Managing Wild Yeasts in Silages and TMR

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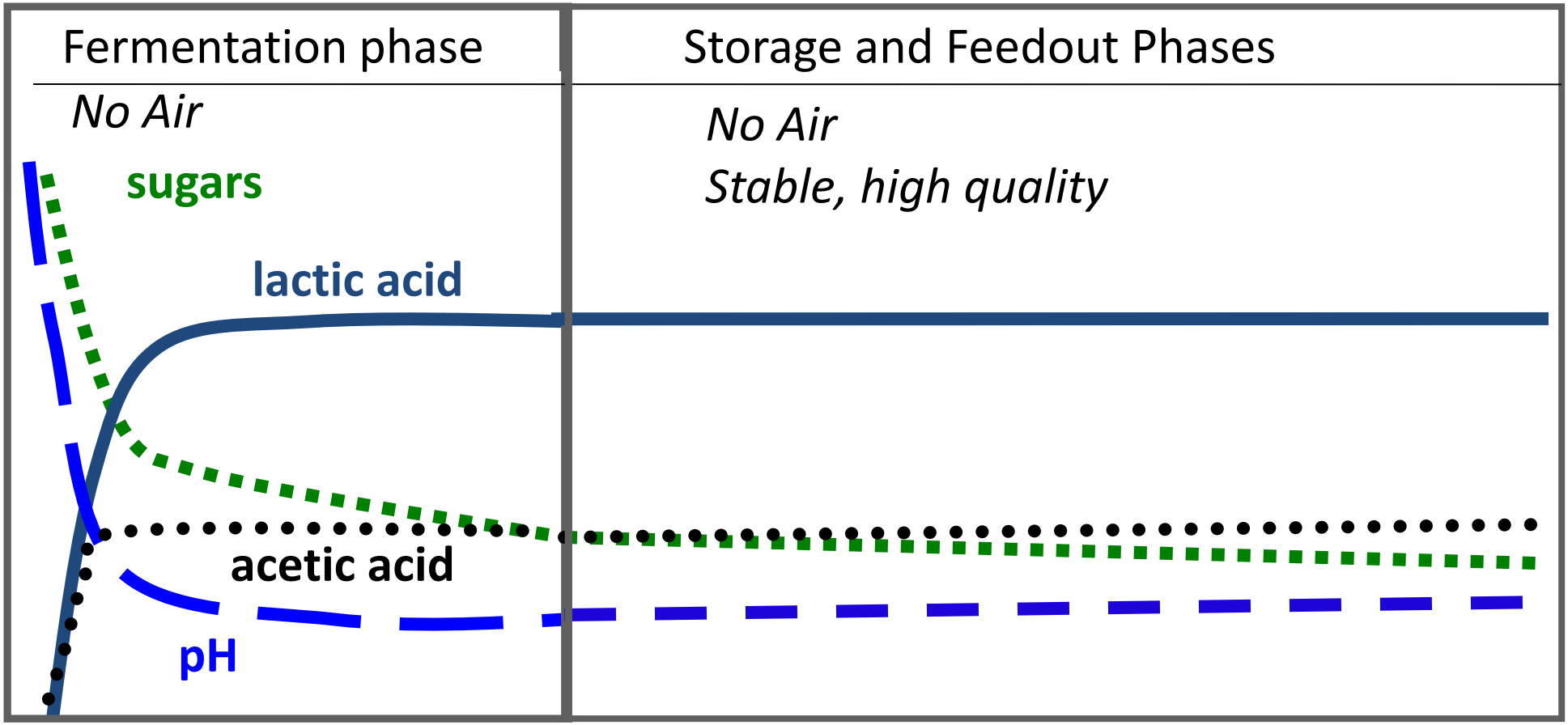
Presentation Topics

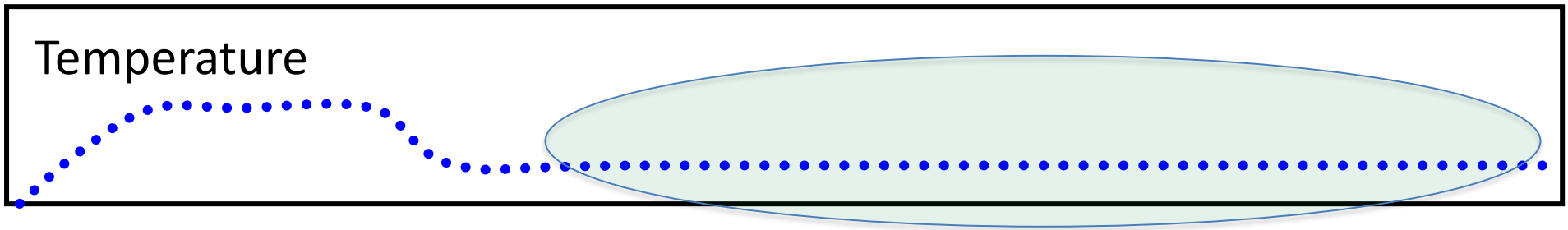
- Silage fermentation
- Yeasts in silages
- Undesirable characteristics of wild yeasts
- Potential negative effects of yeasts on ruminants
- Methods to minimize wild yeasts in silages
- What we don’t know about wild yeasts

Dry Matter Losses From Good and Poor Silo Management

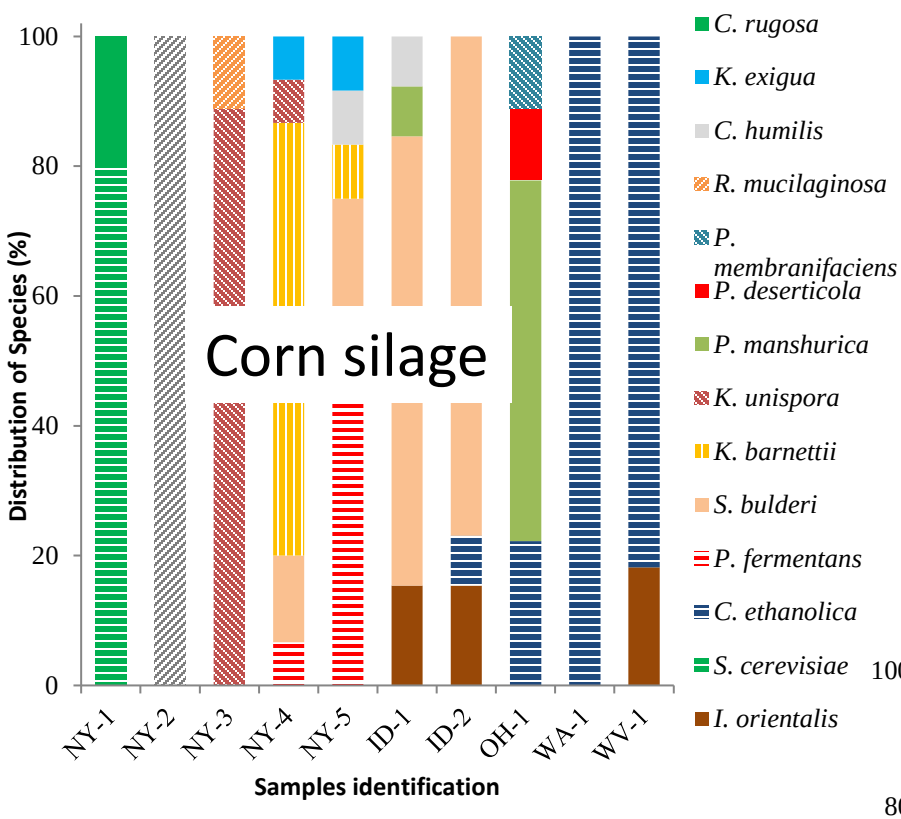
Losses From	Good Management	Poor Management
Respiration	0-4%	5-15%
Fermentation	4-6%	10-20%
Seepage	0-1%	5-10%
Aerobic instability during storage/feeding	5-7%	10-20%
Total	10-15%	20-30%

Ideal Fermentation and Good Storage Conditions

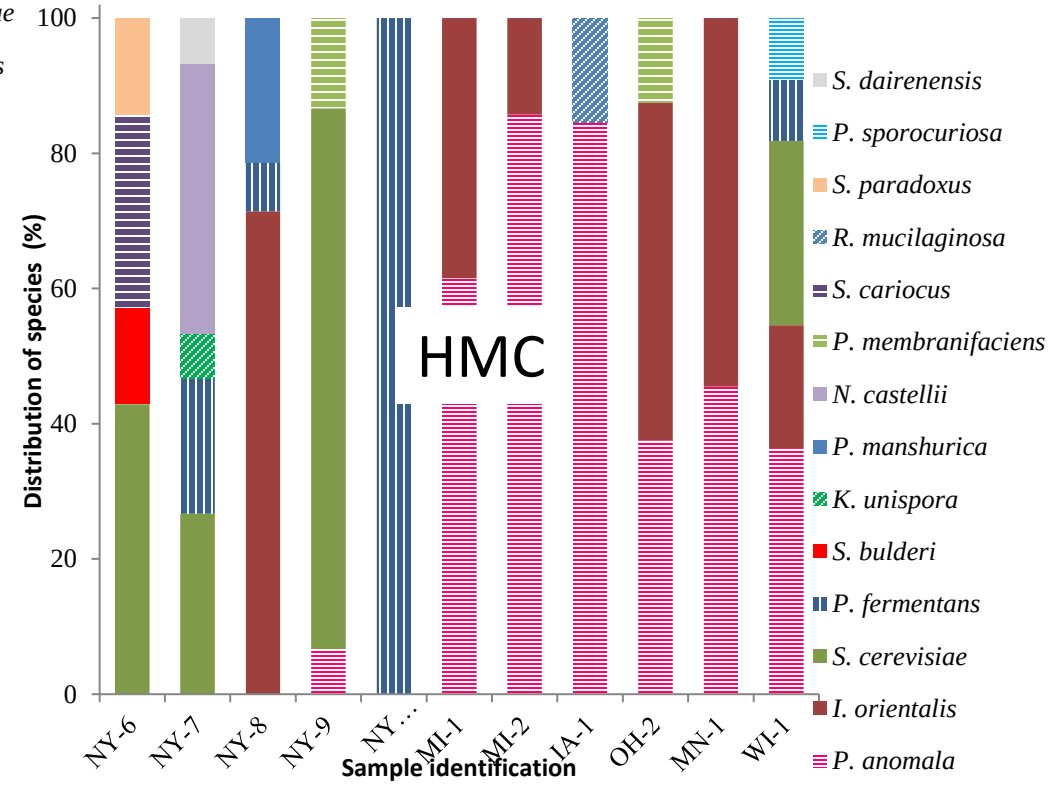




Diversity of Yeasts in Silages



(Santos et al., 2011)



-Several predominant species

- Species variable by feed and farm

Metabolism of Wild Yeasts in Silage

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

  Result: Glucose fermentation yields only 51% recovery of DM

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

  Result: Spoilage -> loss of DM

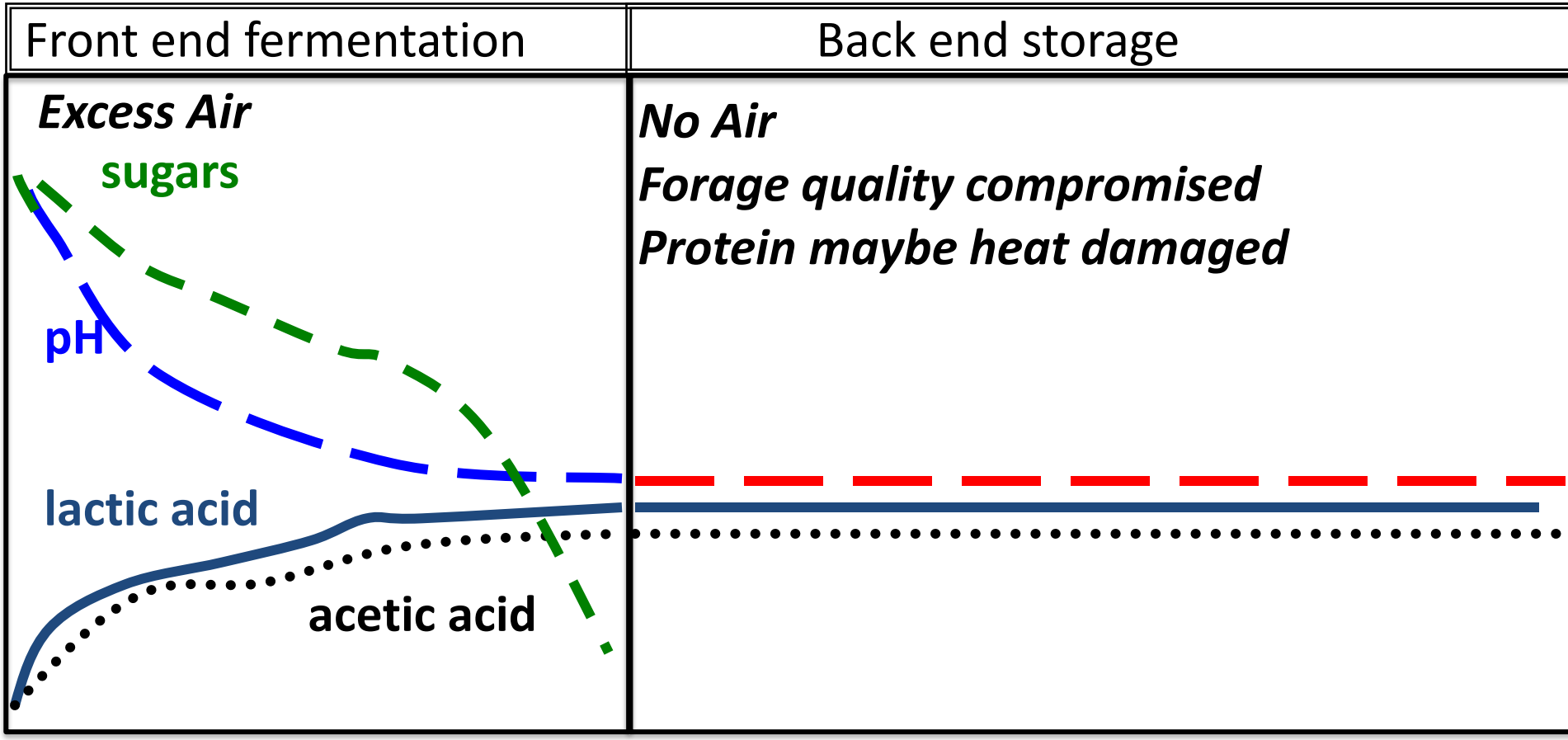
Potential Negative Effects of Yeasts in Silages and TMR

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

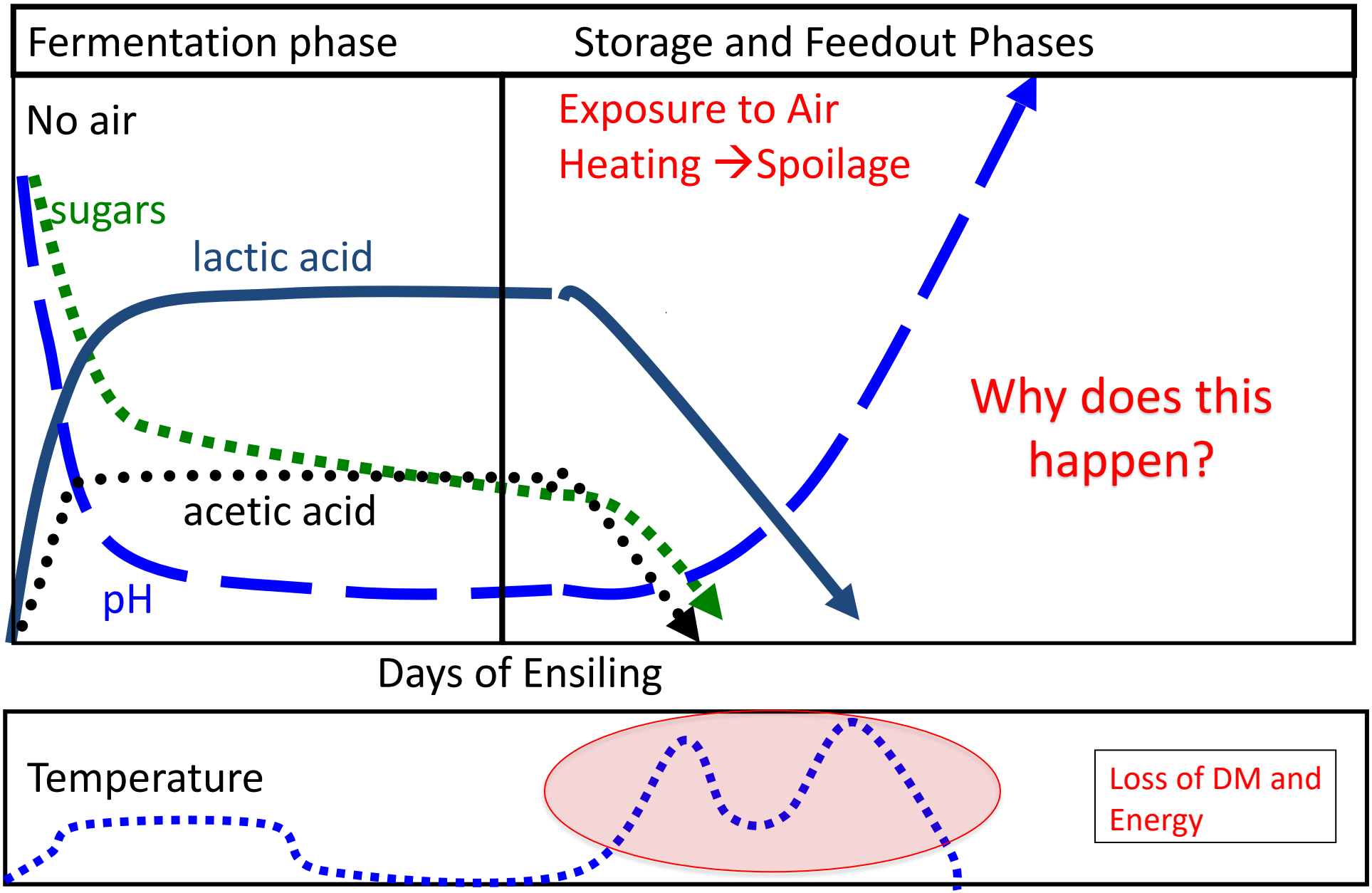
Air is the Worst Enemy of Silage

- 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



Ideal Fermentation, Air During Storage or Feedout

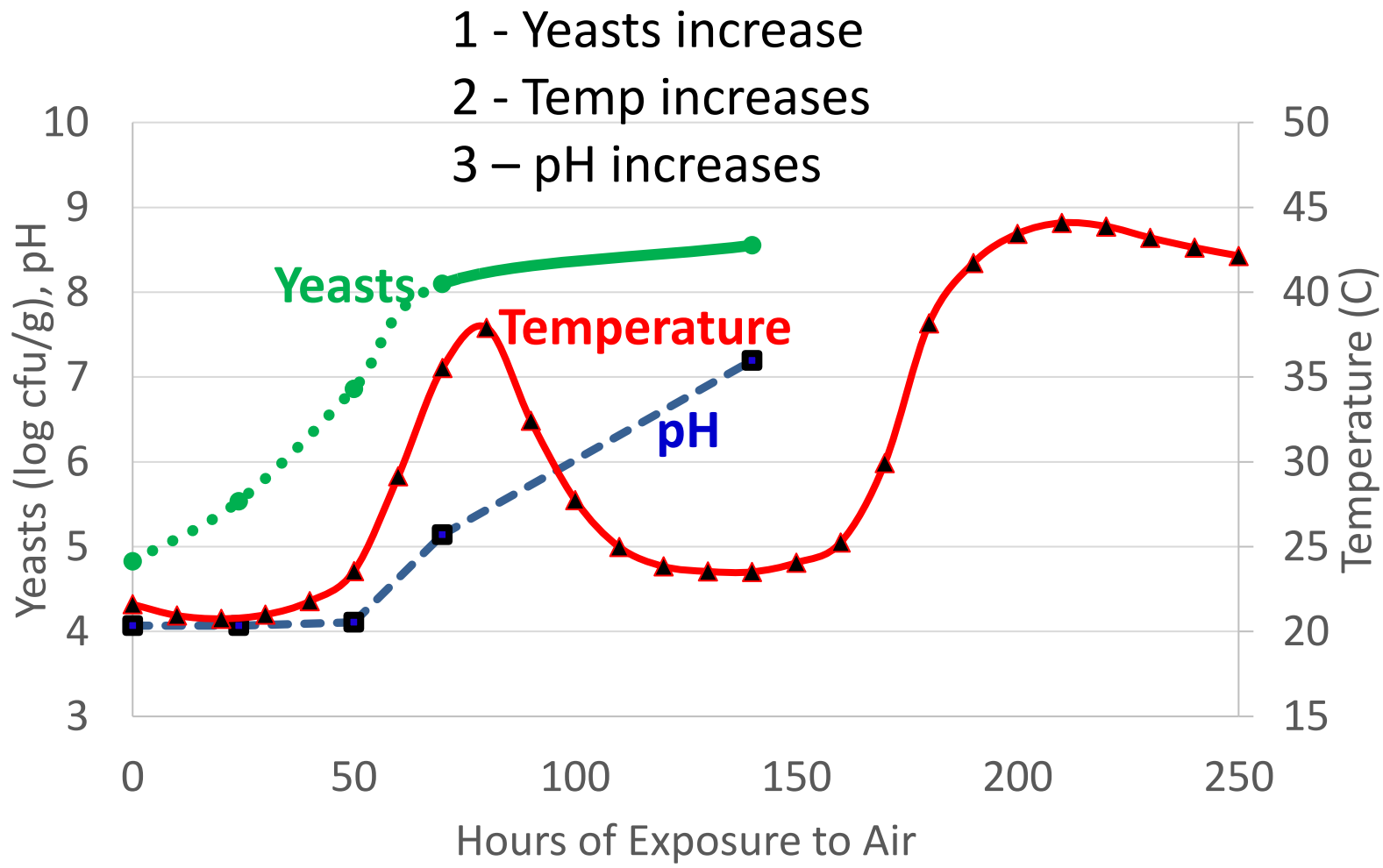


It is a misconception that “molds” cause aerobic instability

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

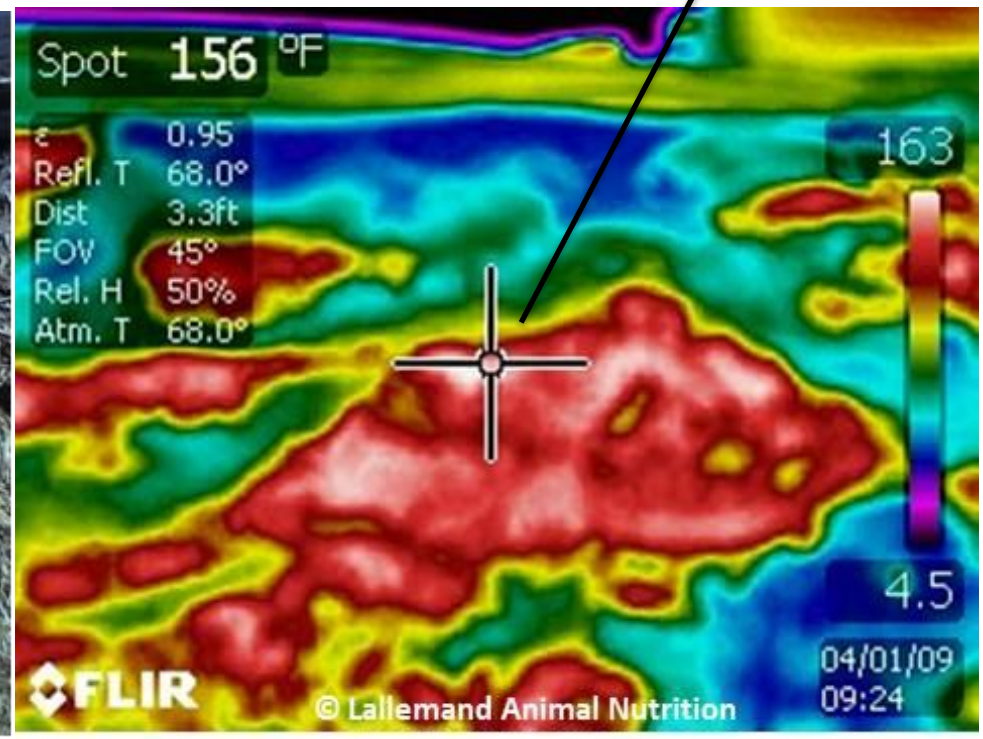
Changes in Yeasts, pH and Temperature of Aerobically Spoiling High Moisture Corn



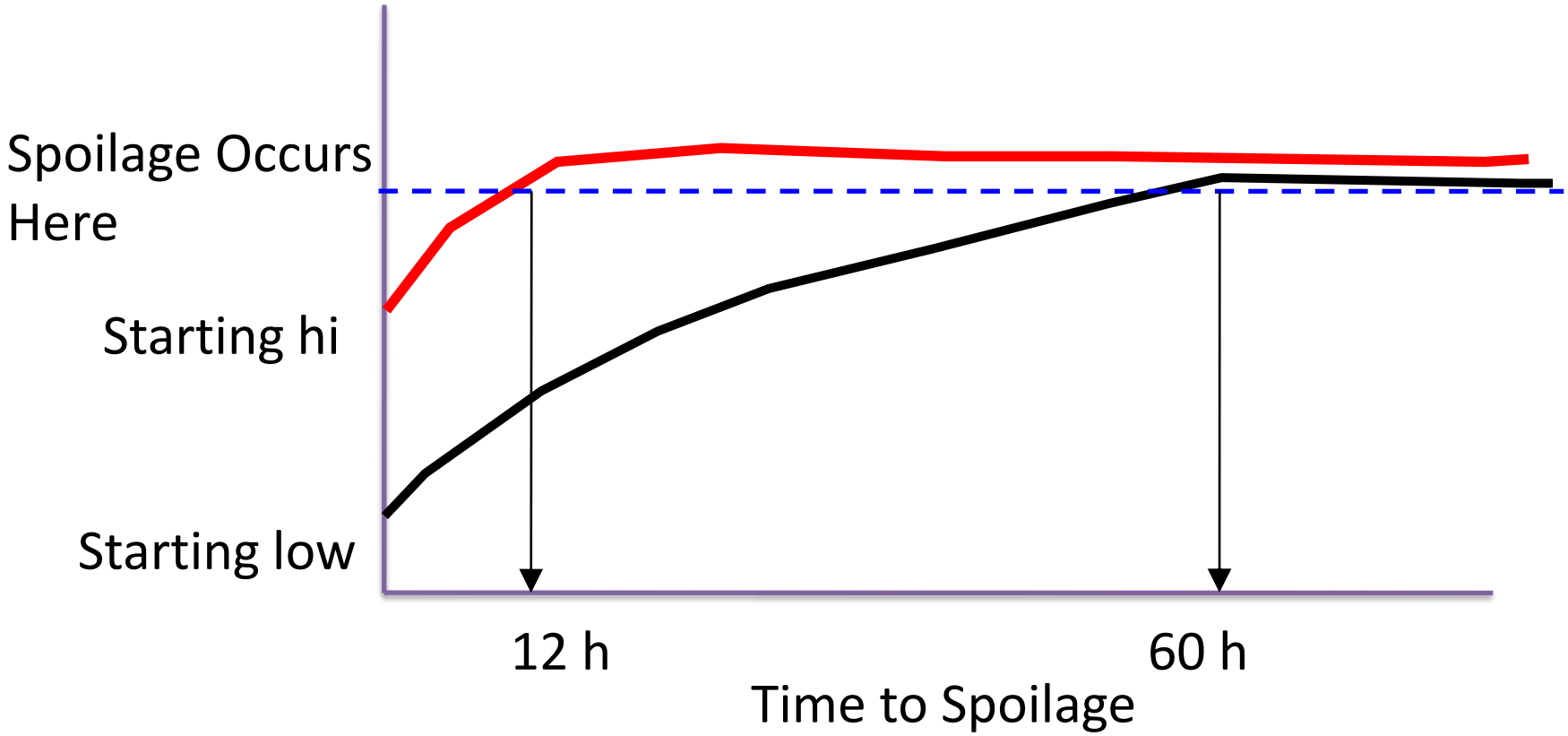
Kung et al., University of Delaware

Aerobically Spoiling Silage Can Reach Temps as High as 160°F….

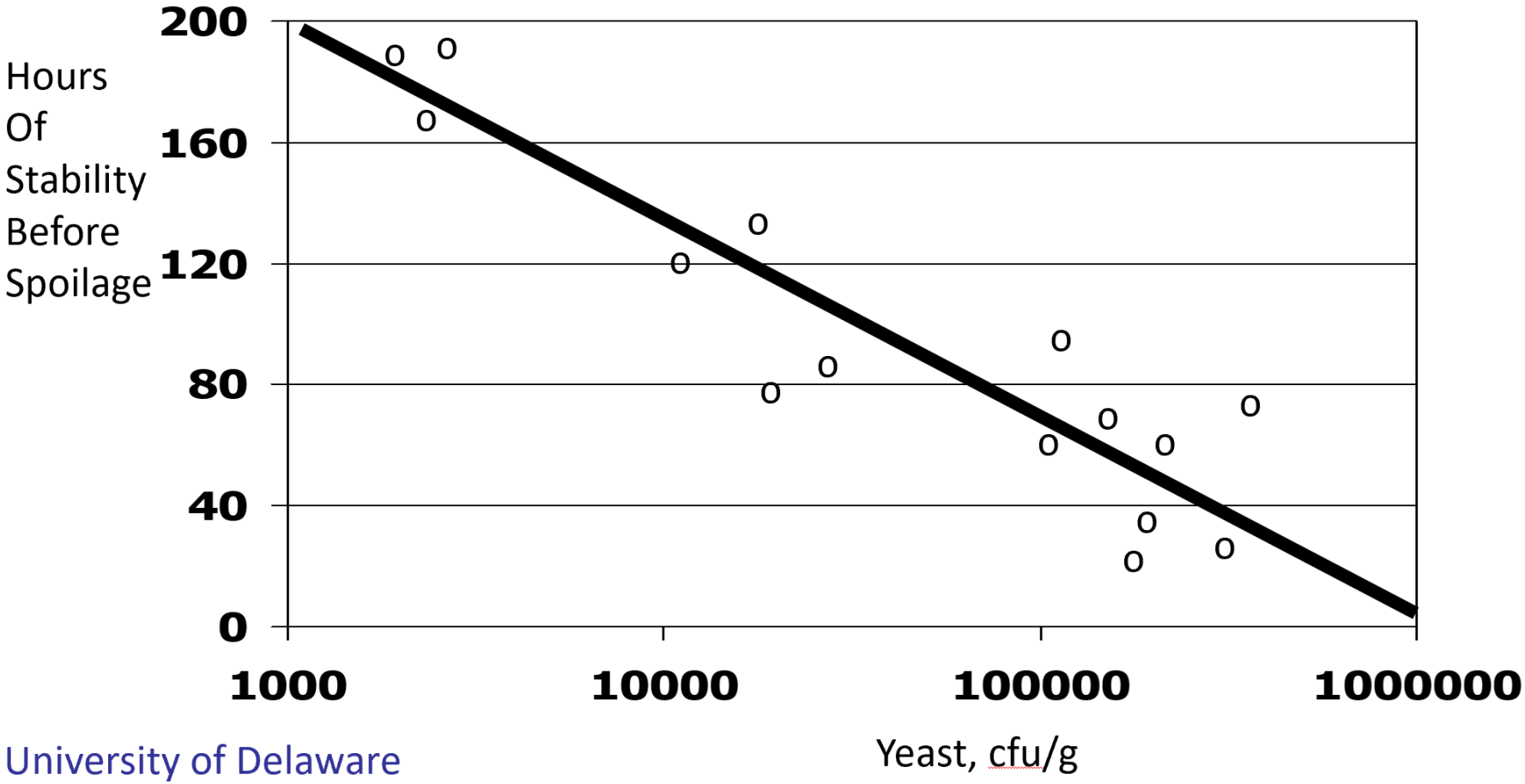
Aerobically Spoiling Silage Becomes Very Hot –> Loss of DM and Energy



How do initial populations of yeasts affect time to spoilage?



The Negative Relationship Between Number of Yeasts and Aerobic Stability



Use Caution When Interpreting Yeast Numbers

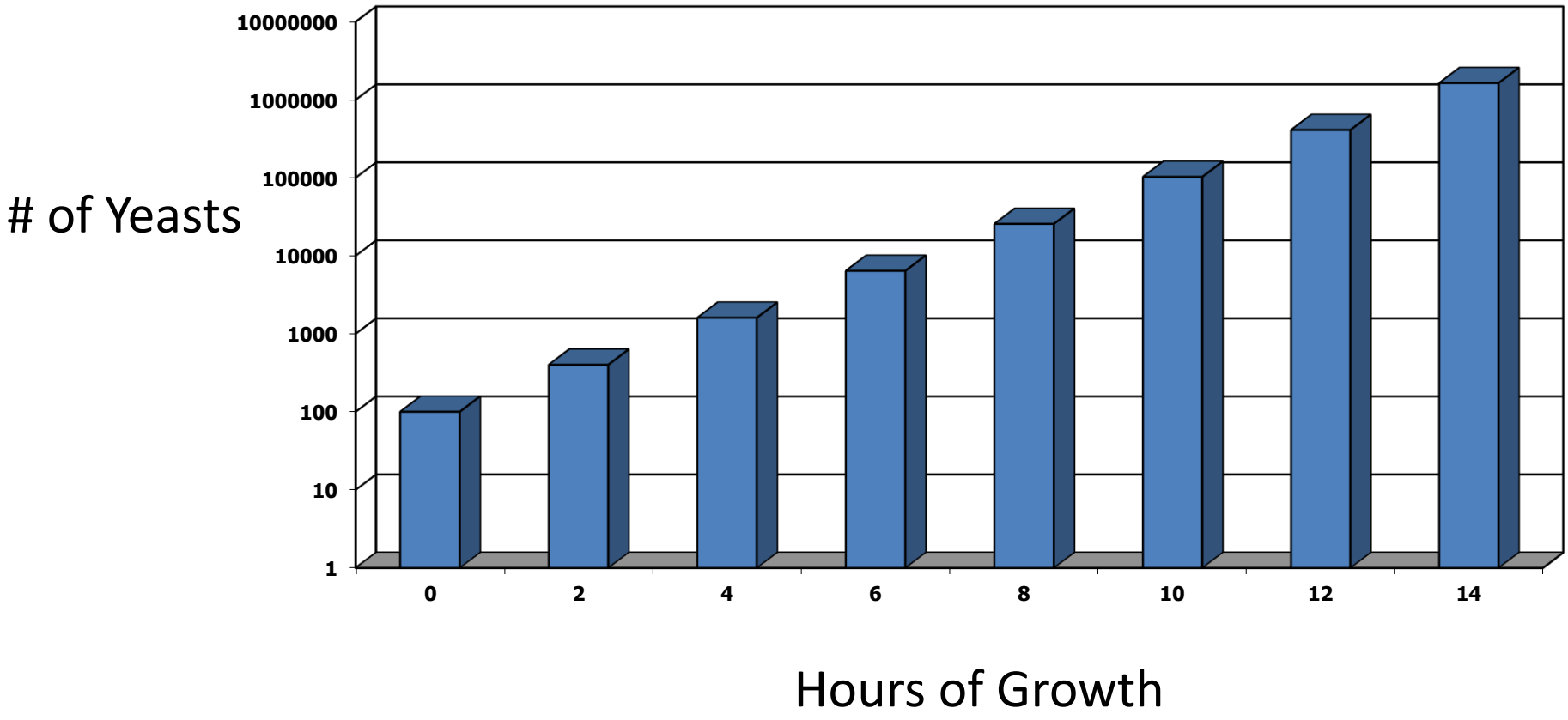
- Are high yeast counts on the standing crop a problem?

  Not if the crop is managed well during storage. Poor silo management is the problem!

- Numbers of yeasts and molds can increase dramatically during shipment to the forage lab (*especially in warm weather*)!

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

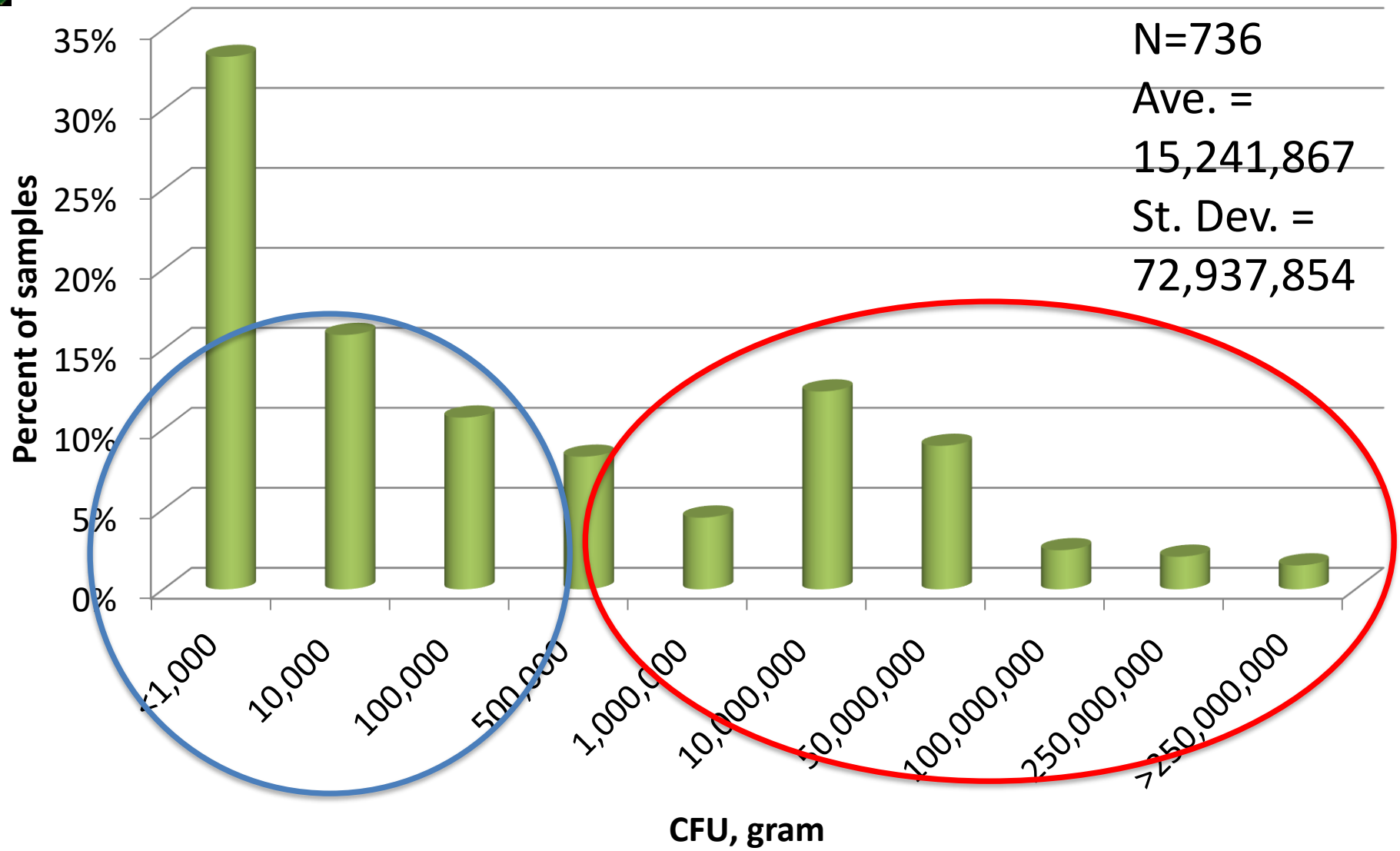
➢1.6 million cfu/g



Numbers of Yeasts (and molds) in Silages and TMR

Item	Number Range
-Standing crop	~100,000 to 500,000 cfu/g (↑ in drier, damaged crops)
-Well preserved silage	~10,000 to 500,000 cfu/g (↓ in additive treated crops)
-Silage exposed to air (during storage or feedout)	~500,000 to > millions of cfu/g
-Clostridial silage -Very old (years of storage) silage -Blackened top layers of bunker or pile silos	Can be “0”

Distribution of Yeast Counts in Corn Silage CVAS



Effects of Feeding Aerobically Spoiled Silage on the Rumen and Cow

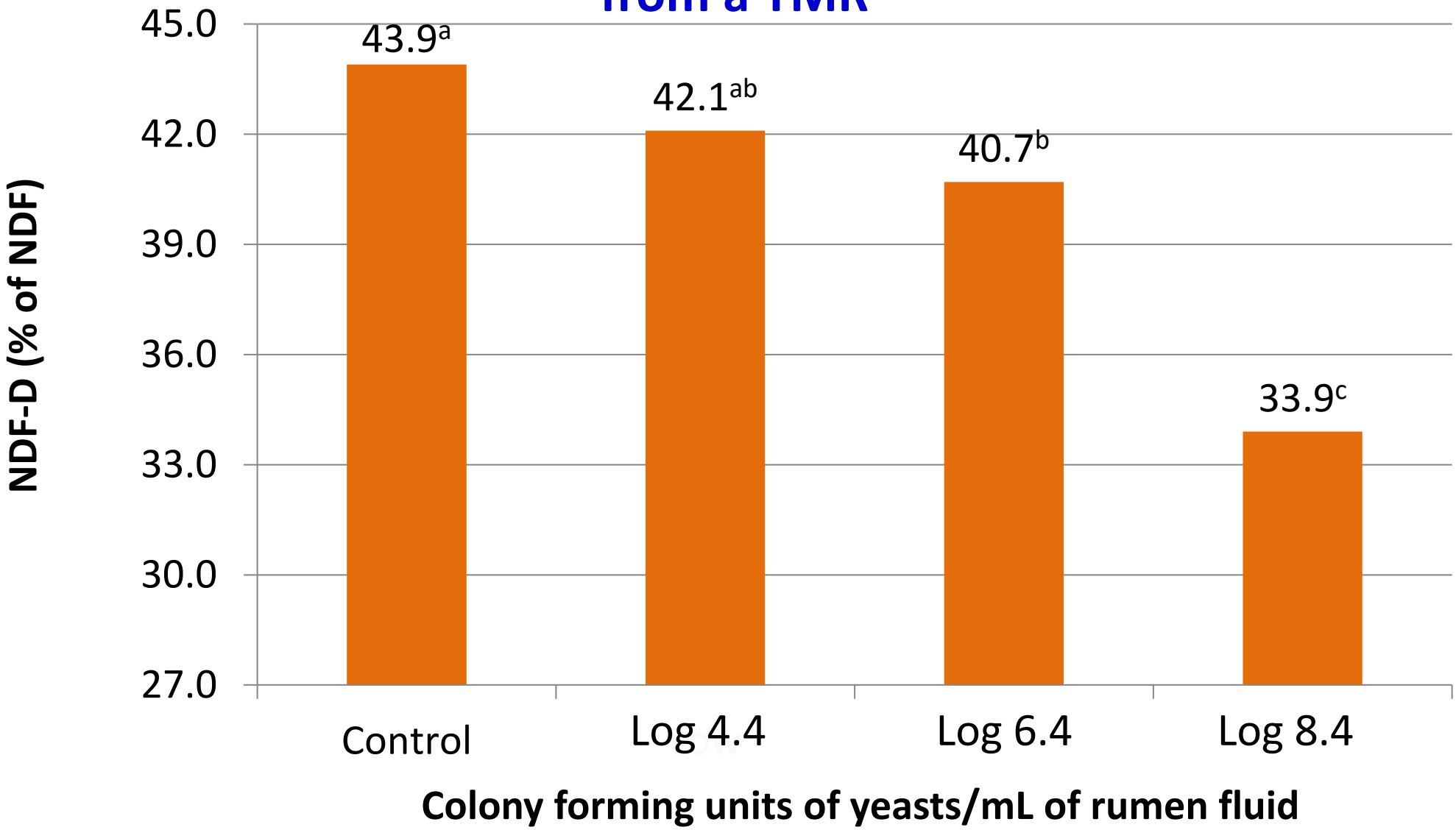
Theoretical Intake of Wild Yeasts by Dairy Cows

Treatment	Levels			
	0x	1x	100x	10,000x
Yeast population in corn silage, log_{10} CFU/g of Fresh Forage	0.0	5.0	7.0	9.0
Theoretical concentration of yeast in rumen, log_{10} CFU/ml of rumen fluid*	0.0	4.4	6.4	8.4
Equivalent intake of Levucell (g/cow/day)**	0.0	0.15	15	1500

*Assuming a cow ate 66 lb (wet weight of 35%DM material) of the silage above

**For comparison purposes only

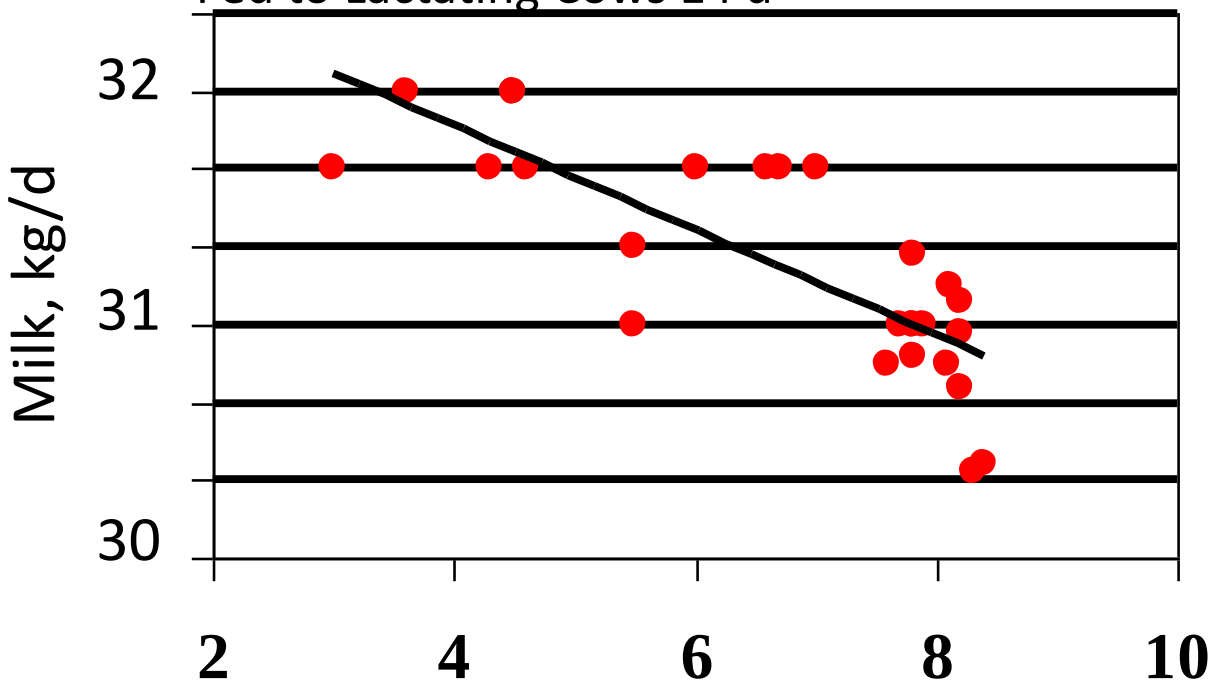
Is There a Direct Rumen Effect of Wild Yeasts? Spoilage Yeasts Decrease In Vitro 12-hr Digestibility of NDF from a TMR



Santos et al., 2011

Feeding Spoiled TMR with Molds Decreases Milk Production

- Hoffman et al 1995
- Exposed to Oxygen
- TMR
- Fed to Lactating Cows 14 d
- Moldy HMC
- Aerobically Unstable
- No Intake Depression



$R^2 = 0.63$

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

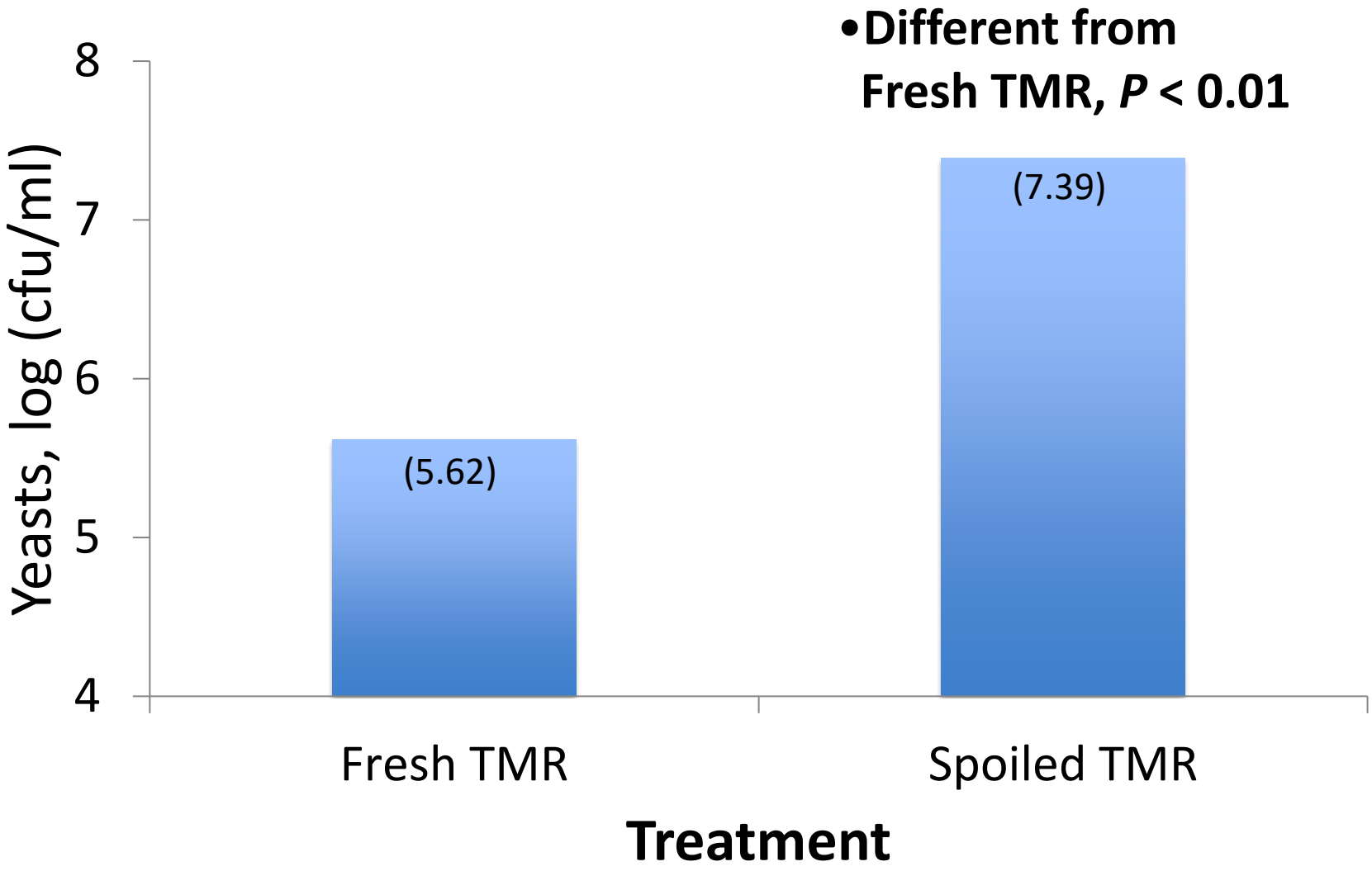
Item	Fresh TMR	Spoiling TMR	*P*-Value
pH	4.16	5.17	<0.01
WSC, %	2.46	1.85	<0.01
Lactic acid, %	4.17	2.59	<0.01
Acetic acid, %	0.97	0.64	<0.01
Ethanol, %	5.82	6.07	<0.01
Yeasts, log_{10} cfu/g	5.03	7.82	<0.01

2013 Windle and Kung

107,151 yeasts/g

66,069,345 yeasts/g

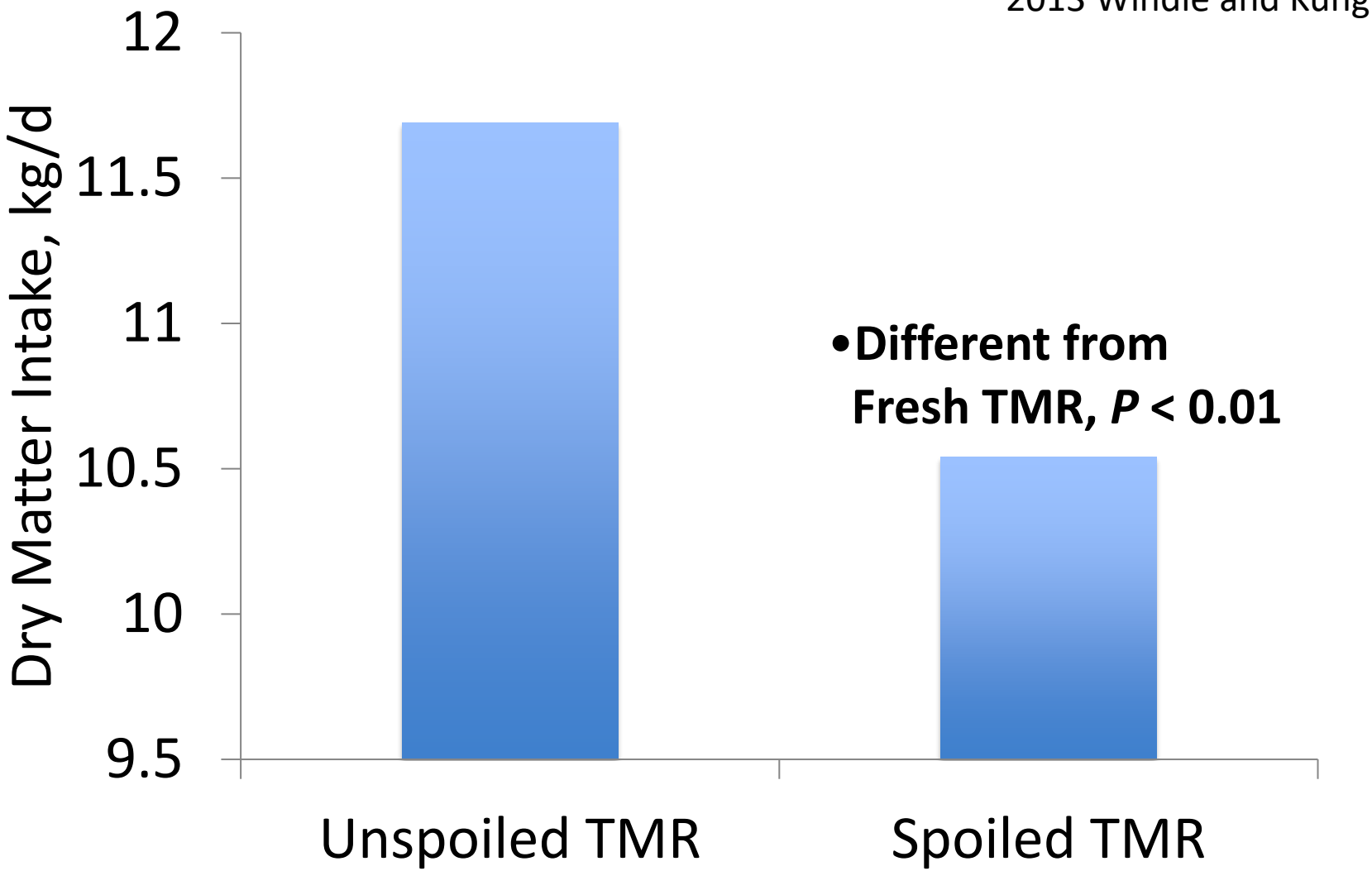
Numbers of Yeasts in Rumen Fluid



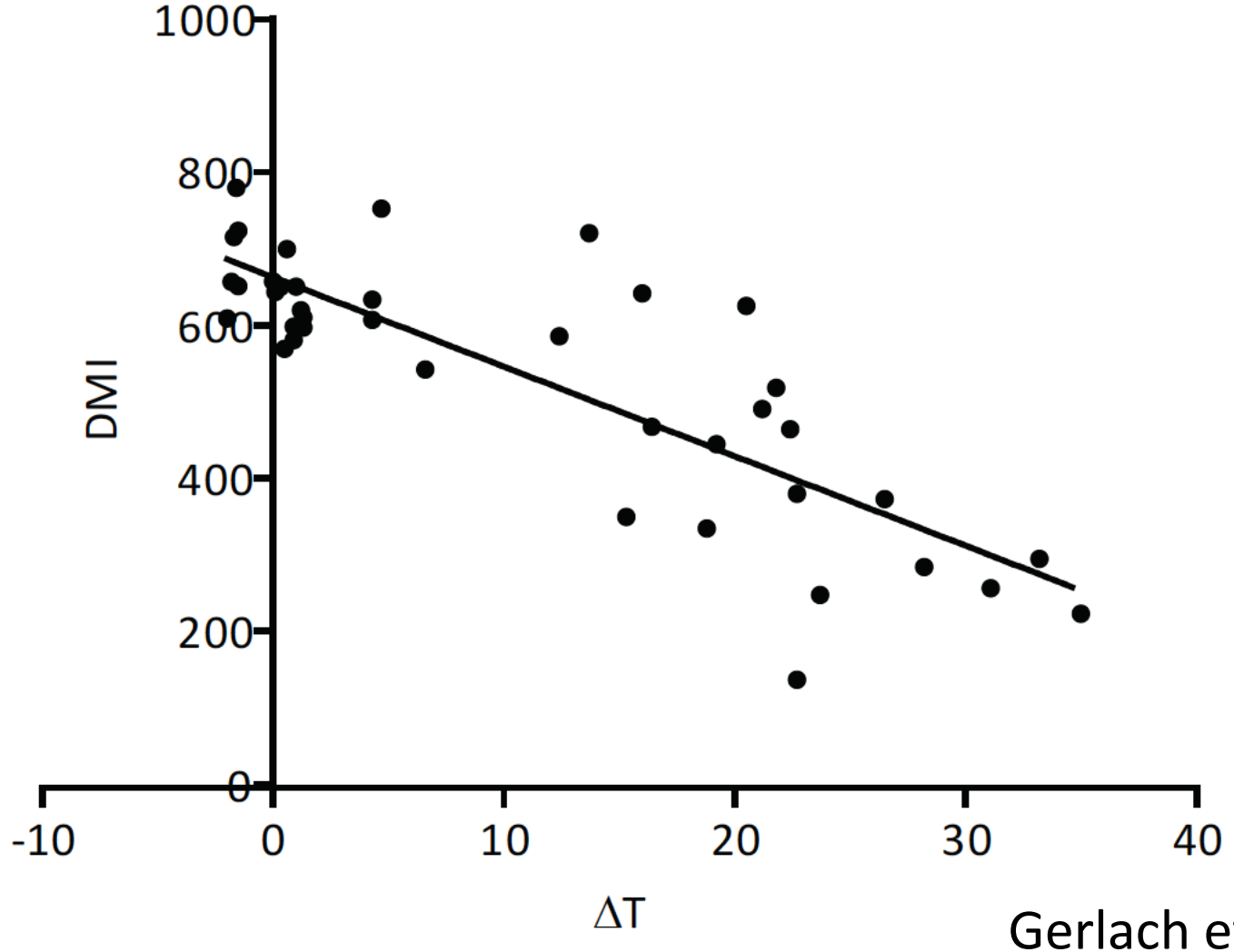
2013 Windle and Kung

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

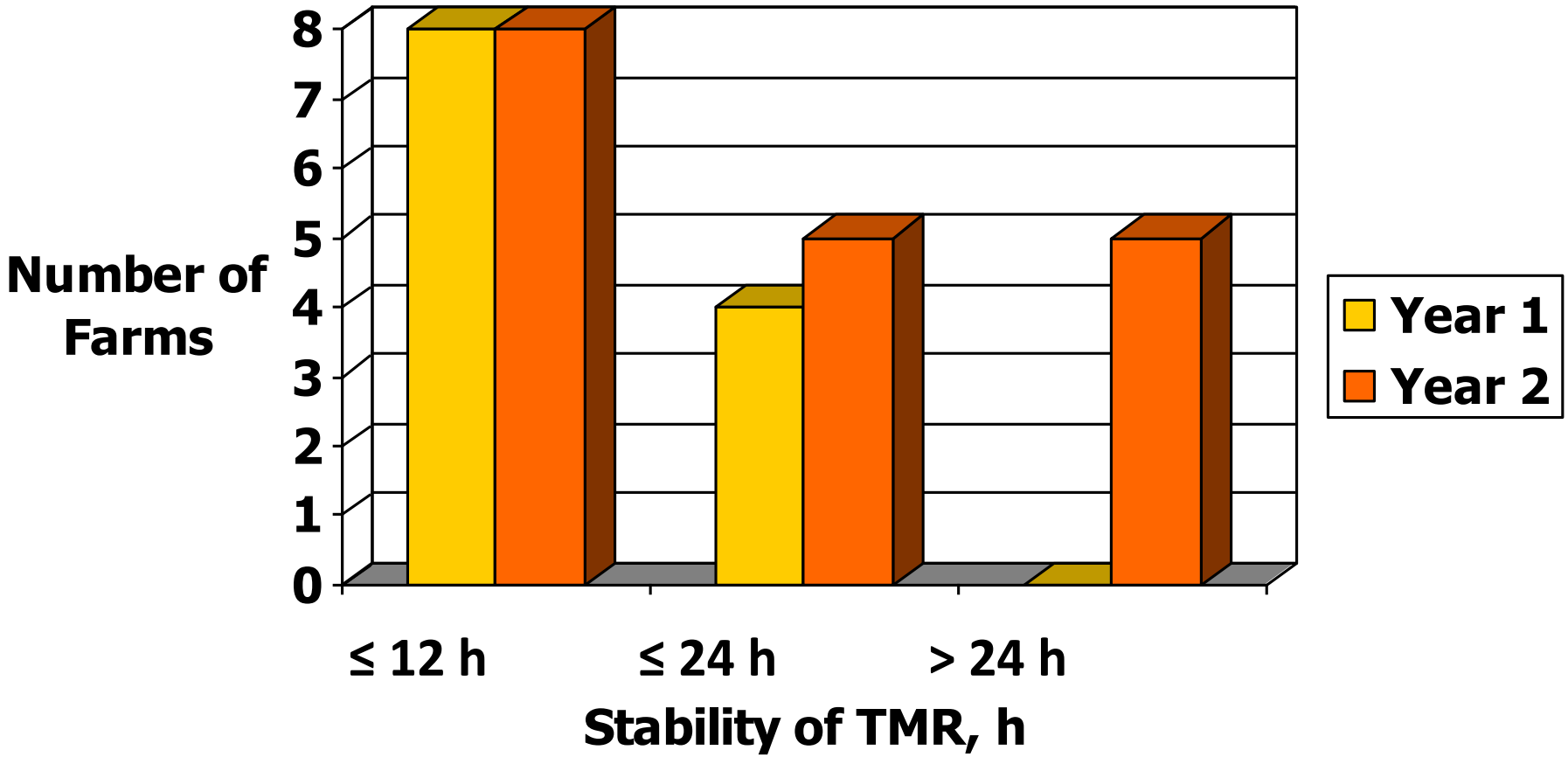
Check the Aerobic Stability of Your Total Mixed Ration

Indications of Aerobic Spoilage in TMR and Silages

- > 95-100°F in “cured” silage
- Reheating in the feed bunk
- Lack of sharp acid or sweet smell
- Musty moldy smell
- Visible signs of molds

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

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

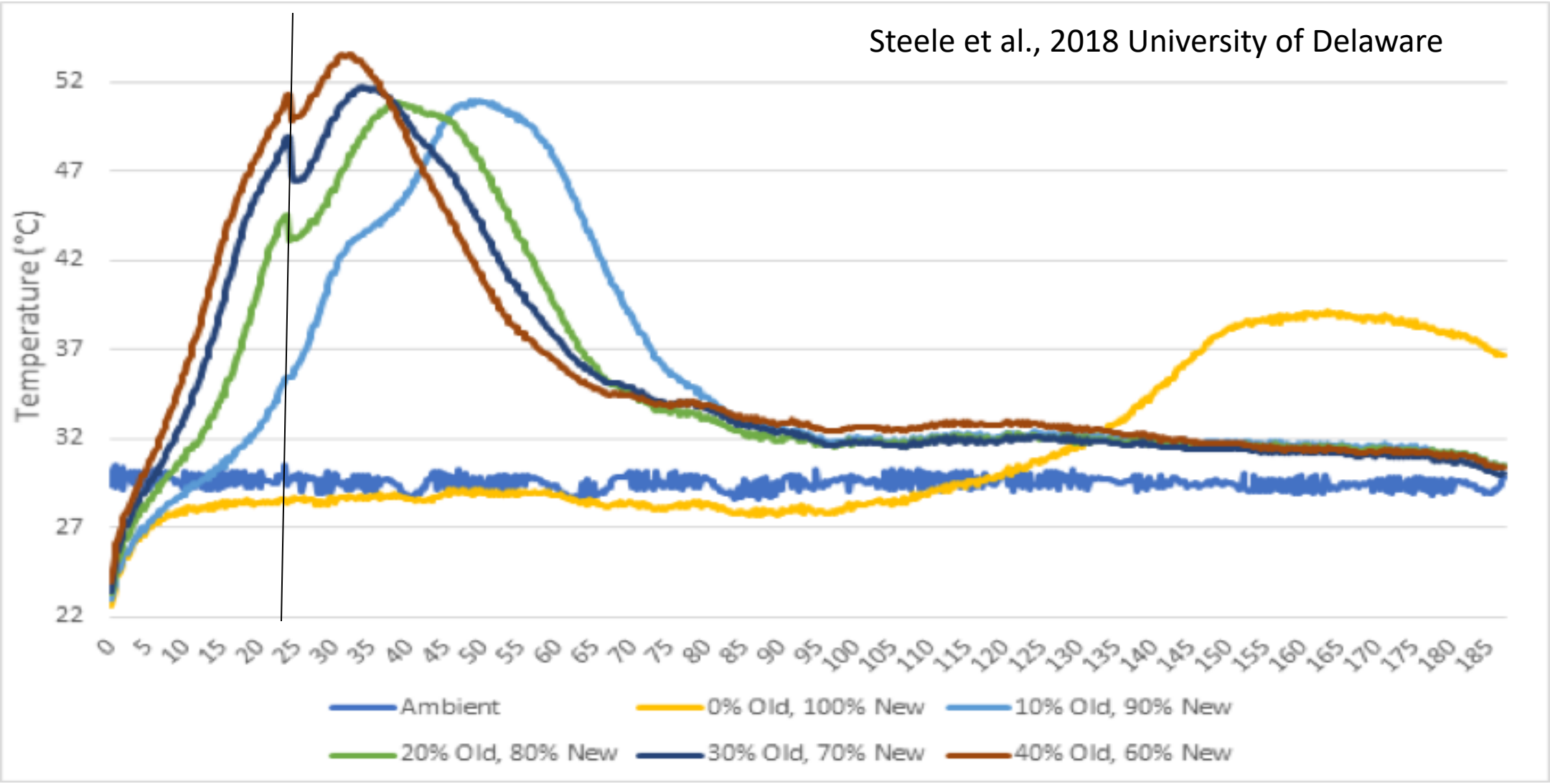
- Remove sufficient silage from the silo to prevent spoilage
- Do not mix spoiled silage with other feeds
- Mix and feed the TMR 2 to 3 times a day
- Mix only enough TMR to feed immediately
- If you must mix the TMR ahead of time, do so at night when it is cooler
- Use a TMR preservative to reduce spoilage

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% of Spoiling Silage Can Destabilize a TMR



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

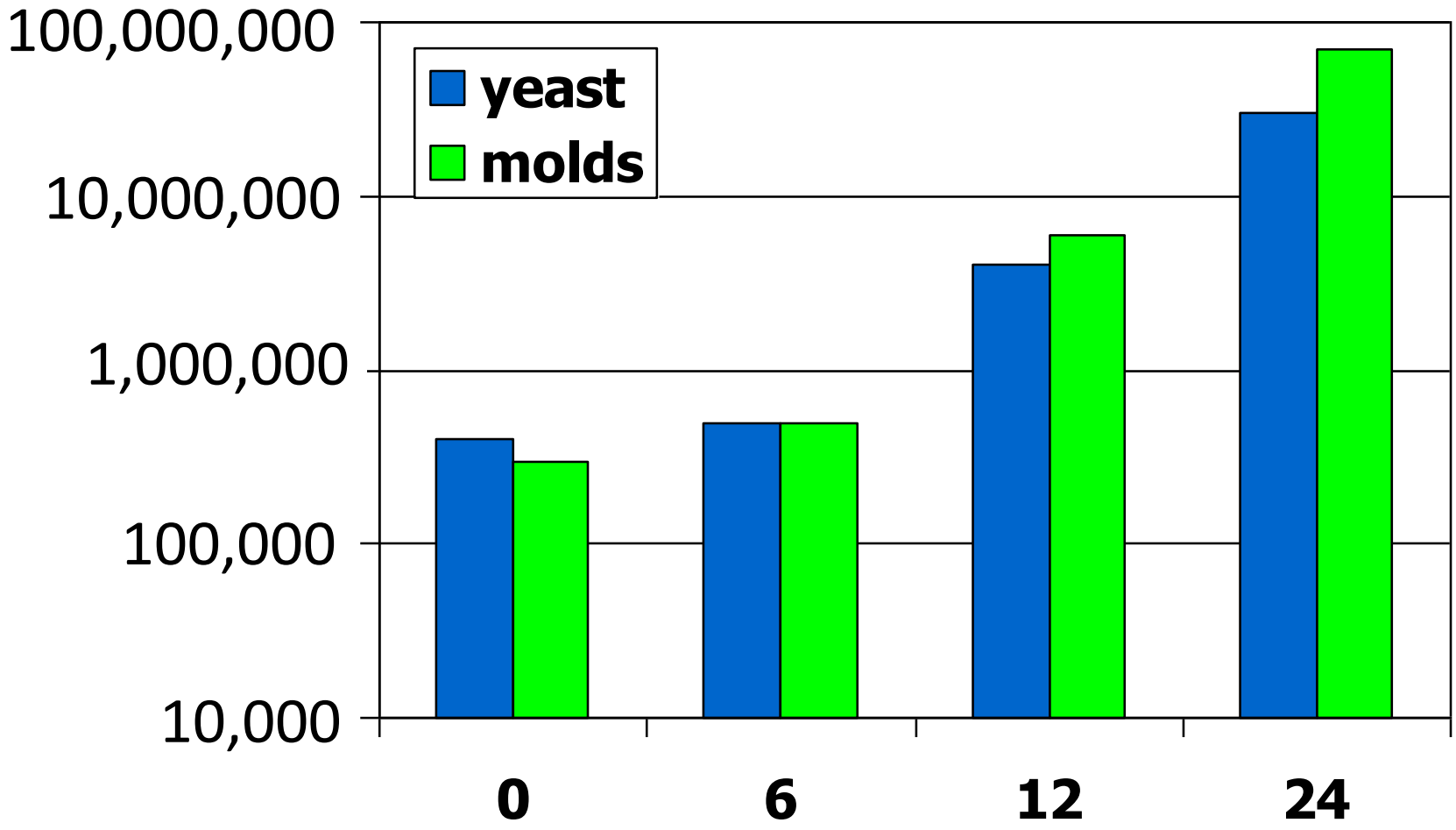
- **Fill quickly,** but not too quickly
- **Pack tightly**
  - 15-17 lb DM/ft^3 CS
  - 16-18 lb DM/ft^3 AS
- Use Bulk Density to control porosity
  - For 30 to 40% DM forage, obtain a minimum of

    44 lb of wet wt/ft^3
- 6-8 inch layers
- Tractor wt/800 = tons per hour to achieve optimum bulk density e.g. 40,000 lb tractor wt/800= 50 t/h

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 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


This Silo Had Too Much Plastic Removed
Before Feeding.
Pull Back Plastic Only to the Amount
Of Silage Removed for the Day.
01.27.2004


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

No Chia-Pet Covers!!!

Kung, 2007

Cover and Seal Silos Immediately

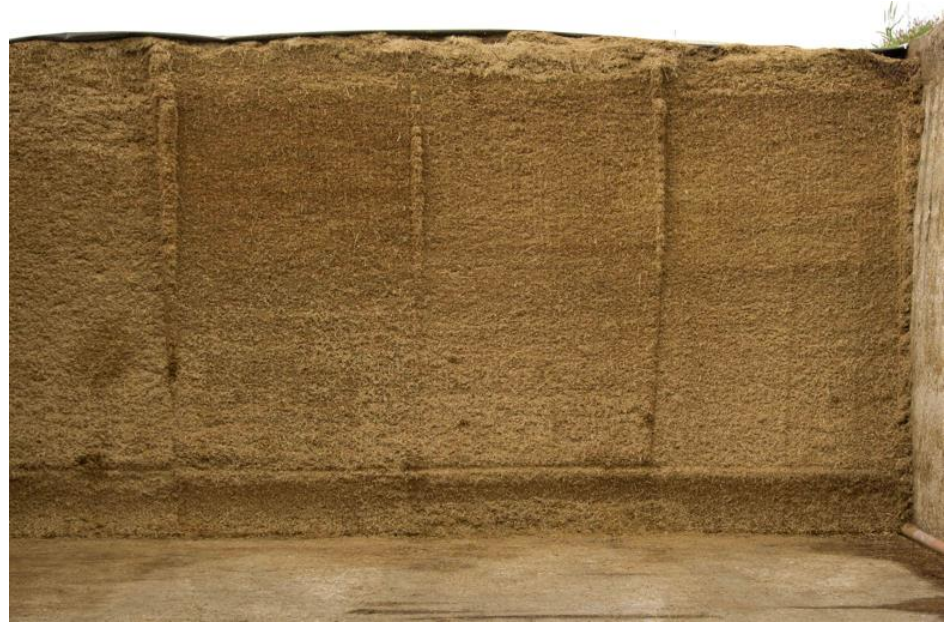
Oxygen Barrier
Plastics?

Excellent Silo Management is Needed to Maintain High Quality Silage

Keep Plastic Down at the Feeding Face

Face Management

- Remove a minimum 6-12 in/day
- Remove more in hot weather and for drier/poorly packed silages
- Keep face clean, minimize face damage
- Knock down only enough silage to feed that day



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


Kung 2004

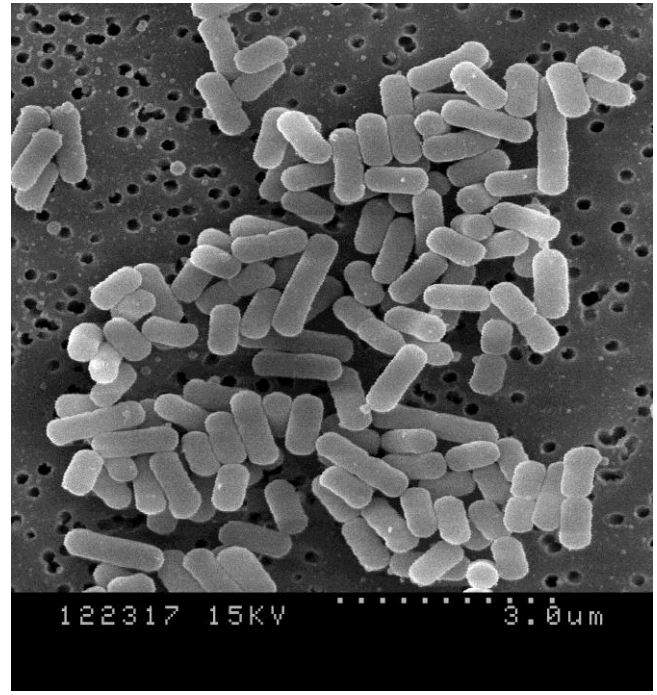

Kung 2004

What Additives Can we Use to Control Yeasts?

- Silages
  - Based on *L. buchneri*
  - Addition of antifungal chemicals
    - Acetic acid
    - Propionic acid
    - Sodium benzoate
    - Potassium sorbate
- TMR
  - Addition of antifungal chemicals

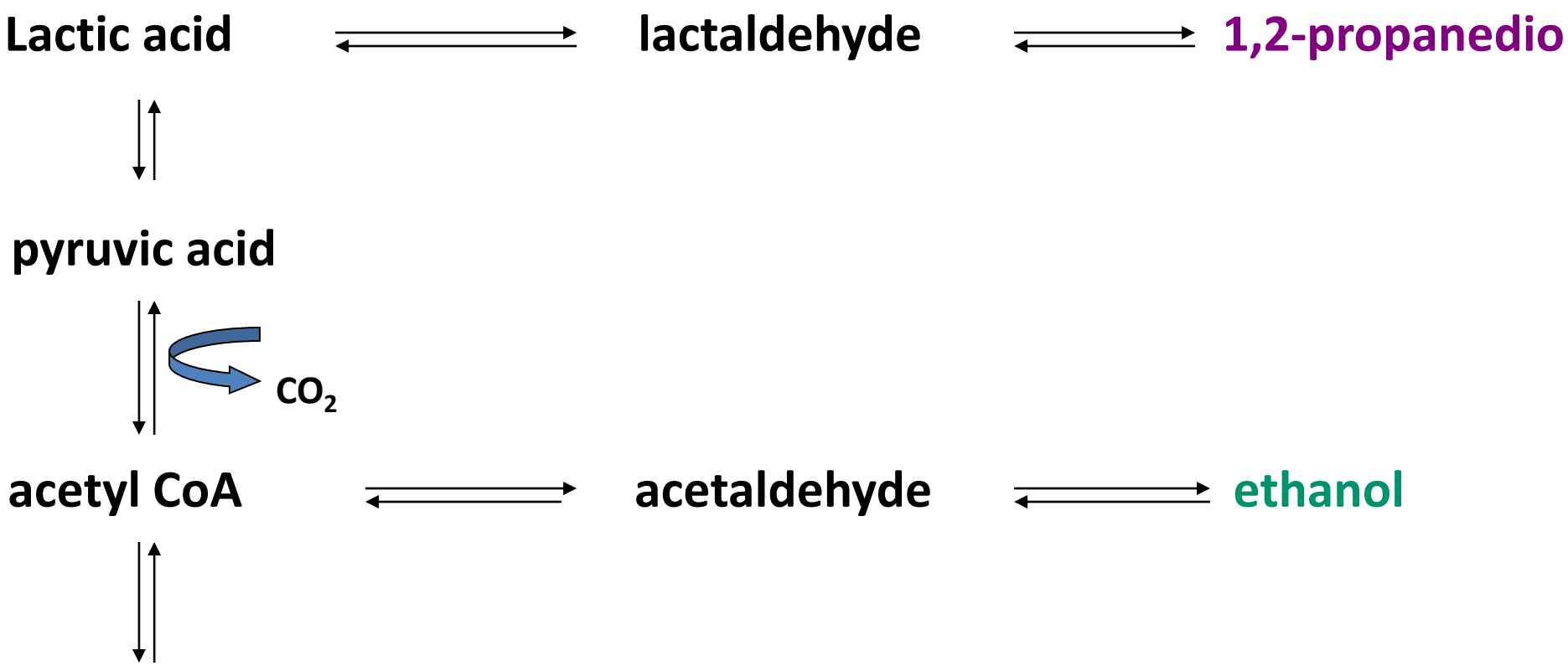
Improving Aerobic Stability with *Lactobacillus buchneri*

- Heterolactic acid lactic acid bacteria 1903, named for E. Buchner
- 2001, only organism ever added to the original grandfathered DFM list of approved microbes for use in animal feed
- Naturally occurring lactic acid bacteria
  - rumen
  - human intestine, mouth
  - grapes, wines, molasses, cheese
  - silages



Pathway of Lactic Acid Degradation by *L. buchneri*

(Oude Elferink et al., 2001)



acetic acid → inhibits yeasts and molds → improves aerobic stability

Published Effects of *L. buchneri* on Fermentation and Aerobic Stability of Maize Silage – A Meta Analysis

Item	Control	LB1*	LB2**
Lactic acid, %	6.6^{d}	5.9^{e}	4.8^{f}
Acetic acid, %	2.2^{c}	2.6^{b}	3.9^{a}
DM recovery, %	95.5^{a}	95.5^{a}	94.5^{b}
Aerobic stability, h	25^{b}	35^{b}	503^{a}

26 published and citable comparisons (journal articles and meeting abstracts – no in house reports or unpublished data)

***LB1 ≤ 100,000 cfu/g; **LB2 ≥ 100,000 cfu/g.**
^{def}Means in a row with unlike differ P < 0.10,
^{abc}Means in a row with unlike differ P < 0.05
Kleinschmit and Kung, 2006.

When Are Additives That Improve Aerobic Stability Most Useful?

- Silages with high starch, HMC, corn silage, cereal grain silages
- Poor bunk life, heating TMR issues
- Challenged silage removal from silos
- High DM silages
- Silage that will be moved
- Summer feeds
- Prolonged storage
- Intermediate feeding piles

What We Don't Know About Wild Yeasts? What Causes Negative Animal Effects?

- Production of toxic end products?

  e.g. mycosins

- Alterations in nutritive value?
  - fatty acid content of yeast cell walls
  - alterations in biohydrogenation of fatty acids
- Organoleptic effects?
  - Taste
  - Smell
  - Hot feel

Conclusions

- All types of yeasts are undesirable in silages and TMR
- Lactate assimilating yeasts primarily initiate aerobic spoilage
- Spoiled/spoiling silage is associated with detrimental effects on animals
- The direct cause of the detrimental effects are unknown
- Improving silo management should be the first place where improvements are made to minimize yeasts in silages and the chances of aerobic spoilage
- Various additives can also be effective in minimizing yeasts in silages

Take Home Message

- We know that wild yeasts are undesirable
- We know they can have detrimental effects on ruminants
- We don’t know the exact mechanisms involved
- **We do know how to minimize their numbers in silage -> excellent silo management and select additives**