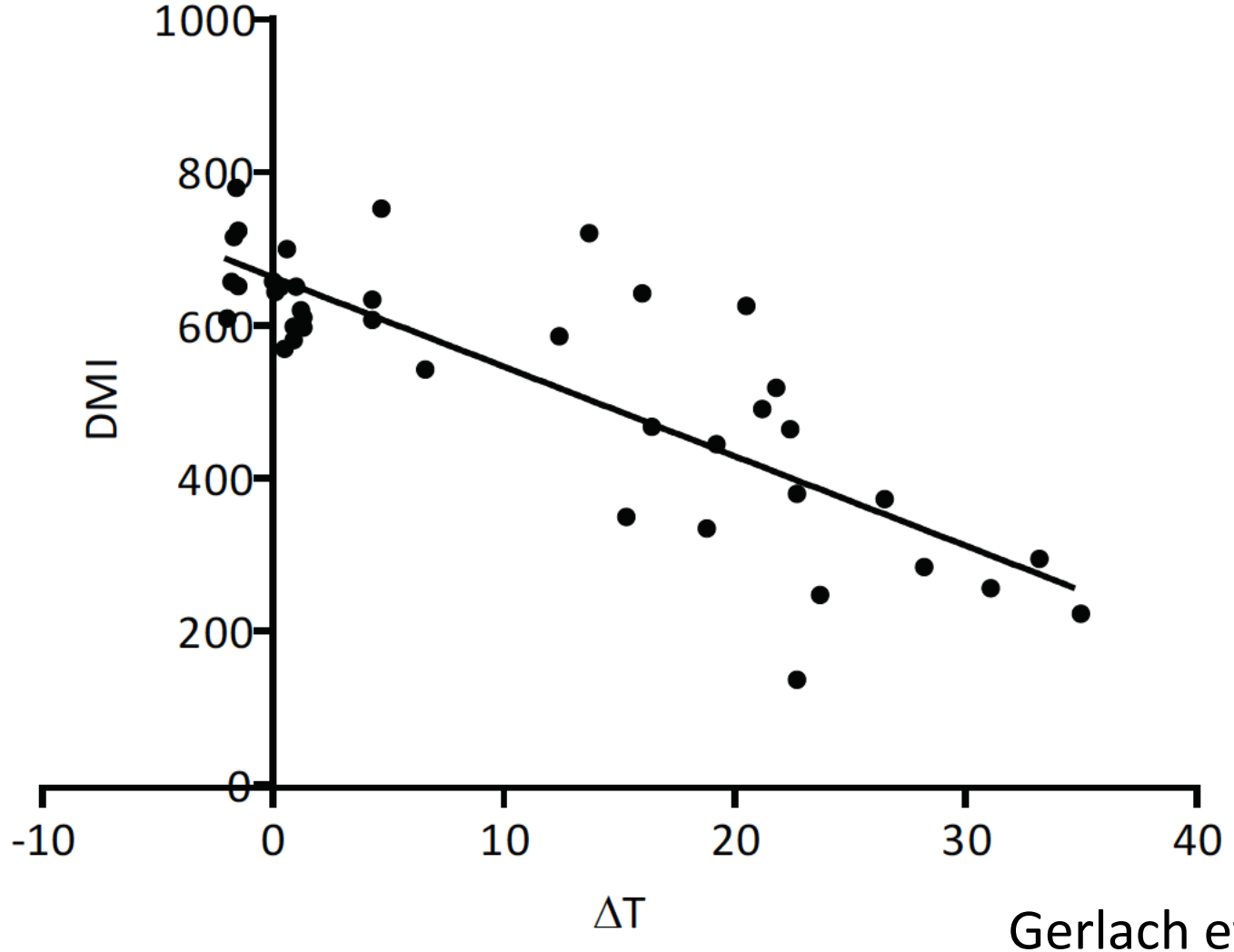
2013 Windle and Kung

Dry Matter Intake of Heifers Fed Fresh vs. Aerobically Spoiling TMR

2013 Windle and Kung



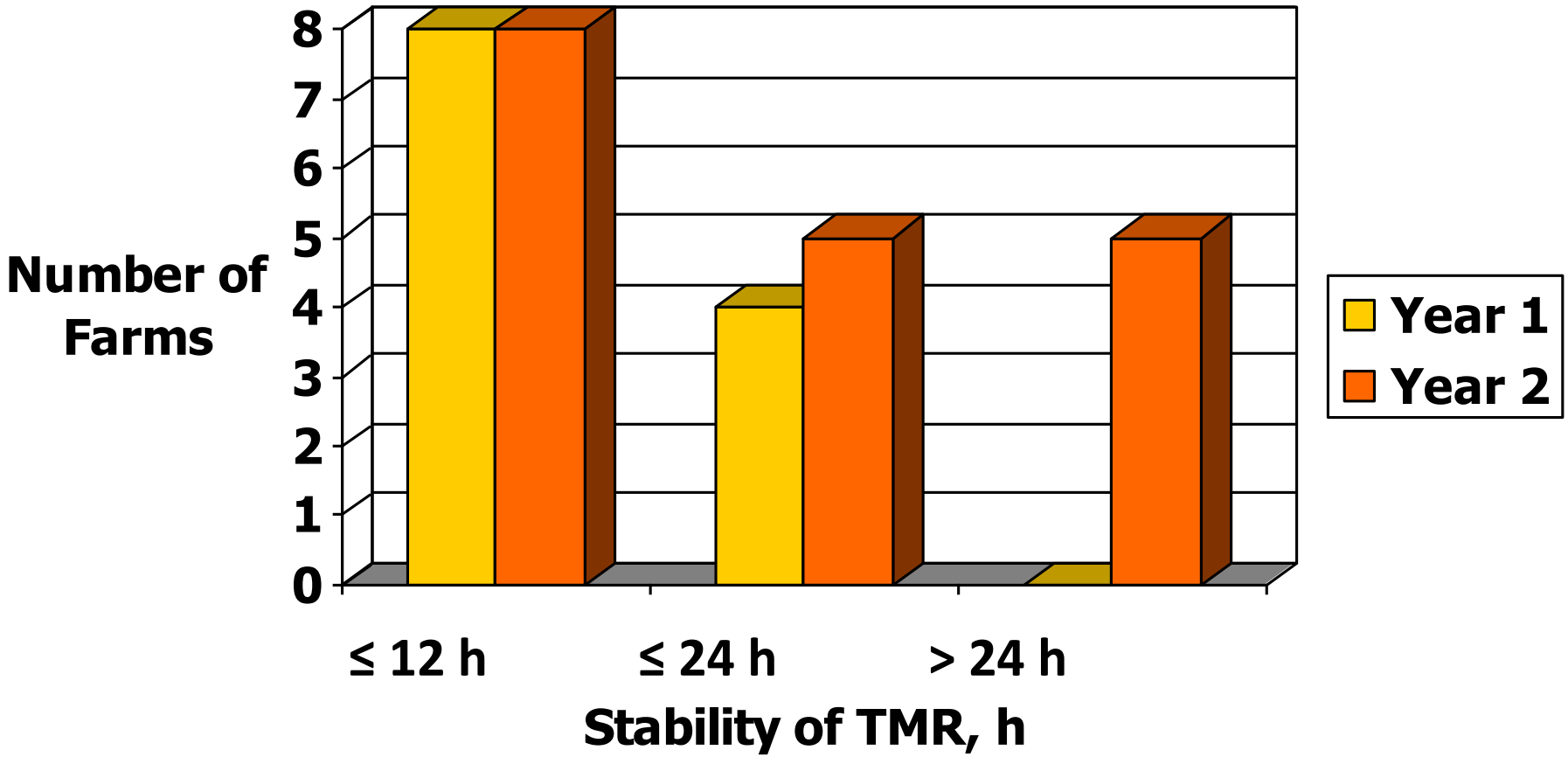
Correlation Between Change in Corn Silage Temperature From Aerobic Spoilage and DMI in Goats R = -0.85 P < 0.0001



Gerlach et al. 2013

Wild Yeasts Can Cause Spoilage of the TMR -

Aerobic Instability of TMR on Farms in the Northeast USA During the Summer



Morges and Kung, 2005

Check the Aerobic Stability of Your Total Mixed Ration

Indications of Aerobic Spoilage in TMR and Silages

- > 35-37°C in “cured” silage
- Reheating in the feed bunk
- Lack of sharp acid or sweet smell
- Musty moldy smell
- Visible signs of molds

How Do We Minimize "Wild Yeasts" in Silages?

- Ensile forages at optimum DM
  - Drier silages are more prone to result in higher yeasts
- Excellent silo management -Keep the silage mass away from air
  - High pack density, good plastic, weights, feed out rate, facers, etc.
- Use an additive designed to minimize yeasts

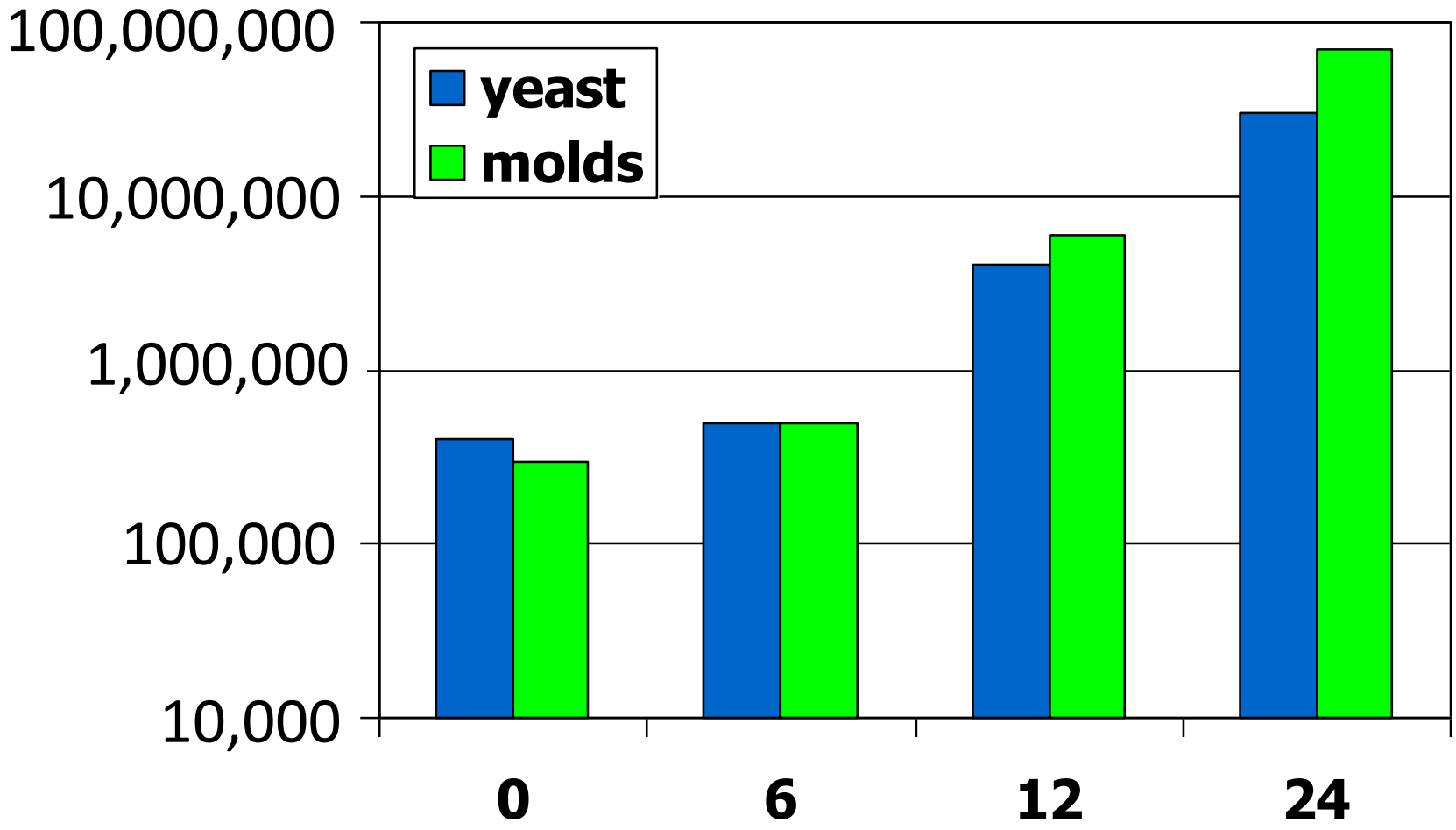
Silo Filling

- **Fill quickly,** but not too quickly
- **Pack tightly**
  - 220-240 kg DM/m^3
- 15-20 cm layers
- Have sufficient pack tractor wt.

If You Chop It, You Must Pack It

- Chopped forages are still respiring
- Do not leave chopped forage in wagons or piles overnight
- 6-8 hr of sitting will cause a massive loss of fermentable sugars
- Leaving chopped unpacked silage in a wagon, or pile overnight is a great way for silage to go clostridial, especially with alfalfa and grasses

Delayed Filling Increases Yeasts and Molds on Corn Forage



Hirsch and Kung, 1999

Keep the Air Out at the Edges and Seams

Insufficient Numbers of Tires

Silo Face Management

- Silage removal dependent on many factors
  - -minimum 15-30 cm/day
  - -more in hot weather
  - - more if drier/poorly packed
- Keep face clean, minimize face damage
- Knock down only enough silage to feed that day
- Remove only enough plastic for the feeding


This Silo Had Too Much Plastic Removed
Before Feeding.
Pull Back Plastic Only to the Amount
Of Silage Removed for the Day.


Kung 2005
Spoilage layer
2 layers
Why double plastic and tires was still a problem:
- Not enough tire weight
- Poor packing density

Cover and Seal Silos Immediately

Oxygen Barrier
Plastics?

Keep Plastic Down at the Feeding Face

-Too Many “Faces”
-Silos with faces that are too Large


Kung 2004


Kung 2004

Excellent Silo Management is Needed to Maintain High Quality Silage

Use Extreme Caution Around Large Silos!!!!

Specific Challenges - Silage Moved to Short-Term Feeding Piles

- Stability is dependent on the status of the crop
  - Wetter crops usually are more stable
  - Silage could be treated with additive to improve stability
  - Stability worse in warmer weather
- Depending on size of the pile
  - Minimize size of the pile and time it lies before use
  - Drive over to “repack”
  - Cover with tarp or plastic

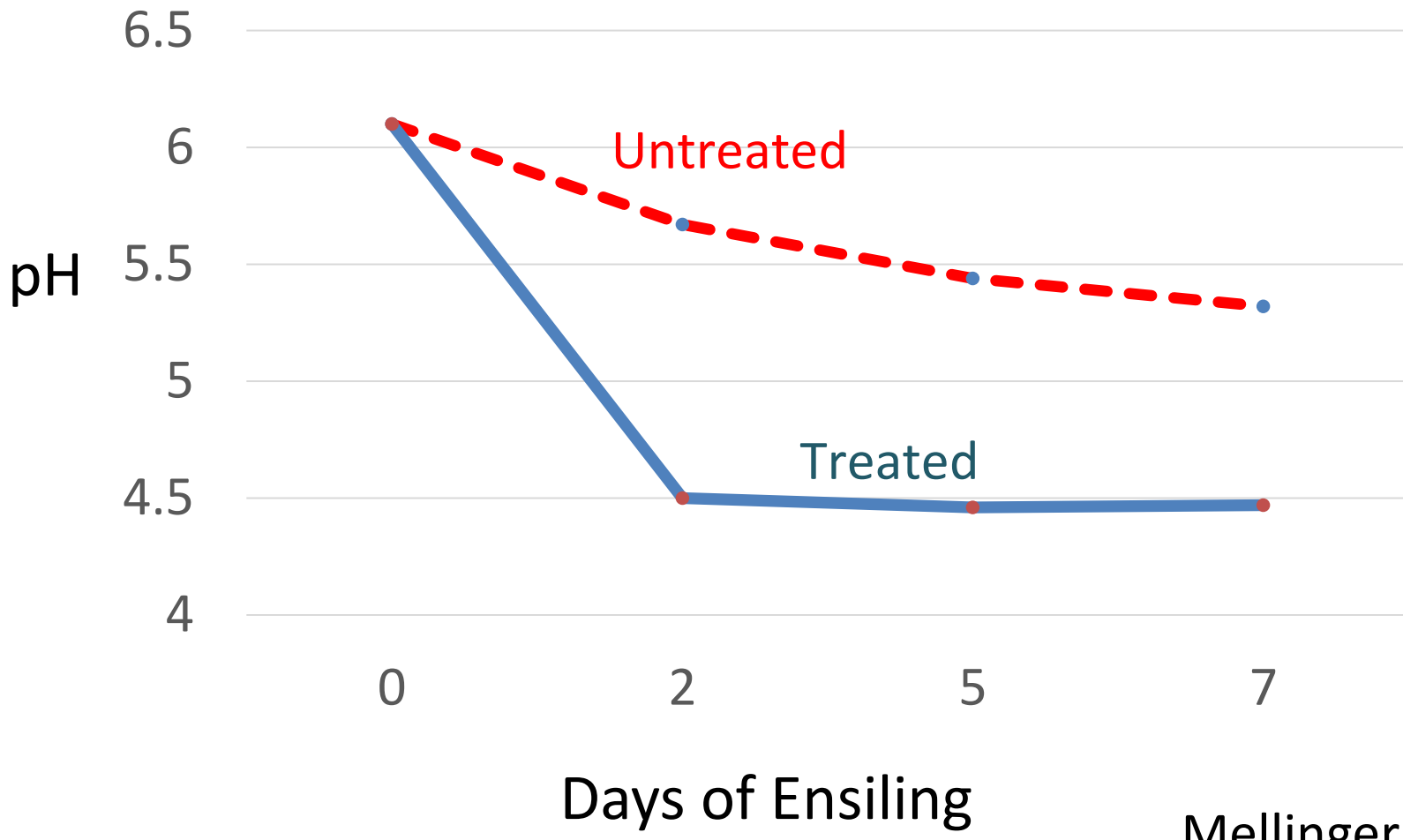
What Additives Can we Use to Control Yeasts and Improve Aerobic Stability?

- Silages
  - Inoculants (e.g., containing *L. buchneri)*
  - Addition of antifungal chemicals
    - Acetic acid
    - Propionic acid
    - Sodium benzoate
    - Potassium sorbate
    - Etc.
- TMR savers
  - Addition of antifungal chemicals

Microbial Inoculants Can Improve Silage Fermentation and Aerobic Stability

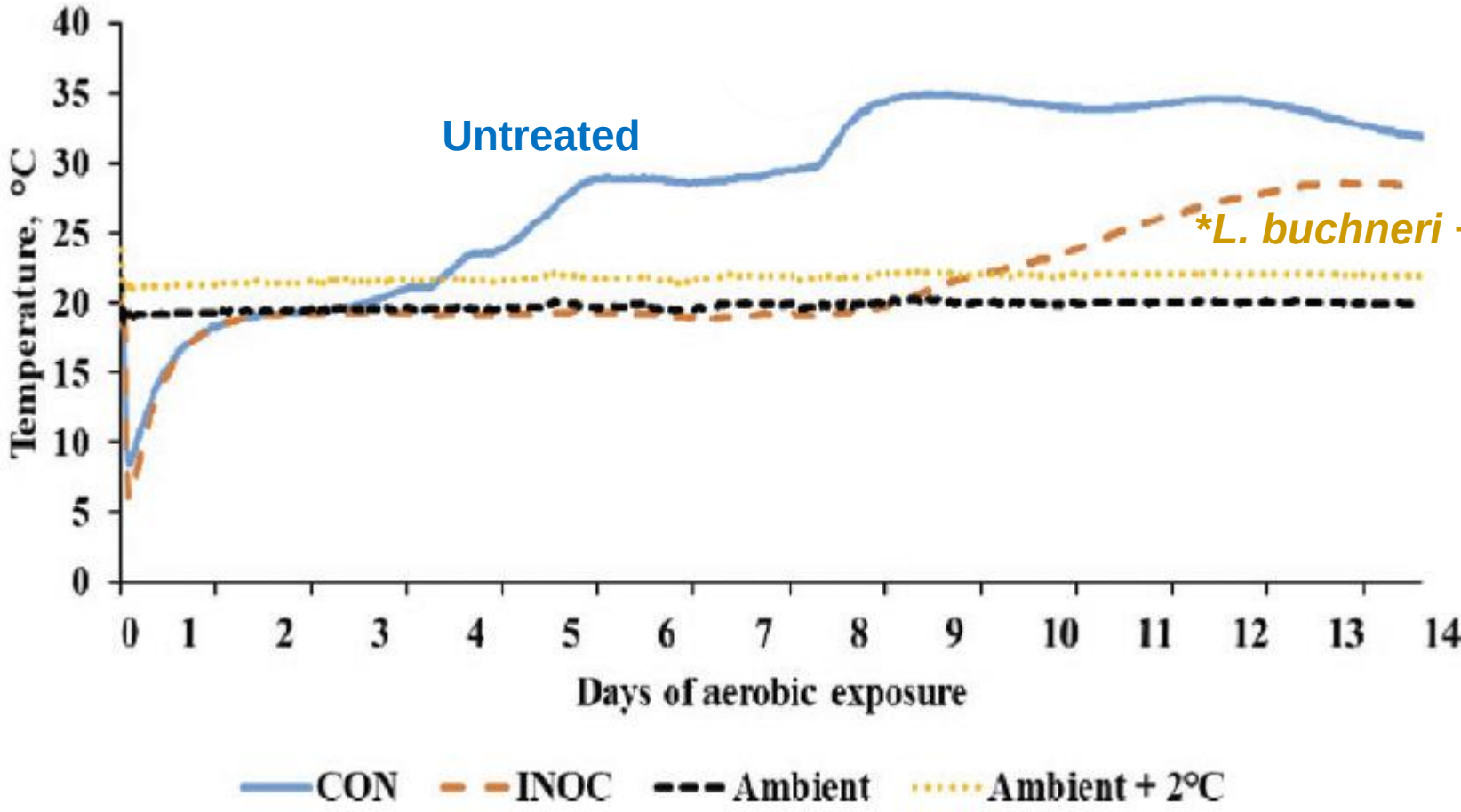
- Help at the Front – Homolactic acid bacteria
  - Faster fermentation
  - Reduce clostridia
  - Improved DM/energy recovery (animal performance)
- Help at the Back – *Lactobacillus buchneri*
  - Improved aerobic stability
  - Fresher feed
  - Less spoiling
  - Better long term DM recovery
- Dual purpose – Combination of the above

Effect of an Inoculant on the Drop of Alfalfa Silage pH



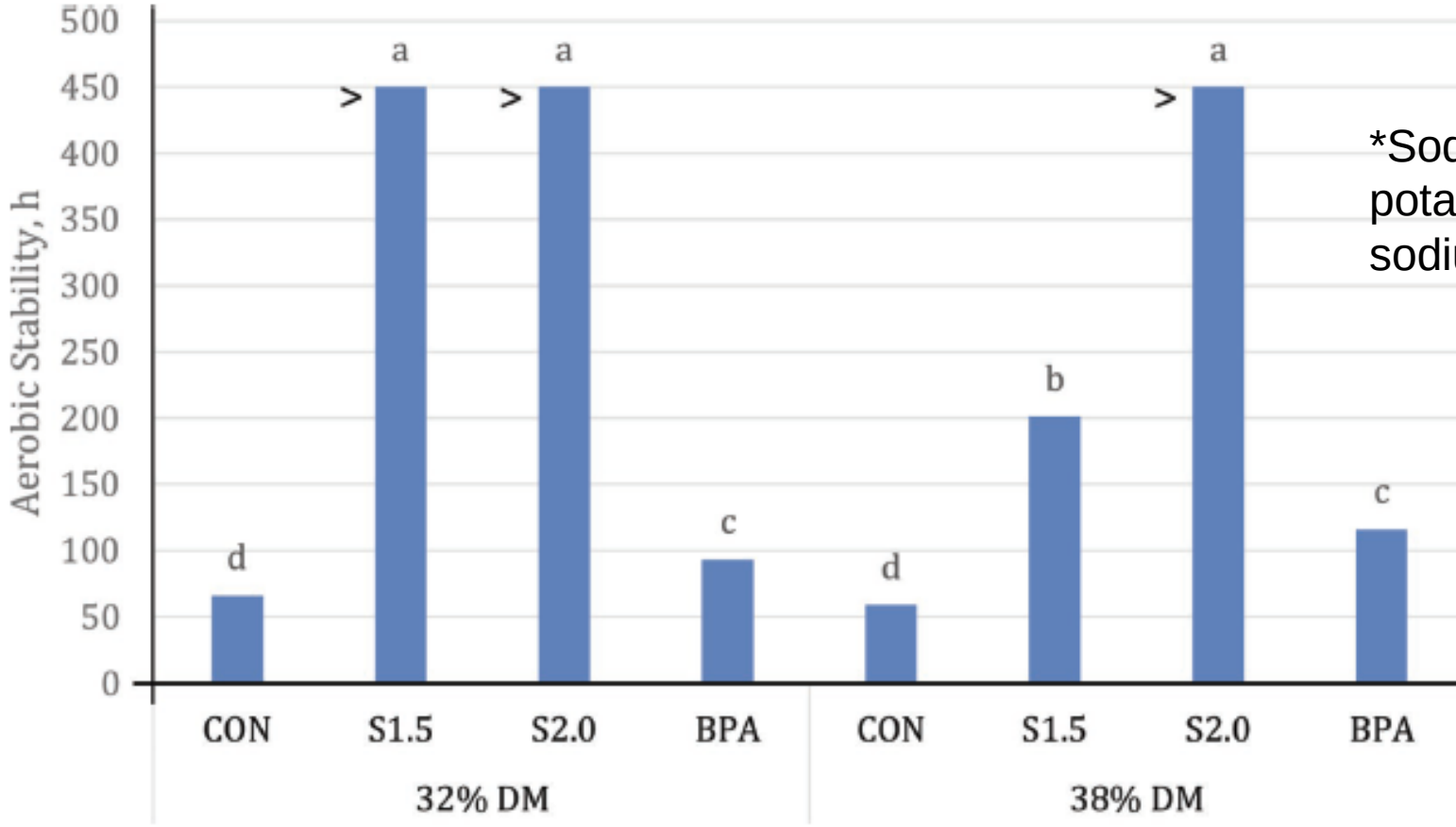
Mellinger et al., 2021

Improvement in Aerobic Stability of Corn Silage with an Inoculant*



Nair et al., 2020

Effect of a Chemical Additive* on the Aerobic Stability of Corn Silage



*Sodium benzoate, potassium sorbate, sodium nitrite

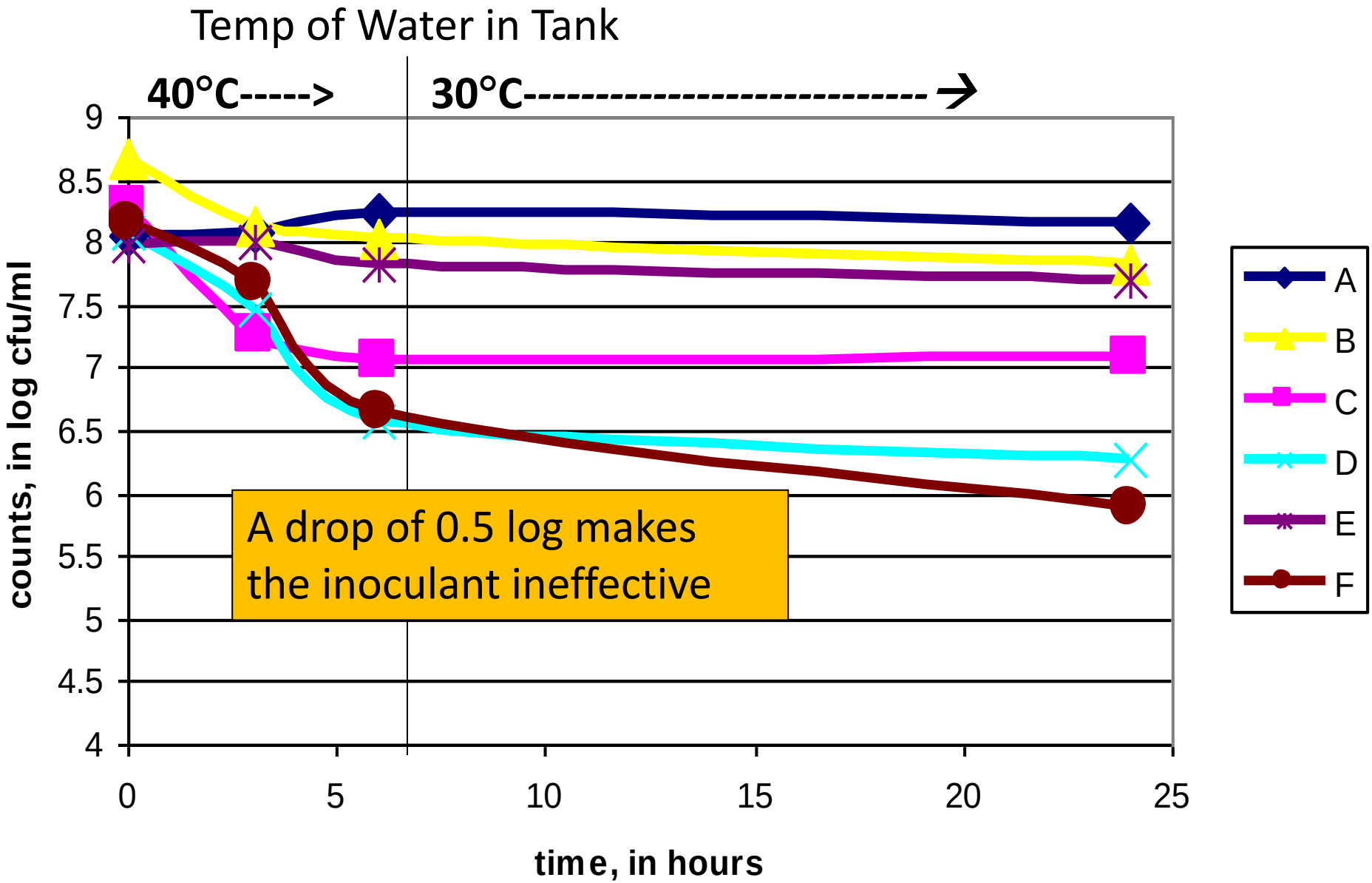
Kung et al., 2018

Distribution of Additives on the Forage Mass is Crucial For Effectiveness

- Less than optimum
- Manual application
- "Shower" methods

Is anyone checking use throughout the day?

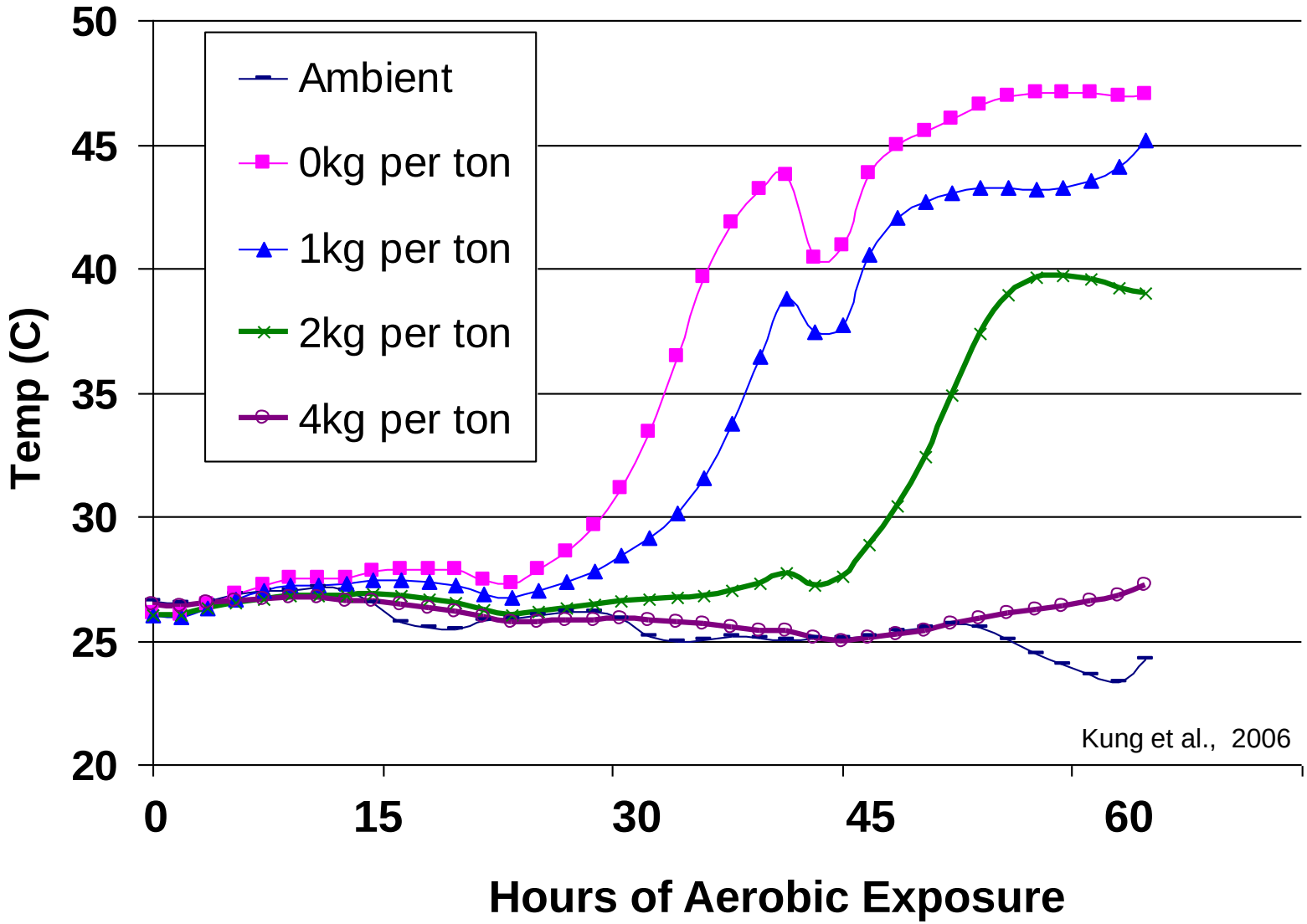
Keep Water in Inoculant Tanks Below 39-40°C



What Can You Do to Minimize the Effects of Aerobic Stability in a Total Mixed Ration in the Feedbunk?

- Remove sufficient silage from the silo to prevent spoilage
- Do not mix spoiled silage with other feeds
- Mix and feed the TMR 2 to 3 times a day
- Mix only enough TMR to feed immediately
- If you must mix the TMR ahead of time, do so at night when it is cooler
- Use a TMR preservative to reduce spoilage

Effects of Adding a Stabilizer on the Aerobic Stability of a Total Mixed Ration

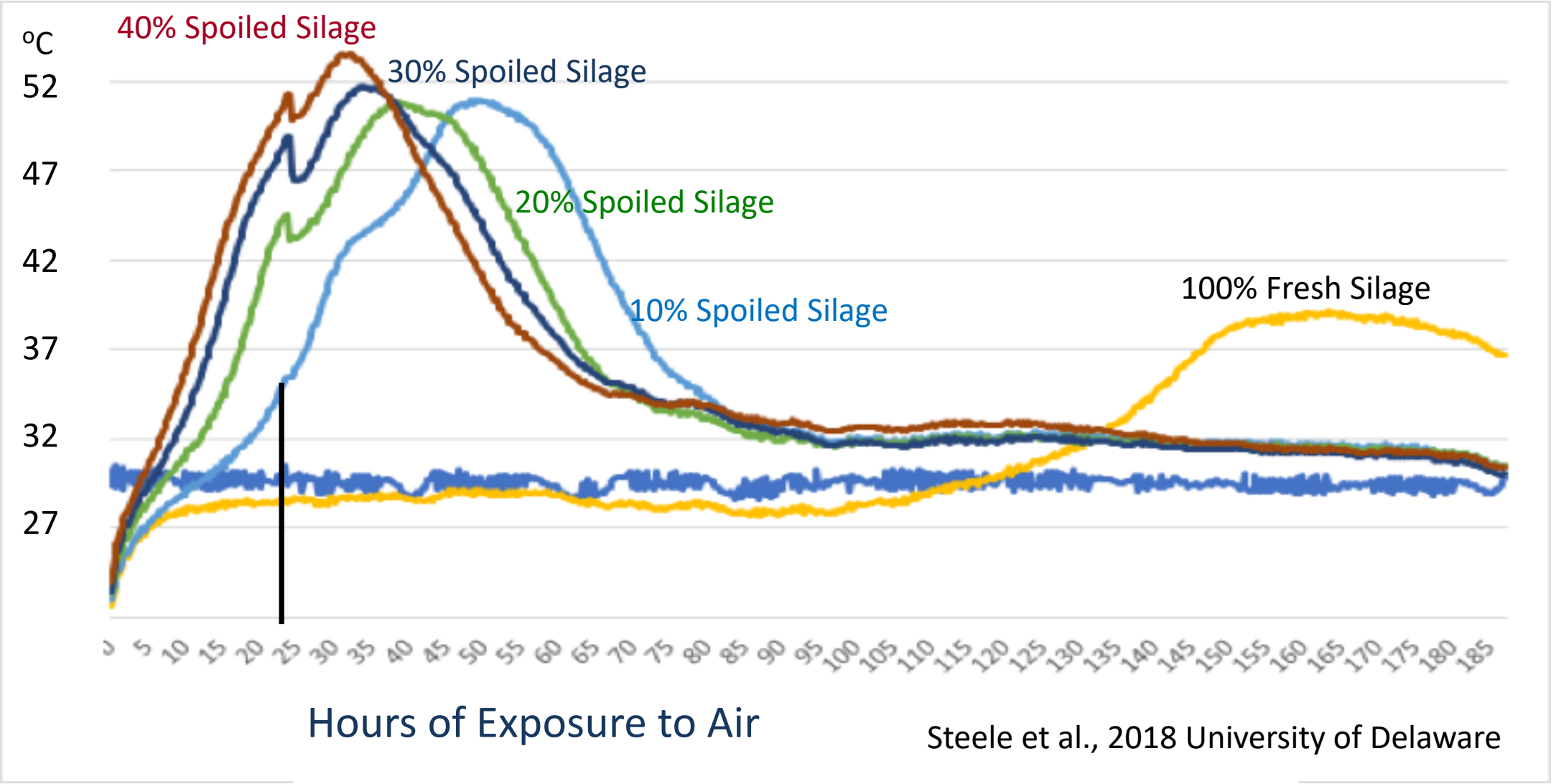


Experiment Using Fresh and Spoiling Corn Silage Used to Make a TMR

Item	DM, %	pH	Yeasts, cfu/g	Molds, cfu/g	Aerobic Stability, hours
Fresh corn silage	46	3.85	3.63	3.87	138
Spoiling corn silage	40	6.57	7.95	7.99	0

Steele et al., 2018 University of Delaware

Mixing As Little as 10% Spoiling Silage into a TMR Can Destabilize it – Heating Peaks of TMR



Steele et al., 2018 University of Delaware

Take Home Message

Start with high quality forage from the field

Follow best silo management practices

Use a research proven additive

Follow best silo feed out practices