Practically improving the feeding value of your maize silage for livestock and AD

Dr. Katrin Gerlach
Institute of Animal Science, University of Bonn, Germany
Outline

• Feeding value: How to predict
• Feeding value of maize products
• Effect of
  – Maturity
  – Ensiling
  – Delayed sealing
  – Aerobic exposure after ensiling
  – Processing
• Summary
In Germany, the following equation is recommended for the prediction of metabolizable energy (ME) in maize products (GfE, 2008)

\[
\text{ME (MJ/kg dry matter (DM))} = 7.15 + 0.00580 \text{ Enzyme soluble organic matter (ESOM)} - 0.00283 \text{ Neutral detergent fibre (aNDFom)} + 0.03522 \text{ Crude fat (CL)}
\]

ESOM, aNDFom, and CL are in g/kg DM
### Chemical composition and feeding value of maize silages in North-Rhine-Westphalia, harvest 2016 (g/kg DM)

<table>
<thead>
<tr>
<th></th>
<th>Mean n = 719</th>
<th>Orientation value</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter (g/kg)</td>
<td>372</td>
<td>280-350</td>
<td>211</td>
<td>546</td>
</tr>
<tr>
<td>Crude protein</td>
<td>72</td>
<td>&lt;90</td>
<td>51</td>
<td>104</td>
</tr>
<tr>
<td>Crude fat</td>
<td>33</td>
<td>14-44</td>
<td>14</td>
<td>44</td>
</tr>
<tr>
<td>aNDFom</td>
<td>410-510</td>
<td>309-584</td>
<td>309</td>
<td>584</td>
</tr>
<tr>
<td>Starch</td>
<td>326&gt;300</td>
<td>150-436</td>
<td>150</td>
<td>436</td>
</tr>
<tr>
<td>ESOM</td>
<td>686&gt;670</td>
<td>600-780</td>
<td>600</td>
<td>780</td>
</tr>
<tr>
<td>ME (MJ/kg DM)</td>
<td>11.1&gt;11.0</td>
<td>9.8-12.1</td>
<td>9.8</td>
<td>12.1</td>
</tr>
<tr>
<td>NEL (MJ/kg DM)</td>
<td>6.7&gt;6.5</td>
<td>5.7-7.5</td>
<td>5.7</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Main cause for variation?
Feeding value of maize products

- Genotype (Hybrid, maturity type,..)
- Site (Soil, climate)
- Maturity at harvest
- Harvesting method/technology
- Conservation
- Agronomic factors (time of sowing, fertilizer,..)

Feeding value of maize products

Schwarz (2014) modified
Effect of harvest maturity on chemical composition of maize silages

Khan et al. (2015)

Literature review, number of observations > 200 for each variable

- Very wet (DM <250 g/kg)
- Wet (DM 250-290 g/kg)
- Normal (DM 300-350 g/kg)
- Dry (DM >350 g/kg)
Effect of harvest maturity on starch content of maize silages

\[ y = -0.0053x^2 + 4.4335x - 548.9 \]

\[ R^2 = 0.55 \]
Effect of harvest maturity on nutrient digestibility of maize silages

Literature review, number of observations between 13 and 38 for each variable, determined using nylon bag technique.
Effect of harvest maturity of maize silages on feed intake and milk yield by dairy cows

Optimum harvest maturity

Literature review, number of observations = 51

- Very wet (DM <250 g/kg)
- Wet (DM 250-290 g/kg)
- Normal (DM 300-350 g/kg)
- Dry (DM >350 g/kg)

Khan et al. (2015)
Optimize harvest date for silage maize

**Kernel Milk Line Indicates Yields**

The kernel milk line (maturity) shows expected yields.

- **Losses from immaturity and seepage from silo**
- **Optimum harvest range**
- **Field losses and inadequate moisture for good ensiling**

Recoverable Dry Matter %

Whole Plant Moisture %

Adapted from Crop and Soil Magazine

Feedipedia.org
Feeding value of maize products

- Agronomic factors (time of sowing, fertilizer, ..)
- Genotype (Hybrid, maturity type, ..)
- Site (Soil, climate)
- Conservation
- Maturity at harvest
- Harvesting method/technology

Schwarz (2014) modified
### Effect of *ensiling period* on feeding value of maize silages

<table>
<thead>
<tr>
<th></th>
<th>Storage length [d]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td><strong>Dry matter</strong></td>
<td>342</td>
</tr>
<tr>
<td><strong>Crude protein</strong></td>
<td>73.4&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>aNDFom</strong></td>
<td>389&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Starch</strong></td>
<td>355</td>
</tr>
<tr>
<td><strong>ME [MJ/kg DM]</strong></td>
<td>10.6&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>In vitro gas production</strong></td>
<td><strong>[ml/200 mg DM]</strong></td>
</tr>
<tr>
<td><strong>ESOM</strong></td>
<td>681&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*aNDFom* = Neutral detergent fibre treated with amylase and expressed exclusive residual ash,
ME = Metabolizable energy, ESOM = Enzyme soluble organic matter

Gerlach et al. (2015)
## Effects of delayed sealing on DM losses and aerobic stability of maize silages

<table>
<thead>
<tr>
<th>Sealing time (d)</th>
<th>Silage Density</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>DM losses (%)</td>
<td>3.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td>5.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Aerobic stability (h)</td>
<td>64</td>
<td></td>
<td></td>
<td></td>
<td>65</td>
<td></td>
</tr>
</tbody>
</table>

Delayed sealing → Increased losses + decreased aerobic stability after opening!

Brüning et al. (in press)
Effect of delayed sealing on feeding value of silage maize

<table>
<thead>
<tr>
<th></th>
<th>Silage maize at harvest</th>
<th>Sealing 2 days delayed</th>
<th>Sealing 4 days delayed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low density</td>
<td>High density</td>
</tr>
<tr>
<td>DM (g/kg)</td>
<td>277</td>
<td>290</td>
<td>304</td>
</tr>
<tr>
<td>Starch (g/kg DM)</td>
<td>285</td>
<td>281</td>
<td>279</td>
</tr>
<tr>
<td>GP (ml/200 mg DM)</td>
<td>60.2</td>
<td>58.9</td>
<td>57.8</td>
</tr>
<tr>
<td>ME (MJ/kg DM)</td>
<td>10.9</td>
<td>10.8</td>
<td>10.6</td>
</tr>
<tr>
<td>Sugar (WSC, g/kg DM)</td>
<td>160</td>
<td>72.3</td>
<td>72.2</td>
</tr>
<tr>
<td>Non-protein N (g/kg of N)</td>
<td>103</td>
<td>182</td>
<td>260</td>
</tr>
<tr>
<td>NH₃-N (g/kg N)</td>
<td>9.1</td>
<td>16.0</td>
<td>13.3</td>
</tr>
</tbody>
</table>

GP = 24 h in vitro gas production, ME = Metabolizable energy, WSC = Water-soluble carbohydrates

**Delayed sealing → Decrease in digestibility, energy content and protein quality**

Brüning et al. (in press)
Approaches for high-quality silages

Silage quality

- Limitation of pathogen introduction at harvest
- Direct inhibition of undesirable microorganisms
- Improving aerobic stability
- Limit air ingress during storage
- Rapid establishment of anaerobic conditions
- Promoting acidification

Rapid sealing

Dunière et al. 2013, modified
Silage quality is not a constant…

- Assessment at silo opening
  → No aerobic degradation processes

  - Penetration of oxygen 1-2 m, air exposure in fodder mix wagon, feeding trough,..
  → Exposure to air > 1 week possible
Aerobic deterioration of silages

- Proliferation of spoilage organisms
- Increase in silage temperature and pH
- Changes in chemical composition
  - Losses of dry matter and nutrients
  - Changes in fermentation pattern
  - Accumulation of degradation products
  - Formation of mycotoxines
- Effect on feed intake?
Aerobic exposure of maize silages

Mean concentration of selected variables in eight maize silages during eight days of aerobic exposure

Lactic Acid (g/kg DM)  Acetic Acid (g/kg DM)  Ethanol (g/kg DM)  WSC (g/kg DM)  pH

Gerlach et al. 2013
Mean counts of spoilage organisms (colony-forming units (cfu)/g) in eight maize silages during eight days of aerobic exposure

Target value yeasts (VDLUFA 2012)

Analysis did not allow yeast counts > $10^7$ cfu/g
Effect of aerobic exposure after ensiling on feeding value of maize silages

Brüning et al. (in press)
Aerobic exposure of maize silages

Dry matter intake of lucerne hay and maize silages after 0-8 days of exposure to air shown by six goats (n=30)

Reason for the decline?
Microbial quality? Mycotoxines? Fermentation products?
No clear assignment!

Animals avoid those silages when having a choice!

Gerlach et al. 2013
Approaches for high-quality silages

Silage quality

- Limitation of pathogen introduction at harvest
- Direct inhibition of undesirable microorganisms
- Improving aerobic stability
- Limit air ingress during storage
- Rapid establishment of anaerobic conditions
- Promoting acidification

Rapid sealing

Avoid air ingress

Dunière et al. 2013, modified
Effect of processing of silage maize on *in vivo* nutrient digestibility

**Shredlage vs. conventionally harvested maize silage**

<table>
<thead>
<tr>
<th>Digestibility (%)</th>
<th>Shredlage</th>
<th>Maize silage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic matter</td>
<td>80.5</td>
<td>81.0</td>
</tr>
<tr>
<td>Crude fat</td>
<td>75.8</td>
<td>73.4</td>
</tr>
<tr>
<td>Crude protein</td>
<td>48.2</td>
<td>46.6</td>
</tr>
<tr>
<td>aNDFom</td>
<td>64.2</td>
<td>64.0</td>
</tr>
<tr>
<td>ME (MJ/kg DM)</td>
<td>11.80</td>
<td>11.83</td>
</tr>
</tbody>
</table>

Pries et al., 2016

No difference
• The feeding value of maize silages is **highly variable**!

• A **number of factors** causes variation in the feeding value of maize silages

• Most of the variation originates from **differences in the maturity of maize at harvest**

• Furthermore, several factors influence the feeding value of silage maize **pre- and post-ensiling**
  - Ensiling process increases digestibility and energy concentration
  - **Delayed sealing** increases losses and decreases feeding value
  - **Aerobic deterioration** after silo opening decreases feeding value and intake
To improve the feeding value of your maize silages

- Optimize harvest date and ensiling conditions
  - Avoid delayed sealing, air ingress etc.
- Use additives (where necessary)
- Don’t open the silo too early
- Avoid aerobic exposure after silo opening

→ Strive for the best possible silage quality AND maintain it!
Thank you!

FRESH MAIZE SILAGE

GREATEST SMELL ON EARTH