Improving the intake and digestibility of poor quality forages

Dr Gbola Adesogan
Department of Animal Sciences
University of Florida
www.animal.ufl.edu/adesogan
adesogan@animal.ufl.edu
Nutritive value of tropical grasses

- Low CP
- Low Sugars & starch
- High NDF
- High lignin

<table>
<thead>
<tr>
<th>Forage</th>
<th>NDF</th>
<th>Lignin</th>
<th>TDN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ryegrass hay</td>
<td>41%</td>
<td>5%</td>
<td>64%</td>
</tr>
<tr>
<td>Bahiagrass hay</td>
<td>72%</td>
<td>11%</td>
<td>51%</td>
</tr>
</tbody>
</table>

(NRC 2000)
Methods of improving forage quality

Improve the forage

1. Breeding
2. Physical methods
   - Processing
   - Thermal/pressure treatment
3. Chemical treatment methods
   - NaOH and CaOH
   - Ammonia
   - Urea
   - Urine
4. Biological methods
   - Inoculants
   - Enzymes

Provide missing nutrients

1. Increasing amount offered
2. Supplementation
   - Concentrates
   - By products
   - Intercropping
Criteria for assessing treatments

- Economics
- Effectiveness
- Safety aspects (for producer & livestock)
- Availability / feasibility
- Infrastructural issues
  - Availability of additive
  - Delivery systems
Breeding

- Examples
  - Cold / short daylength tolerant grasses
  - Brown mid-rib corn
- Effective but slow progress
- Extensive reseeding required
Processing

- Most effective for mature, poor quality forages

- Benefits
  - ↑ surface area & density
  - Less sorting; ↑ intake & gains
  - Easier handling

- Common types
  - Chopping (1-10 cm)
  - Grinding (<1 cm)
  - Pelleting & cubing

Effect of particle size on gut fill

- Finely ground (1mm)
  - Less sorting
  - Less gut fill
  - Higher passage rate
  - Higher intake (10 – 40%)
  - Lower digestibility
    (3% legumes, 15% grasses)

- Unprocessed (>10cm)
  - High gut fill
  - Low passage rate
  - Lower intake
  - More sorting
  - Low performance
Dangers of excess processing

- Reduced effective fiber content
- Reduced fiber digestion
- Decreased salivation
- **Acidosis** risk
- Low milk fat due to low acetate production
- Increased heat-damaged protein
- Dust; respiratory problems

Steam Treatment

- Commercially used for bioconversion of lignin to cellulose
- Steam pressure (5 - 40 kg/cm²) applied for <5 min
- Disrupts cell wall structure
- Solubilizes components
- May cause DM losses if excessive
Steam treatment of corn cobs

![Graph showing the relationship between pressure (kg/cm²) and digestibility, gain, and feed/gain ratio.]

- Digestibility:
  - Pressure 0: 583
  - Pressure 17: 660
  - Pressure 28: 633

- Gain:
  - Pressure 0: 14
  - Pressure 14: 17.5
  - Pressure 17.5: 17.5

- Feed/gain (x 10):
  - Pressure 0: 14
  - Pressure 14: 17.5
  - Pressure 17.5: 17.5
Chemical treatments

- Oxidizing agents
  - Effective on dicots & monocots (solubilize lignin)
  - Too expensive; won’t be discussed
  - Examples: Ozone, peroxides, sulfites

- Hydrolytic agents
  - More effective on monocots (hydrolyzes links)
  - Examples
    - Ammonia, urea and urine
    - CaOH or NaOH, KOH
Mode of action of treatments

Oxidizing agents, SO$_2$, fungi

dissolve  
dissolve

Lignin

Hemicellulose

Alkali-labile linkage

Glycosidic linkage

A  
G  
PC  
FA

NH$_3$ or NaOH

(Chesson, 1986)
**NaOH treatment**

- V. widely used @ 3 – 5 % of DM
- Disrupts linkages and partially solubilizes hemicellulose, lignin etc
- Originally involved soaking in NaOH solution for 3 d
  - Polluted waste water disposal issues
  - Solubilization of nutrients during washing
- NaOH is currently sprayed on forage
  - Less effective than soaking
Effect of NaOH treatment on digestibility (%) of barley straw

(Wanapat et al., 1985)
NaOH treatment issues

- Increased DM intake by 22% (24 studies)
- Hazardous (caustic alkali)
- Sodium accumulation in manure from animals fed treated forages under confinement
- Costly ($25-35/t)
Alkali burns
**Ammoniation**

- Most widely used in US though less effective than NaOH

- Applied at 3-5% of hay DM or 0.7% of silage DM

- Stored for 4-8 weeks

- Effective
  - ↑ TDN by about 10%
  - ↑ CP by about 6%

- Hazardous

(Stewart & Silcox, 2001)
Effect of ammoniation (Kuhl 81)

<table>
<thead>
<tr>
<th></th>
<th>CP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat Straw</td>
<td>0</td>
</tr>
<tr>
<td>Corn Stover</td>
<td>3</td>
</tr>
<tr>
<td>Prairie Hay</td>
<td>6</td>
</tr>
<tr>
<td>Orchardgrass Hay</td>
<td>9</td>
</tr>
</tbody>
</table>

**Untreated** and **Treated**

- Wheat Straw: Untreated 3%, Treated 6%
- Corn Stover: Untreated 6%, Treated 9%
- Prairie Hay: Untreated 9%, Treated 12%
- Orchardgrass Hay: Untreated 3%, Treated 6%
Effect of ammoniation (Kuhl 81)

<table>
<thead>
<tr>
<th></th>
<th>Digestibility (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat Straw</td>
<td></td>
</tr>
<tr>
<td>Corn Stover</td>
<td></td>
</tr>
<tr>
<td>Prairie Hay</td>
<td></td>
</tr>
<tr>
<td>Orchardgrass Hay</td>
<td></td>
</tr>
</tbody>
</table>

- Untreated
- Treated
Effect of ammoniation of hay on steer performance (kg/d)
Effect of ammoniation on wheat straw intake in lambs (gDM/d)

(Wet straw with poor NH$_3$ distribution)

(Adesogan & Owen '1995)
Ammoniation pros & cons

- **Pros**
  - Increased digestibility and protein
  - Decreased mold growth

- **Cons**
  - Price & availability
  - Hazardous for machinery & humans
  - Distribution issues for liquid ammonia

- Ensure diet **CP:S** ratio is > 10:1
- Ensure proper mixing; avoid bovine bonkers
Urea

- Converted to ammonia by plant urease
- **Safer** than ammonia; more variable effects
- Requires adequate
  - Forage moisture (60-70%)
  - **Urease** concentration & activity
  - **Urease** source e.g. Jackbean
- No handling / application problems
- Apply at 0.8% to silage or 3% to hay / straw
- Must use feed grade urea
Urine

- Used in a 1:1 mixture with straw
- Can increase digestibility by 10%
- Collection problems
- Health issues
- May not inhibit mold

## Summary of effects of chemicals

(Flachowsky and Zadrazil, 2003)

<table>
<thead>
<tr>
<th></th>
<th>Availability</th>
<th>Health risk</th>
<th>Equipment needs</th>
<th>Cost</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaOH</td>
<td>✗ ✗</td>
<td>✗</td>
<td>✗ ✗ ✗</td>
<td>✗ ✗ ✗</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>CaOH</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>NH₃</td>
<td>✗ ✗</td>
<td>✗</td>
<td>✗</td>
<td>✗ ✗ ✗</td>
<td>✓ ✓ (+ N)</td>
</tr>
<tr>
<td>Urea</td>
<td>✓ ✓ ✓</td>
<td>✓</td>
<td>✓ ✗</td>
<td>✓ ✓ ✓</td>
<td>✓ ✓ (+ N)</td>
</tr>
<tr>
<td>Urine</td>
<td>✓ ✓ ✓</td>
<td>✗</td>
<td>✓ ✗</td>
<td>✓ ✓ ✓</td>
<td>✓ ✓ ✓</td>
</tr>
</tbody>
</table>

(Scoring: ✗ = Poor, ✗ = Fair, ✗ = Good, ✗ = Excellent, ✓ = Effective)
Fungal treatments

- Fungi solubilize lignin
- White rot fungi are most effective
- Can decrease lignin by 50% & increase digestion by 50 - 80%
- But often cause up to 25% loss of substrate including important carbohydrates
- Need strains that delignify without degrading desirable carbohydrates
Enzyme treatments

- Hydrolyze polysaccharides
- Most based on cellulase & xylanase
- Tend to increase intake
- More effective at increasing the rate not the extent of digestion
- Mostly effective when applied to high quality forages fed to stressed cattle
Enzyme treatment of straw

Increased rate of digestion more typical than increased extent

Nakashima (et al., 1988)
Expt 2: Effect of Promote (P) or NH₃ treatment on digestion of hays

(Dean et al., 2003)
Supplementation

- Most focus has been on using concentrate supplements
- Bi-product and legume supplements may be as effective and cheaper.
Effect of supplementing bahiagrass hay with legumes

<table>
<thead>
<tr>
<th></th>
<th>Bahia</th>
<th>SBM</th>
<th>Annual Peanut</th>
<th>Perennial Peanut</th>
<th>Cow-pea</th>
<th>Pigeon-pea</th>
<th>Soy-bean</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI, kg/d</td>
<td>665&lt;sup&gt;ef&lt;/sup&gt;</td>
<td>726&lt;sup&gt;de&lt;/sup&gt;</td>
<td>975&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1105&lt;sup&gt;a&lt;/sup&gt;</td>
<td>803&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>612&lt;sup&gt;f&lt;/sup&gt;</td>
<td>864&lt;sup&gt;c&lt;/sup&gt;</td>
<td>29.2</td>
</tr>
<tr>
<td>DMD, %</td>
<td>58.5&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>60.3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>64.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>67.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>58.8&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>56.3&lt;sup&gt;d&lt;/sup&gt;</td>
<td>60.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.9</td>
</tr>
<tr>
<td>N retention, g/d</td>
<td>2.0&lt;sup&gt;d&lt;/sup&gt;</td>
<td>4.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.6&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.54</td>
</tr>
</tbody>
</table>

Foster et al. (2008)
Bi-cropping

Aim:
- To determine the effect of replacing concentrates with a pea wheat bi-crop on milk production

Treatments
- Grass silage and 8 kg of conc. (GS8)
- Grass silage and 4 kg of conc. (GS4)
- Pea wheat bi-crop and 4 kg of conc. (SW)
Feed intake and Milk yield (kg/day)

- **Conc. Level**
- **Total DMI**
- **Fat-corrected milk yield**

Forage DMI

Milk yield
Effect of stylo or concentrate supplementation of king grass

<table>
<thead>
<tr>
<th></th>
<th>DMI (x10)</th>
<th>CP intake</th>
<th>Digestibility (%)</th>
<th>BW gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>King grass</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KG + stylo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KG + Conc</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(g/d)

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>King grass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KG + stylo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KG + Conc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

- Various methods are available for improving the nutritive value of poor quality feeds.
- The method of choice at any location should be based on a compromise between availability, effectiveness, cost and safety concerns.
References


- Improving Lower Quality Dry Forages By Ammoniation http://ohioline.osu.edu/agf-fact/0015.html