The Challenges of Estimating Optimal Nutrient Allowances in Growing-Finishing Pigs and the Future of the Swine Industry

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Current sector challenges:

- Changing international trade rules,
- Limited agricultural resources availability given the growing world population,
- Governments gradually reducing sector support, and
- Increasing animal welfare and environmental standards.

To stay competitive the producers need to:

- Increase cost efficiency of their operations,
- Produce safe high quality food, and
- Comply with the highest environmental and animal welfare standards.
Introduction

Pork producers’ challenges

To face producers’ challenges (improve the protein share, stay competitive and comply with the highest environmental) the livestock industry need to,

- Improve nutrient efficiency
- Use alternative feed ingredients

Essential elements for improving nutrient utilization in livestock animals

**Nutrient Supply**

**Nutrient Requirements**

**Feeding Program**: feed composition and distribution (feeding phases)

**Profitability**

**Pork Quality**

**Sustainability**
Nutrient Requirements
The concept

But, what **nutrient requirements** means

- Body growth results from the net synthesis of muscle, adipose tissue, bone, hair, skin and other body components and depends on an adequate supply of nutrients
- Nutrients must be provided in adequate amounts and in forms that are palatable and efficiently utilized for optimal growth
Nutrient Requirements
The concept

✓ For one individual animal at a given time

• For a given nutrient (e.g., Lys), and when all other nutrients are provided at adequate levels, nutrient requirements can be defined as the amount of this nutrient that will allow this individual animal to perform its natural functions in a normal manner

Fuller, 2004; Noblet and Quiniou, 1999
Nutrient Requirements
The concept

✓ For one individual animal at a given time

• Only one diet (one size), which composition can be estimated as the sum of the requirements for **maintenance** and **production** (e.g., growth).
Nutrient Requirements

First challenge (differentiate individual and population requirements)

✓ For one individual animal at a given time

- For a given nutrient (e.g., Lys), and when all other nutrients are provided at adequate levels, nutrient requirements can be defined as the amount of this nutrient that will allow this individual animal to perform its natural functions in a normal manner.
Nutrient requirements vary greatly between the pigs, and for each pig over time following individual patterns.

Hauschild et al., 2010
The big question!
How can we estimate the optimal level of nutrients to be provided to all the animals for optimal population growth at minimal cost?

Nutrient Requirements
First challenge (differentiate individual and population requirements)
Nutrient Requirements

First challenge (differentiate individual and population requirements)

✓ For a group of (heterogeneous) animals
  
  • One feed to all pigs (one size fits all)
  • For a given period of time
For a group of (heterogeneous) animals

- For most nutrients, **underfed** animals will exhibit reduced performance while the **overfed** ones will exhibit near optimal performance.
Nutrient Requirements
First challenge (differentiate individual and population requirements)

✓ For a group of (heterogeneous) animals
  • One feed to all pigs (one size fits all)
Nutrient Requirements
First challenge (differentiate individual and population requirements)

✓ For a group of (heterogeneous) animals

• Population nutrient requirements should be seen as the optimal balance between the proportion of pigs that are going to be overfeed and underfeed

Pomar et al. 2014
Nutrient Requirements

First challenge (differentiate individual and population requirements)

When using a **factorial method** (e.g., *NRC 2012 model*) to estimate the requirements of a population we have to identify,

- **Which is the parameter to optimize (ADG, FC, feed cost)?**
- **To obtain this optimal response, who is the best representative of this population?**
When using a factorial method (e.g., NRC 2012 model) to estimate the requirements of a population we have to identify,

- Which is the parameter to optimize (ADG, FC, feed cost) and who is the best representative of the population?

For a 25 kg BW pig population,

- maximal population response was obtained at 114% for ADG, 104% for FC and 100% for feed cost of the average pig Lys requirements ([Hauschild et al., 2010; Brossard et al., 2009 & 2014] suggested to oversupply the average pig by 15% for optimal ADG).

- We have to be cautious when using factorial methods (e.g., NRC, 2012) given that they had been calibrated for maximal responses when using average population values.
We indicated before that for most nutrients, **underfed** animals will exhibit reduced performance while the **overfed** ones exhibit near optimal performance.
This assumption is based on the principles that, for many nutrients, in particular for amino acids,

- Utilization efficiency is **constant** (e.g., 72% for Lys), this across animals and ages
- Body protein amino acid concentration is **constant** across animals and ages (e.g., 7% for Lys)
- Amino acids are retained following the **ideal protein** profile
However, these principles are weak

- **Nutrient efficiency is not constant** across animals and is affected by production conditions

_Ghimire et al., unpublished results_
However, these principles are weak

- **AA supply affects the amino acid composition of body protein and different body proteins are affected differently**

  ✓ The splanchnic tissues are less affected than carcass muscles (Conde-Aguilera et al. 2010; Conde-Aguilera et al. 2016a; Conde-Aguilera et al. 2016b; Remus et al, unpublished data)

  ✓ Different muscles respond differently to dietary AA supply (Conde-Aguilera et al., 2016b; Remus et al, unpublished data)
However, these principles are weak

- The ideal protein concept does need to be reviewed
However, these principles are weak

- **The ideal protein concept does need to be reviewed**

Remus et al., unpublished results
The ideal protein concept needs to be reviewed for precision feeding

Remus et al., unpublished results
The ideal protein concept needs to be reviewed for precision feeding

Remus et al., unpublished results
Given that pigs are raised in groups, and there is large variation between animals, it is difficult to further improve nutrient efficiency in conventional production systems.

Hauschild et al., 2010
Nutrient requirements
The concept

✓ In conventional feeding
  • One feed to all pigs (one size fits all)
Precision feeding
The concept

✓ Precision farming and precision agriculture is an agricultural concept that relies on the existence of in-field variability.

✓ Precision feeding involves the use of feeding techniques that allow

- the right amount of feed
- with the right composition
- to be provided at the right time
- to each animal of the herd
With precision feeding

- Each pig is fed with a diet tailored daily for him
For **precision feeding**, feeds and feeding, are among the most important control elements.

For the efficient application of precision feeding we need:

- **Measuring devices** (e.g., scales for body weight and feed measurements)
- **Numerical methods** (e.g., mathematical models estimating real-time nutrient requirements)
- **Control devices** (e.g., automatic feeders)
Feeding growing pigs **individually with daily tailored diets** required the development of:

- **New feeding systems**
- **New nutritional concepts**

  a. To feed individual pigs with daily tailored diets based on their own real-time patterns of feed intake and growth (completed)
  b. Introducing some sources of animal variation (ongoing)
  c. Better understanding the animals’ metabolism (future developments)
Many animal trials and many others dealing with the numerical procedures
**Precision feeding**
**Real-time estimation of nutrient requirements**

- **Daily lysine requirements**
  - Estimated for each pig in real-time

- Parameters previously calibrated in two projects

**Inputs**
- Daily Feed Intake (DFI)
- BW
- Genetic potential

**Empirical component**
- Modelling techniques recursive

**Mechanistic component**
- BW
- DFI
- Protein deposit
- NE intake

**Zhang et al., 2012**

**Protein deposition, g/day**

- 60-100 kg BW
- 25-50 kg BW

**Cloutier et al., 2014**

**Protein deposition, g/day**

- 70-100 kg BW
- 25-50 kg BW

- 12 trials
- 6 prototypes

**Hauschild et al., 2012**
**Precision feeding Validation**

**Trial 1:**
- 60 castrated males
- 41.2 ± 3.9 kg

**Trial 2:**
- 35 females and 35 castrated males
- 30.4 ± 2.2 kg

Andretta et al. 2014; 2016
Trial 1 & 2: feeding programs

Three-phase feeding (3P)
Providing within each phase received a fixed blend of premixes A and B satisfying the lysine requirement of the 80th percentile pig.

Precision feeding (PF)
Each pigs received daily a blend of premixes A and B satisfying its specific lysine requirements.

Andretta et al. 2014; 2016
Precision feeding Validation

Trial 1 & 2

Feed A
Feed B

Andretta et al. 2014; 2016
Protein and lipid composition were obtained by transforming the lean and fat values from dual-energy X-ray densitometry to their chemical equivalents.

Nitrogen excretion: ratio between retention and intake

## Precision feeding Validation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Precision vs. Conventional feeding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
</tr>
<tr>
<td>Feed intake</td>
<td>n.s.</td>
</tr>
<tr>
<td>Weight gain</td>
<td>n.s.</td>
</tr>
<tr>
<td>Protein deposition</td>
<td>n.s.</td>
</tr>
<tr>
<td>Lipid deposition</td>
<td>n.s.</td>
</tr>
<tr>
<td>Protein intake</td>
<td>&lt; 16%</td>
</tr>
<tr>
<td>Lysine intake</td>
<td>&lt; 27%</td>
</tr>
<tr>
<td>Nitrogen excretion</td>
<td>&lt; 22%</td>
</tr>
<tr>
<td>Feeding cost, $/pig</td>
<td>&lt; 8%</td>
</tr>
</tbody>
</table>

Andretta et al. 2014; 2016
Individual precision feeding allows:

- **Reducing by 5-10% feeding costs** by reducing the expensive excess supply of nutrients (protein, P, etc.)

- **Reducing by 2-3% feed fabrication costs**, storage, management and shipping by using the same two or more premixes on all farms

- **Reducing by more than 40% the excretion of N, P** and other polluting constituents of manure and the amount of soil required for manure application
Intelligent management of feeds and animals with advanced computerized technologies allows:

✓ **Real-time off-farm monitoring** of feeds and animals for improved economic efficiency

✓ **Reducing labor requirements** and costs through the automatic monitoring and management of feeds and animals
Easy application of dietary treatments facilitates:

- **Early identification of diseases** by monitoring individual feed intake patterns and other animal parameters
- **Reducing antibiotic use** by the precise application of individual veterinary treatments, resulting in improved herd performance and lower veterinary cost
Precision feeding allows:

- In relation to conventional group feeding systems
  - Reducing by 6% climate change ($kg \ CO2\text{-eq}$) impact, and
  - Reducing up to 5% eutrophication and acidification ($kg \ PO4\text{-eq}$ and $SO2\text{-eq}$) impact
Will precision farming change the way we are feeding and raising domestic animals?
Smart farming
The future of the swine industry

Jobs that **NO LONGER EXIST**... because of technological developments
Jobs that ARE DESAPPEARING (or dramatically changing)...
because of technological developments

5. Travel Agent: $31,800

9. Librarian: $54,500
50% of today's occupations will be redundant by 2025!

- Experts believe half of today's jobs will be completely redundant by 2025
- Artificial intelligence will mean that many jobs will be done by computers
- Customer work, process work and middle management will 'disappear'
- Report states that workspaces with rows of desks will no longer exist
Smart farming
The future of the swine industry

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Smart farming
The future of the swine industry

FARM activities that will change in the next 5-10 Years
From the manual handling of animals and feeds and from the feeding in groups with one feed given during long periods of time to the automatic and personalized daily feeding and measuring.
Smart farming
The future of the swine industry

FARM activities that will change in the next 5-10 Years

From the **manual** estimation to the **individual automatic real-time** estimation of nutrient requirements

### Table 1. Amino Acid Requirements of Growing Pigs

<table>
<thead>
<tr>
<th>Amino acid requirements</th>
<th>Lysine</th>
<th>Methionine</th>
<th>Met-Cystine</th>
<th>Threonine</th>
<th>Trp-Orn</th>
<th>Valine</th>
<th>Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance</td>
<td>36 mg/kg</td>
<td>26</td>
<td>123</td>
<td>151</td>
<td>76</td>
<td>67</td>
<td><strong>not estimated</strong></td>
</tr>
<tr>
<td>Protein gain</td>
<td>60 g/100 g PG</td>
<td>27</td>
<td>55</td>
<td>60</td>
<td>18</td>
<td>68</td>
<td><strong>not estimated</strong></td>
</tr>
</tbody>
</table>

1. Trim to lysine
2. Protein deposition (PD)

**Inraporc**

**Experimental day**

Lysine Req., g/NE

0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60

0 10 20 30 40 50 60 70 80

**Experimental day**

Lysine Req., g/NE
Smart farming
The future of the swine industry

**FARM activities that will change in the next 5-10 Years**

From *customized feed formulation* and fabrication to the *automatic on-farm blend* fabrication

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*Image 1: A large industrial facility with grain silos and a semi-truck*

*Image 2: A graph showing the relationship between time or weight and premix incorporation (%)*

*Image 3: A close-up view of automated on-farm blend fabrication equipment*
Smart farming
The future of the swine industry

**FARM activities that will change in the next 5-10 Years**

From a **herd management of diseases** to the use of individual real-time feed, water and behavioural information for **early identification of individual animal health disorders** and **individual management of diseases**.
Smart farming
The future of the swine industry

In a near future (5-10 years), pigs will be raised and feed **not to optimize growth at minimal (feed) costs,**

but **to achieve each pig optimal bodyweight gain** (i.e., reducing heterogeneity) and **carcass leanness** (i.e., maximal carcass value) **at minimal feeding costs** (i.e., $/kg produced meat) **and optimal nutrient efficiency** (i.e., reducing environmental load)
In a near future (5-10 years) pigs will be raised in a fully monitored and off-farm managed farms where,

- **Smart sensors** and devices will produce big amounts of data that will provide unprecedented decision-making capabilities

- Incorporating **Big Data** analysis and the **Internet of Things (IoT)** will provide a new edge for innovation, productivity and competition

- **Smart Farming**

Manyika, 2011; Wolfert et al., 2017
In a near future (5-10 years), pigs will be raised to achieve each pig optimal bodyweight gain and carcass leanness at minimal feeding costs and optimal nutrient efficiency.

But,

- Is this production approach, affordable, achievable, etc.?
- How much the feeders will cost?
- How long will take to pay the equipment?
Smart farming
Final remarks

In a near future (5-10 years), pigs will be raised to achieve each pig optimal bodyweight gain and carcass leanness at minimal feeding costs and optimal nutrient efficiency.

But,
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But,

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- How much the feeders will cost?
- How long will take to pay the equipment?
Smart farming, **not just a question of technology**, but a successful marriage between knowledge and technology

There is a **strong need for coordination** and involvement of different experts and stakeholders in the development and implementation of smart farming (researchers, engineers, technology providers, economists, farmers, consumers and citizens).
Acknowledgements

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Thank you

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