Phase Feeding for Pregnant Sows

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Overview

- Current status of sow feeding
- Amino acid requirements and availability
- Energy requirements and energy use
- Feeding recommendations
Current status

- NRC (1998) recommended:
  - Constant feed allowance during gestation
  - Constant amino acid requirement
  - Use of feedstuffs energy contents and amino acid digestibility from grower pigs

- NRC recommendations currently being revised
  - Acknowledgement of new results and changed feeding practices
New development: phase feeding

- Implemented by some producers
  - Increased feed allowance in late gestation
  - ‘Top dressing’ regular feed allowance
- Benefits aimed for
  - Maintain body composition
  - Better rebreeding
  - Greater longevity
as pregnancy progresses…

Fetal protein mass, mammary weight and sow heat production increase sharply after 70 days of pregnancy.
Recent recommendations

• Modeling sow and conceptus growth, GfE (2008) and Kim et al. (2009) proposed:
  – Phase feeding pregnant sows
  – Feeding pregnant sows according to parity (GfE)

• GfE, Kim: differences in requirement values or when to change diets

• Experimental data needed to validate modeled requirement values
Supporting new data

• Srichana (2006): N balance
  – Lysine requirement for pregnant gilts
  – Use of Lys-HCl in sows

• Ball group (Franco, Levesque, Moehn, Samuel): Indicator amino acid oxidation and calorimetry
  – Amino acid requirement in pregnancy
  – Sow energy expenditure
  – Amino acid availability
New approach: Indicator oxidation with calorimetry

- **Amino Acids - Indicator amino acid oxidation**
  - Isotope tracer in feed, collect $^{13}\text{CO}_2$ in breath
  - Rapid: 2 days adaptation, 1 day measurement
  - 3 weeks – get mean req’t and individual req’ts

- **Energy - Indirect calorimetry**
  - measure oxygen and carbon dioxide in breath
  - calculate heat production every minute for 24 h
  - energy requirement
Experiments – Ball group

• Lysine, threonine, isoleucine maintenance requirement

• Amino acid requirement in gestation
  – Early gestation: ca. day 25-60 of pregnancy
  – Late gestation: ca. day 85-110 of pregnancy

• All experiments
  – 6 amino acid levels tested
  – Each sow received each amino acid level
  – Same Hypor sows used in early and late gestation
# Gestation experiments

<table>
<thead>
<tr>
<th>Parity</th>
<th>n (sows)</th>
<th>n (obs.)</th>
<th>Breeding weight, kg</th>
<th>ME intake, MJ/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threonine 2</td>
<td>6</td>
<td>71</td>
<td>165.5</td>
<td>32.0</td>
</tr>
<tr>
<td>Threonine 3 - 4</td>
<td>8</td>
<td>92</td>
<td>209.8</td>
<td>33.2</td>
</tr>
<tr>
<td>Isoleucine 4</td>
<td>7</td>
<td>76</td>
<td>231.7</td>
<td>34.5</td>
</tr>
<tr>
<td>Lysine 2 - 3</td>
<td>7</td>
<td>78</td>
<td>185.7</td>
<td>33.7</td>
</tr>
<tr>
<td>Tryptophan 2</td>
<td>6</td>
<td>68</td>
<td>167.7</td>
<td>33.2</td>
</tr>
</tbody>
</table>
## Sow performance

<table>
<thead>
<tr>
<th>Parity</th>
<th>BW, kg</th>
<th>Mat. gain, kg</th>
<th>PD, g/d</th>
<th>RE, MJ/d</th>
<th>Litter size</th>
<th>Litter wt., kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>EG</td>
<td>177</td>
<td>44</td>
<td>32</td>
<td>3.0</td>
<td>13.8</td>
</tr>
<tr>
<td></td>
<td>LG</td>
<td>215</td>
<td></td>
<td>126</td>
<td>-0.7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>EG</td>
<td>205</td>
<td>40</td>
<td>38</td>
<td>1.2</td>
<td>13.6</td>
</tr>
<tr>
<td></td>
<td>LG</td>
<td>244</td>
<td></td>
<td>119</td>
<td>-0.9</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>EG</td>
<td>240</td>
<td>25</td>
<td>4</td>
<td>1.5</td>
<td>15.8</td>
</tr>
<tr>
<td></td>
<td>LG</td>
<td>266</td>
<td></td>
<td>64</td>
<td>-1.3</td>
<td></td>
</tr>
</tbody>
</table>

1BW, body weight; PD, protein deposition; RE, retained energy
Gestation lysine requirement
(2nd and 3rd parity combined)

Early gestation
Requirement = 9.4 g/d

Late gestation
Requirement = 17.4 g/d

Requirement (NRC, 1998)
13.4 g/d
## Amino acid requirements (g/d)

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; parity</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; parity</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt;, 4&lt;sup&gt;th&lt;/sup&gt; parity</th>
<th>NRC&lt;sup&gt;5&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EG</td>
<td>LG</td>
<td>EG</td>
<td>LG</td>
</tr>
<tr>
<td>Lysine&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>15.0</td>
<td>18.0</td>
<td>13.1</td>
<td>18.4</td>
</tr>
<tr>
<td>Threonine&lt;sup&gt;3&lt;/sup&gt;</td>
<td>7.0</td>
<td>13.6</td>
<td>5.0</td>
<td>12.3</td>
</tr>
<tr>
<td>Tryptophan&lt;sup&gt;4&lt;/sup&gt;</td>
<td>1.7</td>
<td>2.6</td>
<td>3.6</td>
<td>9.7</td>
</tr>
<tr>
<td>Isoleucine&lt;sup&gt;4&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Srichana 2006 (1<sup>st</sup> parity); 2 Samuel et al. 2010; 3 Levesque et al. 2011a; 4 Unpubl.; 5 greatest requirements listed in NRC 1998
Summary: AA requirements

• AA requirements are greater in late gestation than in early gestation, regardless of parity

• AA requirements decrease as sows grow older
  – Reduced sow growth
  – Applies to both early and late gestation

• Difference between EG and LG requirement increases from 1\textsuperscript{st} to 4\textsuperscript{th} parity
Consequence: AA ratios to lysine

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Early Gestation</th>
<th>Late Gestation</th>
<th>NRC (1998) Pregnant Sows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threonine, 2nd par.</td>
<td>54</td>
<td>74</td>
<td>76 - 94</td>
</tr>
<tr>
<td>Threonine, 3rd par.</td>
<td>63</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>Isoleucine</td>
<td>44</td>
<td>75</td>
<td>58</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>13</td>
<td>14</td>
<td>19</td>
</tr>
</tbody>
</table>

Change in AA ratios from EG to LG, between parities:
- Different AA may be first limiting
- Lysine may not be 1st limiting
Energy requirements

• Constant feed allowance leads to underfeeding in late gestation
  – Especially young sows
  – May reduce rebreeding success

• Issue is energy deficit:
  – Sows insulin resistant when given constant feed
  – Insulin resistance disappeared when 540 g/d starch were added to feed in LG (Bikker et al. 2007)
Parity and back fat

- At constant feed allowance during gestation, young sows lose back fat in late gestation:
  - Gilts lost 140 g/d fat (Close et al. 1985)
  - 2nd parity but not 3rd parity sows lost back fat (McMillan 2003)
  - 2nd parity sows increased heat production in LG compared to EG (Samuel et al. 2007)
  - Multi parity sows reduced energy retention but did not lose back fat in LG (Ramonet et al. 2000)
Increase in energy intake in LG

• Suggested increase in energy allowance:
  – 6.0 - 8.0 MJ/d in last 4 weeks (GfE 2008)
  – 7.5 MJ/d needed to prevent 140 g/d fat loss
  – Bikker et al. (2007): ~9 MJ/d more in LG
  – 9.8 MJ/d more in LG for 2\textsuperscript{nd} parity sows (Samuel et al. 2007)

• 1.5 MJ/d more maintenance energy
• 2.5 MJ/d more heat associated with growth, equivalent to 8.3 MJ ME at $k_{pf} = 0.7$
### Difference EG - LG:
**Fat retention and maintenance**

<table>
<thead>
<tr>
<th>Parity</th>
<th>Retained fat energy</th>
<th>Maintenance energy</th>
<th>ME intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parity 2</td>
<td>4.6</td>
<td>3.4</td>
<td>9.2</td>
</tr>
<tr>
<td>Parity 3</td>
<td>3.8</td>
<td>3.4</td>
<td>8.2</td>
</tr>
<tr>
<td>Parity 4</td>
<td>2.6</td>
<td>2.2</td>
<td>5.4</td>
</tr>
</tbody>
</table>
Extra feed needed

• GfE (2008): barley-based rations
  – 750 g/d 1st to 3rd parity
  – 500 g/d 4th parity and older

• Our estimate:
  – Corn-soybean meal rations, approx 13.6 MJ/kg
  – 600 g/d for 1st parity
  – 500 g/d for 2nd parity
  – 400 g/d for 3rd parity and older sows
Phase feeding

• Offering feed in two phases:
  – Early and mid gestation: up to day 84
  – Late gestation: day 85 to put up

• Increased feed allowance in late gestation:
  – Covers increased energy requirement
  – Maintains sow body condition
  – Can prevent sows starting lactation in catabolic state
  – No effect on lactation feed intake (Miller et al. 2000)
Early and mid gestation

• U of A: constant feed allowance during gestation maintains body composition
• Feed allowance marginal in LG
• Therefore, maintaining body composition means overfeeding in early/mid gestation
• For phase feeding, feed allowance:
  – Reduce below constant allowance in EG
  – Makes ‘space’ for increased feed allowance in LG
<table>
<thead>
<tr>
<th></th>
<th>1&lt;sup&gt;st&lt;/sup&gt; parity</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; parity</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; parity and older</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early gestation (day 1 to 84)</td>
<td>1.8</td>
<td>2.2</td>
<td>2.4</td>
</tr>
<tr>
<td>Late gestation (day 85 to 112)</td>
<td>2.4</td>
<td>2.7</td>
<td>2.8</td>
</tr>
<tr>
<td><strong>Average daily feed:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase feeding</td>
<td>1.95</td>
<td>2.32</td>
<td>2.50</td>
</tr>
<tr>
<td>Constant allowance</td>
<td>2.00</td>
<td>2.40</td>
<td>2.50</td>
</tr>
</tbody>
</table>

Based on corn-soybean meal diets.
Assuming average sows in good condition
Lactation weight loss?

- To regain weight lost, increase feed allowance
  - Throughout gestation?
  - Place regaining weight by increasing feed in early/mid gestation by increasing feed?
- GfE (2008) suggests for each 10 kg lactation weight loss:
  - 1.5 g/d Lys, 0.9 g/d Thr, 2 MJ/d ME
  - Or 150 – 200 g/d extra feed throughout gestation
## Dietary AA contents (% of diet)

<table>
<thead>
<tr>
<th></th>
<th>1\textsuperscript{st} parity</th>
<th>2\textsuperscript{nd} parity</th>
<th>3\textsuperscript{rd} parity and up</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Early gestation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lys</td>
<td>0.83</td>
<td>0.60</td>
<td>0.34</td>
</tr>
<tr>
<td>Thr</td>
<td>0.32</td>
<td>0.32</td>
<td>0.21</td>
</tr>
<tr>
<td>Trp</td>
<td>0.08</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>Ile</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td><strong>Late gestation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lys</td>
<td>1.00</td>
<td>0.84</td>
<td>0.54</td>
</tr>
<tr>
<td>Thr</td>
<td>0.62</td>
<td>0.62</td>
<td>0.51</td>
</tr>
<tr>
<td>Trp</td>
<td>0.12</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>Ile</td>
<td></td>
<td></td>
<td>0.40</td>
</tr>
</tbody>
</table>

Total diet AA contents given the suggested feed allowances
Amino acid availability

- Lys and Thr standardized ileal digestibility:
  - Corn: greater for sows than growing pigs
  - Barley, wheat, canola: similar for sows and GF pigs (Stein et al. 2001)

- Thr availability in corn:
  - Greater for sows than GF pigs (Levesque et al. 2011b)

- Safer to assume same digestibility for sows and growing pigs
Free amino acid in sow diets?

• Feeding once daily reduces utilization of free Lys-HCl in growing pigs
• Srichana (2006): pregnant sows can fully utilize up to 0.2% Lys-HCl in diet
• Data for other free amino acids not available
  – It can be expected that moderate levels of free amino acids can be fully utilized
# Diet ingredients (%) and limiting AA

<table>
<thead>
<tr>
<th>Parity:</th>
<th>1</th>
<th>2</th>
<th>3 and up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early gestation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>75.0</td>
<td>83.3</td>
<td>92.7</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>21.0</td>
<td>12.7</td>
<td>3.3</td>
</tr>
<tr>
<td>Limiting AA¹</td>
<td>Lys</td>
<td>Lys</td>
<td>Lys, (Trp ?)²</td>
</tr>
<tr>
<td>Late gestation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>68.8</td>
<td>74.1</td>
<td>81.1</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>27.2</td>
<td>21.9</td>
<td>14.9</td>
</tr>
<tr>
<td>Limiting AA</td>
<td>Lys</td>
<td>Thr</td>
<td>Thr</td>
</tr>
</tbody>
</table>

¹Amino acid determining the necessary soybean meal content  
²Tryptophan content was calculated as 0.077%
Feeding regimen

• Use low/high diet?
  – To cover the minimum/maximum nutrients required
  – Feed proportionally for intermediate requirements
  – Suitable for electronic sow feeders

• Other possibilities lose out on benefits:
  – Two diets: one for greater, one for lower req’ts
    • Better parity 1, 2 vs. older than EG vs. LG
  – Top dressing – soybean meal
Phase feeding: cost savings

Corn-soybean meal diets. Low and high price difference.
Different diets for gilts and older sows but constant feed allowance.
Feed cost advantage

• Greater for older sows
  – Lower AA requirements means cheaper diets than when feeding a single diet

• Dependent on price ratio soybean meal to corn
  – High ratio – phase feeding more advantageous

• Basis of comparison: current feeding regimen
  – Different diets for gilts and older sows
  – Add feed in LG without adjustment in EG
Parity-segregated phase feeding

• Correct supply of nutrients for pregnant sow throughout her life
  – Better body condition when entering lactation
  – Possibly larger piglets in 1st litter (Soto et al. 2011)
  – Better rebreeding success after 1st litter (Shelton et al. 2005)
  – Possibly prolonged sow use - save restocking cost

• Reduced feed cost
  – Estimated up to $10 per sow and year
Summary

• Amino acid requirements
  – Greater in late than in early and mid gestation
  – Greater in young than in older sows

• Energy requirement increases in late gestation

• Parity-segregated phase feeding
  – The right amounts of nutrients at the right time
  – Saves feed cost and improves production
  – Thus, results in improved production economics
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  – Sick Children Hospital, Toronto, ON