Effects of a sequential offer of hay and TMR on feeding and rumination behaviour of dairy cows

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Introduction: background: grassland utilisation

Grassland-based ruminant production:

› **A matter of global nutrient resource efficiency**
  › less feed-food competition for arable land
  › less need in protein concentrates, shifts across the globe

› **A matter of ecological resources**

› At least grassland-rich regions are challenged to make better use of this resource (e.g. Switzerland)

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**Land use (in billion ha and %)**

- Permanent Grassland: 3.4; 66%
- Arable land for forage production: 0.39; 8%
- Arable land for food production: 1.27; 24%
- Permanent cultures for food production: 0.13; 2%
Introduction: background: concentrate reductions

- Switzerland: GMF («Grassland-based milk and meat production»)
  - Min. 75% of the feed must come from grassland resources (including artificial grasslands within crop rotations). This means: maize silage + concentrates = max. 25% of the diet.

- Switzerland: organic standards of BioSuisse
  - Min. 90% roughages in milk production (calculated per herd and year).

- But: differentiated feeding management options for concentrate-reduced production systems are lacking.
Introduction: roughage based feeding management

› Which management options exist for a zero- or low-concentrate-strategy?
  › Production, storage and feeding of different roughage qualities
  › How to increase roughage intake by feeding management?
    › Diversity on pastures?
    › TMR or separate offers?
    › Performance-groups?

› Which parameters do we measure to assess feeding situations?
  › Only feed quality and animal performance?
  › Or additionally animal related parameters like feeding behaviour, faeces quality and BCS?
Introduction: Aims of the project

› Evaluating in one experiment:

› Roughage-based feeding management options
  › concentrate reductions
  › sequential offer of different roughages

› Animal-related assessment parameters (feeding behaviour)
  › Eating and rumination behaviour
  › Faeces particle composition
Methods: animals / farm

› Organic dairy farm near Berne, Switzerland
› Swiss Fleckvieh (average performance: 7000kg milk / a)
Methods: barn

Stanchion barn with separated feeding troughs
Methods: experimental schedule

- 2 groups of 15 cows each
  - «Prot+»: 2.4 kg individually fed concentrates / cow / day
  - «Prot-»: 0 kg individually fed concentrates
  - Excluded animals: 3 in Prot+, 4 in Prot-

- 2 experimental periods (21 days each)
  - Period 1: TMR1 *ad libitum* for all cows
  - Period 2: TMR2 *ad libitum* for all cows; 6.00 a.m.- 8.00 a.m. hay *ad libitum* for all cows
Materials: diets

› TMR1:
  › 0.30 maize silage,
  › 0.32 grass silage,
  › 0.21 hay,
  › 0.09 dried alfalfa meal,
  › 0.05 potatoes
  › 0.03 soybean cake.

› TMR2:
  › 0.35 maize silage,
  › 0.38 grass silage,
  › 0.06 hay,
  › 0.11 dried alfalfa meal,
  › 0.06 potatoes
  › 0.04 soybean cake
Materials: RumiWatch® chewing sensors

- Pressure tube, filled with oil
- Sensors, data storage, transmission
Methods: sampling

› Sampling weeks in days 17-21 of each period

› Individual feed intake hand weighed, daily
› Feed samples twice per week
› Milk yield and sampling: twice per week
› Chewing sensors: 96h per week (72h used for analysis)
› BCS and body weight: once per week
Results: eating pattern (group Prot+)

Eating time [min]

Hours of the day

- **6-14 Uhr**
- 14-22 Uhr
- 22-6 Uhr

Period 1, TMR1
Period 2, TMR2
+ hay in the morning
Results: eating pattern (group Prot-)

<table>
<thead>
<tr>
<th>Period 1, TMR1</th>
<th>Period 2, TMR2</th>
<th>Hay in the morning</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-14 Uhr</td>
<td>14-22 Uhr</td>
<td>22-6 Uhr</td>
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</tbody>
</table>

Eating time [min]

Hours of the day

- **: Significant difference
- *: Moderate difference

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Results: rumination pattern (group Prot+)

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Rumination time [min]

Hour of the day

- Period1, TMR1
- Period2, TMR2
- + hay in the morning
Results: rumination pattern (group Prot-)

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<td>22-6 Uhr</td>
</tr>
</tbody>
</table>

Rumination time [min]

Hour of the day
Results: Dry matter intake of cows (kg DM / d)

Period 1
- Prot+: [Data]
- Prot-: [Data]

Period 2
- Prot+: [Data]
- Prot-: [Data]
Results: Crude protein and NEL intake of cows

CP [kg/d]

NEL [MJ/d]
Results: BCS, body weights, milk acetone

BCS

Body weight

milk acetone

[BCS]

Period 1  Period 2  Period 1  Period 2
Prot+  Prot-  Prot+  Prot-

[Body weight]

Period 1  Period 2  Period 1  Period 2
Prot+  Prot-  Prot+  Prot-

[milk acetone]

Period 1  Period 2  Period 1  Period 2
Prot+  Prot-  Prot+  Prot-
## Results: Eating time and activity changes

<table>
<thead>
<tr>
<th></th>
<th>Period 1</th>
<th>Period 2</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group Prot+</td>
<td>Group Prot−</td>
<td>Group Prot+</td>
</tr>
<tr>
<td><strong>Eating time</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eating [min/Tag]</td>
<td>376</td>
<td>376</td>
<td>400</td>
</tr>
<tr>
<td>Eating 6–14 h [min/h]</td>
<td>18,4</td>
<td>18,5</td>
<td>23,2</td>
</tr>
<tr>
<td>Eating 14–22 h [min/h]</td>
<td>19,5</td>
<td>18,8</td>
<td>18,8</td>
</tr>
<tr>
<td>Eating 22–6 h [min/h]</td>
<td>9,7</td>
<td>10,8</td>
<td>8,0</td>
</tr>
<tr>
<td><strong>Activity change</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity changes in 24 h [number/h]</td>
<td>7,86</td>
<td>7,76</td>
<td>6,35</td>
</tr>
<tr>
<td>Activity changes 6–14 h [number/h]</td>
<td>8,27</td>
<td>8,37</td>
<td>7,30</td>
</tr>
<tr>
<td>Activity changes 14–22 h [number/h]</td>
<td>8,75</td>
<td>8,50</td>
<td>7,22</td>
</tr>
<tr>
<td>Activity changes 22–6 h [number/h]</td>
<td>6,06</td>
<td>6,76</td>
<td>4,53</td>
</tr>
</tbody>
</table>

Leiber et al., 2015: *Agrarforschung Schweiz* 6(10): 462-469
Results: performance and protein efficiency

<table>
<thead>
<tr>
<th>Period (P)</th>
<th>Period 1</th>
<th>Period 2</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group (G)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prot + (n=12)</td>
<td>Prot - (n=11)</td>
<td>Prot + (n=12)</td>
<td>Prot - (n=11)</td>
</tr>
<tr>
<td>Milk yield [kg/d]</td>
<td>24.7</td>
<td>21.6</td>
<td>23.4</td>
</tr>
<tr>
<td>Milk protein concentration [g/100g]</td>
<td>3.09</td>
<td>3.20</td>
<td>3.22</td>
</tr>
<tr>
<td>Milk fat concentration [g/100g]</td>
<td>3.81</td>
<td>4.14</td>
<td>3.91</td>
</tr>
<tr>
<td>Milk urea concentration [mg/dl]</td>
<td>16.4</td>
<td>14.3</td>
<td>19.3</td>
</tr>
<tr>
<td>Protein efficiency [g milk protein / g CP intake]</td>
<td>0.235</td>
<td>0.235</td>
<td>0.222</td>
</tr>
</tbody>
</table>

Leiber et al., 2015, *Journal of Dairy Research* 82, 272-278
Results: protein efficiency

Milk protein / ingested CP

Prot+
Prot-
Conclusions I

- Sequential offer of hay in the morning significantly influenced the eating pattern, increasing intake time during daytime and decreasing intake during night time.
- Consequently the number of activity changes per hour decreased, especially during the night time.
  - We assume that this is positively related with animal welfare and health.
- Sequential offer of hay did not influence intake amounts (DM, CP, NEL)
- Concentrate reduction did not influence feeding and rumination behaviour nor milk production
- But concentrate reduction did influence roughage intake positively and promoted a higher ruminal utilisation of degraded CP in the Prot- group (published in: Leiber et al., 2015: J. Dairy Research, 82,272-278)
Conclusions II

- Feeding and rumination behaviour parameters as measured with the noseband sensors proved to be sensitive to feeding management interventions.
- These parameters appear to be useful to assess production- and welfare-relevant responses of cows to feeding management.
- To deepen these aspects and to develop practicable tools on this basis, much broader farm-based data and experiment-based physiological research are needed.
Thank you for your time and attention!
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Introduction: roughage based feeding management

- Ruminal fermentation rate: Moving from the maximum to the optimum?
- Feeding options:
  - Extensive feeding
  - Roughage quality
  - Lower protein supply
  - Plant secondary compounds
- Definitions
- Indicators
- Trade-offs
- Mitigation of methanogenesis
- Improved protein and fibre utilization?
- Higher quality of lipids in products
- Animal parameters:
  - Animal health?
  - Longevity?
  - Feeding behaviour and rumination
- Production parameters
- Animal parameters:
  - Animal health?
  - Longevity?
  - Feeding behaviour and rumination
### Results: intake and apparent digestibility

<table>
<thead>
<tr>
<th>Period (P)</th>
<th>Period 1</th>
<th>Period 2</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group (G)</strong></td>
<td>Prot+ (n=12)</td>
<td>Prot- (n=11)</td>
<td>Prot+ (n=12)</td>
</tr>
<tr>
<td>Intake [kg/d]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total dry matter</td>
<td>20.5</td>
<td>20.4</td>
<td>20.0</td>
</tr>
<tr>
<td>TMR</td>
<td>18.1</td>
<td>20.4</td>
<td>13.7</td>
</tr>
<tr>
<td>Concentrates</td>
<td>2.43</td>
<td>0.0</td>
<td>2.43</td>
</tr>
<tr>
<td>Extra hay</td>
<td>0.0</td>
<td>0.0</td>
<td>3.79</td>
</tr>
<tr>
<td>Crude protein</td>
<td>3.25</td>
<td>2.85</td>
<td>3.21</td>
</tr>
<tr>
<td>NEL [MJ]</td>
<td>117</td>
<td>112</td>
<td>115</td>
</tr>
<tr>
<td><strong>Apparent protein digestibility [%]</strong></td>
<td>68.6</td>
<td>60.7</td>
<td>68.0</td>
</tr>
</tbody>
</table>
## Materials: diet composition

<table>
<thead>
<tr>
<th></th>
<th>TMR1</th>
<th>TMR2</th>
<th>Hay, 2\textsuperscript{nd} cut</th>
<th>Concentr. 1</th>
<th>Concentr. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Avera\textsuperscript{ge}</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude protein [g/kg DM]</td>
<td>140 ±4.5</td>
<td>133 ±3.0</td>
<td>172 ±13.0</td>
<td>250</td>
<td>380</td>
</tr>
<tr>
<td>Acid detergent fibre [g/kg DM]</td>
<td>298 ±30</td>
<td>293 ±0.0</td>
<td>335 ±20.5</td>
<td>80.7</td>
<td>77.2</td>
</tr>
<tr>
<td>Lignin [g/kg DM]</td>
<td>41.9 ±0.65</td>
<td>38.9 ±1.35</td>
<td>48.0 ±6.45</td>
<td>2.7</td>
<td>2.5</td>
</tr>
<tr>
<td>Crude Ash [g/kg DM]</td>
<td>91.6 ±0.05</td>
<td>85.8 ±0.10</td>
<td>90.2 ±0.95</td>
<td>70</td>
<td>95</td>
</tr>
<tr>
<td>NEL [MJ/kg]</td>
<td>5.65 ±0.05</td>
<td>5.70 ±0.00</td>
<td>5.40 ±0.30</td>
<td>7.5</td>
<td>7.0</td>
</tr>
</tbody>
</table>
Results: protein efficiency

Milk protein / ingested CP

Milk protein / app. digested CP

Prot+

Prot-
Results: protein efficiency

![Graph showing protein efficiency for milk protein ingested CP and milk protein applied digested CP with Prot+ and Prot- categories.](chart.png)