Treatment with lactic acid of concentrates alleviates the lack of inorganic P in dairy cow diets

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Background

- **Phosphorus (P):** key mineral for rumen microbes and the host ruminant
- in high-producing cows: P mainly provided via concentrates
  -> phytate-bound

- incomplete degradation of phytate via ruminal microbial phytase
- -> typically inorganic P supplemented

**P is the main polluting nutrients!**

-> Methods to enhance the efficiency of the usage of phytate-P needed!
Background

- Treatments of grains with organic acids (i.e., Lactic Acid)

J. Dairy Sci. 98:8107–8120
http://dx.doi.org/10.3168/jds.2015-9913

Treatment of grain with organic acids at 2 different dietary phosphorus levels modulates ruminal microbial community structure and fermentation patterns in vitro

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Aim of the study

Evaluation of the effects of feeding concentrates steeped in 5% Lactic Acid (LA) with or without inorganic P supplementation on:

- Feed intake
- Milk production performance
- Metabolic health variables
Material and Methods

- 16 cows (4 primiparous, 12 multiparous)
- 12 Simmental cows (initial BW: 798 ± 24 kg)
- 4 Brown Swiss cows (initial BW: 642 ± 22 kg)

- Included: from the day of parturition until d 37 postpartum

- loose-housing stable with straw bedding
- individual feeders with electronic weighing scales and computer-regulated access gates

- allocated to 1 of 3 different experimental groups
Treatment of concentrate with LA

5% LA mixed soaked for 24 h
Ratio solution: grain: 1.2/1

Fed as TMR

Individual feeders
Different TMRs for early lactating cows

<table>
<thead>
<tr>
<th>Ingredient, % of DM</th>
<th>CON</th>
<th>LA (+P)</th>
<th>LA (-P)</th>
<th>Nutrient, % of DM unless stated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meadow hay</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
<td>DM, % of FM</td>
</tr>
<tr>
<td>Grass silage</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
<td>Ash</td>
</tr>
<tr>
<td>Corn silage</td>
<td>33.0</td>
<td>33.0</td>
<td>33.0</td>
<td>CP</td>
</tr>
<tr>
<td>Concentrate with inorganic P, without LA treatment¹</td>
<td>-</td>
<td>47.0</td>
<td>-</td>
<td>NDF</td>
</tr>
<tr>
<td>Concentrate with inorganic P, with LA treatment²</td>
<td>-</td>
<td>-</td>
<td>47.0</td>
<td>ADF</td>
</tr>
<tr>
<td>Concentrate without inorganic P, with LA treatment³</td>
<td>-</td>
<td>-</td>
<td>47.0</td>
<td>NFC</td>
</tr>
</tbody>
</table>

1 55% barley, 25% soybean meal, 9% rapeseed meal, 4% wheat bran, 3% dried beet pulp, 0.45% limestone, 0.25% salt, 
0.8% monocalciumphosphate, 0.5% urea, and 2% mineral premix containing 4% P.

2 comprised of the same ingredients as the CON-concentrate but was soaked in 5% LA for 24 h prior to feeding.

3 contained: 56.6% barley, 25% soybean meal, 9% rapeseed meal, 4% wheat bran, 2% dried beet pulp, 0.60% limestone, 
0.25% salt, 0.5% urea and 2% mineral premix without P and was soaked in 5% LA for 24 h prior to feeding.
Data Collection and Analysis

- Weekly analysis of TMRs
- Weekly determination of body weight
- Milked twice daily and milk yield recorded
- **Blood samples** collected 1 h before morning feeding on d 11, 18, 25 and 37 in milk
  - Analysis of selected blood metabolites related to glucose and lipid metabolism, liver enzymes (AST, GLDH, GGT), acute phase protein (SAA) and minerals (Ca, P)
- on d 36 and 37: 0, 2, 4, and 12 h after morning feeding
  - Analysis of diurnal variation of metabolites related to glucose and lipid metabolism as well as Ca and P
Statistical analysis

- ANOVA, Proc MIXED (SAS, 9.2)
- **Fixed effects:** diet, time (i.e., DIM or hour relative to morning feeding), diet x time
- **Random effects:** breed, lactation number
- Data from same cow: repeated measurements (first-order autoregressive)
- Tukey`s Test for comparisons among LSM
- **Linear Contrasts:**
  -> overall effect of LA (CON vs. average of LA(+P) and LA(-P))
  -> overall effect of inorganic P supplementation ((LA(-P) vs. average of CON and LA(+P))
- Pd0.05: significance; 0.05 < P d 0.10: trend
DMI of early lactation TMRs

Start of ad libidium feeding of early lactation TMRs

Additional ad libidium feeding of close-up TMR

CON  LA (+P)  LA (-P)

Diet: $P<0.01$
CON vs. LA: $P<0.01$
+P vs. -P: $P=0.02$
Glucose and NEFA

Diet: $P=0.10$
CON vs. LA: $P=0.28$
+P vs. -P: $P=0.04$

Diet: $P=0.14$
CON vs. LA: $P=0.07$
+P vs. -P: $P=0.07$
Diurnal Variation NEFA and Insulin

**NEFA (mmol/L)**
- Diet: $P=0.02$
- CON vs. LA: $P<0.01$
- +P vs. -P: $P=0.08$

**Insulin (µg/L)**
- Diet: $P=0.08$
- CON vs. LA: $P=0.03$
- +P vs. -P: $P=0.14$
Cholesterol and Serum Amyloid A

**Diet:**
- **CON vs. LA:** $P < 0.01$
- **+P vs. -P:** $P = 0.01$

- **Diet:** $P = 0.69$
- **CON vs. LA:** $P = 0.41$
- **+P vs. -P:** $P = 0.52$

**Graphs:**
- Cholesterol (mg/dL) vs. Day in milk
- Serum Amyloid A (µg/mL) vs. Day in milk
P and Ca:P

Diet: P=0.22
CON vs. LA: P=0.10
+P vs. -P: P=0.61

Diet: P=0.12
CON vs. LA: P=0.05
+P vs. -P: P=0.47
## Milk Parameters and Body Weight

<table>
<thead>
<tr>
<th></th>
<th>Diet</th>
<th>SEM</th>
<th>P-Value&lt;sup&gt;1&lt;/sup&gt;</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>CON</td>
<td>LA (+P)</td>
<td>LA (-P)</td>
</tr>
<tr>
<td>Milk yield, kg/d</td>
<td>33.4</td>
<td>34.9</td>
<td>32.4</td>
</tr>
<tr>
<td>Milk composition, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>3.88</td>
<td>4.21</td>
<td>3.68</td>
</tr>
<tr>
<td>Protein</td>
<td>3.27</td>
<td>3.08</td>
<td>3.14</td>
</tr>
<tr>
<td><strong>Lactose</strong></td>
<td><strong>4.79&lt;sup&gt;a&lt;/sup&gt;</strong></td>
<td><strong>4.66&lt;sup&gt;b&lt;/sup&gt;</strong></td>
<td><strong>4.68&lt;sup&gt;ab&lt;/sup&gt;</strong></td>
</tr>
<tr>
<td>Fat:Protein</td>
<td>1.24</td>
<td>1.38</td>
<td>1.18</td>
</tr>
<tr>
<td>SCC, cells/mL</td>
<td>41,769</td>
<td>24,685</td>
<td>33,984</td>
</tr>
<tr>
<td>MUN, mg/dL</td>
<td>38.4</td>
<td>38.4</td>
<td>36.4</td>
</tr>
<tr>
<td>Milk pH</td>
<td>6.54</td>
<td>6.52</td>
<td>6.53</td>
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<tr>
<td>BW, kg</td>
<td>745.3</td>
<td>700.8</td>
<td>701.4</td>
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<tr>
<td>BW change, kg</td>
<td>-26.6</td>
<td>-26.4</td>
<td>-23.2</td>
</tr>
</tbody>
</table>
Conclusions

Feeding early-lactating cows concentrates steeped in 5% LA with or without inorganic P supplementation:

- impaired DMI during the first 2 weeks of ad libitum feeding
- did not affect milk production or body weight
- lowered serum NEFA, insulin and cholesterol
  -> improved energy status
- tended to increase serum P
  -> potential to save inorganic P supplements
Acknowledgments

- Team of Animal Nutrition at Vetmeduni Vienna
- Staff of research station Kremesberg (Vetmeduni)
- Funders:
  - „optGerste“
  - „functional feed for cows“
Thank you very much for your attention!
### Further Blood Analysis

<table>
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<th>Diet</th>
<th>SEM</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CON</td>
<td>LA (+P)</td>
<td>LA (-P)</td>
</tr>
<tr>
<td>BHB, mmol/L</td>
<td>0.52</td>
<td>0.61</td>
<td>0.51</td>
</tr>
<tr>
<td>Lactate, mmol/L</td>
<td>0.69</td>
<td>0.76</td>
<td>0.72</td>
</tr>
<tr>
<td>BUN, mg/dL</td>
<td>36.7</td>
<td>34.3</td>
<td>36.9</td>
</tr>
<tr>
<td>TP, g/dL</td>
<td>7.27</td>
<td>7.11</td>
<td>7.37</td>
</tr>
<tr>
<td>Ca, mmol/L</td>
<td>2.36</td>
<td>2.38</td>
<td>2.39</td>
</tr>
<tr>
<td>AST, U/L</td>
<td>71.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>90.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>63.8&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>GLDH, U/L</td>
<td>21.92</td>
<td>14.44</td>
<td>8.41</td>
</tr>
<tr>
<td>GGT, U/L</td>
<td>22.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.7&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bilirubin, mg/dL</td>
<td>0.109</td>
<td>0.122</td>
<td>0.069</td>
</tr>
<tr>
<td>Bile acids, µmol/L</td>
<td>58.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>42.1&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>28.5&lt;sup&gt;b&lt;/sup&gt;</td>
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</tbody>
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