Supplementary crude protein and phosphorus levels: effect on spring milk production in dairy cows

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Introduction

- Irish dairy industry is grass-based system
- Effectively grazed grass is cheapest feed available for Irish farms (Dillon et al., 1995)
- Maximum profitability for dairy farms achieved through optimum utilisation of grass (O’Donovan et al., 2007)
- Dietary crude protein can affect milk composition (Broderick 2003)
  - Protein composition of milk is central to milk processability (O’Brien et al., 1996)
Introduction

- Phosphorus has more known functions in animal body than other minerals
  - Vital for energy metabolism in the formation of phosphates and ATP/ADP (McDonald et al., 2001)
- Reduced dietary phosphorus can have negative impact on milk protein (Wu and Satter, 2000)
  - Anecdotal evidence of cows exhibiting signs of phosphorus deficiency (e.g. eating stones)
Background

- In 2012, 58% whole milk was processed as butter and 31% as cheese (IDB, 2012)
  - Necessary to include measurements related to milk processability in experimental studies

- Milk urea nitrogen (MUN) is an indicator of non-protein nitrogen (NPN) in milk. The concentration of NPN is an important factor in terms of milk processability
  - high NPN $\rightarrow$ poor processability

- \(~\) half of phosphorus in milk protein is complexed with casein
  - a reduction in dietary phosphorus may have negative implications for casein concentration
  - and processability (Satter 2003)
Objectives

- Assess effects of differing dietary nitrogen and phosphorus concentrations on:
  - Milk yield
  - Milk composition
  - Dry matter intake
  - Body weight (BW) and body condition score (BCS)
  - Animal N and P status
    - Faecal and urine N and P concentration
    - Blood N and P concentration

- Duration: 8 weeks (March – May 2012)
Materials and Methods (1)

- 48 spring-calving dairy cows
- In early lactation (Mar – May)
- Randomly allocated to one of four supplementary concentrate treatments (4 kg DM per cow per day) (randomised complete block design)
  - High protein, high phosphorus (HPr-HP)
  - Medium protein, high phosphorus (MPr-HP)
  - Low protein, high phosphorus (LPr-HP)
  - Low protein, low phosphorus (LPr-LP)
- Randomised based on:
  - Calving date
  - BW and BCS
  - Milk yield and composition
- Offered 13 kg DM grass per cow per day
- Breed
- Economic Breeding Index (EBI)
- Age/Parity
### Materials and Methods (2)

- **Diet summary**

<table>
<thead>
<tr>
<th></th>
<th>Crude Protein (g/kg DM)</th>
<th>Phosphorus (g/kg DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPr-HP</td>
<td>266</td>
<td>3.5</td>
</tr>
<tr>
<td>MPr-HP</td>
<td>239</td>
<td>3.0</td>
</tr>
<tr>
<td>LPr-HP</td>
<td>224</td>
<td>3.1</td>
</tr>
<tr>
<td>LPr-LP</td>
<td>224</td>
<td>2.2</td>
</tr>
</tbody>
</table>

- Mean grass CP: $268 \pm 30.8$ g/kg DM (higher than expected)
- Mean grass P: $2.7 \pm 0.31$ g/kg DM (lower than expected)
Materials and Methods (3)

- Milk yield
  - Monitored and recorded daily

- Milk composition:
  - Assessed using four concurrent milkings per week (by cow)
  - Analysed by mid infra-red spectroscopy (MIR)

- Milk nitrogen fractions
  - Assessed on three occasions with bulked treatment samples
  - Analysed using the Kjeldahl method

- Grass dry matter intake (DMI):
  - Assessed on one occasion using the n-alkane technique (Dillon and Stakelum, 1989)

- BW and BCS:
  - Assessed and recorded weekly
Materials and Methods (4)

- Animal N and P status
  - Faecal and urine N and P concentration assessed on one occasion
  - Blood N and P concentration:
    - Three occasions – Pre experiment, mid-experiment and post-experiment
Statistical Analysis

- Data analysed using PROC MIXED (SAS, 2001)
  - Terms for treatment, week and treatment x week interaction included in model
  - Cow included as random effect
  - Appropriate covariate used in model
Results (1)

The effects on animal performance of offering concentrates differing in crude protein and phosphorus concentration to grazing dairy cows in early lactation

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<thead>
<tr>
<th></th>
<th>HPr-HP</th>
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<th>Significance</th>
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<tbody>
<tr>
<td>Milk Yield (Kg)</td>
<td>27.6</td>
<td>27.0</td>
<td>26.2</td>
<td>27.0</td>
<td>0.73</td>
<td>ns</td>
</tr>
<tr>
<td>Milk Fat (g/kg)</td>
<td>44.5</td>
<td>45.4</td>
<td>46.2</td>
<td>42.7</td>
<td>1.43</td>
<td>ns</td>
</tr>
<tr>
<td>Milk Protein (g/kg)</td>
<td>34.0</td>
<td>33.6</td>
<td>33.7</td>
<td>33.9</td>
<td>0.37</td>
<td>ns</td>
</tr>
<tr>
<td>Milk Solids Yield (Kg)</td>
<td>2.1</td>
<td>2.1</td>
<td>2.0</td>
<td>2.1</td>
<td>0.05</td>
<td>ns</td>
</tr>
<tr>
<td>Casein (%)</td>
<td>2.66</td>
<td>2.60</td>
<td>2.60</td>
<td>2.61</td>
<td>0.031</td>
<td>ns</td>
</tr>
<tr>
<td>Conc Intake (kg DM)</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.8&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>3.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.08</td>
<td>**</td>
</tr>
<tr>
<td>BW Change (Kg)</td>
<td>39</td>
<td>23</td>
<td>12</td>
<td>22</td>
<td>6.6</td>
<td>ns</td>
</tr>
<tr>
<td>BCS Change</td>
<td>-0.05</td>
<td>-0.10</td>
<td>-0.13</td>
<td>-0.05</td>
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a-b Means within a row not sharing a common superscript differ significantly (P < 0.05)
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The effects on animal performance of offering concentrates differing in crude protein and phosphorus concentration to grazing dairy cows in early lactation

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<tr>
<td>GDMI (kg DM)</td>
<td>11.9</td>
<td>12.4</td>
<td>13.6</td>
<td>13.2</td>
<td>0.48</td>
<td>0.06</td>
</tr>
</tbody>
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<sup>a-b</sup> Means within a row not sharing a common superscript differ significantly (P<0.05)
Results (2)

High MUN is an indicator of excess protein in the diet

Both low protein diets, irrespective of P conc, had similar and lower MUN conc

- Significant time by treatment interaction
- During weeks 1 – 7 there were differences between treatments
The effects on milk N fractions of offering concentrates differing in crude protein and phosphorus concentration to grazing dairy cows in early lactation

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<th>LP&lt;sub&gt;r&lt;/sub&gt;-HP</th>
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<th>Sig.</th>
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<td>Total Protein</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>True Protein</td>
<td>0.941</td>
<td>0.946</td>
<td>0.948</td>
<td>0.950</td>
<td>0.0056</td>
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</tr>
<tr>
<td>NPN</td>
<td>0.059</td>
<td>0.054</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casein</td>
<td>0.829</td>
<td>0.814</td>
<td>0.822</td>
<td>0.828</td>
<td>0.0049</td>
<td>ns</td>
</tr>
<tr>
<td>Whey</td>
<td>0.171</td>
<td>0.186</td>
<td>0.178</td>
<td>0.172</td>
<td>0.0049</td>
<td>ns</td>
</tr>
</tbody>
</table>
Results (5)

The effects on animal N status of offering concentrates differing in crude protein and phosphorus concentration to grazing dairy cows in early lactation

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<tr>
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<th>HP r-HP</th>
<th>MP r-HP</th>
<th>LP r-HP</th>
<th>LP r-LP</th>
<th>S.E.</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faecal N (g/kg DM)</td>
<td>32.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>31.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>33.4&lt;sup&gt;ac&lt;/sup&gt;</td>
<td>34.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.29</td>
<td>*</td>
</tr>
<tr>
<td>Urine N (mmol/l)</td>
<td>13.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.8&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>9.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.76</td>
<td>***</td>
</tr>
</tbody>
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![Blood Urea Concentration](chart.png)

Blood Urea Concentration

- **HP r-HP**: Red line
- **MP r-HP**: Black line
- **LP r-HP**: Green line
- **LP r-LP**: Blue line

Sample Period:
- **pre**
- **mid**
- **post**
# Results (6)

The effects on animal P status of offering concentrates differing in crude protein and phosphorus concentration to grazing dairy cows in early lactation

<table>
<thead>
<tr>
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<th>HP&lt;sub&gt;r&lt;/sub&gt;-HP</th>
<th>MP&lt;sub&gt;r&lt;/sub&gt;-HP</th>
<th>LP&lt;sub&gt;r&lt;/sub&gt;-HP</th>
<th>LP&lt;sub&gt;r&lt;/sub&gt;-LP</th>
<th>S.E.</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faecal P (g/kg dm)</td>
<td>6.48&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.90&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.678</td>
<td>***</td>
</tr>
<tr>
<td>Urine P (mmol/l)</td>
<td>0.21</td>
<td>0.24</td>
<td>0.17</td>
<td>0.19</td>
<td>0.009</td>
<td>ns</td>
</tr>
<tr>
<td>Blood P (mmol/l)</td>
<td>1.28&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.23&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.95&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.071</td>
<td>***</td>
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Blood P in LP<sub>r</sub>LP dropped below NRC (2001) recommended level of 1.1 mmol/l
Effect of Dietary Protein

- No effect of dietary CP on
  - Milk yield
  - Milk solids

  However......

- Reduction in dietary CP significantly reduced MUN concentration
  - Positive processability implications
Effect of Dietary Phosphorus

- Reduction in dietary P significantly reduced faecal P output
  - Positive environmental implications – as reduced excretion to the environment
  - But dietary P dropped below recommended levels when low P diet was offered
Take Home Message

- Low protein supplementary feeds have an important role in grass-based diets
- Knowledge of farm mineral status is essential in order to meet dietary mineral recommendations

Thank you
Questions that were asked:

Q: What was the herbage P conc?
   » A: 2.7 g/kg

Q: Were the treatment balanced for energy isometrically, and were the PDIN:PDIE levels adequate to support a lactating dairy cow at this stage of lactation?
   » A: yes, all treatment were balanced for energy, with concentrate UFL’s ranging from 1.12 – 1.14, and the PDIE:PDIN were above the recommended level.

Q: Are there any full-lactation studies, why such a short study?
   » A: Wanted to capture the early lactation period as this is the time that concentrates are routinely offered. It is the aim of Irish grass-based systems to include as much grass in the diet, so when there is enough grass, it becomes the sole constituent of the diet.

Q: What was the herbage CP?
   » A: 27%

Q: Was I recommending that a high-protein conc should be offered, as they produced more milk, even though it wasn’t significant?
   » A: No, it wasn’t significant and the reduction in MUN was significant, meaning better suited for processing. Provided there is adequate grass in the diet, there should be enough CP to allow a low CP conc to be given.

Q: What is the optimum MUN concentration that processors want?
   » A: Studies on high-input systems have recommendations of approx 15 – 25 mg/100ml, however, not much research on grass-based systems. In terms of processors, the lower the better. We had high levels due to there being high protein in the grass.