Silage

- More energy per acre than hay
- Flexible harvest schedule
- Lower harvest losses
- Totally mechanized handling
- Less dependent on weather

but....

- Higher capital investment
- Must be fed soon after taken from storage
- No ready off-farm market
- Bulky to store; costly to transport
Key Factors

• Quality at time of harvest
  – Silage only preserves -- does not really enhance forage quality
• Suitability of forage for ensiling
• Harvest and preservation techniques
• Storage methods
Forage Moisture Affects Dry Matter Harvest & Storage Losses

Source: Hoglund (1984)
Forage Moisture Testing

Heater/fan dryer (Koster® unit) $365

Electrical conductance moisture meter $426

Microwave $50 - $100

Reference: Determining Forage Moisture Concentration
http://pubs.ext.vt.edu/442/442-106/442-106.html

Prices as of December 2014

Photo Credit:
www.enasco.com/product/C16283N

Photo Credit:
www.enasco.com/product/C08633N

Photo Credit:
www.agry.purdue.edu/ext/forages/publications/ID-172.htm
Three Basic Rules of Good Silage

- Chop short
- Fill quickly
- Exclude air
Phases of the Fermentation Process

Source: Adapted from Pitt and Shaver, University of Wisconsin, 1990.
Losses in Dry Matter in Making Silage

- Respiration = 1-3%
- Fermentation losses = 5-10%
- Seepage losses = 5-7% common
- Surface losses = 2-4% with plastic cover
- Air pockets
- Weathering of surfaces after opening
  - More of a problem on large bunker silos
Losses in Making Silage

• Heat damage
  – Temperature should not exceed 100°F
  – Low-moisture silage (haylage)
  – Maillard product formation or tobacco-brown silages (caramelization)
  – Protein digestibility decreases

• Cold fermentation, <75°F
  – 75-80% M.C. silages (direct-cut legumes)
  – High butyric acid formation common
Factors Influencing Silage Process and Quality

• Storage conditions
  – Silo construction
  – Rate of filling
  – Compaction and density
  – Sealing method
  – Oxygen access
  – Temperature and insulation
  – Mechanical treatment
3 Major Controllable Factors That Affect Silage Quality

- Moisture
- Carbohydrate level
- Oxygen exclusion
3 Major Controllable Factors That Affect Silage Quality

- **Moisture** – probably the most important
  - 50-72% ideal – storage facility dependent
  - Too wet causes
    - Seepage
    - Undesirable clostridial activity and high butyric acid
    - High fermentation losses
    - Intake and animal performance losses
  - Too dry
    - Problems eliminating air
    - Problems achieving sufficiently-low pH
    - Aerobic deterioration high
Harvest Moisture Content Depends on Silo Type

- Conventional tower silos = 63–68% M.C.
- Limited-oxygen silos = 55-60% M.C.
- Horizontal silos = 65–70% M.C.
- Silage bales = 50-60% M.C.
- Silo bags = 65% M.C.
D.M. Losses Based on Moisture Content

Source: USDA
D.M. Losses Based on Silo Type

Source: USDA
Control Moisture in Silage by....

• Maturity, recommended
  – Corn – fully dented (65% M.C.)
  – Alfalfa – recommended stage for each harvest for prime hay
  – Perennial grasses – late boot to early heading
  – Sorghum – soft-dough kernels
  – Small grains – boot (high energy & protein/lb.); soft-dough (max. yield digestible nutrient/acre)

• Dry matter additions

• Adding water (1% M.C. change = 20 lbs. water/ton)

• Wilting to desired moisture

3 Major Controllable Factors That Affect Silage Quality

• Carbohydrate level
  – Ideal crop
    • Adequate fermentable CHO
    • Low buffering capacity
    • Physical structure suitable for compacting
    • Several-day harvest period
  – Controlled by
    • Crop maturity
    • CHO additions
    • Crop selection
  – Most crops adequate
Best Forage Cutting Stage

- Tall fescue / Native WSG = boot
- Orchardgrass = blooms emerged
- Bermudagrass = every 28 days
- Caucasian bluestem = late boot
- Red clover = 1/4 to 1/2 bloom
- Alfalfa = 1/10 bloom, then every 28 days
- Lespedeza = 30% bloom
- Cereal crops = boot to milk
3 Major Controllable Factors That Affect Silage Quality

- **Oxygen exclusion**
  - Chopping length = ¼” to ½” ideal
  - Filling rate, packing and sealing
  - Storage structure = 10-25%
Tower Silo

- Silage can be 55 to 65% M.C.
- Silage packs due to weight from top
- Various sizes available (50-4000 tons)
- Minimal exposure to weather
- Lower storage losses compared to bunkers or bags
Tower Silo Safety

• Silo fires
  – Many occur in the top 10 feet of dry, loosely packed silage
  – *Contact your local fire department immediately*

• Silo gases
  – Carbon dioxide (CO₂) and nitrogen dioxide (NO₂)
  – Signs of gas
    • Faint yellow or red haze that appears from the top of a conventional silo to the bottom of the ladder chute
    • Staining on the silo and silage
    • Bleach-like odor that may be present at the base of the silo
  – Avoid 3 days; ventilate 2-3 weeks
Bunker, Trench or Pile Silo

- Sizing is very flexible
- Silage can be of higher moisture than tower silo
- Requires more labor to pack down
- Requires plastic and tires to cover
- Increased exposure to weather
- Higher storage losses compared to tower silo
- System needs 3 people
  - 1 person to harvest
  - 1 person to transport
  - 1 person to pack the forage
### Horizontal Silo Capacity

**Table 8-3. Horizontal silo capacity, wet tons.**

65% moisture; 40 lb/ft³ or 50 ft³ = 1 ton; 1.25 ft³/bu. Silo assumed level full. Capacities rounded to nearest 5 tons. To calculate capacity of other silo sizes: (silage depth, ft × silo width, ft × silo length, ft) ÷ 50.

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
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<td>130</td>
<td>160</td>
<td>190</td>
<td>225</td>
<td>255</td>
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<td>18</td>
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<td>110</td>
<td>145</td>
<td>180</td>
<td>215</td>
<td>250</td>
<td>290</td>
<td>325</td>
<td>360</td>
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<tr>
<td>20</td>
<td>80</td>
<td>120</td>
<td>160</td>
<td>200</td>
<td>240</td>
<td>280</td>
<td>320</td>
<td>360</td>
<td>400</td>
</tr>
</tbody>
</table>

Reference: MWPS-6 Beef Housing and Equipment Handbook
# Horizontal Silo Capacity

## Table 8-4. Horizontal silo capacity, dry matter.
Silo assumed level full. Capacities rounded to nearest 5 tons.

<table>
<thead>
<tr>
<th>Depth ft</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tons dry matter/10’ length</td>
<td></td>
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<td></td>
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<td>85</td>
<td>100</td>
<td>110</td>
<td>125</td>
<td>140</td>
</tr>
</tbody>
</table>

Reference: MWPS-6 Beef Housing and Equipment Handbook
Calculating Silo Size

Assume 120 cows are fed 24 lbs. DM/day of 60% M.C. corn silage

1. Amount DM/day fed = 24 lbs. DM/cow x 120 cows
   = 2880 lbs./day

2. Volume removed/day = 2880 lbs/day ÷ 16 lbs./ft³ \((\text{Table 1})\)
   = 180 ft³/day

3. Select initial wall height = 10 ft.

4. Settled depth = Wall height x 0.85 = 10 ft. x 0.85 = 8.5 ft.

5. Select face removal rate (let’s use 8” or 0.67’ for corn silage)
   - 6” minimum per day for corn silage
   - 8” minimum per day for haylage
# Silage Density

## Table 1. Dry matter density based on wet bulk density and moisture content.

<table>
<thead>
<tr>
<th>Wet Bulk Density</th>
<th>Moisture Content, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td>lb/ft³</td>
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<tr>
<td>20</td>
<td>9.0</td>
</tr>
<tr>
<td>25</td>
<td>11.3</td>
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<td>30</td>
<td>13.5</td>
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<tr>
<td>40</td>
<td>18.0</td>
</tr>
<tr>
<td>45</td>
<td>20.3</td>
</tr>
<tr>
<td>50</td>
<td>22.5</td>
</tr>
</tbody>
</table>

Note: Typical range of silage dry matter densities are:
- alfalfa: 12.3-14.0 lb/ft³,
- corn: 14.0-17.3 lb/ft³ and
- sorghum: 13.0-16.5 lb/ft³.

Reference: BAE-1011 Bunker Silo Sizing and Management, Oklahoma State University
Calculating Silo Size

6. Bunker width = \frac{180 \text{ ft}^3/\text{day}}{0.67 \text{ ft./day} \times 8.5 \text{ ft.}} = 31.6 \text{ ft.} = \text{Use 32 ft.}

- 16 ft. minimum width needed to facilitate packing
- 30+ ft. bottom width will increase labor efficiency

7. Bunker length = 0.67 \text{ ft./day} \times 360 \text{ days}
   = \text{One @ 240 ft. long}
   = \text{Two @ 120 ft. long}
   = \text{Three @ 80 ft. long}

8. Silo capacity in tons (wet basis)
   = \frac{32 \text{ ft.} \times 10 \text{ ft.} \times 240 \text{ ft.} \times 40 \text{ lbs./ft}^3 \text{ (Table 1)}}{2000 \text{ lbs./ton}}
   = 1306 \text{ tons (w.b.)}
Bunker Silo Arrangement

Reference: BAE-1011 Bunker Silo Sizing and Management, Oklahoma State University
Constructing a Bunker or Trench Silo

Reference: MWPS35 Farm and Home Concrete Handbook
Constructing a Bunker or Trench Silo

• Pick site with good drainage  
  – Slope site 2%+ away from silo
• Slope bunker or trench walls outward 1.5” per foot of depth (1:8 slope)
• Slope floor at least 1/8” per ft. toward center and toward open end(s)
• Use 4500 psi concrete with 6% air entrainment
• Place 5” thick concrete floor over 4-mil poly film
• Thicken 10+ ft. apron floor entrance to 8” for strength
Constructing a Bunker or Trench Silo
Bunker, Trench or Pile Silo Management

• Inspect and patch cracks in walls to block air movement

Before

After

• Spread and pack no more than 6” layers at a time
Filling Methods - Bunker and Trench Silo

A. Full-length layers.

B. Progressive wedge.
Bunker, Trench or Pile Silo Management

- Pack with progression wedge on 3:1 maximum slope
- Wheel tractors pack better than track-type tractors
Bunker, Trench or Pile Silo Management

- Achieve a high packing density (min. 12-14 lbs. of D.M./cu.ft.) within the top 3 feet of the silage surface
  - Pack 1-4 minutes/ton

- Make 2X passes against silo walls
Bunker, Trench or Pile Silo Management

• Back, front and sides should not exceed a 3:1 slope
• All surfaces should be smooth, so water drains off ... not in!
• Seal immediately after filling is complete
  – Two 6-mil sheets of plastic are preferred over a single sheet
  – A sheet of Silostop® under a sheet of 6-mil plastic is preferred over two sheets of plastic
  – Overlap the sheets by at least 4-6 feet
  – Sheets should reach at least 4-6 feet off the forage surface around the entire perimeter of drive-over piles
Bunker, Trench or Pile Silo Management

• Hold down plastic with tire sidewalls, with tires touching
• Put uniform weight on the sheets over the entire surface and double the weight on the overlaps
• Mow areas surrounding a bunker or pile and put up temporary fencing
• Regularly inspection and repair holes in cover
• Contain silo runoff to your property
Bunker, Trench or Pile Silo Management

• Don’t expose more than 3 days of feed as you uncover it
• Dispose of spoiled silage rather than feeding it
• Don’t remove any more silage than you’ll feed in one feeding
Bunker, Trench or Pile Silo Hazards

- Fall from height
- Run-over by machinery
- Tractor roll-over
- Entangled in machinery
- Crushed by an avalanche
- Complacency

“We have nothing to lose by practicing safety; but we have everything to lose by not practicing it.”

-- Dennis Murphy, Extension Safety Specialist
Penn State University
Bunker, Trench or Pile Silo Safety

• Use rails on walls for worker sight and fall protection
• Use ROPS and seat belt on tractors

Photo credit: Penn State University
Photo credit: Keith Bolsen, KSU
Photo credit: University of Wisconsin
Bunker, Trench or Pile Silo Safety

- Keep more tractor weight on upslope end
- Don’t overfill
  - Mound silage above walls no more than 1/6th the width
Bunker, Trench or Pile Silo Safety

• Don’t undercut at feedout

• Walk 2-3 ft. away from face for each 1 ft. of height
Silage Bags

- Normal size: 150-200 ft. long by 9 ft. diameter
- Minimal amount of labor required
- May wear out tractor more quickly
- Spoilage due to weather or rodents
- Easy to regulate silage removal
- Takes up lots of space

Bag Capacity Per Running Foot

<table>
<thead>
<tr>
<th>Bag Size</th>
<th>Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>8'</td>
<td>1</td>
</tr>
<tr>
<td>9'</td>
<td>1-1/4</td>
</tr>
<tr>
<td>10'</td>
<td>1-1/2</td>
</tr>
<tr>
<td>11'</td>
<td>1-3/4</td>
</tr>
<tr>
<td>12'</td>
<td>2-1/4</td>
</tr>
</tbody>
</table>

Photo credit: Penn State University

Photo credit: University of Wisconsin
Filling Silage Bags
Silage Bag Site Prep & Management

• Place bags in accessible area for easy feed removal
• Place bags on a well-drained, hard, level surface
• Place bags side-by-side for blending of feeds
• Number and date bags for ease of testing and material ID
• Protect the storage area from livestock
• Don’t allow dogs, cats and other animals to get on the bags
• Inspect bags regularly and patch holes or damage to the bags ASAP
• Remove >1 ft. of feed per day from face of the bag to prevent aerobic instability and heating problems
Proper Bag Feed Out Technique for Large Operations

1. Cut the bag open down the top-center of the bag and lay it out flat on the ground. To prevent the plastic from hanging up in the loader bucket, drive the front wheels onto the plastic.

2. Tip the top of the pile. This will loosen it up. Lower the loader bucket 1 inch above the plastic.
Proper Bag Feed Out Technique for Large Operations

3. Skim doze directly from the front.

4. Lift the plastic edges and shake product back to the center of the bag.
# Suggested Daily Feed Out Rates

## Winter Rates - October - April

<table>
<thead>
<tr>
<th>Bag Size</th>
<th>Feet/Day</th>
<th>Tons/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>8'</td>
<td>1'</td>
<td>1</td>
</tr>
<tr>
<td>9'</td>
<td>1'</td>
<td>1-1/4</td>
</tr>
<tr>
<td>10'</td>
<td>2'</td>
<td>3</td>
</tr>
<tr>
<td>11'</td>
<td>2-1/4'</td>
<td>4</td>
</tr>
<tr>
<td>12'</td>
<td>2-1/2'</td>
<td>5-1/2</td>
</tr>
</tbody>
</table>

## Summer Rates - May - September

<table>
<thead>
<tr>
<th>Bag Size</th>
<th>Feet/Day</th>
<th>Tons/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>8'</td>
<td>2'</td>
<td>2</td>
</tr>
<tr>
<td>9'</td>
<td>2-1/4'</td>
<td>2-3/4</td>
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<tr>
<td>10'</td>
<td>2-1/2'</td>
<td>4</td>
</tr>
<tr>
<td>11'</td>
<td>2-3/4'</td>
<td>5</td>
</tr>
<tr>
<td>12'</td>
<td>3'</td>
<td>6-1/2</td>
</tr>
</tbody>
</table>
Annual cost of storage of 384 tons D.M.

Source: “Choosing Forage Storage Facilities”, B.J. Holmes, Univ. of Wisconsin
**Annual cost of storage of 3,072 tons D.M.**

![Bar chart showing annual cost of storage for different structures.](chart)

Source: “Choosing Forage Storage Facilities”, B.J. Holmes, Univ. of Wisconsin
Big Baleage

- Lower initial cost than a conventional silage system
- Lower harvest losses than hay
- Easier to market than conventional silage
- Flexible harvest options
Making Good Baleage

• Wilt forage to 50 to 60% moisture
  – Upper end for grasses
  – Lower end for legumes
• Make bales as dense as possible
  – Longer fiber slows fermentation
• Wrap as quickly as possible
  – Within 5 hours of baling

KEEP THE OXYGEN OUT!
Baleage - Storage

• Store in a well-drained site
• Store bales where animals won't damage them
• Weeds encourage rodents
• Storing on the flat side prevents squatting
• Patch holes promptly
Other Baleage Tips

- Do not use treated sisal twine. The treatment breaks down the plastic.
- Inoculants may help if the moisture isn’t right – speeds up lactic acid formation.
- Don’t wrap in the rain.
- Bales should be fed within one year of wrapping.
- Wrapping area and storage areas should be close.
Questions??

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Natural Resource Engineering Specialist
Webster County Extension Center
800 S. Marshall St.
Marshfield, MO 65706
Voice: 417-859-2044
Fax: 417-468-2086
E-mail: schultheisr@missouri.edu
Web: extension.missouri.edu/webster

Program Complaint Information
To file a program complaint you may contact any of the following:

University of Missouri
- MU Extension AA/EEO Office
  109 F. Whitten Hall, Columbia, MO 65211
- MU Human Resources Office
  130 Heinkel Bldg, Columbia, MO 65211

USDA
- Office of Civil Rights, Director
  Room 326-W, Whitten Building
  14th and Independence Ave., SW
  Washington, DC 20250-9410

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