Feeding silage and haylage to horses

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Introduction

• Shift from hay to wrapped forages during the latest 10-15 years

• Respiratory problems, mould spores
  (e.g. Robinson et al., 1996)

• Wrapped forage generally contains less respirable particles than hay (Raymond et al., 1997; Vandenput et al., 1997, 1998; McGorum et al., 1998).

• Commonly, haylage is used for horses
  (Holmquist & Müller, 2002; Enhäll et al., 2012).
Relative air humidity

Log CFU mould/g hay

Moulds at hay surface log/g
Ambient relative humidity

Sundberg et al., 2008
In Canadian hay, presence of Deoxynivalenol (vomitoxin), T2-toxin and zearalenone as well as of 
*Aspergillus* spp., *Fusarium* spp., *Alternaria* spp., *Cladosporium* spp. etc (Raymond *et al.*, 2000). Subjective examination of the hay did not correlate well with objective analysis.

Forage conservation methods

18-50 % DM
- Silage
- Lactic acid fermentation, low pH, less residual WSC content, anaerobic storage

50-84 % DM
- Haylage
- Restricted fermentation, higher residual WSC content, anaerobic storage

Above 84 % DM
- Hay
- Conserved by drying, aerobic storage

Increasing dry matter (DM) content

(Gordon et al., 1961; Finner, 1966; Jackson & Forbes, 1970)
Horses differ

- Forage is the most important feed for all horses
- At least 1 % of BW in roughage dry matter daily (NRC, 2007)
- Nutrient requirement differs vastly (NRC, 2007)
Energy requirement - poll

• Daily requirement of metabolizable energy for a 500 kg bw riding horse in moderate exercise?

a) 70 MJ
b) 150 MJ
c) 25 MJ
d) 200 MJ
Effect of forage conservation methods on forage digestibility in equines

- Apparent digestibility of dry matter, organic matter, NDF and CP did not differ between silage and hay harvested from the same grass crop, but ADF digestibility was slightly higher for silage (Muhonen et al., 2009)

- Apparent organic matter digestibility slightly higher for bunker silage compared to big bale silage and hay from the same grass crop (Austbø, 1990)

- Similar digestibility coefficients for hay and haylage from the same meadow (Bergero and Peiretti, 2011)

- Similar hindgut fiber digestion of hay and silage harvested from the same grass sward (Miyaji et al., 2008)
Athletic horses

- Standardbred yearlings may grow and exercise on a forage-only diet (grass haylage 500 g DM/kg, 11 MJ ME/kg DM) fed *ad libitum* (Ringmark and Jansson, 2011)

- Silage had higher digestibility and higher evaporative losses than hay from the same grass crop when fed to exercising horses (Muhonen *et al.*, 2009)
Equine digestion of grass conserved as silage, haylage or hay

• The microbial profile in the large intestine of the horse is affected by the composition of the diet (e.g. Hintz et al., 1971; Kern et al., 1973; Moore and Dehority, 1992; de Fombelle et al., 2001; Julliand et al., 2001; Medina et al., 2001 etc).

• Effect of silage, haylage and hay on biochemical (and microbial) composition in the large intestine (RVC)?
Effect of forage conservation method on forage composition  
Müller et al., 2008

<table>
<thead>
<tr>
<th>Variable, g/kg DM</th>
<th>Silage</th>
<th>Haylage</th>
<th>Hay</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter (g/kg)</td>
<td>343 a</td>
<td>548 b</td>
<td>815 c</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Crude protein</td>
<td>176 a</td>
<td>151 b</td>
<td>165 a</td>
<td>0.0004</td>
</tr>
<tr>
<td>Water soluble carbohydrates</td>
<td>80 a</td>
<td>126 b</td>
<td>116 b</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Neutral detergent fibre</td>
<td>421 a</td>
<td>468 b</td>
<td>486 b</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>In vitro DOM</td>
<td>905</td>
<td>893</td>
<td>895</td>
<td>0.19</td>
</tr>
<tr>
<td>pH</td>
<td>4.40 a</td>
<td>5.60 b</td>
<td>5.96 b</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Lactic acid</td>
<td>43.0 a</td>
<td>1.3 b</td>
<td>0.3 b</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total organic acids</td>
<td>50.6 a</td>
<td>2.6 b</td>
<td>0.5 b</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Ammonia-N/total-N</td>
<td>7.3 a</td>
<td>2.4 b</td>
<td>1.5 b</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
Effect of forage conservation method on biochemical composition in right ventral colon in horses fed silage, haylage and hay

Müller et al., 2008

<table>
<thead>
<tr>
<th>Variable in RVC</th>
<th>Silage</th>
<th>Haylage</th>
<th>Hay</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter, g/kg</td>
<td>81</td>
<td>117</td>
<td>50</td>
<td>NS</td>
</tr>
<tr>
<td>pH</td>
<td>6.81</td>
<td>6.64</td>
<td>6.75</td>
<td>NS</td>
</tr>
<tr>
<td>Lactic acid, mM</td>
<td>0.16</td>
<td>0.08</td>
<td>0.05</td>
<td>NS</td>
</tr>
<tr>
<td>Acetic acid, mM</td>
<td>43</td>
<td>37</td>
<td>48</td>
<td>NS</td>
</tr>
<tr>
<td>Propionic acid, mM</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>NS</td>
</tr>
<tr>
<td>i- and n-butyric acid, mM</td>
<td>4.4</td>
<td>4.3</td>
<td>4.7</td>
<td>NS</td>
</tr>
<tr>
<td>i- and n-valeric acid, mM</td>
<td>1.2</td>
<td>0.8</td>
<td>1.2</td>
<td>NS</td>
</tr>
<tr>
<td>Total organic acids, mM</td>
<td>60</td>
<td>54</td>
<td>66</td>
<td>NS</td>
</tr>
</tbody>
</table>
Fermentation kinetics of right ventral colon - effect of forage conservation method

Müller et al., 2008
Forage intake rate in relation to NDF content

(Jansson et al., 2012, compilation of 5 different studies)

\[ Y = 0.0964x - 23.1 \quad (R^2 = 0.73, \quad P = 0.0002) \]
Equine intake of haylage

- Plant maturity affects ingestion of haylage:

<table>
<thead>
<tr>
<th>Variable</th>
<th>June haylage</th>
<th>July haylage</th>
<th>August haylage</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eating time, min/kg DM</td>
<td>29 a</td>
<td>37 b</td>
<td>36 b</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>No. of chews/min</td>
<td>84 a</td>
<td>78 b</td>
<td>77 b</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Chews/swallowing</td>
<td>51 a</td>
<td>65 b</td>
<td>81 c</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>No. of chews/kg DM</td>
<td>2472 a</td>
<td>2947 b</td>
<td>2969 b</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Müller, 2011
Equine intake of haylage

- Cut and long stemmed haylage:
  - Very small differences in ingestion

<table>
<thead>
<tr>
<th></th>
<th>Eating time for haylage, min</th>
<th>Eating time, min/kg DM</th>
<th>Chewing rate, no. of chews/min</th>
<th>No. of chews/kg DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut haylage</td>
<td>32 (4.4)</td>
<td>28 (3.9)</td>
<td>84 (3.8)</td>
<td>2368 (346.9)</td>
</tr>
<tr>
<td>Long-stemmed haylage</td>
<td>34 (7.0)</td>
<td>30 (6.2)</td>
<td>82 (3.9)</td>
<td>2441 (454.9)</td>
</tr>
</tbody>
</table>

\textit{P} Forage type

NC

<0.0001

Müller, 2009
Equine preference of silage, haylage, and hay from the same crop

Conservation method may influence preference (Müller et al., 2007)
Hygienic quality of silage and haylage and horse health

Hygienic quality of feeds placed on the market - regulated by EU legislation:
EG 183/2005 (implemented in 2006)

- Moulds, spores and mycotoxins
- Bacterial problems
Moulds and mycotoxins

• Aerobic fungi with filamentous growth
• Moulds generally grows at lower $a_w$ than bacteria
• Haylage of late harvest and high dry matter content – increased risk of mould growth (O’Brien et al., 2008)
  - Predominant in Ireland: *Penicillium roquefortii*, may produce mycotoxins roquefortine C, PR-toxin etc (O’Brien et al., 2008) (*neurotoxic, immunotoxic, mutagenic etc*)
  - Predominant in Norway: *Aspergillus fumigatus*, may produce several mycotoxins *e.g.* gliotoxin, aflatoxins etc (Skaar, 1996) Abortion, liver damage in young horses, death, disturbances in central nervous system (Asquith, 1991)
  - Predominant visible mould in Sweden: *P. roqueforti* (Schenck et al., 2012), but also *A. fumigatus, Cladosporium* spp., *Fusarium* spp. and *Mucor* spp.
Schizophyllum spp (?)

Photo: Jenny Möller, DeLaval
Sweden
Bacterial problems

• Contamination by soil, decaying plant material, manure and cadavres causing malfermentation (pH over 5, butyric acid/ammonia)

• Presence of *Clostridia* spp. and/or *Enterobacteria* spp. which may cause gastrointestinal disorders and/or toxicosis (Roberts, 1988; Browning *et al*., 1991; van Duijkeren *et al*., 2000)

• *Clostridia* spp. are anaerobic, gram-positive, spore-producing bacteria, favoured by **high pH, high a<br>, high temperature, high buffer capacity** in the crop etc

• Three main phenotypic groups of clostridia: proteolytic (*C. sporogenes, C. bifermantans, C. botulinum*), saccharolytic (*C. butyricum*), both proteo- and saccharolytic (*C. tyrobutyricum*) (Pahlow *et al*., 2003).
**Clostridium botulinum and botulin**

- Produces the toxin botulin, causing botulism
- Rarely found in silage (Notermans, 1979; Spoelstra, 1981)
- Toxin production with only grass as substrate requires $a_w >0.94$ at $pH \geq 5.8$, and $a_w >0.985$ if $pH = 5.3$ (Notermans *et al.*, 1979)

- Common factor in case reports of botulism in horses is poor feed hygiene irrespective of feed, or achieved on pasture (US) (Szabo *et al.*, 1974; Johnson *et al.*, 2010)
<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haesebrouck et al., 1990</td>
<td>Lucerne silage pH 6.7-8.9, lots of visible mould</td>
<td>Type B Holland</td>
</tr>
<tr>
<td>Heath et al., 1990</td>
<td>Hay, oats – decaying feed in manger/feed through</td>
<td>Type C Canada</td>
</tr>
<tr>
<td>Hunter et al., 2002</td>
<td>Round bale hay, stored outdoors. Rotten and mouldy.</td>
<td>Type C? USA</td>
</tr>
<tr>
<td>Kelly et al., 1984</td>
<td>Oat chaff with cadavre</td>
<td>Type C or D Australia</td>
</tr>
<tr>
<td>Gudmundsson, 1987</td>
<td>Round bale silage with bird cadavres, fed <em>ad lib.</em></td>
<td>Type B Iceland</td>
</tr>
<tr>
<td>Müller, J. 1963</td>
<td>Cadavre in hay, straw, silage (cows and horses)</td>
<td>Type C Denmark</td>
</tr>
<tr>
<td>Switzer et al., 1984</td>
<td>Heated lawn clippings in a big heap</td>
<td>Type D? California</td>
</tr>
<tr>
<td>Ricketts et al., 1984</td>
<td>Big bale silage with high pH and strong smell of ammonia</td>
<td>Type B UK</td>
</tr>
</tbody>
</table>
Enterobacteria

• Large group! *E.g. Salmonella spp.* and *E. coli*

• Usually dies off during the first days of ensiling, sensitive for lowering of pH (Heron *et al.*, 1993), can persist in haylage and hay (Müller *et al.*, 2007)

• *E. coli* is suspected to be able to cause diarrhoea in both foals (Browning *et al.*, 1991) and adult horses (van Duijkeren *et al.*, 2000).

• Not much knowledge of relation between enterobacteria in feed and health problems in horses
Aerobic storage stability of bales

• Equine population differ from other livestock - >0.75 of Swedish horses are housed at farms with 1-4 horses (Persson, 2005) = low daily consumption rate

• In addition, high DM content of haylage = higher residual WSC content (e.g. Müller et al., 2008), and larger porosity (McGechan & Williams, 1994)
Aerobic storage stability in haylage bales after opening (Müller, 2009)
Yeast and mould counts in silage 300 g DM/kg (SIL), haylage 500 g DM/kg (HLL) and haylage 700 g DM/kg (HLH) after 7 days of aerobic storage, P<0.0001 (Müller & Johansen, 2012, unpubl.)

Treatments (cont = control; fill = additive at silo filling; open = additive at silo opening; fill + open = additive at silo filling and silo opening). Acid based additive.
Summary and further research

• Forage conservation methods may influence preference but not digestion/digestibility of forage to the same extent (in horses fed for maintenance)

• Haylage more commonly fed to horses – challenges include keeping wrapping intact due to high dry matter content, late harvest and during transport of bales etc
Summary and further research, cont.

- Low daily rate of consumption - Aerobic storage stability in bales important – additives helpful? Bale size? Other?

- Increased knowledge of microbial and biochemical community in haylage required (e.g. moulds and mycotoxins?), and development of methods for assessment of hygienic quality of forages