Determining Silage Density

World Dairy Expo
October 1, 2008

Brian J. Holmes, Ph.D.
Professor and
Extension Agricultural Engineer
Biological Systems Engineering Dept.
Univ. of Wisconsin - Madison
Why Know Silage Density?

1. Inventory feed supplies
   How long feed will last
   Estimate yields
   How much is sold/bought

2. Dry matter loss is related

3. Storage capacity is related
Silage Density Coring Method

Procedure:
1. Core sample at face to depth of 12 inches (0.305 m) at multiple sites
2. Weigh samples
3. Dry Samples
4. Weigh dry samples
5. Calculate core density and average
Suggested Coring Locations

Maximum Height (ft)

Wall Height (ft)
Silage Face Coring Method

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Accurate at point</td>
<td>1. Dangerous</td>
</tr>
<tr>
<td></td>
<td>2. Site specific</td>
</tr>
<tr>
<td></td>
<td>Height Walls</td>
</tr>
<tr>
<td></td>
<td>Fissures</td>
</tr>
<tr>
<td></td>
<td>3. Requires special tools</td>
</tr>
<tr>
<td></td>
<td>4. Time consuming</td>
</tr>
<tr>
<td></td>
<td>5. Many cores required</td>
</tr>
<tr>
<td></td>
<td>6. After filling/removal</td>
</tr>
</tbody>
</table>
Silage Density Calculator Method
Adjusted Density in Relation to the Packing Factor

Adjusted Density, kg/cu. m

Packing Factor

Lbs/cu ft

0 135 269 404 539 673 808 942 1077 (English Units)

0 1000 2000 3000 4000 5000 6000 7000

XY (Scatter) 1

Single

Dual Rear

All Duals

6.2

12.5

18.7

24.9

31.2

Adjusted Density in Relation to the Packing Factor

Adjusted Density in Relation to the Packing Factor

Adjusted Density in Relation to the Packing Factor
Combined Packing Factor

• Looked at various combinations of factors to find the best explanation of variability in density

\[ PF = \frac{W}{L} \sqrt{T \cdot D} \]

\( W = \text{Avg. Tractor Weight (lbs or Kg)} \)
\( L = \text{Initial Layer Thickness (inches or cm)} \)
\( T = \text{Packing Time, Tractor Hours/Tonne or Ton As Fed} \)
\( D = \text{Dry Matter Content (decimal)} \)
Predicted Average Silo Densities

• Using the packing factor (P) and silage height (H), predicted silo density is:
  \[ \rho = (136.3 - 0.042P) \cdot (0.818 + 0.0446H) \] Metric
  \[ \rho = (8.5 - 0.016P) \cdot (0.818 + 0.0136H) \] English

• Spreadsheet available at: http://www.uwex.edu/ces/crops/uwforage/storage.htm
Silage Density Calculator Method

Procedure:
1. Establish packing procedure:
   - Tractor weight(s)
   - Number Tractors
   - Percent packing time
   - Layer thickness
   - Harvest rate
   - Dry matter content
   - Wall height
   - Peak height
2. Calculate average density with spreadsheet
## Silage Density Calculator Method

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Average Density</td>
<td>1. Not site specific</td>
</tr>
<tr>
<td>2. What If? before filling</td>
<td>2. Requires filling procedures</td>
</tr>
<tr>
<td>3. Time efficient</td>
<td>3. Not consistently accurate</td>
</tr>
<tr>
<td>4. Any time</td>
<td></td>
</tr>
<tr>
<td>5. Safe</td>
<td></td>
</tr>
</tbody>
</table>
Est Density VS Measured Density

2004 Dauphin Co. Study

- Pennsylvania Results
- Y = X

- Overestimate
- Underestimate

Est. Density (lbs/cu ft)

Measured Density (lbs/cu ft)
Silage Density Feed Out Method
Average Density

Volume Removed = $R \times W \times (PH + WH) / 2$

Av. Density = Weight Removed / Volume Removed
Figure 10. Marks painted on the sidewall to aid in determining feeding rates and remaining capacity.
Silage Density Feed Out Method

Procedure:
1. Mark location of feed out face day #1
2. Feed out for several days and weigh feed into each load
3. Measure distance face moves
4. Measure face dimensions (wall height, peak height, average width, etc.)
5. Calculate volume removed
6. Sum weights removed
7. Divide weight removed by volume removed to get average AF density
8. For DM density, moisture sampling is needed
Example Average Density

Volume Removed = 12’*40’*(15’+10’)/2 = 6,000 cu ft

Av. Density = 90,000 lb DM/6,000 cu ft = 15 lbs DM/cu ft
<table>
<thead>
<tr>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Average Density</td>
<td>1. Not site specific</td>
</tr>
<tr>
<td>2. Safe</td>
<td>2. TMR scales</td>
</tr>
<tr>
<td>3. TMR scales</td>
<td>3. During Feedout</td>
</tr>
<tr>
<td></td>
<td>4. Feeder commitment</td>
</tr>
<tr>
<td></td>
<td>5. Start/End w smooth &amp;</td>
</tr>
<tr>
<td></td>
<td>vertical face</td>
</tr>
</tbody>
</table>
Comparing three different methods for assessing corn silage density.


University of Idaho
Eighteen storages were studied.

Three core samples were collected twice.

Core samples were collected at mid height at the center, left, and right of the silage face.

Inputs for the Silage Density Calculator were obtained.
Methods

Silage face measurements and face location were obtained during three farm visits (10 to 14 day intervals).

Area calculated using digital image.

Silage weight removed was the sum of weight specified for each load on the load sheet for one day.

Density was calculated by dividing the weight of silage fed by the volume of silage removed during the interval between farm visits.
Results

• Variation in density between storages was significantly higher for Feedout method than core sampling or calculator methods (p<0.001).

• Core density measurements were highly correlated with Calculator estimates (r = 0.71, p<0.001) but not with Feedout density estimates (r = -0.06, p<0.82).
Results

• Feedout method did not perform satisfactorily due to non-uniform silage faces and the inherent challenges in measuring volume of silage fed at the farm level.

• Feedout method may provide more reliable estimates on operations utilizing silage facers (more uniform face).

• It is challenging to obtain reliable inputs for the calculator method at the farm level.
Conclusions

• Core sampling and calculator methods provide reasonably similar estimates of silage density.

• Collecting duplicate samples is needed to accurately assess core sample density.

• Feedout method was a poor predictor of silage density and is not recommended.
Conclusions

Taking care to keep a vertical uniform face and weigh all loads with TMR scales will improve accuracy significantly.

-- BJH
Conclusions

• Core sampling is recommended for directly assessing silage density and the calculator method is recommended for evaluating alternative management strategies during the filling and packing process.
Run Silage Stored Density Spreadsheet?

YES

NO
QUESTIONS?