

Health Effects of a Silage Fermentation Gone Awry

Focus on Clostridium

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Case Study Farm #2

New York dairy

Decreasing milk production

Increasing metabolic disorders

	<u>Alfalfa 1st</u>		<u>Alfalfa 3rd</u>
Cows	Inconsistent...	→	Bright, Alert, Attentive
Milk	66 lbs		72 lbs
	%		%
ADF	39.9		39
NDF	46.6		44
CP	20.4		20.2
DM	26.5		34
pH	5.7		4.7
NH3 -N,	33		12
% of total N			
Lactic	.8		5.5
Acetic	3.5	→	1.5
Butyric	4.4		<.01
Total VFA	10.1		7.4

NY Dairy

What we'll discuss...

- Causes and characteristics of these fermentations
- Animal trials with Clostridial silages or their fermentation end-products
- Management of Clostridial silages
- Prevention of Clostridial fermentations

How bad is this fermentation?

Fermentation analysis (objective)

- DM
- Common volatile fatty acids (acetate, butyrate, propionate, possibly isobutyrate)
- Lactate
- pH
- Ammonia nitrogen
- Possibly ethanol and ash

Nose analysis (more subjective)

Characteristics of Clostridial silage

Physical signs

- Odor - reeks
- Color - greenish
- Feel - wet, slimy

Laboratory signs

- Dry matter <32%
- pH > 5
- Butyrate > .1% (1 - 4 common)
- ammonia N > 10% of CP

What happens in a Clostridial fermentation?

- Clostridia are present in the soil
- Cannot tolerate acid conditions
 - optimum growth in pH range 7.0-7.4
 - sufficient quantities of lactic acid inhibit their growth
- Prefer wet silage (< 32% DM)
- Legume crops are more likely to have problems
 - highly buffered, low in water soluble carbohydrates

What happens in a Clostridial fermentation?

- Inhibitory pH not reached (~ 4.8), wet crop (< ~ 34% dm)
- Fermentation of lactic acid
 - pH of silage increases
- Fermentation of amino acids
 - Deamination - NH₃ released, organic acid residue
 - Decarboxylation - amine formation
 - Oxidation/reduction reactions of amino acids
 - NH₃ is released

Clostridia in silage

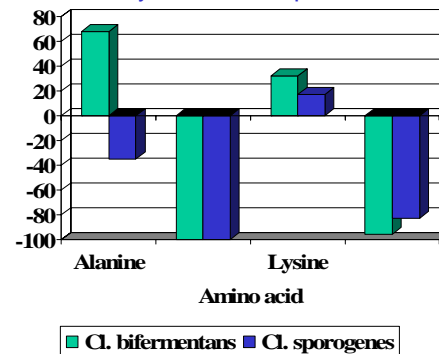
Lactate fermenters	Amino acid fermenters	Others
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Cl. butyricum	Cl. bifermentans	Cl. perfringes
Cl. paraputrificum	Cl. sporogenes	Cl. sphenoides
**Cl. tyrobutyricum		

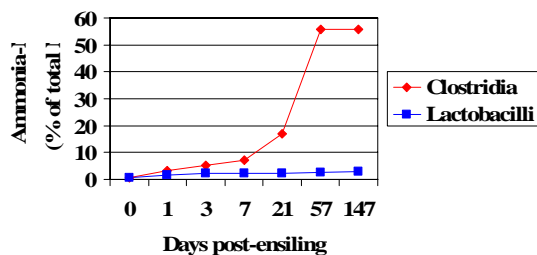
Seven Clostridia species are thought to be of importance in silage fermentations

Gibson 1965 J. Appl. Bact.

Percentage change in aa as affected by Clostridial species

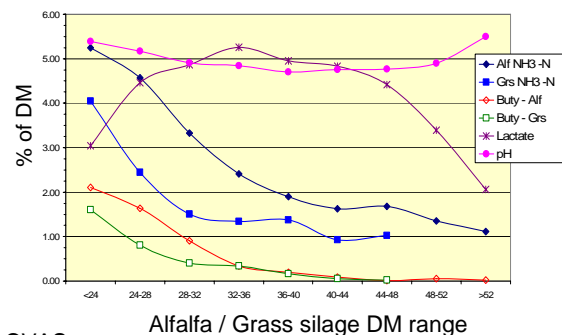


Ammonia-N as influenced by inoculant type



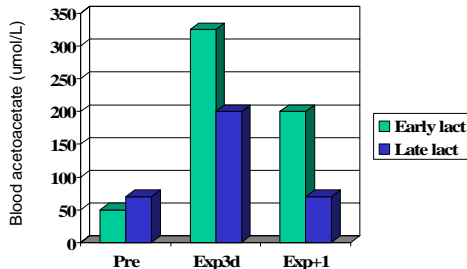
Kemble 1956 J. Sci. Food Agric.

The Relationship Between Silage DM and the Resultant Fermentation



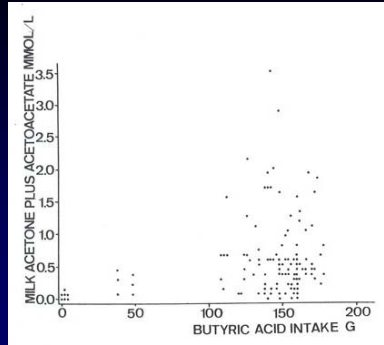
CVAS

Butyrate increases blood ketone levels



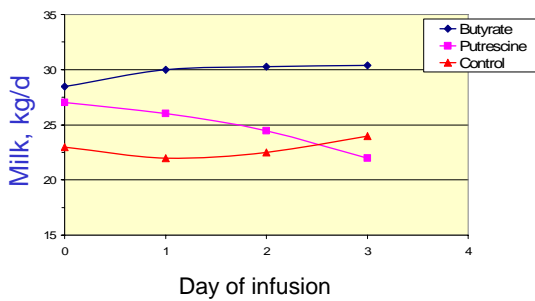
Lingaas 1992 J Dairy Sci

Butyric acid intake and Milk AO-AC



Andersson and Lundstrom 1985

Effect on milk production of ruminal intubation with butyrate or putrescine



Lingaas 1992 J Dairy Sci

Despite the results of food selection observed in experiment 3 (sheep ate the bad stuff), several other trials that we have conducted have shown that sheep generally self-select forage low in amines.

Buchanan-Smith 1982 BSAP

"I've fed silage like this before and didn't have these problems!"

Various producers

Correlation between various amines, lactic, and butyric acid*

	Putresine	Cadaverine	Lactate	Butyrate
Putresine	-	.93	-.63	.09
Cadaverine	.93	-	-.68	.21
Lactate	-.63	-.68	-	-.67
Butyrate	.09	.21	-.67	-

*Data from eleven samples, but only 2 different silos
Tveit 1992 J. Dairy Sci.

Why the variability in response?

- Type of animal evaluated
 - early vs. late lactation
 - high vs. low production
 - wethers vs. lactating cows
- Variability in fermentation end-products
- Interactions between fermentation end-products, the rumen, and the animal

Summary of reasons to keep Clostridial silage away from (transition) cows

- Likely reduction in DMI
- No water soluble carbohydrates
- Loss of amino acids
- Increase in blood ketones

What we'll discuss...

- Causes and characteristics of these fermentations
- Animal trials with Clostridial silages or their fermentation end-products
- **Management of Clostridial silages**
- Prevention of Clostridial fermentations

Can we volatilize some of these noxious compounds?



Samples
Layer of 3rd - alfalfa
Bunker of oatlage
Good 1st alfalfa

August 10, 2004

Bill,

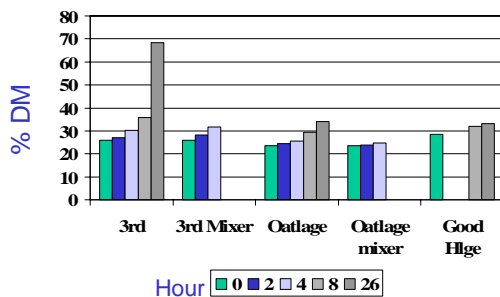
First, thank you so much for the opportunity of a lifetime to process these samples. The stench was overwhelming as the samples dried in the oven. We've dried our share of foul samples in our day, and yours rank near the top. It's a good thing they hit the oven near the end of the day, otherwise we probably would have had to evacuate the lab...

Thanks again..

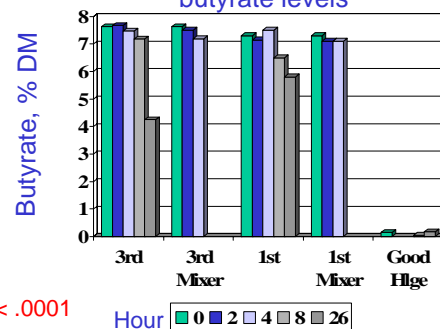
Best regards,

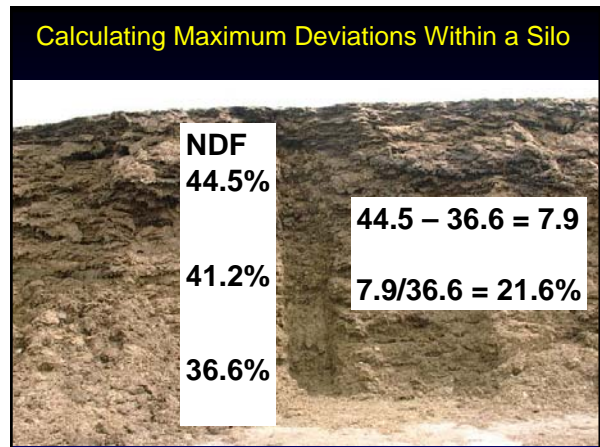
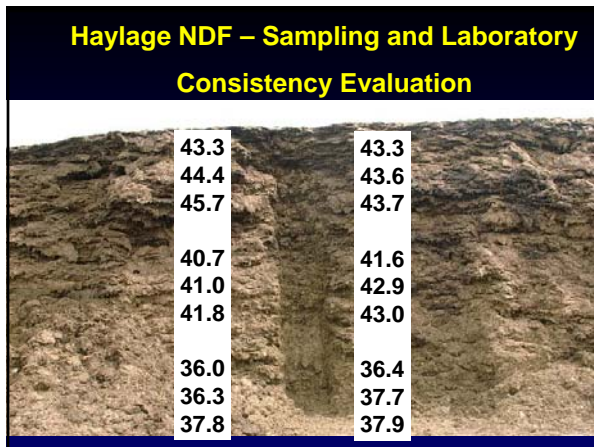
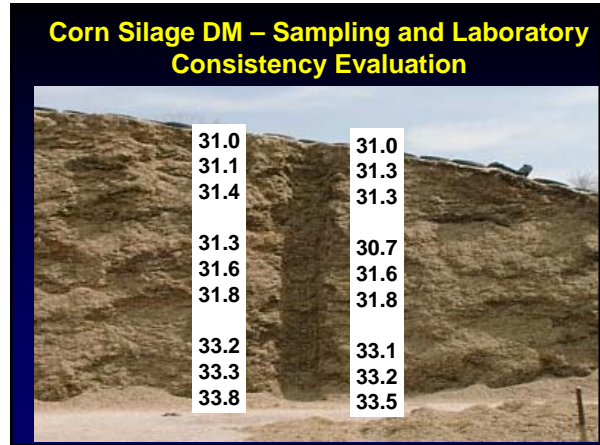
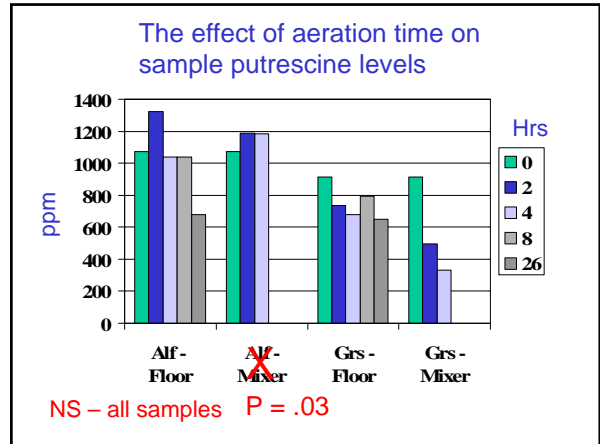
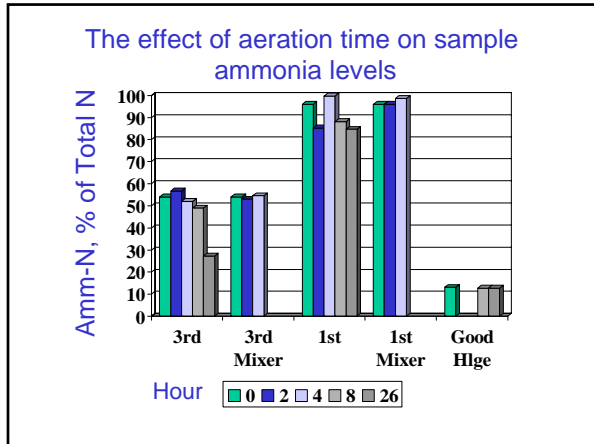
Paul Sirois
Director of forage lab services, Dairy One

The effect of aeration time on sample DM



The effect of aeration time on sample butyrate levels





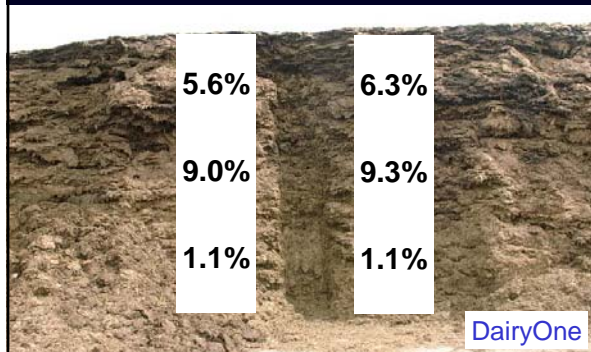
Haylage Bunker Results – 9 silos

	<u>DM</u>	<u>ADF</u>	<u>NDF</u>
Smallest deviation, %	5.2	1.1	5.4
Largest deviation, %	44.7	20.0	24.8
Average deviation, %	21.0	10.7	14.7
Median deviation, %	19.4	9.9	14.4

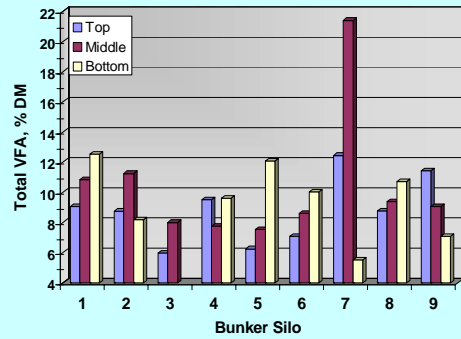
Corn Silage Bunker Results – 11 silos

	<u>DM</u>	<u>ADF</u>	<u>NDF</u>
Smallest deviation, %	1.3	2.3	.5
Largest deviation, %	55.0	18.3	18.6
Average deviation, %	12.3	8.4	8.6
Median deviation, %	8.3	8.6	8.4

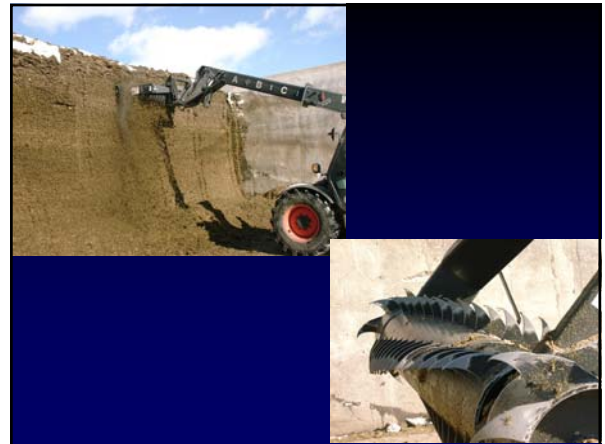
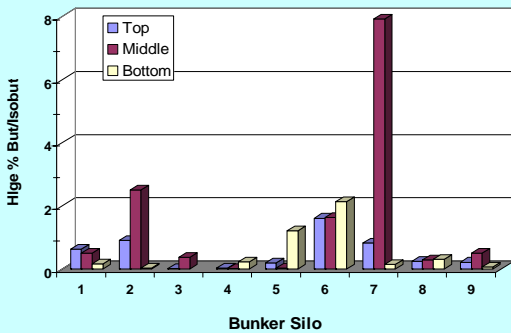
Haylage Lactate – Sampling and Laboratory Consistency Evaluation



Haylage Total VFA by Silo and Location Within Silo



Levels of Butyric/Isobutyric Acid by Silo and Location within Silo



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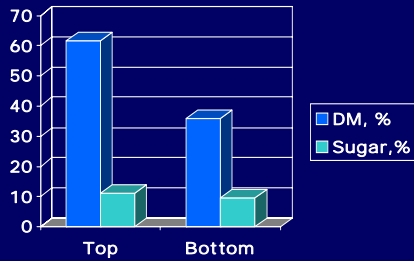
Forage Goals

Table 1. Characteristics of quality silage

	Type of Silage		
	Alfalfa	Grass	Corn
✓ Neutral Detergent Fiber, %	39-43	48-55	40-45
✓ Dry matter, %	Bunker	34-40	32-36
	Upright (stave)	34-42	34-38
	Bag	34-45	32-38
✓ Odor	Little or none at a distance; slightly sharp, pleasant up close		
	Lactic acid	Wet (< 35% DM) 6-8%, Wilted (>40% DM) 3-4%	
	Acetic acid	< 1-2%; ratio of at least 3:1 lactic:acetic	
	Butyric acid	< .1%	
	Total VFA	< 10%	
✓ Particle length	8-15% of TMR on coarse screen		
✓ Iron	< 200 ppm		

Windrow Width

The effect of location within the windrow on DM and Sugar levels



Wide swath



Courtesy of Tom Kilcer



14' disc bine



Narrower haybine 7' windrow

Hlge 2nd 2004

DM 39%
CP 22%
Bound 1%
Sol CP 61%
ADF 31%
NDF 39%



9' merger

Wide Swath Dries 3X Faster
Caution: it can get too dry Quickly!



Courtesy of Tom Kilcer

Management approaches to avoid Clostridial fermentations

- Harvest at the appropriate DM (34 – 44% DM)
- Maximize sugar level at time of ensiling
 - cut after several sunny days (!)
 - enhance dry-down time → wide windrows
- Minimize soil contamination of the crop
- Minimize the aerobic phase (packing)
- Inoculate
- Feed “suspect” silage quickly

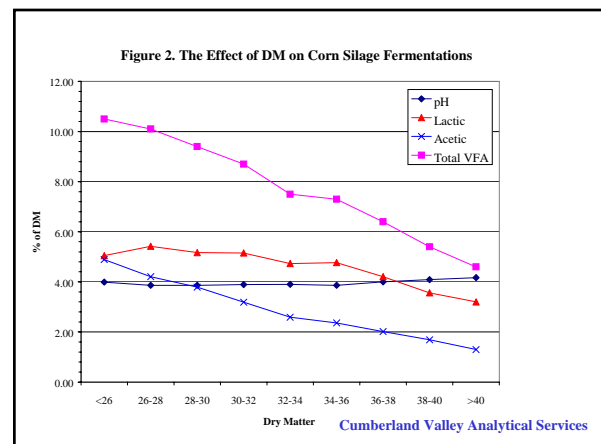
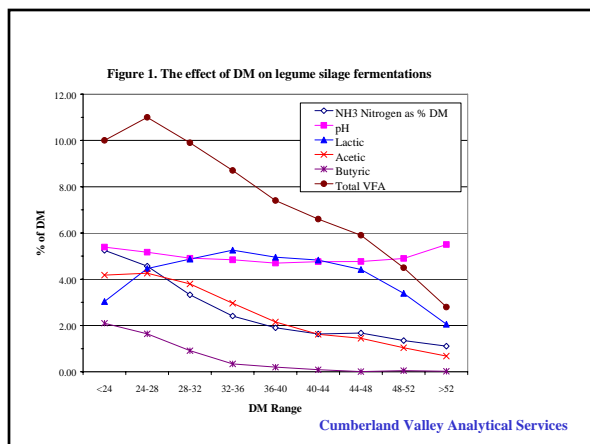
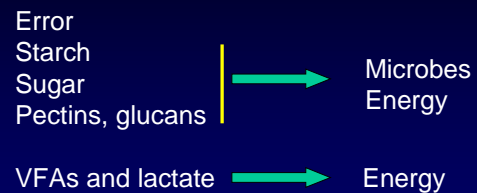
Working with Clostridial fermentations

- Keep them away from transition (and high production) cows
- “Aerating” these feeds can volatilize some noxious components, and heating is not an issue

Using Fermentation Analyses

- As an educational and motivational tool to help improve the dairy’s forage management program (Report card)
- As an additional means of evaluating a forage and determining its most appropriate use
- To help identify layers or regions of poor quality silage
- To more accurately describe the NFC fraction in ration formulation programs

Components of the NFC fraction



The effect of silage fermentation acid level on predicted ME and MP allowable milk¹

Silage, lbs. DM in ration	29	29
Ration, lbs. DM	51	51
Silage fermentation acid level, % of DM	5	12
Metabolizable Energy allowable milk, lbs.	91.5	91.9
Metabolizable Protein allowable milk, lbs.	92.2	87.2
Total metabolizable protein, g	2730	2615
Bacterial MP, as a % of total MP	51.1	48.9

¹Based on CPM Dairy predictions

Summary

- Clostridial silages can reduce intake and production, and increase metabolic health disorders and digestive disturbances
- The entire silo or only a few layers of silage may be affected
- Harvesting drier is the best way to minimize the problem