Precision feeding and nutrition of pigs

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Summary

✓ Importance of feed efficiency
- Handling between-animal variability
- Principles of precision farming/feeding
- Some application of precision feeding
- Conclusion and perspectives
Nutrition a major lever to improve the sustainability of pig production

- **Economy**
  - Feed = about 2/3 of production cost

- **Environmental impact**
  - Reduction of resource use (feed)
  - Reduction of nutrient excretion (N, P...)

- **Quality of products**
  - Lean to fat ratio
  - Homogeneity of products
  - Fat quality

→ The improvement of feed efficiency is a major issue for sustainability of all pig production systems (conventional & alternative)

Source: IFIP, 2016
Evaluation of efficiency of utilization of feed

- Expressed as a ratio
  - Feed conversion ratio = \( \frac{\text{Feed}}{\text{Gain}} \) => economic representation of a « cost of production »
  - Feed efficiency ratio = \( \frac{\text{Growth}}{\text{Gain}} \) => representation of the efficiency of a biological process

- Different units of expression
  - kg feed / kg gain
  - MJ Energy / kg gain
  - € of feed / kg gain
Biological meaning of feed conversion ratio

Observed FCR = \frac{\text{Feed distribution}}{\text{Pig growth}}

Observed FCR = \frac{\text{Feed intake} + \text{spillage}}{\text{Pig growth}}

“Real” FCR = \frac{\text{Feed intake}}{\text{Growth}}
Biological meaning of feed conversion ratio

\[
\text{FCR} = \frac{\text{Indigestible} + (\text{Maintenance} + \text{Growth})}{\text{lean} + \text{fat} + \text{bone} + \text{skin} + \text{organs}...}
\]

\[
\text{FCR} = \frac{\text{Indigestible} + (\text{Maintenance} + \text{Growth})}{\text{(protein} + \text{water}) + \text{lipids} + \text{minerals}}
\]

=> means that FCR depends on:

- digestibility of feed and digestive efficiency of pigs
- composition of weight gain (lean/fat ratio)
- importance of maintenance versus growth (ADG)
Biological meaning of efficiency of nutrient utilization (amino acids, phosphorus)

\[ \text{Lysine efficiency} = \frac{\text{lysine retained (in body protein)}}{\text{Indigestible} + (\text{maintenance} + \text{growth} + \text{oversupply})} \]

\[ \text{P efficiency} = \frac{\text{P retained (in bones and soft tissues)}}{\text{Indigestible} + (\text{maintenance} + \text{growth} + \text{oversupply})} \]

=> means that efficiency of nutrient utilization

- digestibility of the nutrient
- oversupply
Strategies to improve feed and nutrient efficiency

❖ Adapt the energy supply to animal’s growth potential
  ➢ avoid excessive supply which increases fat deposition and FCR
  ➢ avoid insufficient supplies which growth rate maintenance FCR
  ➢ the optimal supply depends on pig genotype and sex, and age

❖ Insure adequate amino acid supplies
  ➢ sufficient to maximize protein retention (FCR)
  ➢ not in excess to avoid the increase in excretion

❖ Insure adequate mineral supplies
  ➢ sufficient to maximize growth and sufficient bone mineralization
  ➢ not in excess to avoid the increase in excretion

❖ Difficult to implement in practice
  ▪ variation of requirements over time
  ▪ variability between animals

⇒ New opportunities offered by precision livestock farming
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The heterogeneity between individuals

Feed intake

Feed intake, kg/d

Age, d
The heterogeneity between individuals

Feed intake

Nutrient intake

Daily weight gain

Composition of gain

Weight at a given age

Carcass lean content

Feed composition

Amount of feed

Growth potential

Pig weight, kg

Age, d

% of carcasses

Distribution of lean % at slaughter

Castrates
Males
Females
All
The heterogeneity between individuals

Feed intake

Feed composition

Amount of feed

Nutrient intake

Growth potential

Daily weight gain

Composition of gain

Weight at a given age
carcass lean content

Nutritional requirements
(ex.: Lys, g/MJ EN)
The heterogeneity between individuals

Feed intake

Feed composition → Amount of feed

Nutrient intake

Growth potential → Daily weight gain

Composition of gain

→ Weight at a given age

carcass lean content

→ Nutritional requirements

(ex.: Lys, g/MJ EN)
Managing the heterogeneity between individuals

- Variability in weight and potential => difficult to manage in practice (feeding strategy, slaughter decision...)
- New opportunities offered by **Precision Livestock Farming**
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Principles of precision livestock farming
adapted from Clément Allain (IDELE)

Automated action (milking, feeding)

RFID

Data

Observations

Automated control

Computer
Smartphone...

Database

Sensors

Décision

bidental parameters

Animal

Feeder
Milking parlor...

FARMER

J.Y. Dourmad and L. Brossard
Precision feeding and nutrition of pigs
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Principles of precision feeding

- Improve the characterization of individual animals (or small groups)
  - Feed intake, Growth potential
  - Body condition
  - Physical activity, health…

- To better adapt nutrient supplies …
  - Quantity / Quality
  - According to time
  - to groups or individuals

- … and improve efficiency
  - reduction of cost
  - reduction of excretion
  - control of quality
Apply up-to-date nutritional concepts and use simulation/prediction models

- **Protein-Amino acids**
  - Stand. ileal digestibility
  - « Ideal » protein

- **Energy**
  - Net energy

- **Phosphorus**
  - Digestible phosphorus

- **Using nutritional simulation models** (e.g. InraPorc®) to handle the information and take the decisions
  - Determination of optimal nutrient supplies
A new approach of data use: from an «a posteriori analyses» to «real time» prediction

The classical approach:

- Data are collected on groups of pigs are averaged and used to predict the requirement of the average pig or of the population
- These requirements are used to formulate the diets
A new approach of data use: from an «a posteriori analyses» to «real time» prediction

The precision feed approach:
- Data are collected at high frequency on each pig (weight, intake)
- Algorithms are used to predict the requirements of each pig for the next period
Example of algorithm
Haushild et al. (2014)
Which data can / could be used?

- Housing conditions
  (temperature, gas, ventilation...)

- Body condition
  (back fat, shape...)

- Body weight, age, physiological status

- Health status
  (body temperature, activity, drinking behaviour...)

- Physical activity

- Feed intake

- Feed characteristics
  (density, humidity...)

- An increasing variety of available data with the evolution of technologies (sensors)

- Development of data treatment and decision algorithms
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Some results in fattening pigs
Andretta et al. (2014)

Comparison of:

- 3-Phase group feeding (3P)
- Multiphase group feeding (MPG)
- Multiphase individual feeding (MPI)

Average SID lysine content of diets fed

Period, d
Some results in fattening pigs
Andretta et al. (2014)

Comparison of:
- 3-Phase group feeding (3P)
- Multiphase group feeding (MPG)
- Multiphase individual feeding (MPI)

- **ADG, g/d**
  - 3P: 1100
  - MPG: 1100
  - MPI: 1100

  *ns*

- **FCR, kg/kg**
  - 3P: 2.60
  - MPG: 2.60
  - MPI: 2.60

  *ns*
Some results in fattening pigs
Andretta et al. (2014)

Comparison of:
- 3-Phase group feeding (3P)
- multiphase group feeding (MPG)
- multiphase individual feeding (MPI)

**Nitrogen balance, g/d**

- 3P: 100
- MPG: 87.6
- MPI: 78.4

Excretion (P<0.001)
Retention ns

**Phosphorus balance, g/d**

- 3P: 100
- MPG: 84.7
- MPI: 72.9

Excretion (P<0.001)
Retention (P<0.01)
Some results in fattening pigs
Andretta et al. (2014)

Comparison of:
- 3-Phase group feeding (3P)
- Multiphase individual feeding (MPI)

- **Pomar et al. (2010), simulation study**
  - ↓ 11% Feeding cost
  - ↓ 38% Nitrogen and phosphorus excretion

- **Zhang et al. (2011), experimental approach**
  - ↑ 5% GMQ (ns)
  - ↓ 17 et 10% Intake of N and P
  - ↓ 41 et 31% Excretion of N and P
Some results in fattening pigs
Monteiro et al. (2016)

Evaluation of environmental impact of 2P, 4P, MP and Precision Feeding by life cycle assessment (LCA), in Brazil and France
Some results in sows (simulation)
Dourmad et al. (2012)

Comparison of:
- 1-Phase gestation feeding (1P)
- 2-Phase gestation feeding (2P)
- Multiphase gestation feeding (MPI)

→ Improvement of nutrient efficiency
→ Reduction of excretion and feeding cost
Summary

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✓ Conclusion and perspectives
Practical application of precision feeding in pig production

- Development of equipments to:
  - Measure or estimate the body weight of animals
  - Control the amount of feed distributed and measure feed intake
  - Mix different diets to prepare individual ration to be fed
  - Control the quality of feed
  ...

- Development of decision support tools to:
  - Determine optimal individual/group supplies
  - Make corrections for housing conditions or animal behavior
  ...
Exemple of Equipment for sows

- Lactation
- Gestation
Example of equipment for fattening pigs

- Commercial

- Experimental (Univ. Lleida-Agriculture Canada, INRA, IFIP)
Example of research in progress: BEALIM+

**Objective:**
Improve the welfare and performance of gestating sows with new technologies and sensors for the determination of their behavior and new decision support tools for their precision feeding.

Energy cost of activity
Respiratory chambers

Video-supervision
Image analysis

Activity sensors
• Adapted feed, animals and feeding techniques for more efficient and sustainable monogastric livestock production systems (pig, poultry, rabbit)

• 23 Research and Industry partners from 12 countries

• 7 work packages

✓ WP3 Modelling biological functions with emphasis on feed use mechanisms

✓ WP4 Management systems for precision feeding

✓ WP7 Dissemination, training and technology transfer

http://www.feed-a-gene.eu
Thank you for your attention