Silage: A Brief Overview

- Forage preservation by fermenting sugars into acid, which prevents spoilage
  - Plant sugars -> lactic acid ($1^\circ$), acetic acid ($2^\circ$), & other products
  - Must occur in anaerobic conditions to prevent spoilage by molds, yeasts, and bacteria.
  - Low pH reduces enzyme activity, inhibiting growth undesirable bacteria (e.g., clostridial bacteria)

- Ensiling started ~1500 B.C. (Egypt and Carthage)
Baled Silage

Wilting
2-5% loss

Baling
2-5% loss

Storage
4-15% loss

Feeding
Minimal loss

Can be more efficient...

Fewer Losses Accumulate With Each Step

End Result: 90% of Original DM
Quality Advantages

- Enables timely harvest
- Lowered risk of rain damage
- Less shatter loss
- Higher forage quality\(^1\)
  - Lower NDF, ADF, ADL
  - Higher CP
  - Increased digestibility
  - Increased palatability

However,
“Garbage in = Garbage out!”

\(^1\) Han, et al. 2005; Hancock and Collins, 2006.
Baled vs. Precision-Chopped Silage
Alfalfa/Grass

Muck (2006) – adapted from Nicholson et al. 1991; average moisture content of silages was 61%. *Slide credit: Dr. Wayne Coblentz, USDA-ARS*
Fermentation Characteristics  
Chopped Haylage vs. Baled Silage

Annual ryegrass silages harvested mid-April in southeast Louisiana (1993-94). Baled silage was 4 x 4 round bales

McCormick et al. (1998) Slide credit: Dr. Wayne Coblentz, USDA-ARS
1: Cut down no more than you can handle.

- Lay down an appropriate amount of forage for wilting, baling and wrapping.
  - Cut mid-afternoon on one day, bale & wrap the next day.

- Amount cut = how much can be baled and wrapped on same day.

- Bales should be wrapped w/in 12 hrs of baling.
### Effects of Delaying Wrapping on Internal Bale Temperature (63% M)

<table>
<thead>
<tr>
<th>Wrap Delay</th>
<th>At Wrapping</th>
<th>Day 1*</th>
<th>Day 2</th>
<th>Day 4</th>
<th>Day 6</th>
<th>Day 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>h</td>
<td>°F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No wrap</td>
<td>99</td>
<td>121</td>
<td>127</td>
<td>150</td>
<td>145</td>
<td>135</td>
</tr>
<tr>
<td>0</td>
<td>91</td>
<td>93</td>
<td>95</td>
<td>89</td>
<td>84</td>
<td>76</td>
</tr>
<tr>
<td>24</td>
<td>110</td>
<td>119</td>
<td>114</td>
<td>101</td>
<td>92</td>
<td>75</td>
</tr>
<tr>
<td>48</td>
<td>136</td>
<td>142</td>
<td>130</td>
<td>109</td>
<td>95</td>
<td>72</td>
</tr>
<tr>
<td>96</td>
<td>147</td>
<td>145</td>
<td>133</td>
<td>110</td>
<td>92</td>
<td>73</td>
</tr>
</tbody>
</table>

Vough et al. (2006): data adapted from Undersander et al. (2003); all square bales of alfalfa wrapped with eight mils of plastic film.

* Denotes days from wrapping.
2: Choose the right bale wrapper.

Consider:
Cost, Labor, Speed, Volume
Wrapper Costs

Wrapper Styles

• 3 point hitch ($8,000 - $22,000)

• individual ($14,000 - $26,000)

• in-line ($20,000 - $42,000)
Baled Silage Costs

Plastic Cost: $6.00 - $8.00/ton DM

Wrapper cost: $2.00 - $5.00/ton DM

Fuel & Repairs: $0.50 - $5.00/ton DM

Labor: $0.75 - $2.00/ton DM
## The Unseen Cost of Hay Storage

<table>
<thead>
<tr>
<th>Expected Losses</th>
<th>Cost of Production ($/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$80</td>
</tr>
<tr>
<td>Hay, no cover/on ground</td>
<td>50%</td>
</tr>
<tr>
<td>Hay, under roof</td>
<td>25%</td>
</tr>
<tr>
<td>Baleage</td>
<td>15%</td>
</tr>
</tbody>
</table>

*Value of Losses in the System ($/ton)*
Probability of Savings from either Bermuda Grass or Winter Annual Baleage for Varying Qualities of Hay

- **Bermuda Grass Baleage**
- **Winter Annual Baleage**

Quality of Hay:
- Good Hay
- Avg. Hay
- Poor Hay
Summary of Economic Analysis

- Baleage technology has economic merit for medium-sized producers
  - Ex: Breakeven beef cow-calf herd size is approximately 100 cows to justify owning the equipment
- Combined reduction in feeding and storage losses helps make it economically feasible, but not enough
- Baleage becomes more economical with higher-quality forages such as:
  - Winter annuals, alfalfa, clovers/other legumes mixed with grass, high quality summer annuals
- VERY difficult to justify baleage only considering bermudagrass, bahiagrass, or lower-quality forages.
3: Explore your options.

Own for Own Use

Own & Custom on the Side

Custom Hire
4. Bale at the right range of moisture

**Ideal Range, 50-65% Moisture**

- Toxic Potential (Clostridial, Listeriosis)
- 70% Moisture
- 40% Moisture
- Poor Fermentation
Effects of Moisture Content on Silage pH

Hancock and Collins (2006): combined data from two trials; alfalfa harvested at mid-bud stage of maturity
Effects of Moisture Content on Lactic Acid

Hancock and Collins (2006): combined data from two trials; alfalfa harvested at mid-bud stage of maturity
**Effects of Moisture Content and Rain-Damage on Fermentation**

Borreani and Tabacco (2006)

*Slide credit: Dr. Wayne Coblentz, USDA-ARS*
Hancock and Collins (2006): combined data from two trials; alfalfa harvested at mid-bud stage of maturity; estimate for hay is mean of bales made at 16.6 and 19.8% moisture, and stored outdoors, uncovered.
Determining Moisture

Methods:
4. Hay Moisture Testers/Probes
3. By feel (if calibrated).
2. Microwave moisture test

MEASURING THE MOISTURE CONTENT OF FORAGE USING A MICROWAVE OVEN

1. Chop fresh forage into short lengths (< 1 inch) for ease of handling and uniform drying.
2. Weigh out at least 100 grams (3.5 ounces) of chopped forage.
3. Spread forage thinly on a microwave-safe dish and place into microwave. (A cup of water placed in the microwave beside the sample will help prevent the sample from igniting once dry.)
4. Heat for 1-2 minutes and reweigh.
   - If forage is not completely dry, shake and redistribute the sample, and repeat the heating cycle until the sample reaches a stable weight. (Microwaves vary considerably in drying capacity. It is better to dry for short intervals and reweigh until the last two weights are constant, than to overdry and run the risk of burning and damage to oven.) If charring occurs, use the previous weight.
5. Calculate moisture content using the following equation:

\[
\% \text{ Moisture Content} = \frac{W1 - W2}{W1}
\]

Where:  
W1 = weight of forage before heating  
W2 = weights of forage after heating

Dry matter (DM) is the percentage of forage that is not water. DM equals 100% minus the % Moisture Content.


Adapted from: Southern Forages 4th Edition, Page 303
Determining Moisture

Methods:
1. Moisture tester (e.g., Koster)
2. Microwave moisture test
3. By feel (if calibrated).
4. Hay Moisture Testers/Probes
5. Make good bales

- Maximize bale size
  - match to tractor
  - dense bales
  - 4’x 5’ bale is most popular
    - 11-1500 lbs, depending on % M
  - square edges

- Use plastic twine or net
  - sisal twine degrades plastic
### Effects of Bale Density on Fermentation

<table>
<thead>
<tr>
<th></th>
<th>Moisture 58.7%</th>
<th>Moisture 52.4%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density, lbs/ft³</strong></td>
<td>12.9</td>
<td>12.4</td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>4.7</td>
<td>4.8</td>
</tr>
<tr>
<td><strong>lactic acid, %</strong></td>
<td>7.0</td>
<td>7.1</td>
</tr>
<tr>
<td><strong>acetic acid, %</strong></td>
<td>2.4</td>
<td>3.3</td>
</tr>
<tr>
<td><strong>max temp, °F</strong></td>
<td>107</td>
<td>108</td>
</tr>
<tr>
<td><strong>DM REC, %</strong></td>
<td>98.6</td>
<td>97.8</td>
</tr>
</tbody>
</table>

Han et al. (2004): high density bales created at 842 x 10³ Pa of chamber pressure; lower density bales made at 421 x 10³ Pa.
6. Choose an appropriate site for wrapping

- Where feed out is easy
- Good sod and no stobs

- Wrap at the storage site
  - reduces handling
  - reduces risk of spoilage
7. Apply enough plastic but no more.

The plastic is not impermeable to oxygen. Each layer has a permeability of \( \sim 10,000 \text{ 100\% } O_2 \text{ cm}^3/\text{m}^2/24 \text{ h}. \)
Application Amount – Inline Wrapper

- Eight+ layers (+ double on joints)
  - 12.5 - 16.7% overlap
  - two rolls rotating around bales
- Pre-stretched to 50-70%
- Tacky side towards the bale
- 60-80+ bales per hour
Application Amount - Ind. Wrapper

- Six+ layers (2 + 2 + 2 system)
  - 50% overlap
  - Three full bale rotations
  - If short term, 4-layers may be ok
- 15-40 bales per hour
Alfalfa silage & hay
2, 4, or 6 layers of film

<table>
<thead>
<tr>
<th>Storage Treatment</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 layers</td>
<td>53%</td>
</tr>
<tr>
<td>4 layers</td>
<td>84%</td>
</tr>
<tr>
<td>6 layers</td>
<td>88%</td>
</tr>
<tr>
<td>Hay</td>
<td>44%</td>
</tr>
</tbody>
</table>

Hancock and Collins (2006): one trial; alfalfa harvested at mid-bud stage of maturity
8. Feed it in an appropriate way.

- Match quality to animals needing that quality
- Use a ring (or cone) feeder
- OK for mixed rations
  - Bale grinder
  - May need to be sliced
9. Feed the bales within 9 months.

- Bales will squat and be difficult to handle.
- Plastic will deteriorate over time.
- Bales will begin to spoil.
Surface pH after Exposure

Adapted from Rhein et al. (2005)
10. Have a plan for handling the plastic.

- Recycling is not currently an option
- Reduce the bulk to aid in handling
Baled Silage: Frequently Asked Questions
Dr. Dennis Hancock, Forage Extension Specialist

Some Points on Feeding Baled Silage
Dennis W. Hancock, Extension Forage Specialist, The University of Georgia

Silage makes an excellent feed for ruminant animals. However, feeding silage is much different than feeding hay. Silage, because it is much wetter than hay, is much more susceptible to deterioration. Sealed from oxygen during storage, the forage undergoes fermentation. However, when it is once again exposed to air when

Baling Forage Crops for Silage
Jimmy C. Henning, Michael Collins, David Ditsch, and Garry D. Lacefield
Species Differences: Fermentation Characteristics

Han et al. (2006): mean of ideal (48.8%) and low (29.5%) moisture bales
Species Differences: Effects on pH

Han et al. (2006): mean of ideal (48.8%) and low (29.5%) moisture bales