Nutrition of the hyper-prolific sow during lactation

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Summary

✓ Introduction
  ✓ A drastic increase in lactation performance of sows
✓ Nutrient utilisation by lactating sows
  ✓ Energy
  ✓ Amino acids
  ✓ Phosphorus and calcium
✓ InraPorc a tool for decision making in sow nutrition
  ✓ Description of the model
  ✓ Examples of calculation of requirements & simulations
✓ Appetite : a key issue for the feeding of lactating sows
  ✓ Intrinsic factors
  ✓ Extrinsic factors
✓ Conclusions & perspectives

Effect of litter size on milk production

Evolution of litter size over the 25 last years in France

Source IFIP – GTTT (...2010)

Effect of litter size on milk production

Milk, kg/d/piglet

Milk, kg/d


2 4 6 8 10 12 14 16

2.5 2.0 1.5 1.0 0.5

2 4 6 8 10 12 14 16

Litter size

+2.3 weaned

+3.0 TB

1994: hyper prolific breeds arrived in piggeries

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Prolificacy and nutritional balance

Intake → Nutritional requirements

Piglets → Milk → Nutritional requirements → Requirements → Nutritional deficiency

Piglets Milk

Nutritional requirements

Prolificacy and nutritional balance

Factors of variation

Feed intake

Estimation

Improved nutritional status of the lactating sow

Amount of feed intake → Quality of feed intake

Energy utilisation by lactating sows

ME = ME_m + E_milk / k_m - ER_m/(k_rm x k_m)

ME_m: = 460 kJ.BW^{0.75}.d^{-1}
E_milk: energy in milk
MeanE_{milk} = (20.6 x ADGlitter - 376 x litter size)
DailyE_{milk} = MeanE_{milk} x (2.76 - 0.014 d_{lact})x0.7 - 0.125x0.5 - 0.125
k_m: efficiency of ME for milk
k_rm: efficiency of body reserves for milk
ER_m: energy from body reserves

Nobel and Etienne (1987, 1989)
Dourmad et al. (2008)
**Lysine utilisation by lactating sows**

**Factorial calculation**

$Lysine_{dig} = LYS_m + \frac{LYS_{milk}}{k_{ly}}$

$LYS_m = 0.036 \times BW^{0.75}$

$N_{milk}$: nitrogen in milk

$MeanN_{milk} = (0.0257 \times ADG_{start} + 0.42 \times \text{litter size})$  

$DailyN_{milk} = MeanN_{milk} \times (2.76 - 0.014 \times dact) \times e^{-0.025t} \times e^{0.5-0.1t}$

$Lys_{milk} = Lysine \times (N_{milk} \times 6.38) \times 1.5$  

$k_{ly} = \text{Efficiency of lysine for milk} = 0.81$

**Empirical calculation**

$N$ balance = $-14.2 + 1.335 \times Lysine_{dig} + 0.629 \times N_{milk}$

$Lysine_{dig} = (14.2 + 0.629 \times N_{milk}) / 1.335$ (without N mobilisation)

**Response curve of N balance according to digestible lysine supply and litter growth rate**

**Requirement for other amino acids**

- Ideal protein for lactation -

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Lysine</th>
<th>Met+Cys</th>
<th>Thr</th>
<th>Ile</th>
<th>Leu</th>
<th>Thr+Ile</th>
<th>Valine</th>
<th>Phe+Tyr</th>
<th>Histidine</th>
<th>Arginine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
<td>60</td>
<td>66</td>
<td>60</td>
<td>115</td>
<td>65</td>
<td>115</td>
<td>67</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**P and Ca utilization by lactating sows**

$P$ balance = $P_{dig} - 0.01 \times BW - P_{milk}$

$P_{dig} = 0.01 \times BW + P_{milk}$

$Ca_{tot} = 3.2 \times P_{dig}$

$P_{milk}$: P in milk

$MeanP_{milk} = (0.0257 \times ADG_{start} + 0.42 \times \text{litter size}) \times 6.38 \times 1.55 / 50$  

$DailyP_{milk} = MeanP_{milk} \times (2.76 - 0.014 \times dact) \times e^{-0.025t} \times e^{0.5-0.1t}$

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The objectives of InraPorc

- Development of a decision support tool for the nutrition of sows (and growing pigs)
- Integrate current knowledge of nutrient utilization by sows and growing pigs
  - net energy - SID AA - digestible P
- Predict the response of the animal to nutrient supply
  - weight gain – feed efficiency – body composition
- Identify the limiting factors and excess in the diet
- Improve the definition of nutritional requirements
  - objectives of performance
  - account for the dynamic change in requirements
  - adapted to the animal profile (genotype/sex)

The decision support tool

- Herd / Sows / Parity
- Performance
- Feeding
- Housing
- Feeding plan
- Sow profile
- Calibration
- Simulation
- Weight P2
- Limitations
- Factorial calculation
- Herd
- Sow
- Requirement

Simulation of body composition changes during lactation (high productive sows - parity 1)

- Body weight, kg
- Backfat thickness, mm
- Stage of lactation, d
- Stage of lactation, d
Simulation of energy utilisation (parity 1)

![Gross Energy MJ/d](image1)

Simulation of digestible lysine utilisation (parity 1)

![g/d](image2)

Sensitivity of lysine requirement to appetite (Parity 1)

![g/kg](image3)

Simulation of long-term feeding strategies

Effect of appetite during lactation

![BW (kg) vs. Backfat thickness (mm)](image4)
Simulation of long-term feeding strategies

**Effect of appetite during lactation**

- **High:** 7.0 kg/d
- **Low:** 5.0 kg/d

**Variation factors of appetite in lactating sows**

**Intrinsic factors**

- The Sow
- The Environment

**Extrinsic factors**

- The animal
- The feed
- The feeding procedure

**The Sow**

- Genotype
- Litter size
- Stage of lactation
- Parity / body weight
- Health

**The Environment**

- Ambient temperature
- [Net energy]
- Thermic effect of feed
- Feeding plan during lactation
- Meal frequency

**The feeding procedure**

- Feed allowance during the previous gestation
- Backfat thickness
- Previous experience

**Intrinsic factors**

- Parity

**Parity**

- Primiparous
- Multiparous

**Primiparous**

- ADFI: -15 / -20%
- ADG
- Milk production: -8 / -10%

**Multiparous**

- Higher risk of nutritional imbalance in parity 1

**Backfat thickness at farrowing**

(Feed allowance during the previous gestation)

**Feed intake**

(kg/d)

<table>
<thead>
<tr>
<th>Feed intake (kg/d)</th>
<th>7.0</th>
<th>6.5</th>
<th>6.0</th>
<th>5.5</th>
<th>5.0</th>
<th>4.5</th>
<th>4.0</th>
<th>3.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backfat thickness at farrowing (mm)</td>
<td>15</td>
<td>17</td>
<td>19</td>
<td>21</td>
<td>23</td>
<td>25</td>
<td>27</td>
<td>29</td>
</tr>
</tbody>
</table>

**Higher risk of nutritional imbalance in parity 1**

- Dourmad et al. (1991)
- Primiparous sows

**Quiniou (2008)**

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Previous experience
(Feedstuffs used in gestation/lactation diets)

In / Extrinsic

ADFI, kg/d

QAAP 2010 – s25 – 3
Quiniou (2006)
transition performed on the 3rd d post-partum

The ambient temperature
When temperature was kept constant over 24 h/24 h

Extrinsic factors

Temperature

<table>
<thead>
<tr>
<th>Temperature</th>
<th>18°C</th>
<th>25°C</th>
<th>29°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADFI, kd/d</td>
<td>7.78</td>
<td>6.31</td>
<td>3.50</td>
</tr>
<tr>
<td>Number of meals / d</td>
<td>6.8</td>
<td>7.2</td>
<td>4.5</td>
</tr>
<tr>
<td>Meal size, g</td>
<td>1372</td>
<td>931</td>
<td>883</td>
</tr>
<tr>
<td>Diurnal feed intake, %</td>
<td>84</td>
<td>79</td>
<td>91</td>
</tr>
</tbody>
</table>

Extrinsic factors

The ambient temperature

Within the thermo-neural zone
Production = exportation

Under heat stress :
Production > exportation capacities

Is it possible to adapt dietary characteristics to ambient temperature?

Extrinsic factors

Within the thermo-neural zone
Production = exportation

Under heat stress :
Production > exportation capacities

Quiniou and Noblet (1999)
Renaudeau et al. (2001), Quiniou et al. (2000)
**Thermic Effect of Feed and dietary components**

<table>
<thead>
<tr>
<th>Lipid</th>
<th>Starch</th>
<th>Protein dig.</th>
<th>Fibers dig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME from</td>
<td>5%</td>
<td>15%</td>
<td>46%</td>
</tr>
</tbody>
</table>

**Efficiency of ME utilisation from different components**

- Lipid
- Starch
- Protein dig.
- Fibers dig.

**Extra Heat Production**
- Under warm exposure

**Low TEF diets or increased NE and AA contents and performance**

- Extrinsic factors

<table>
<thead>
<tr>
<th>Quiniou et al. (2000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renaudeau et al. (2001)</td>
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<tr>
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</tr>
<tr>
<td>Quiniou and Noblet (1999)</td>
</tr>
</tbody>
</table>

**Meal frequency**

<table>
<thead>
<tr>
<th>Number of meals/day</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Ad lib</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADFI, kg</td>
<td>5.9</td>
<td>6.4</td>
<td>6.9</td>
<td>7.4</td>
</tr>
</tbody>
</table>

**Extrinsic factors**

- EAAP 2010 – s25 – 3
- Noblet et al. (1989)
- EAAP 2010 – s25 – 3
- EAAP 2010 – s25 – 3
- EAAP 2010 – s25 – 3

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**Feeding plan during lactation**

<table>
<thead>
<tr>
<th>Feed allowance or spontaneous feed intake, kg/d</th>
<th>ADFI (kg)</th>
<th>BW at weaning (kg/piglet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.5</td>
<td>8.2</td>
</tr>
<tr>
<td></td>
<td>5.9</td>
<td>8.2</td>
</tr>
<tr>
<td></td>
<td>5.6</td>
<td>8.0</td>
</tr>
</tbody>
</table>

**Extrinsic factors**

- **ADFI**: Ad libitum
- **BW at weaning**: kg/piglet

**EAAP 2010 – s25 – 3**

**EDE Bretagne (1995)** from a survey performed in piggeries

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  - Phosphorus and calcium
- **InraPorc a tool for decision making in sow nutrition**
  - Description of the model
  - Examples of calculation of requirements & simulations
- **Appetite: a key issue for the feeding of lactating sows**
  - Intrinsic factors
  - Extrinsic factors
- **Conclusions & perspectives**

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**Conclusions**

- Increase in performance of lactating sows over 20 years
  - Prolificacy (+30%) & milking potential (+100%)
  - Little increase in feed intake
  - Increased risk of nutrient deficiency
    - Affects milk production
    - Affects subsequent reproductive performance
- Knowledge on nutrient utilisation in lactating sows over the recent years
  - Energy, amino acid, digestible phosphorus
  - Prediction models are available and allow to address nutrient utilisation in a more dynamic way
- Limited feed intake of lactating sows remains a major problem in practice

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**Perspectives**

- **Scientific knowledge**
  - Improvement of determination of AA requirements
  - Contribution of AA from body reserves
  - Contribution of body reserves to mineral supply
  - Thermoregulation & appetite
  - Integration of knowledge in more mechanistic models
- **Application**
  - Feed composition adapted to
    - Environmental conditions
    - Parity (primiparous / multiparous), feed intake, performance...
  - Precision feeding
    - "Intelligent" feeders with mixing of two diets
REFERENCES

• Quiniou N. 2004. Effect of reduction of dietary protein level, associated with an adjusted electrolytic balance or not, on performance of lactating sows exposed to 23 or 26°C on average. Journées de la Recherche Porcine 36, 235-242. [in French]
• Quiniou N. 2006. Is the lactating sow’s spontaneous feed intake influenced by the feedstuffs profile continuity in gestation and lactation diets? TechniPorc 29(5), 23-29. [in French]