Feed4Foodure
Phosphorus utilization in dairy cattle

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Contents

- Reducing Phosphorus (P) excretion by dairy cows
- P metabolism: Dairy cows ≠ pigs
- Research aspects that provide the most interesting opportunities to improve P utilization in dairy cattle
- Modelling P utilization
Reducing P excretion by dairy cows

No mineral element with more known biological functions than P (NRC, 2001), but...

- Increased environmental concerns related to P
  - Nutrient leaching from agricultural soils (eutrophication risks)
- Stringent legislation on nutrient management (EU, USA)
  - Costs of manure disposal
- Expected scarcity of mineral P resources (Cordell et al. 2009)
  - P recycling and efficient use of P

P utilization: A dairy cow is not a pig...

<table>
<thead>
<tr>
<th>Important aspects regarding P utilization in pigs</th>
<th>Relevance in dairy cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>P intake</td>
<td>=</td>
</tr>
<tr>
<td>Phytate/phytase</td>
<td>×</td>
</tr>
<tr>
<td>Ca:P ratio in diet</td>
<td>= ×</td>
</tr>
<tr>
<td>P absorption in the GI tract</td>
<td>×</td>
</tr>
<tr>
<td>Urinary P excretion</td>
<td>×</td>
</tr>
</tbody>
</table>

Because P metabolism in dairy cows is different
Major P flows in dairy cattle

- P intake
- Rumen microbial P
- Saliva P
- Plasma P
- Bone/tissue P
- Urinary P
- Fecal P
- Milk P

P utilization lactating dairy cows

- Example P efficiency based on data from 6 balance trials (Valk et al., 2002)
  - Average FCM yield 33 kg/d
  - Average DMI 23 kg/d (3.4 g P/kg DM)

<table>
<thead>
<tr>
<th>P flow</th>
<th>g/d (% of intake)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P intake</td>
<td>78 (100)</td>
</tr>
<tr>
<td>P in feces</td>
<td>38 (49)</td>
</tr>
<tr>
<td>P in milk</td>
<td>34 (43)</td>
</tr>
<tr>
<td>P in urine</td>
<td>1 (1)</td>
</tr>
<tr>
<td>P balance</td>
<td>5 (6)</td>
</tr>
</tbody>
</table>
**Importance of P dynamics bone/tissue**

Meta-analysis (25 studies, 130 treatments)

P in feces (g/d) = \(-3.8(\pm 3.45) + 0.64(\pm 0.038) \times \) P intake (g/d)

P balance data from 14 studies (n=81)

Klop et al., 2013 – JDS 96:3936-3949

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**Importance of P dynamics bone/tissue**

Meta-analysis (25 studies, 130 treatments)

P in feces (g/d) = \(19.9(\pm 5.07) + 0.79(\pm 0.060) \times \) P intake (g/d) 
\(-1.04(\pm 0.127) \times \) milk production (kg/d)

P balance data from 14 studies (n=81)

Klop et al., 2013 – JDS 96:3936-3949
Long term effects of lower dietary P?

- Dairy cattle rations in the NL → difficult to feed far below P requirements
- Influence of lactation stage/P balance?
- Need for **accurate** ‘tools’ to monitor P status and P utilization efficiency in dairy cows...

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sampling constraints</th>
<th>Indicator for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saliva</td>
<td>Differences between glands</td>
<td>Plasma P/P supply to gastro-intestinal tract</td>
</tr>
<tr>
<td>Blood</td>
<td>Simple, but still invasive</td>
<td>?</td>
</tr>
<tr>
<td>Milk</td>
<td>None</td>
<td>P use efficiency</td>
</tr>
<tr>
<td>Feces</td>
<td>Diurnal variation</td>
<td>P use efficiency/P status</td>
</tr>
</tbody>
</table>

**P in milk**

- Comprises a major fraction of total P requirements (*CVB, 2005; NRC, 2001*)
- Concentration of P in milk is **NOT** constant (*Lenstrup, 1926; Bannink et al., 2010*)
- Milk P (g/kg) is partly related to milk composition (*Klop et al., 2013*)
- What are other reasons for variation?
P requirements and milk production

Fig. 10.4. Dependency of recommended P allowance on milk yield of (dry and lactating) cows in various countries: UK (AFRC, 1991); GE (GIE, 1993); USA (NRC, 2001); NL (CVB, 2005).

Bannink et al., 2010

P in milk - Empirical relationships (1)

- Protein and lactose and P content of milk
- Empirical relationship, but also physiological mechanism
- Explains more of the observed variation than fixed value of either 0.9 or 1.0 g P/kg milk

Klop et al., J Agric. Sci., accepted
P in milk - Empirical relationships (2)

Independent prediction based on protein and lactose content of milk

Fixed value (NRC, 2001)

R² = 0.526

Observed milk P content (g/kg milk) vs Predicted milk P content (g/kg milk)

Klop et al., unpublished data

Mechanistic modelling of P

- Better understanding of P dynamics
  - Response based
  - Variation in milk P content
  - Influence P dynamics bone/tissue

- Input data from reliable in vivo experiments

- Extant mechanistic model on P metabolism in dairy cows needs to be improved
Take home message

- P metabolism in dairy cows differs from non-ruminant species → different research questions
- Most important areas for further research
  - P in milk
  - P dynamics bone/tissue i.r.t. P utilization
  - Biomarkers in feces, saliva, milk as simple tools?
  - Mechanistic modelling of P metabolism in dairy cows
Thank you

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