A comparison of Chaffhaye and alfalfa hay on digestibility and glucose metabolism in mature, stock type horses

BY ASHLEY HANSEN
Problems with managing horses in confinement

Nutrient Requirement
Horse’s Individual Nutrient Needs

- Physiological Level
  - Growing
  - Reproductively Active
  - Lactating
  - Etc.

- Level of Work

- Body Weight

* Consistent Feedstuff is Important

(NRC, 2007)
Problems with managing horses in confinement

Nutrient Requirement

Fecal Output
Fecal Output and Disposal

- A horse defecates:
  
  - 37 lbs per day
  - 13,505 lbs per year

  (Fabian, 2001)

- Agricultural runoff is the main cause of water quality problems for lakes and rivers

  (USEPA, 1990)
Problems with managing horses in confinement

- Nutrient Requirement
- Fecal Output
- Metabolic Issues
Equine Metabolic Challenges

Rapid intake of non-structural carbohydrate (NSC) can cause:

Irregularities in:
- Insulin production
- Glucose metabolism

- Insulin Resistance
- Laminitis
- Founder
- Equine Metabolic Syndrome

(Obel, 1948; Ralston, 1996; Treiber et al., 2005; Frank, 2009)
Insulin Resistance

- Typically seen in obese horses and ponies (Longland & Byrd, 2006)

\[
\text{Glucose Intake} \quad = \quad \text{Insulin Production}
\]

Causes Insulin Receptors Shut Down
Laminitis/Founder

- Largely caused by high intake of **NSC** (Obel, 1948)

  Increased Fermentation in Hindgut
  - Drop in pH
  - Blood Acidosis
  - Reducing Glucose Uptake by Cell
  - Inflammation/Separation of Sensitive Laminae

(Garner et al., 1977)
Laminitis

- Insulin Resistance
- Low Glucose Uptake
- Laminitis

All horses receiving insulin developed laminitis in all 4 feet 72 h after administration (Asplin et al., 2007)
Problems with managing horses in confinement

- Nutrient Requirement
- Water Intake
- Fecal Output
- Metabolic Issues
Water Intake

Adequate water intake can prevent:

- Colic
  - (Thompson, 1992)
- Choke
  - (Hillyer, 1995)
- Ulcers
  - (MacAllister and Sangiah, 1993)
Feeding Higher Digestibility Forage

- Utilization of Feed
- Fecal Output
- Impaction Colic

(Cohen et al. 1995)
Digestibility in horses can be affected by:

- **Feeding Level** = **DM Digestibility**
  (Pearson et al., 2001; Ragnarsson and Lindberg, 2009)

- **Particle Size of Forage** = **DM Digestibility**
  (Rodrique and Allen, 1960; Wolter et al., 1977; Sellers et al., 1982)

- **Moisture Content** = **DM Digestibility**
  (Olsson and Ruudvere, 1955; Uden et al., 1982; Moore-Colyer et al., 2003)

- **Processing** = **DM Digestibility**
  (Moore-Colyer et al., 2003; Muhonen, 2009)
Feeding forage with lower NSC

- High amounts of NSC can affect blood glucose levels and induce insulin resistance (Storlien et al., 2000)
How Haylages are Produced

- Low moisture silage- Haylage (40-60 % DM)
- 4 Steps:
  - harvesting
  - packing
  - covering
  - fermentation
- Molasses and inoculants often added (Kellems and Church, 2010)
Higher Digestibilities for Haylage/Silage in Horses

- Silage fed to horses had significantly higher DM, ADF, NDF and CP digestibilities when compared to dried hay (Moore-Colyer et al., 2003)

- DM, OM, NDF, and ADF higher digestibilities for horses fed silage than hay (Muhonen, 2009)
# Lower WSC Concentration in Ensiled Forages

Ensiling process lowers WSC concentrations in silage when compared to dried hay \(\text{(McDonald, 1991)}\)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Hay</th>
<th>Silage</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSC (g/kg DM)</td>
<td>157</td>
<td>140</td>
</tr>
</tbody>
</table>

*Harvested Simultaneously \(\text{(Muhonen, 2009)}\)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Hay</th>
<th>Haylage</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSC (g/kg DM)</td>
<td>101</td>
<td>71</td>
</tr>
</tbody>
</table>

*Harvested Simultaneously \(\text{(Muller and Uden, 2006)}\)
Chaffhaye

Alfalfa Chaff
+ Molasses
+ Inoculants

(Pediococcus pentosaceus & Propionibacterium freudenreichii)
+ Fermentation
= Chaffhaye

* Produced in irrigated field
Evaluation of nutrient intake, in situ disappearance, and fermentation characteristics of fermented Chaffhaye with alfalfa hay and prairie grass hay in steers

- 6 rumen fistulated steers
- *In situ* NDF disappearance (12 and 24 hour incubations) were greater (*P* ≤ 0.0001) for Chaffhaye & alfalfa hay vs. grass hay diet
- 96 hour incubation the NDF disappearance for the Chaffhaye was greater (*P* = 0.024) than the alfalfa hay.

(Guantam et al., 2014)
Objective

To compare digestibility and metabolic response in mature stock-type horses fed Chaffhaye or dried alfalfa forage diets.
Hypothesis

- That Chaffhaye will be more readily digestible when compared to dried alfalfa in mature horses across most nutritive parameters and have lowered glucose and insulin response after a meal.
Study Design

- All procedures were approved by NMSU IACUC
- Utilize 10 mature, stock type geldings
  - Avg. Age: 13.8 y ± 8 y
  - Avg. Weight: 553.2 kg ± 81 kg
- Crossover design
  - Groups were stratified by age and weight
Treatments

- 2 treatments:
  - Chaffhaye and dried alfalfa hay
  - Fed at 1.9% of BW (AF) per day

- Diets were divided in 2 equal rations and fed in 12 hr intervals
- Orts were collected and recorded
- Ad libitum access to water & mineral block
- Water intake was recorded

In order to feed like “Real-World” horse owner
Project Timeline

Adaption Period
Day 1-21

Blood Collection
Day 22

Fecal Collection/
Water Intake
Day 23-26

x 2
Dietary Adaption Period

- 21 Days
- Stalled with 2 h turnout/d
- Ensure palatability
- Microorganism adaption

(Julliand, 2001)
Blood Collections

- Day 22
- Insert catheter 30 min before meal
- Blood samples: 0 (directly before meal) 30, 60, 120, 240, 360 min
Digestion Trial

- 4 days
- Total fecal collection harnesses
- Empty harnesses every 6 hours
- Mix contents
- Preserve 5% sub sample & freeze
Analyses

Forage
- DM, OM, CP, Crude Fat, NDF, ADF, NFC, WSC, ESC, Starch, Ash

Fecal
- DM, OM, CP, Crude Fat, NDF, ADF, NFC, Ash

Glucose Insulin:
- Glucose Serum- colorimetric analyses
- Insulin Serum- Immulite 1000 Assay
- Analyzed for AUC and PEAK
Statistical Analysis

- Mixed procedure SAS
  - Fixed effects:
    - Treatment (fiber source)
    - Period
    - Horse
    - No Random Effect

- Effects will be considered significant when $\alpha \leq 0.05$ and a trend $0.15 \geq \alpha > 0.05$
Table 1. Nutrient analysis of Chaffhaye\(^1\) (CHAF) and alfalfa hay (ALF).

<table>
<thead>
<tr>
<th>Nutrient % (DM Basis)</th>
<th>Period 1</th>
<th></th>
<th>Period 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ALF</td>
<td>CHAF</td>
<td>ALF</td>
<td>CHAF</td>
</tr>
<tr>
<td>DM</td>
<td>92.5</td>
<td>39</td>
<td>91.5</td>
<td>45</td>
</tr>
<tr>
<td>OM</td>
<td>81.7</td>
<td>25.7</td>
<td>80.7</td>
<td>31.7</td>
</tr>
<tr>
<td>NDF</td>
<td>52.5</td>
<td>33</td>
<td>43.7</td>
<td>32.7</td>
</tr>
<tr>
<td>ADF</td>
<td>44.9</td>
<td>24.8</td>
<td>35.2</td>
<td>25.9</td>
</tr>
<tr>
<td>CP</td>
<td>14.3</td>
<td>23.8</td>
<td>16.6</td>
<td>21.6</td>
</tr>
<tr>
<td>CF</td>
<td>1.7</td>
<td>3.8</td>
<td>1.7</td>
<td>3.8</td>
</tr>
<tr>
<td>Ash</td>
<td>10.76</td>
<td>13.35</td>
<td>10.76</td>
<td>13.35</td>
</tr>
<tr>
<td>NFC(^2)</td>
<td>20.74</td>
<td>26.05</td>
<td>27.24</td>
<td>28.55</td>
</tr>
<tr>
<td>Starch</td>
<td>0.6</td>
<td>2.7</td>
<td>1.1</td>
<td>2.6</td>
</tr>
<tr>
<td>WSC</td>
<td>8.3</td>
<td>4.8</td>
<td>8</td>
<td>5.2</td>
</tr>
<tr>
<td>ESC</td>
<td>5.6</td>
<td>2.4</td>
<td>7.6</td>
<td>3</td>
</tr>
<tr>
<td>TDN</td>
<td>56</td>
<td>63</td>
<td>58</td>
<td>63</td>
</tr>
</tbody>
</table>

\(^1\) Alfalfa haylage with cane molasses and dried fermentation product of *Pediococcus pentosaceus* and *Propionibacterium freudenreichii* in a sealed bag, Dell City, Texas Chaffhaye, Incorporated.

\(^2\) NFC= 100% - (CP % + Fat % + Ash % + NDF %) (values on a DM basis).
Nutrient Intake Results

Nutrients Fed

*(P < 0.0001)
Nutrient Intake Results Cont.

*(P ≤ 0.0228)*

Intake Kg/d

<table>
<thead>
<tr>
<th>Nutrients Fed</th>
<th>ALF</th>
<th>CHAF</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NFC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starch</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Water Intake Results

(P = 0.4132)
Wet Total Fecal Output Results

\[ (P < 0.0001) \]
Fecal Output Results

*(P ≤ 0.0007)*

Nutrients in Fecal Matter:
- DM
- OM
- NDF
- ADF
- CP
- CF
- NFC
- Ash
Digestibility Results

*(P ≤ 0.0011)*
Digestibility Results

*($P \leq 0.0182$)  
($P = 0.8369$)
Glucose Results

Average Glucose Response To Meal (n = 9)

Blood Glucose (mg/dL)

Min after Meal

AUC (P = 0.5494)
PEAK (P = 0.5398)
Insulin Results

Average Insulin Response
To Meal
(n = 9)

Blood Insulin (uU/mL)

Minutes after Meal

ALF
CHAF

AUC (P = 0.0791)
PEAK (P = 0.1120)
Horses with Insulin Resistance

- Two horses were discovered on this project to be generally accepted as IR
- Resting blood INS concentration of 6 times higher than counter parts. (Frank et al., 2006)
- Evaluated on a case study basis
Glucose Response to Meal

Blood Glucose (mg/dL) vs. Minutes after Meal

- Non-IR ALF
- Non-IR CHAF
Insulin Response to Meal

Blood Insulin (uU/mL) vs. Minutes after Meal for Non-IR ALF and Non-IR CHAF.
Insulin Response to Meal

Blood Insulin (uIU/mL) vs. Minutes after Meal

- Non-IR ALF
- Non-IR CHAF
- IR ALF
- IR CHAF

Graph showing the insulin response to a meal over time for different groups.
Digestibility Discussion

ALFALFA HAD:

- DM, OM, NDF & ADF Digestibility than CHAF

  (Disagreeing with previous research: Moore-Colyer et al., 2003; Muhonen, 2009)

This could be due to:

- Moisture = Longer Rate of Passage

  (Olsson and Ruudvere, 1955; Uden et al., 1982; Drogoul et al., 2000; Drogoul et al., 2001)

- Fiber length = Longer Rate of Passage

  (Wolter et al., 1974; Sellers et al., 1982; Morrow et al. 1999)
Digestibility Discussion

CHAFHAYE HAD:

**CP and Crude Fat Digestibility**

(Agrees with previous research; Moore-Colyer et. al., 2003)

This could be due to:

Increased availability for absorption

in small intestine due to fermentation

(Van Weyenberg et al., 2006)
Metabolite Discussion

ALFALFA & CHAFFHAYE HAD:

Similar Glucose Metabolism

(Agrees with previous research: Deboer et al., 2017)

This could be due to:

Horses were able to regulate GLU levels through insulin- Even IR horses (Deboer et al., 2017)
Metabolite Discussion

**CHAFFHAYE HAD:**

- Insulin AUC and PEAK

This could be due to:

- Overall DM intake
- NFC (WSC and ESC) content

(Storlien et al., 2000; Staniar et al., 2014)
Nutrient Requirement- Implications

**CHAF had higher CP and CF digestibilities**

**CHAF could assist:**
- Horses that have high CP and CF requirements or are high energy

**ALF had higher DM, OM, NDF, and ADF digestibilities**

**ALF could assist:**
- Horses requiring a high energy diet or prone to colic
Problems with managing horses in confinement

- Nutrient Requirement
- Fecal Output
- Water Intake
- Metabolic Issues
Fecal Output-Implications

CHAF had lower wet fecal output

CHAF could reduce:

- Cost of manure cleanup
- Disposal challenges
- Environmental effects
Problems with managing horses in confinement

- Nutrient Requirement
- Water Intake
- Fecal Output
- Metabolic Issues
Metabolic Issues-Implications

CHAF had lower WSC and ESC concentration & tended to have a lower insulin response

CHAF could assist:

- Preventing metabolic diseases
- Horses prone/with metabolic diseases
Problems with managing horses in confinement

- Nutrient Requirement
- Fecal Output
- Water Intake
- Metabolic Issues
Water Intake- Implications

No significant differences

- Considering water from feed:
  - CHAF intake 6-10 L per day

CHAF could reduce:

- Colic, choke, ulcers
- Digestibility of forage
Problems with managing horses in confinement

- Nutrient Requirement
- Fecal Output
- Water Intake
- Metabolic Issues
A Big Thank You!

My Family

My Lab:
Dr. White
Alyssa Oates
Dustin Gaskins

My Committee:
Dr. Loest
Dr. Turner
Dr. Hodnett

Graduate Students

Judging Team
Questions?