USDA
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Management of Baled Silages – Things to Consider

Virginia State Feed Association Livestock Conference and Dairy Nutrition Cow College

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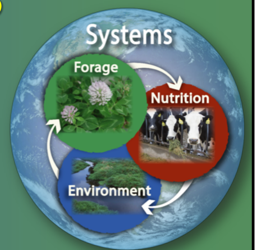


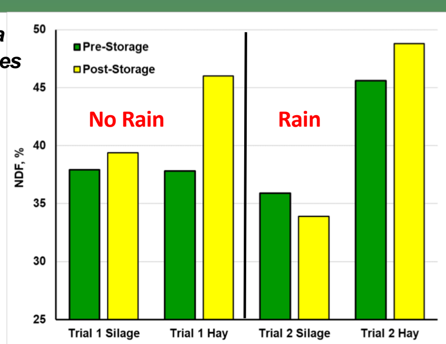
U.S. Dairy Forage Research Center, USDA Agricultural Research Service

Why Choose Baled Silage over Hay?

- *well-made baled silage will often exhibit better quality characteristics than corresponding hays*
  - *less leaf loss (legumes)*
  - *less wilting time required*
  - *reduced risk/exposure to rain damage*
  - *little or no spontaneous heating*
  - *no weathering after baling (outdoor storage)*


Why Choose Baled Silage over Hay?

Alfalfa Forages

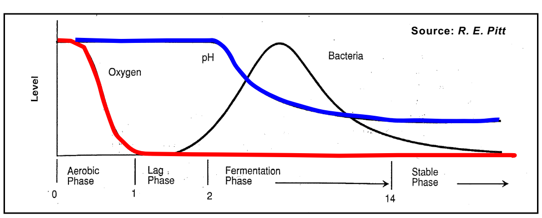


adapted from *Hancock and Collins (2006)*

Regardless of silo type, most management principles are the same.

- *start with high-quality forage*

Goal: Silage Preservation



Ideally, the goal is to establish a stable silage mass by lowering pH and maintaining anaerobic conditions!

Lactic Acid, The "Good Silage" Acid

plant sugars → lactic acid

Homofermentative

glucose or fructose + 2ADP + 2 Pi → 2 lactate + 2 ATP + 2 H_2O

Heterofermentative (multiple pathways)

glucose or fructose + ADP + Pi → lactate, acetate, ethanol, mannitol, ATP, H_2O, and CO_2

Typical Characteristics of Chopped Grass Silages in Northern Europe from Different Fermentation Types

Item	Lactic Acid	*Wilted*	*Clostridial*	Acetic Acid	Sterilized
Moisture, %	81.0	*69.2*	*83.0*	82.4	78.8
pH	3.9	*4.2*	*5.2*	4.8	5.1
Ammonia N, % of N	7.8	*8.3*	*24.6*	12.8	3.0
Lactic Acid, %	10.2	*5.9*	*0.1*	3.4	2.6
Acetic Acid, %	3.6	*2.4*	*2.4*	9.7	1.0
Butyric Acid, %	0.1	*0.1*	*3.5*	0.2	0.1
WSC, %	1.0	*4.8*	*0.6*	0.3	13.3

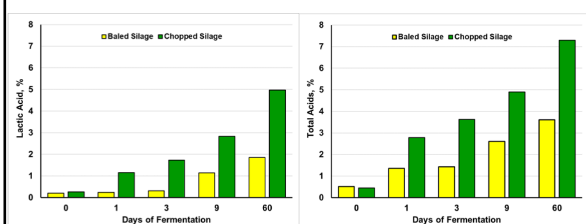
adapted from *McDonald and Edwards (1976)*

Baled Silage vs. Precision-Chopped Haylage

- *silage fermentation is restricted by the lower moisture content of baled silage*
- *lack of chopping action in baled silages forces sugars to diffuse from inside the plant to reach lactic-acid producing bacteria adhered to the outside of the forage*
- *although dependent on many factors, baled silage may be less dense (DM/ft^3) than some other (chopped) silo types, which also may restrict availability of sugars to lactic-acid producing bacteria*

Fermentation Characteristics of Alfalfa Forages Ensiled as Large-Round Bales or as Precision-Chopped Silages[1]

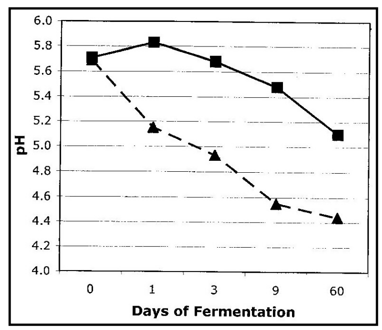
Lactic Acid ***Total Acids***



[1] Mean moisture concentration = 61%.

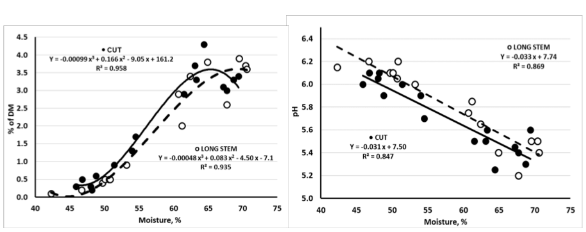
Nicholson et al. (1991)

Baled vs. Precision-Chopped Silage Alfalfa/Grass



Muck (2006) – adapted from *Nicholson et al. (1991)*; moisture concentration was 61%

Bale-Cutting Effects: Long-Stem vs. Cut Baled Alfalfa/Grass Silages



Lactic Acid ***Final pH***

Coblentz and Akins (2019)

Plant Factors

- ***Water Soluble Carbohydrates (WSC)***
- ***Buffering Capacity***

Fermentable Sugars
Water-Soluble Carbohydrates (WSC)

Sources of Variation for WSC

Species
Cultivar Within Species
Stage of Growth
Time of Day
Climate
Drought
Frost Events
N Fertilization
Rain
Poor/Extended Wilting Conditions
Management

Lactic Acid,
The "Good Silage" Acid

plant sugars → lactic acid

Water Soluble Carbohydrates (WSC) for Selected Forage Crops

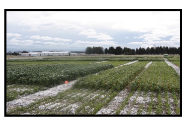
Crop/Species	WSC, % of DM
Corn Silage	10 - 20
Forage Sorghum	10 - 20
Sudan, Sorghum-Sudan, Millet	10 - 15
Rye, Oat, Wheat, Triticale	8 - 12
Ryegrass	8 - 12
Alfalfa	4 - 7
Bermudagrass, Stargrass	2 - 4
Bahiagrass	< 5
Limpograss	< 5
Perennial Peanut	1 - 4

Adesogan and Newman, 2013

Water Soluble Carbohydrates (WSC) for Fall-Grown Oat as Affected by N Fertilization Rate

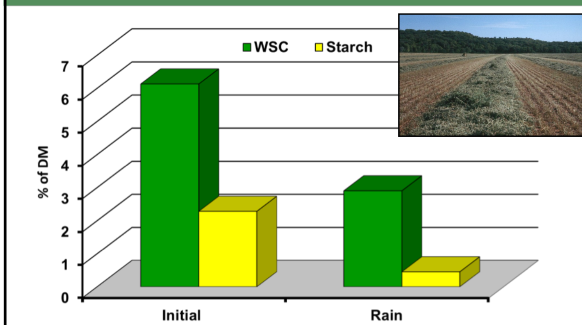
N Fertilization Rate	2011	2012
lbs N/acre	----------------- % of DM	----------------
0	12.4	19.3
22	12.3	17.4
45	11.5	17.4
67	10.0	16.5
90	10.1	16.3
SEM	0.76	0.53
Contrast	---------------- *P > F*	---------------
Linear	0.004	< 0.001
Quadratic	ns	ns
Cubic	ns	ns

[1] ns, non-significant ($P > 0.05$)



Coblentz et al. (2014)

WSC and Starch in Rain-Damaged Alfalfa (1.9 inches)



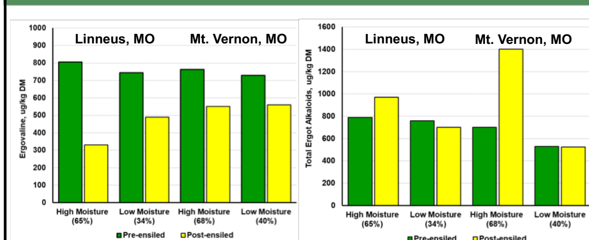
Coblentz and Muck, 2012

Buffering Capacities (mEq/kg DM) for Selected Forage Crops

Crop/Species	Range	Mean
Corn Silage	149-225	185
Timothy	188-342	265
Fall Oat (Headed)	300-349	323
Orchardgrass	247-424	335
Red Clover	. . .	350
Fall Oat (Boot)	360-371	366
Italian Ryegrass	265-589	366
Alfalfa (mid-bloom)	313-482	370
Perennial Ryegrass	257-558	380
Alfalfa (1/10 bloom)	367-508	438
Alfalfa	390-570	472
White Clover	. . .	512

compiled from various sources

Tall Fescue Toxicity



Caution: Tests for ergovaline were reduced in response to ensiling, but total ergot alkaloids were not.

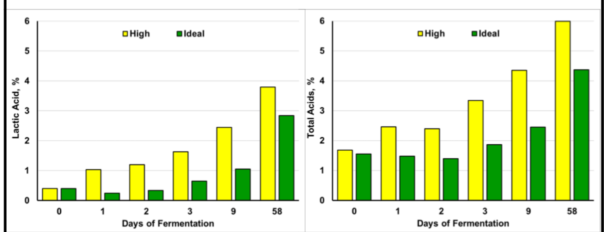
Roberts et al. (2014)

Moisture Management

Generally, baled silage should be packaged at 45 to 55% moisture (Shinners, 2003); the average for the whole field or group of bales should be about 50%.

- ***moisture recommendations for chopped silages are < 70%***
- ***production of silage fermentation acids is positively associated with moisture concentration***
- ***as a result, baled silage fermentation is inherently restricted, resulting in a slower fermentation, and a greater (less-acidic) final pH***

Fermentation Characteristics of Alfalfa Ensiled in Large-Round Bales at High (60 to 65%) or Ideal (49 to 54%) Moisture



Nicholson et al. (1991)

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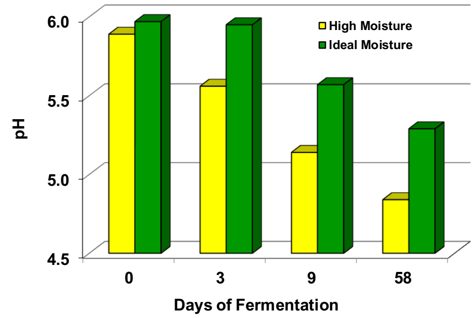
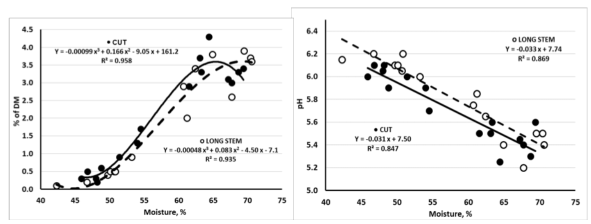


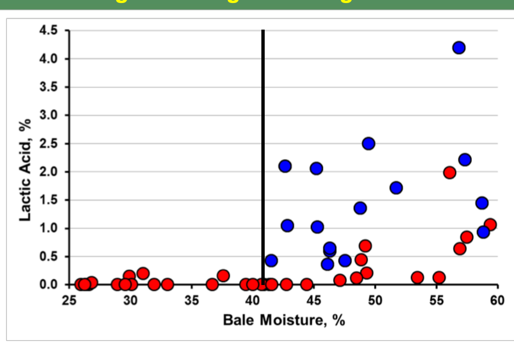
Nicholson et al. (1991)

Long-Stem vs. Cut Baled Alfalfa/Grass Silages (Again)



Coblentz and Akins, unpublished

Lactic Acid Production in Alfalfa Silages Packaged in Large-Rectangular Bales[1]



[1] Red and blue dots represent different harvests.

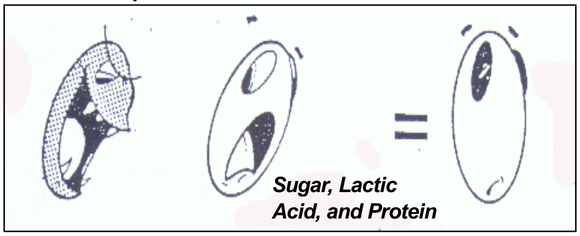
Coblentz et al. (2014)

So Why Not Bale Forage Wetter?

- ***Safety***
- ***Equipment/Baler***
- ***Clostridial Fermentations****

Clostridial Fermentations

Clostridial spores



Butyric Acid, Ammonia
"Bad, Evil-Smelling Silage"

Clostridial Fermentations
(Products: Butyric Acid, Ammonia)

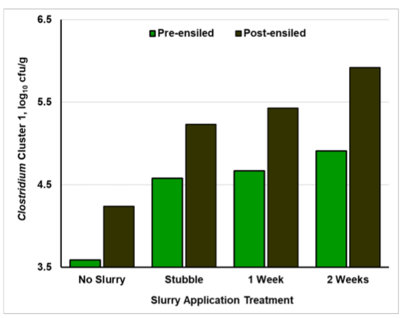
Some Characteristics of High-Risk Forages

- *high moisture concentration*
- *direct cut forages*
- *immature, rapidly growing forages*
- *highly contaminated with dirt, manure, or both*
- *low sugar*
- *high buffering capacity*
- *high protein*
- *leguminous*
- *non-homogenous forages (baled silage)*

The best prevention is to wilt the forage prior to ensiling! As such, baled silage is generally at low risk.

Clostridial Counts ($\log_{10}$ genomic copies/g) for Pre-Ensiled and Post-Ensiled Alfalfa Forages Following Applications of Dairy Slurry Using qPCR Methods[1]



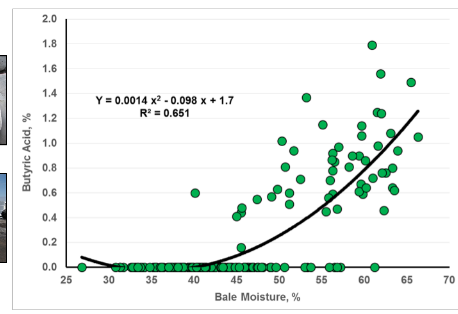


[1] *Clostridium tyrobutyricum* was not detected in dairy slurry or any forage/silage.

Coblentz et al. (2014)

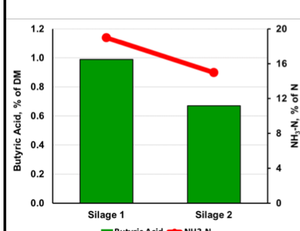
Butyric Acid in Alfalfa Round Bale Silage

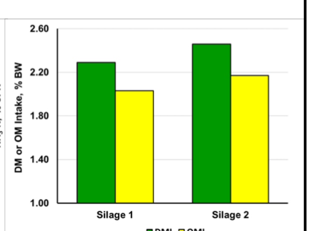




Coblentz et al. (2016)

Butyric Acid in Alfalfa Round Bale Silage and Voluntary Intake by Gestating Sheep

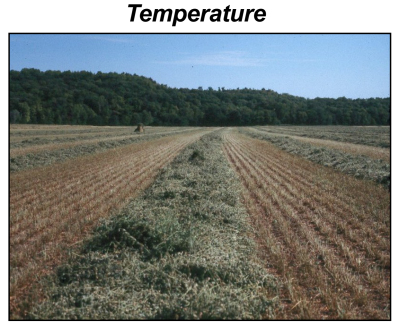


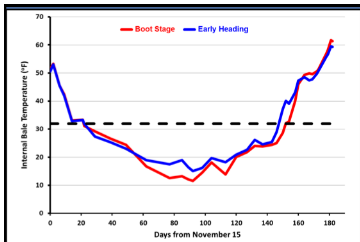


Adapted from Coblentz et al. (2016) and Niyigena et al. (2019)

Weather Factors

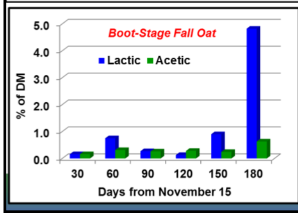
Temperature

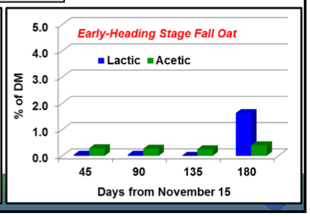




Effects of Cold Weather on Fermentation of Fall-Grown Oat

Coblentz et al. (2015)





Ethanol-Dominated Fermentation in Highly Sugared Forage Crops[1]

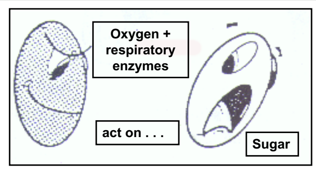
Treatment	Bale Moisture	WSC	Lactic Acid	Ethanol	pH	NDF	CP	TDN
		---------- % of DM ---------				----- % of DM ------		
Boot Stage								
Initial	67.6	22.6	. . .	. . .	6.90	40.3	13.7	71.4
Final	74.0	17.8	4.82	5.82	4.61	47.0	17.9	67.8
Early Heading Stage								
Initial	63.7	21.0	. . .	. . .	6.94	46.9	14.6	69.7
Final	67.3	11.9	1.63	4.85	5.71	55.0	16.0	60.9

[1] *'Vista' fall-grown oat.*

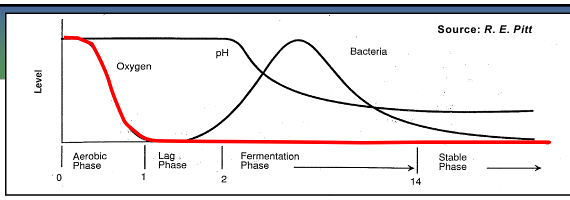
Coblentz et al. (2015)

Elimination of Air

Consequences of Air Access! (Mostly Before Sealing)



- *respiration of plant sugars to CO_2, water, and heat*
- *reduces pool of fermentable sugars*
- *dry matter loss*
- *increases (indirectly) fiber content of the silage*
- *decreases energy density of silage*



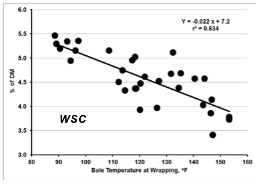
bulk density >10 lbs DM/ft³

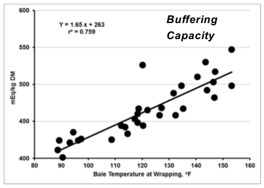
- *reduce ground speed*
- *thinner windrows will increase revolutions/bale*
- *manage moisture appropriately (≈ 50%)*
- **maintain constant bale size*
- *baler/operator experience*

Sealing the Bale

- *wrap as quickly as possible after baling (within 2 hours is ideal; minimal damage likely within 24 hours)*
- *use (at least) four layers (1 mil or 25 microns) of stretched plastic (at least 6 or 8 for long-term storage and/or in southern states)*
- *storage site selection/maintenance is important*
- *patch holes with appropriate tape*
- *do not puncture plastic - isolate from cattle, pets, and vermin*

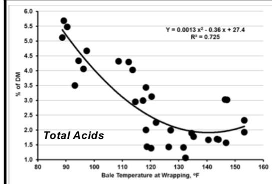
Fermentation Characteristics of Alfalfa Ensiled in Large-Round Bales as Affected by Wrapping Delays

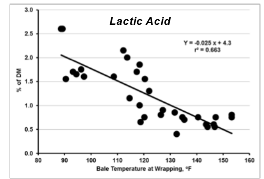


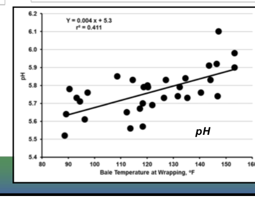


Coblentz et al. (2016)

Fermentation Characteristics of Alfalfa Ensiled in Large-Round Bales as Affected by Wrapping Delays

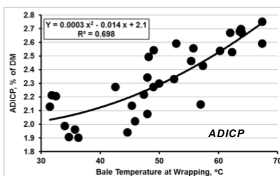


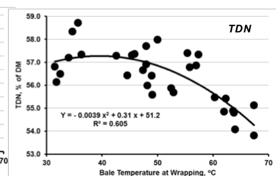




Coblentz et al. (2016)

Fermentation Characteristics of Alfalfa Ensiled in Large-Round Bales as Affected by Wrapping Delays





* While bales should be wrapped as soon as possible, this study suggests damage within the first 24 hours is relatively minor.

Coblentz et al. (2016)

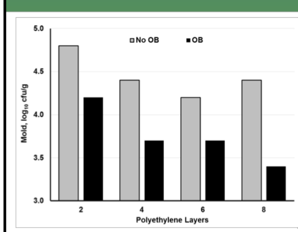
How Many Plastic Layers?

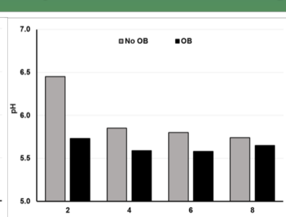
Plastic Layers	Bale Moisture	pH	Lactic Acid	Acetic Acid	Mold
#	%		------------	% of DM	------------
4	59.4	5.44	2.81	3.53	7.7
6	65.9	4.76	4.52	2.81	2.7
8	65.0	4.79	4.83	2.21	0

* Summary of 3 trials with alfalfa silages stored for 150 days.

Keller et al. (1998)

Effects of Wrapping Layers and an Oxygen-Limiting Barrier on the 30-mm Surface Layer of Alfalfa Baled Silage



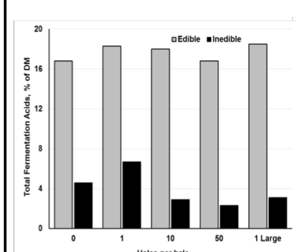


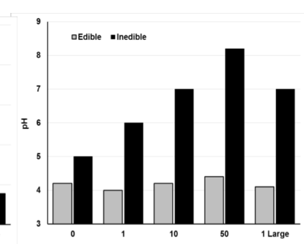
* Four plastic layers may be adequate for fermentation, but may not provide adequate security from birds, vermin, or internal puncture by rigid stems

** Differences between OB and non-OB plastics often have been limited to more desirable counts of yeasts and molds at the surface layer, rather than improved fermentation or nutritive value measured on a whole-bale basis.

Borreani and Tabacco (2008)

Effects of Simulated Bird Damage to Grass Baled Silages in Ireland[1]





[1] Bales were intentionally punctured with 0, 1, 10, or 50 small (3-mm) holes, or 1 large (24-mm) hole to simulate bird damage, and then stored for 155 d.

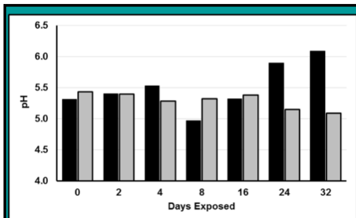
McNamara et al. (2002)

Aerobic Stability of Wheat and Orchardgrass Baled Silage During Winter

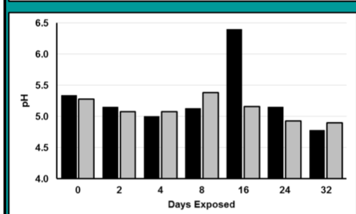
Rhein et al. (2005)

Wheat
- harvested at milk stage
- 37.6% moisture
- 11.1 lbs DM/ft^3

Orchardgrass
- harvested at heading stage
- 45.6% moisture
- 13.6 lbs DM/ft^3



■ Bale Surface
■ Bale Core



Summary

- *Forage crops differ; learn their characteristics.*
- *Most principles of management for conventional chopped silage still apply to baled silage.*
- *Moisture management is critical; generally, baled silage techniques will accommodate drier (<50%) forages better than relatively wet (>60%) ones.*
- *Fermentation occurs at a slower rate for baled silage because forages are:*
  - *ensiled on a whole-plant basis*
  - *usually drier and less dense than chopped silages*

Summary

- *As a result, producers should diligently address other management details:*
  - *maximize bale density (> 10 lbs DM/ft^3)*
  - *consider an inoculant (LAB) if forage is damaged, manure has been applied, or if bale moisture approaches 60% (alfalfa); grasses are a bit more forgiving*
  - *apply plastic wrap promptly and properly (damage is likely relatively minor up to 24 hours)*
  - *protect the product (4 plastic layers is the minimum, 6 or 8 are better)*
  - *stabilize your investment by excluding air (select a good storage site, check and repair holes)*

QUESTIONS?

Leading the world in integrated dairy forage systems research

U.S. Dairy Forage Research Center

www.ars.usda.gov/mwa/madison/dfrc