Influence of dietary calcium on growth performance and mineral status in weaned piglets.

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## Materials and methods

### Two experiments

<table>
<thead>
<tr>
<th>Diet</th>
<th>Exp 1</th>
<th>Exp 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>DE [MJ/kg]</td>
<td>14.0</td>
<td>14.0</td>
</tr>
<tr>
<td>CP [g/kg]</td>
<td>170</td>
<td>186</td>
</tr>
<tr>
<td>P [g/kg]</td>
<td>4.1</td>
<td>4.2</td>
</tr>
<tr>
<td>Phytic P [g/kg]</td>
<td>n.d.</td>
<td>2.4</td>
</tr>
<tr>
<td>Phytase [FTU/kg]</td>
<td>1300</td>
<td>650</td>
</tr>
<tr>
<td><strong>Digestible P [g/kg]</strong></td>
<td>3.0</td>
<td>2.9</td>
</tr>
</tbody>
</table>

### Treatments:

**Exp 1:** 2 treatments: 6; 8 g Ca / kg (68 piglets; 4 pens)

**Exp 2:** 3 treatments: 4; 7; 10 g Ca / kg (36 piglets; 3 pens)

### Supplemented dietary Ca sources:

**Exp 1:** DCP (4.1 g/kg), Ca formiate (10 g/kg), CaCO₃ (0 – 6.1 g/kg)

**Exp 2:** Ca butyrate (2 g/kg), CaCO₃ (4.4 – 20 g/kg)
Materials and methods
Materials and methods

Data:
- Performance (FI, ADG, FCR)
- Urine (pH, creatinine, Ca and P content)
- Blood (Ca and P content in serum)
- Bone (ash, density, breaking strength)

Measure of bone (tibia) breaking strength
Materials and methods

Data analysis

GLM procedure

\[ Y = a + a_{\text{block}} + Ca + Ca^2 + e \]

\(a\) is the intercept
\(a_{\text{block}}\) is the effect of the animal block on the intercept \(a\)
\(Ca\) is the dietary \(Ca\) content
\(e\) is the error

The piglet was considered as the experimental unit.
# Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>Intercept</th>
<th>Ca</th>
<th>Ca²</th>
<th>P-values</th>
<th>P-values</th>
<th>Ca</th>
<th>Ca²</th>
<th>R²</th>
<th>r.m.s.e</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWG</td>
<td>[g/d]</td>
<td>365</td>
<td>-10.236</td>
<td></td>
<td>*</td>
<td>n.s.</td>
<td>0.51</td>
<td>72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FI</td>
<td>[g/d]</td>
<td>513</td>
<td></td>
<td></td>
<td></td>
<td>n.s.</td>
<td>0.52</td>
<td>99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FCR</td>
<td></td>
<td>1.36</td>
<td>0.039</td>
<td></td>
<td>***</td>
<td>n.s.</td>
<td>0.57</td>
<td>0.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urinary pH</td>
<td></td>
<td>7.50</td>
<td>-0.840</td>
<td>0.0817</td>
<td>+</td>
<td>*</td>
<td>0.85</td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urinary Ca</td>
<td>[mol / mol creatinine]</td>
<td>-3.265</td>
<td>0.849</td>
<td></td>
<td>***</td>
<td>n.s.</td>
<td>0.84</td>
<td>1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urinary P</td>
<td>[mol / mol creatinine]</td>
<td>7.60</td>
<td>-2.146</td>
<td>0.151</td>
<td>***</td>
<td>***</td>
<td>0.69</td>
<td>0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum Ca</td>
<td>[mmol/l]</td>
<td>2.21</td>
<td>0.103</td>
<td></td>
<td>***</td>
<td>n.s.</td>
<td>0.75</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum P</td>
<td>[mmol/l]</td>
<td>4.80</td>
<td>-0.265</td>
<td></td>
<td>***</td>
<td>n.s.</td>
<td>0.70</td>
<td>0.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bone ash</td>
<td>[g/kg DM]</td>
<td>348</td>
<td>47.7</td>
<td>-3.082</td>
<td>+</td>
<td>+</td>
<td>0.41</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bone density</td>
<td>[g/cm³]</td>
<td>0.65</td>
<td>0.158</td>
<td>-0.011</td>
<td>+</td>
<td>+</td>
<td>0.39</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bone breaking strenght</td>
<td>[N]</td>
<td>609</td>
<td>173.73</td>
<td>-13.34</td>
<td>*</td>
<td>*</td>
<td>0.72</td>
<td>158</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** P < 0.001; ** P < 0.01; * P < 0.05; + P < 0.10; n.s. P > 0.10

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Results

dietary Ca ↑: ⇒ Deteriorated growth (BWG, FCR)
Results

With dietary Ca $\geq$ 8 g Ca / kg diet.

⇒ P deficiency

⇒ Reason: probably reduced P absorp.

⇒ Reduced growth is probably the consequence.

Lower Ca ref. : 2.3 mmol/l

Lower P ref. : 2.5 mmol/l
Results

With dietary Ca
⇒ increased uri Ca
⇒ decreased uri P
High serum P and urinary P indicate: P mineralisation due to limiting Ca
⇒ Consequence: reduced bone characteristics

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Results

Dietary Ca [g/kg]

FCR
Serum Ca
Serum P
Urinary Ca
Urinary P
BWG
Bone breaking strength
Bone ash

Results

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Conclusions

This data illustrates the importance of dietary Ca in optimizing P efficiency when feeding low P diets including exogenous phytase (3 g dP / kg diet)

- **Low dietary Ca (< 5.0 g Ca / kg):** insufficient for optimal P use.
  
  Reason: The absorbed P can’t be mineralized due to missing Ca.
  
  Shown with serum P ↑ urinary P ↑ and bone characteristics ↓

- **High dietary Ca ( > 8.0 g Ca / kg):** excessive for an optimal P use.
  
  Reason: possibly limited P absorption by complexing in the digestive tract with inorganic P to form insoluble, thus unabsorbable P.
  
  Shown with serum P ↓ urinary P ↓, bone breaking strength ↓ and growth ↓
Conclusions

In low P diets including exogenous phytase (3 g dP / kg), the following critical Ca levels were observed:

<table>
<thead>
<tr>
<th></th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Optimal growth:</strong></td>
<td>5.0 – 5.5 g Ca / kg diet (with 3.0 g dP)</td>
</tr>
<tr>
<td></td>
<td>Ca : dP of 1.7 – 1.8</td>
</tr>
<tr>
<td><strong>Maximal bone characteristics:</strong></td>
<td>6.0 – 7.0 g Ca / kg diet (with 3.0 g dP)</td>
</tr>
<tr>
<td></td>
<td>Ca : dP of 2.0 – 2.3</td>
</tr>
<tr>
<td><strong>Risk for Ca-deficiency:</strong></td>
<td>&lt; 4.5 g Ca / kg diet (with 3.0 g dP)</td>
</tr>
<tr>
<td></td>
<td>Ca : dP of &lt; 1.5</td>
</tr>
<tr>
<td><strong>Risk for P-deficiency:</strong></td>
<td>&gt; 8.5 g Ca / kg diet (with 3.0 g dP)</td>
</tr>
<tr>
<td></td>
<td>Ca : dP of &gt; 2.8</td>
</tr>
</tbody>
</table>
Thanks !