Corn silage, fermentation time, and starch digestibility – what makes it tick

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The Wacky World of Starch Digestibility in Dairy Cows

It’s these hybrids
Process it properly
Plant a floury corn
Hybrid doesn’t matter for HMC
Ferment HMC 6 months before feeding
Kernels in fall manure
We need ruminal starch
Low prolamin corn is the key
Gas production fermametrics
Resistant starch
Maturity and processing are the key
4 mm in vitro starch
Fecal starch

Hybrid has no effect on starch
What does properly mean
Fine grind vitreous corn
but HMC feeds better in spring…
Who’s paying for the extra storage
Spring corn acidosis
and starch kd of a two pool model
Greater starch yield is the key
Cow relevant starch
Retrograde starch
Starch hydrolysis potential
Can’t adjust to on farm MPS
Lab methods are wrong
The World of Starch Digestibility in Dairy Cows

Corn Chemistry and Morphology
Corn is a Seed

Vitreous Endosperm

Floury Endosperm

Germ
The Starch-Protein Matrix

Vitreous Endosperm

Floury Endosperm

Scanning electron microscopy of starch granules in corn: A) starch granules heavily imbedded in prolamin-protein matrix, B) starch granules in opaque corn endosperm with less extensive encapsulation by prolamin-proteins (Gibbon et. al., 2003).

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The Starch-Protein Matrix

- Prolamin Zein (4 Types) – αβγδ
- Form on the Starch Granule Surface
- Prolamin Proteins Can Cross-link
- Encapsulate Starch into a Matrix

- Degraded Via Fermentation
Increased Vitreousness Decreases Starch Degradability

Particle digestion resistance (PDR)

(Crude (% of DM) or zein (mg/endosperm)) protein

CP, % of DM  Zein, mg/endosperm

N fertility, kg N/ha

(Tsai et al., 1980)
Starch Digestibility-Corn Silage
Maturity & Kernel Processing
Kernel Processing
## Digestibility Responses to Kernel Processing

### Total Tract % units for Processed minus control

<table>
<thead>
<tr>
<th>Trial</th>
<th>DMD</th>
<th>StarchD</th>
<th>NDFD</th>
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Corn Silage Starch Digestibility Fermentation
Ruminal in situ starch degradability of corn silage over time in storage
Newbold et al., JDS, 2006 abstr.

<table>
<thead>
<tr>
<th>Months in Silo</th>
<th>Starch % Degradability</th>
<th>CP</th>
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<tr>
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<td>6</td>
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<td>8</td>
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<tr>
<td>10</td>
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</tbody>
</table>
Intensity and Duration Increases Starch Digestion in HMC

Benton et al., 2004
Univ. of Nebraska

Ensiling Period (d)
Hoffman et al., JDS 2011

Methods:

1) 2 random HMC (25.7 and 29.3 % moisture)

2) Treated with or without 600,000 cfu/g of *L. Buchneri* 40788

3) Ensiled in vacuum sealed plastic bags

4) Storage time = 0, 15, 30, 60, 120, 240 d
Electron Microscopy
High Moisture Corn Electron Micrographs

HMC1 = 25.7 % Moisture
Storage Time = 0 d
Total Zein Peak Area = 231

HMC2 = 29.3 % Moisture
Storage Time = 0 d
Total Zein Peak Area = 130

HMC1 = 25.7 % Moisture
Storage Time = 240 d
Total Zein Peak Area = 174

HMC2 = 29.3 % Moisture
Storage Time = 240 d
Total Zein Peak Area = 61
High Moisture Corn Electron Micrographs

Fermentation -> Individual Starch Granules

HMC1 = 25.7 % Moisture
Storage Time = 0 d
Total Zein Peak Area = 231

HMC2 = 29.3 % Moisture
Storage Time = 0 d
Total Zein Peak Area = 130

HMC1 = 25.7 % Moisture
Storage Time = 240 d
Total Zein Peak Area = 174

HMC2 = 29.3 % Moisture
Storage Time = 240 d
Total Zein Peak Area = 61
Starch Digestibility and Fermentation

“A product of fermentation intensity and duration”

- Fermentation Intensity
  - Moisture Content
  - Temperature
  - Bacteria
  - Access to Endosperm Proteins (Processing)

- Duration
  - Length of Ensiling Time
  - Chronic Proteolytic Activity

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Prior to Ensiling

Hoffman et al, 2011

Ensiled 240 d

Intensity

Duration

0-12 h GP, %

HMC1  HMC1 + I  HMC2  HMC2 + I
High Moisture Corn

Fate of Degraded Proteins =

Markers of Fermentation Intensity and Duration

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High Moisture Corn
NH3-N as a Marker of Intensity and Duration

NH3-N, % of total N

12 h in vitro gas production, % of total

R² = 0.77
Corn Silage Starch Digestibility

Changing Definitions

Corn Silage Starch = Static, constant, fixed

Corn Silage Starch\(v\) = Variable, change, moving
### Evaluating Grain Quality: A Dairy Cow’s Perspective

#### Grain Quality: Simple Test

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Material</th>
<th>PDR</th>
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<tbody>
<tr>
<td>Mean Particle Size</td>
<td>Dry and HMC</td>
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<tr>
<td>Kernel Processing Score</td>
<td>Corn Silage</td>
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<tr>
<td>Vitreousness</td>
<td>Dry Corn</td>
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<tr>
<td>Crude Protein</td>
<td>Dry Corn</td>
<td>+ PDR</td>
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<td>Prolamin Protein</td>
<td>Dry Corn</td>
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<td>Soluble Protein</td>
<td>HMC Corn Silage?</td>
<td>- PDR</td>
</tr>
<tr>
<td>Ammonia Nitrogen</td>
<td>HMC Corn Silage?</td>
<td>- PDR</td>
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<tr>
<td>Starch</td>
<td>Dry, HMC, and Corn Silage</td>
<td>Important</td>
</tr>
<tr>
<td>In Vitro Starch Digestibility</td>
<td>Dry, HMC, and Corn Silage</td>
<td>-+ PDR</td>
</tr>
</tbody>
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PDR = particle digestion resistance