Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

The impact of feeding growing-finishing pigs with daily tailored diets using precision feeding techniques on animal performance, nutrient utilization and feeding cost

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Canada

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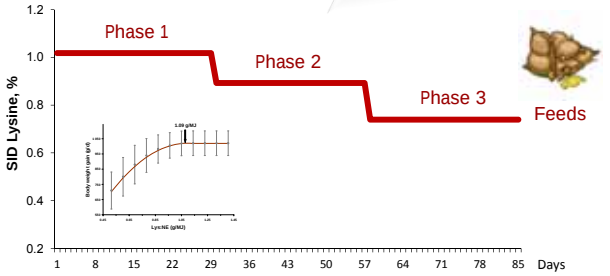
Introduction

Pigs are feed in groups and feeding programs are proposed to maximize group responses at minimal feed costs



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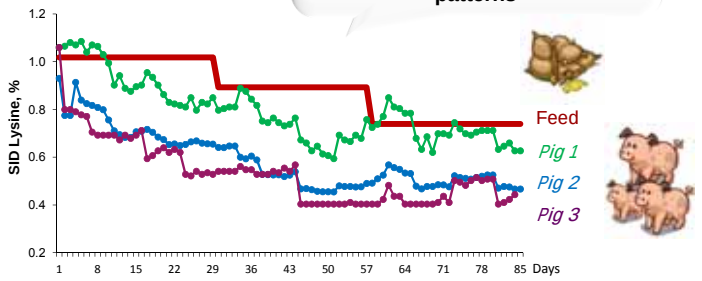
Introduction

Nutrient requirements however vary greatly between the pigs of a given population, and for each pig over time following individual patterns



Brossard et al., 2009 ; Pomar et al., 2009

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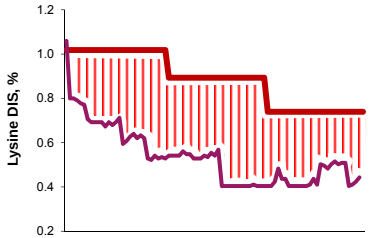
Introduction

To optimize population responses, nutrients are provided at levels that satisfy the requirements of the most demanding pigs



Therefore, most of the pigs receive more nutrients than they need to express their genetic potential

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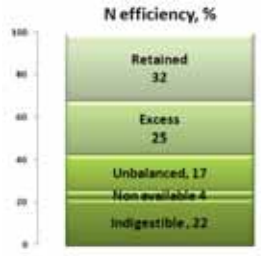
Introduction

- ✓ Non retained dietary nitrogen and other nutrients → feces and urine
- ✓ N efficiency (retention/ingestion) seldom ≥ 30%
- ✓ Improving nutrient efficiency = ↓ feed cost



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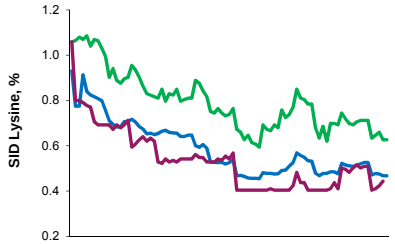
Introduction

Nutrient efficiency can be improved by providing **each pig each day** with the required nutrients



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Introduction

- ✓ **Precision farming** or 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 pig** of the herd

Introduction

- ✓ **Precision feeding** is defined in many different ways, some times referring to precision formulation, precision group feeding and many others
- ✓ In this presentation, **precision feeding** refers to the use of feeding techniques that provides individual pigs with daily tailored diets

Objectives

- ✓ To review the concept of estimating nutrient requirements
- ✓ To describe the proposed method for real-time estimation of nutrient requirements in growing-finishing pigs
- ✓ To present recent experimental results comparing individual precision feeding with conventional group feeding systems

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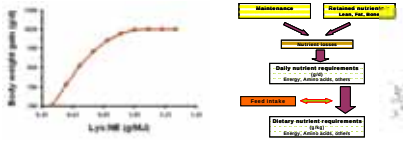
Essential elements for precision feeding

- ✓ **For nutrients requirements,**
  - The concept
  - Actual methods used in commercial conditions
  - Limitations of actual methods
  - The real-time estimation for individual pigs



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Nutrient requirements: **the concept**

- ✓ 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

NRC, 1998

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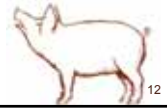
Nutrient requirements: **the concept**

- ✓ **<u>For one individual animal at a given time</u>**
  - 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 individua animal to perform its natural functions in a normal manner**
  - The requirements are estimated for a given animal at a given point in time as the sum of the requirements for **maintenance** and **production**



Fuller, 2004; Noblet and Quiniu, 1999

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Nutrient requirements: **the concept**

✓Nutrient requirements are modulated by factors that are related to the,

- animal (e.g., genetic potential, age, weight and sex)
- feed (e.g., nutrient composition, digestibility and anti-nutritional factors)
- environment (e.g., temperature and space allowance)

✓These modulating factors can change overtime

Noblet and Quiniou, 1999

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Nutrient requirements: **the concept**

✓**For a group of (**heterogeneous**) animals**

- Pigs within a population have different weight, age, genetic potential and therefore, have different requirements
- For most nutrients, **underfeed** animals will exhibit reduced performance while the **overfeed** ones will exhibit near optimal performance

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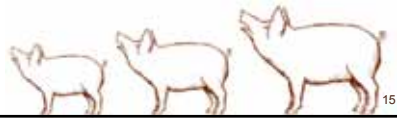
Nutrient requirements: **the concept**

✓**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**
- This optimal balance can be defined as **the amount of nutrients needed for specific production purposes** (e.g., optimal population growth, protein deposition, feed efficiency, feed cost/kg of gain)



Pomar et al., 2014

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Nutrient requirements: **the concept**

✓**For a group of (**heterogeneous**) animals**

- Providing one feed to all pigs

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Nutrient requirements: **the concept**

✓ **For a group of (**heterogeneous**) animals**

- Providing one feed to all pigs

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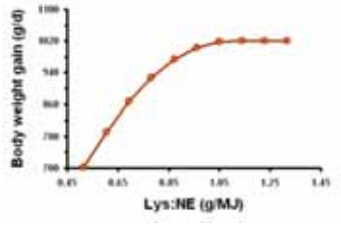
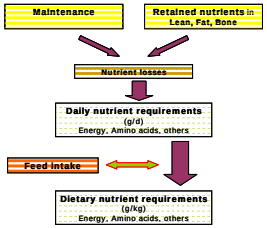
Nutrient requirements: **actual methods**

There are two methods used in practical conditions to estimate nutrient requirements in domestic animals

✓ **Empirical method**: optimizing animal responses

✓ **Factorial method**: adding maintenance and production requirements





Fuller & Chamberlain, 1982; Patience et al., 1995

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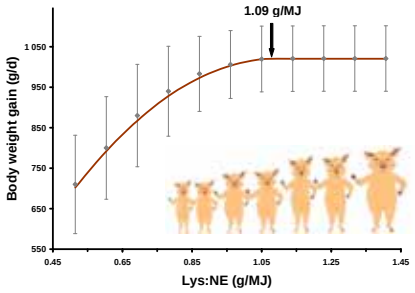
Nutrient requirements: **actual methods**

In the **empirical method**, nutrient requirements are obtained by studying the response to varying nutrient levels in animal populations



Hauschild et al., 2010

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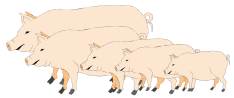
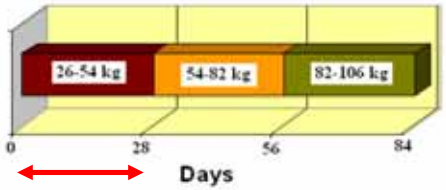
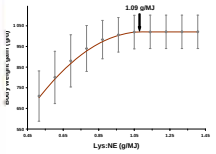
Nutrient requirements: **actual methods**

The **empirical method** estimates optimal nutrient allowances from



- **a <u>population</u> perspective**
- **during <u>long periods</u> of time**
- **for a given performance parameter (ADG)**





Pomar et al., 2007

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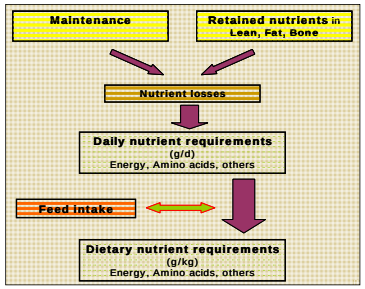
Nutrient requirements: **actual methods**

In the **factorial method**, daily nutrient requirements are the sum of the requirements for **maintenance** and **production**

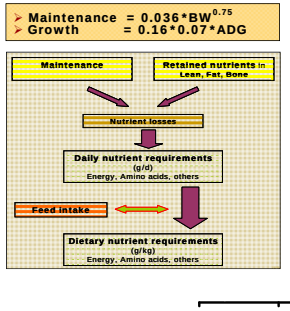
- Maintenance = $0.036*BW^{0.75}$
- Growth = $0.16*0.07*ADG$

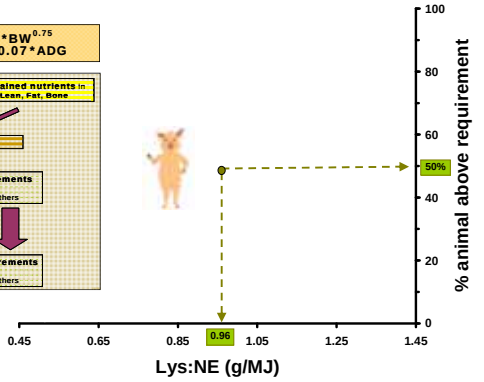


Nutrient requirements: **actual methods**

In **factorial method**, for the average pig of a population:

- Maintenance = $0.036*BW^{0.75}$
- Growth = $0.16*0.07*ADG$

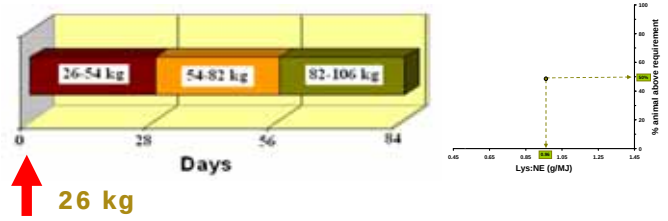




Nutrient requirements: **actual methods**

The **factorial method** addresses the needs of

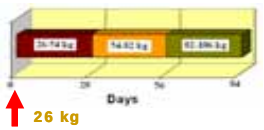
- **one reference animal**
- **during a very short period, normally one day**
- **for normal (maximal) performance**

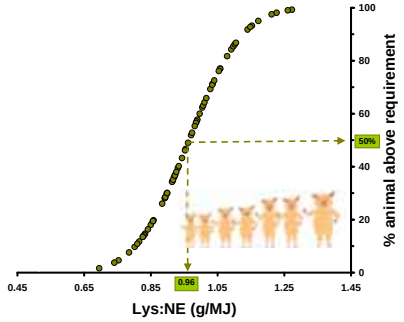


Pomar et al., 2007

Nutrient requirements: **actual methods**

It is possible to use the **factorial method** to estimate the population requirements at fixed point in time





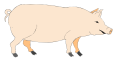
Pomar et al., 2003; Brossard et al., 2009; Hauschild et al., 2010

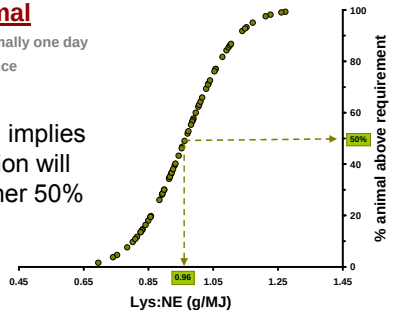
Nutrient requirements: **actual methods**

The **factorial method** addresses the needs of

- **one reference animal**
- during a very short period, normally one day
- for normal (maximal) performance

Feeding the **average pig** implies that 50% of the population will be overfeed while the other 50% will be underfeed





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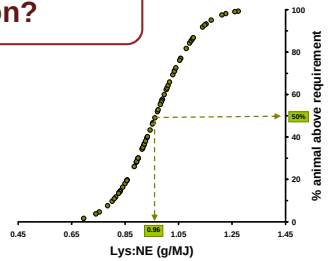
Nutrient requirements: **actual methods**

To use the **factorial method** to address the requirements of a population

Who is the best representative of this population?



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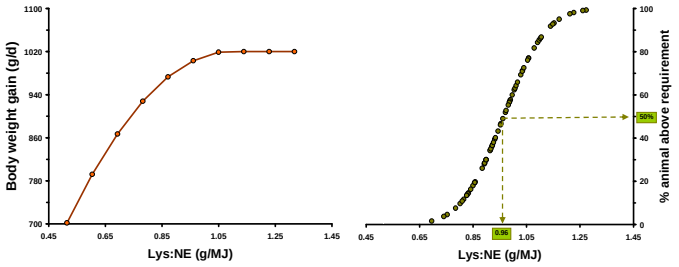
Nutrient requirements: **actual methods**

The objective of using the **factorial method** to estimate population requirements is to optimize population performance… that is, the **empirical requirement**!



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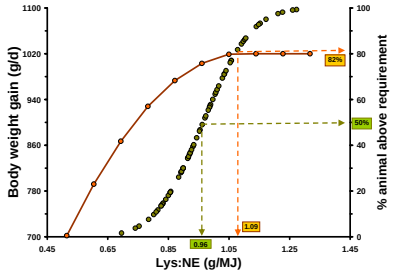
Nutrient requirements: **actual methods**

The relationship between **empirical** and **factorial** methods is difficult to establish and is affected by many factors related to the animal, growth state and population heterogeneity



Hauschild et al., 2010

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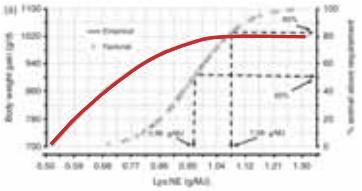
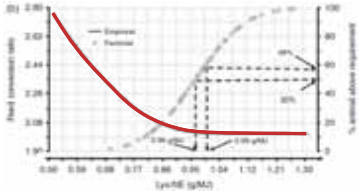
Nutrient requirements: **actual methods**

ADG



FCR



In the 25-50 kg BW interval			
	Maximal population	Average pig	Pop/average pig
Lys requirements, g/MJ EN	1.09	0.96	114%
Performance, ADG, g/d	1000	900	111%

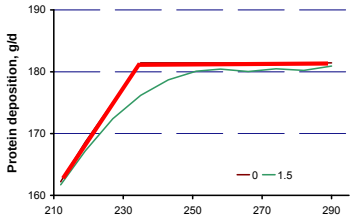
In the 25-50 kg BW interval			
	Maximal population	Average pig	Pop/average pig
Lys requirements, g/MJ EN	0.99	0.96	103%
Performance, FCR	2.44	2.35	104%

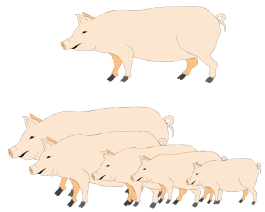
Hauschild et al., 2010

Nutrient requirements: **actual methods**

When the factorial method is used to estimate population requirements it should be taken into account that,

✓ **Individual and population responses differ in form and magnitude**



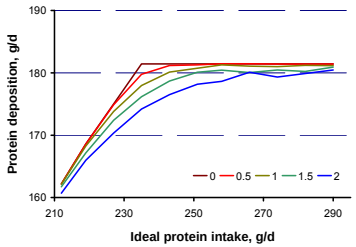


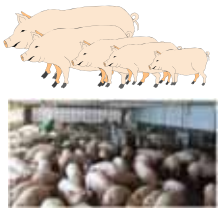
Pomar et al., 2003

Nutrient requirements: **actual methods**

When the factorial method is used to estimate population requirements it should be taken into account that,

✓ **These differences increase with the heterogeneity of the populations**

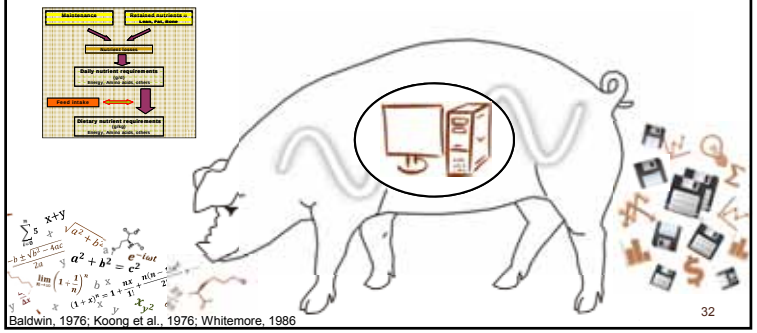




Pomar et al., 2003

Nutrient requirements: **actual methods**

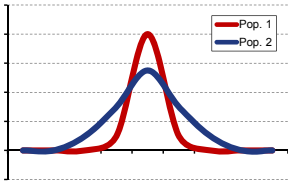
Mechanistic mathematical models that implement the factorial approach are proposed because of the complexity of animal responses and the numerous factors modulating them



Baldwin, 1976; Koong et al., 1976; Whitemore, 1986

Nutrient requirements: **actual methods**

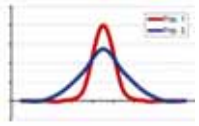
- **Mathematical models have significantly evolved**
  Whittemore et Fawcett 1974; Black et al. 1986
- **New approaches are proposed today to simulate pig populations**
  Ferguson et al. 1994, 2008, Knap 2000, Pomar et al. 2003, Wellock et al. 2004, Van Milgen et al. 2008, Brossard et al. 2009, Hauschild et al. 2012, NRC 2012, Vautier et al. 2013

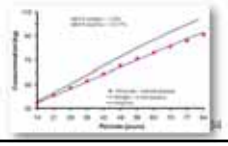


Nutrient requirements: **actual methods**

These mathematical models are challenged by complex problems such as,

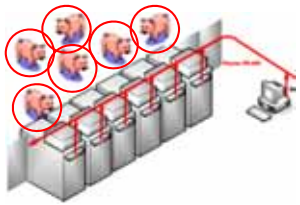
- ✓ the difficulty of identifying **the right reference population** for calibration,
- ✓ the difficulty of representing **population heterogeneity** and,
- ✓ the fact that animals may follow **different feed intake and growth patterns** than the ones observed in the reference population





Nutrient requirements: **real-time estimation**

Feeding growing pigs **individually** with daily tailored diets, whose formulation is based on their own **real-time patterns** of feed intake and growth requires the development of **new mathematical models**



Pomar and Pomar 2012; Hauschild et al. 2012; Rivest et al., 2012

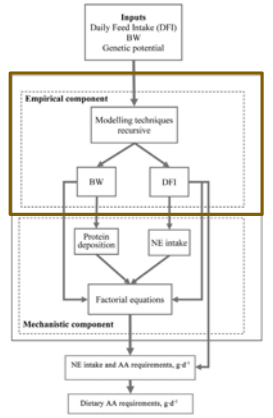
Nutrient requirements: **real-time estimation**

The proposed model includes **empirical** and **mechanistic** components

The **empirical model component** estimates daily feed intake (DFI), body weight (BW), and daily gain (DG) based on individual pig information collected in real-time

$$DFI_{t\to t_m}(kg) = a_i + b_i m$$
$$BW_{t\to t_m}(kg) = a_i + b_i m$$

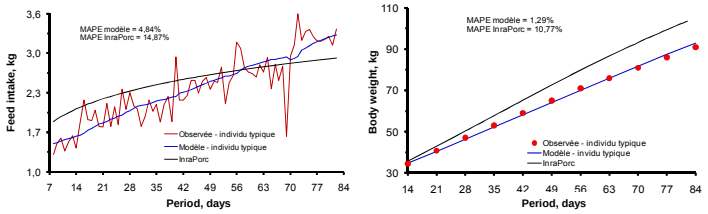
$$a_i = 2S_i^* - S_{i_1}$$
$$b_i = \frac{\alpha}{1-\alpha}(S_i^* - S_{i_1})$$



Hauschild et al. 2012

Nutrient requirements: **real-time estimation**

Daily feed intake and **body weight** are estimated based on individual pig information collected in real-time



Hauschild et al. 2012

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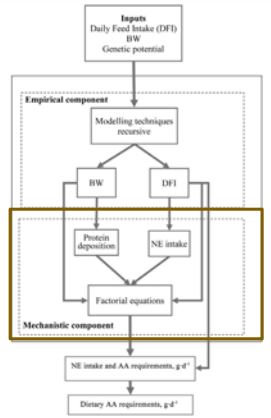
Nutrient requirements: **real-time estimation**

The **mechanistic model component** uses classic factorial equations to estimate the optimal concentration of nutrients based on DFI, BW, and DG estimates from the empirical component

$$\text{Lys maint (g/d)} = \text{LysBas}\cdot BW^{0.75} + \text{Lysme}\cdot BW^{0.75} + \text{LysEndo}\cdot FI$$

$$\text{Lys growth (g/d)} = DG \cdot PD/DG \cdot \text{Lys}/PD$$

$$\text{Lys req (g/kg)} = (\text{Lys Maint} + \text{Lys growth})/FI$$



Hauschild et al. 2012

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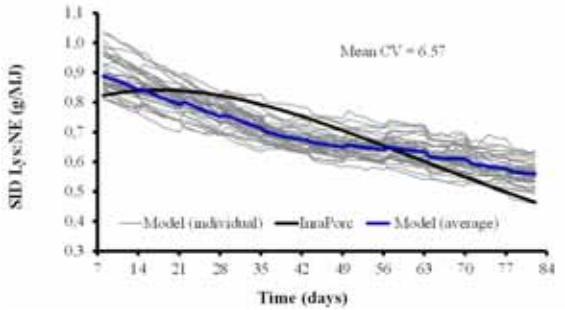
Nutrient requirements: **real-time estimation**

Optimal concentration of lysine (Lys :EN) estimated by the model for a group of animals and by InraPorc



Hauschild et al. 2012

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Precision feeding

Does it works with real animals ?

6 feeder prototypes

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Precision feeding

Does it works with real animals ?

7 animal trials and several others dealing with the numerical procedures

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Precision feeding: **first calibration trial**

- ✓ Sixty animals were housed in one pen equipped with five automatic feeders
- ✓ Daily SIDLys was estimated for each pig daily
- ✓ Pigs were assigned to one of the 6 dietary treatments (**60, 70, 80, 90, 100 and 110%** of the estimated SIDLys)
- ✓ Pigs' performance and body composition measured with DXA at the beginning and at end of 2 growing intervals (25 - 50 kg and 70 - 100 kg BW)

Zhang et al., 2012

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Precision feeding: **first calibration trial**

	SEM	P values			Statistics		
		Linear	Quad.	Res.	Mean	Max	Min
25-55 kg BW	0.88	<0.0001	0.086	0.941	7.0	8.7	5.8
70-100 kg BW	0.40	<0.0001	0.092	0.826	5.4	7.1	4.1

Zhang et al., 2012

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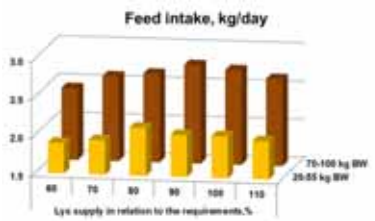
Precision feeding: **first calibration trial**



	SEM	P values			Statistics		
		Linear	Quad.	Res.	Mean	Max	Min
25-55 kg BW	0.20	0.195	0.052	0.529	2.0	2.1	1.9
70-100 kg BW	0.27	0.040	0.035	0.905	2.6	2.8	2.4

Zhang et al., 2012

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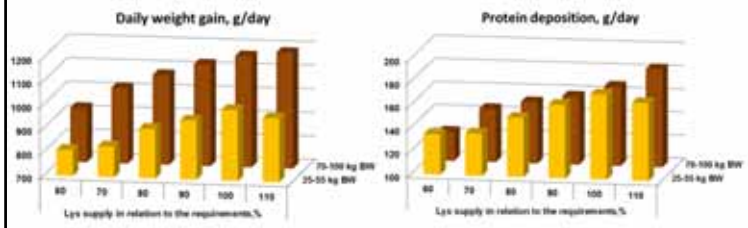
Precision feeding: **first calibration trial**



	SEM	P values			Statistics		
		Linear	Quad.	Res.	Mean	Max	Min
25-55 kg BW	114	<0.0001	0.304	0.614	912	1000	810
70-100 kg BW	106	<0.0001	0.147	0.999	1067	1190	930

	SEM	P values			Statistics		
		Linear	Quad.	Res.	Mean	Max	Min
25-55 kg BW	19.4	<0.0001	0.320	0.387	155	174	135
70-100 kg BW	9.7	<0.0001	0.827	0.580	156	185	125

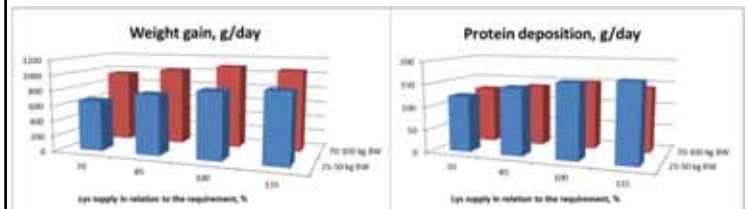
Zhang et al., 2012

Precision feeding: **second calibration trial**

- ✓ One hundred and forty-seven barrows were housed in one pen equipped with five automatic feeders
- ✓ Daily SIDLys was estimated for each pig daily
- ✓ Pigs were assigned to a 2 (genetic lines) x 4 (dietary treatments: **70, 85, 100 and 115%** of the estimated SIDLys) factorial design
- ✓ Pigs' performance and body composition measured with DXA at the beginning and at end of 2 growing intervals (25 - 50 kg and 70 - 100 kg BW)

Cloutier et al., 2013

Precision feeding: **second calibration trial**



	Lysine supply in relation to requirements, %				SEM
	70	85	100	115	
25-50 kg BW	664^{c}	777^{b}	864^{ab}	900^{a}	109
70-100 kg BW	950^{b}	1020^{ab}	1090^{a}	1060^{ab}	150

	Lysine supply in relation to requirements, %				SEM
	70	85	100	115	
25-50 kg BW	126^{b}	136^{ab}	150^{a}	142^{ab}	25
70-100 kg BW	124^{c}	147^{b}	163^{ab}	170^{a}	20

Cloutier et al., 2013

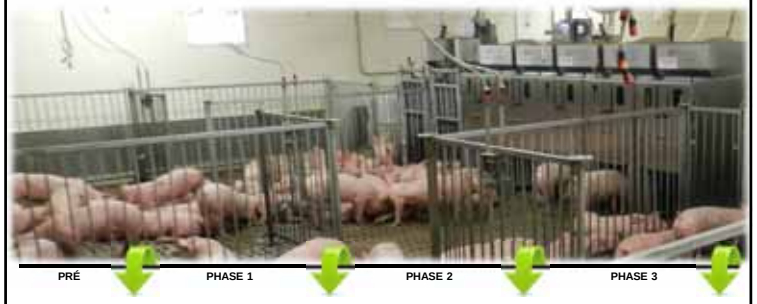
Precision feeding: **two validation trials**

Two trials were conducted to evaluate the impact of feeding growing-finishing pigs with daily tailored diets using precision feeding techniques on animal performance, nutrient utilization, body and carcass composition, and feeding cost

Andretta et al., 2014

Precision feeding: **two validation trials**

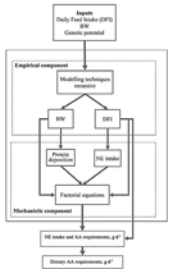
Trial 1 :	**Trial 2 :**
60 castrated males 41,2 ± 3,9 kg	35 females and 35 castrated males 30,4 ± 2,2 kg



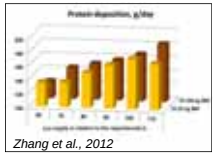
Andretta et al., 2014

Validation trials: **lysine requirements**

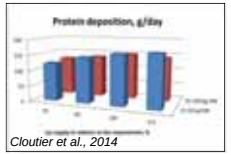
Estimated for each pig in real-time



Parameters previously calibrated in two projects



Zhang et al., 2012



Cloutier et al., 2014

Hauschild et al., 2012

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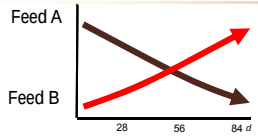
Validation trials: material and methods



Trial 1

Comercial feeds I, II e III

Feed A

Feed B

Trial 2

Feed A

Feed B

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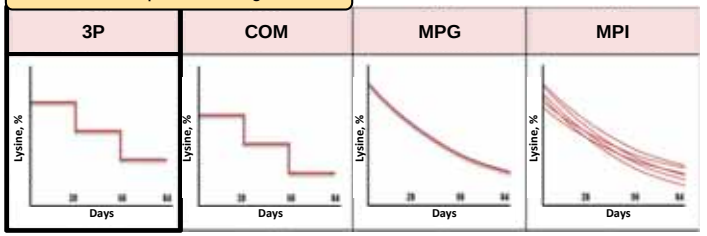
Trial 1: feeding programs

Three-phase feeding



Three-phase feeding A+B (3P)

Providing within each phase a fixed blend of premixes A and B calculated during the first 3 days of each phase to satisfy the lysine requirement of the 80th percentile pig of this group

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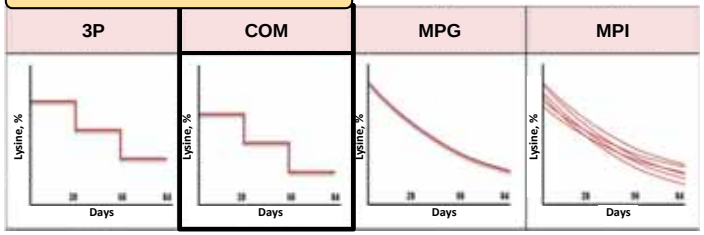
Trial 1: feeding programs

Three-phase feeding



Three-phase comercial feeding

Pigs were fed with complete diets formulated according to local industry standards, used in this project in order to validate the results of 3P group as representatives for industrial conditions

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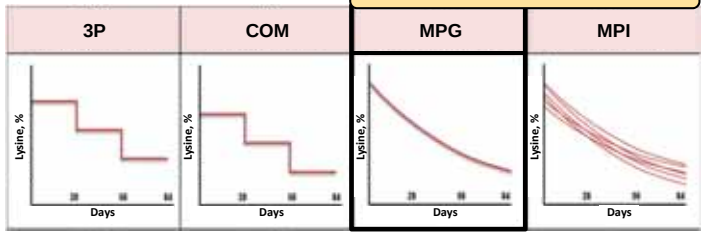
Trial 1: feeding programs

Multi-phase feeding



Daily-phase-group feeding

All pigs received the same blend of premixes A and B calculated at the beginning of each day to satisfy the lysine requirement of the 80th percentile pig of this group

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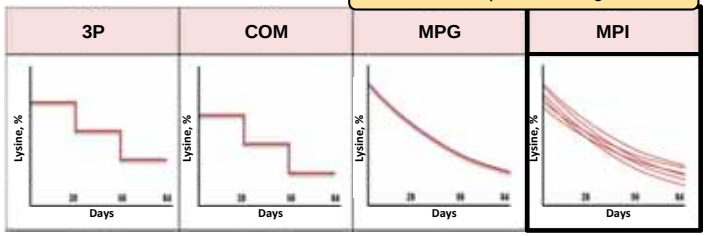
Trial 1: feeding programs

Multi-phase feeding



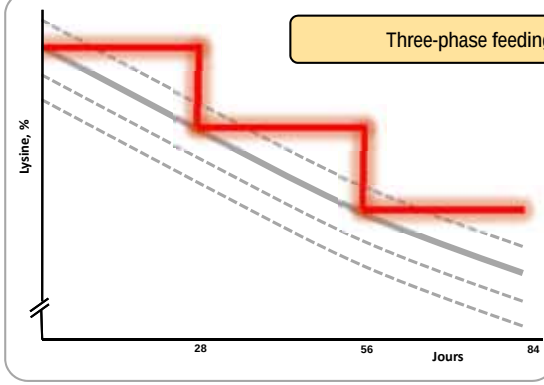
Daily-phase-individual feeding

Pigs were fed with a blend of premixes A and B calculated at the beginning of each day to satisfy the lysine requirement of each pig individually

55

Trial 2: feeding programs

Three-phase feeding A+B (3P)



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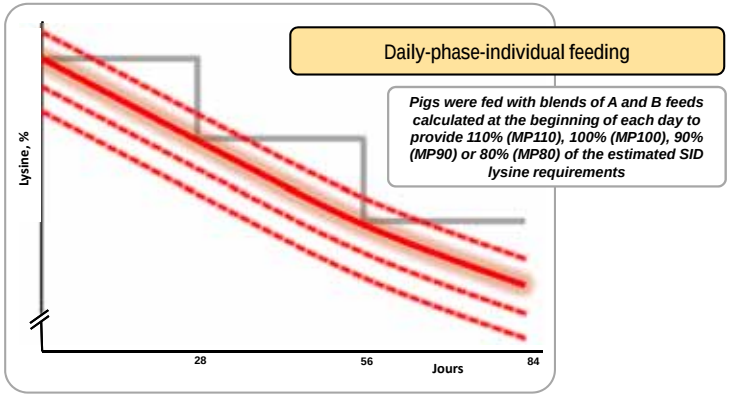
Trial 2: feeding programs



57

Validation trials: material and methods

Feed intake was recorded in real time for each pig through a computerized registering system. Pigs were weighed weekly during the project.

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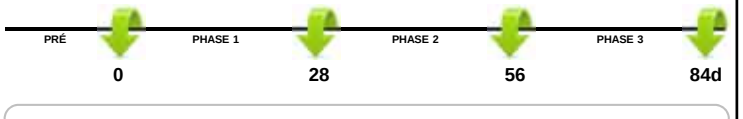
Validation trials: material and methods



Protein and lipid amounts were obtained by transforming the lean and fat values from the dual-energy X-ray absorptiometry densitometry measurements to their chemical equivalents

Nitrogen excretion: ratio between retention and intake

Pomar et Rivest, 1996

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Validation trials: material and methods

Feed costs:
calculated using recent feed ingredients prices in Quebec

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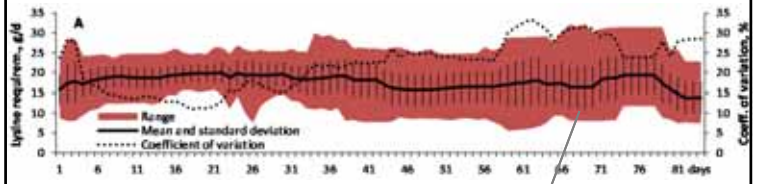
Validation trials: results

Trial 1



Max. range: 24.1 g/j

Average intra-day range	**16,7 g/d SID Lys**
Average intra-day CV	**22%**

Andretta et al., 2014

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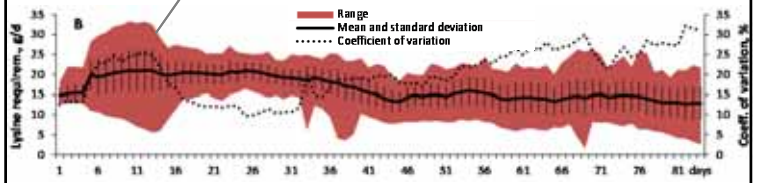
Validation trials: results

Trial 2

Average intra-day range	**15.2 g/d SID Lys**
Average intra-day CV	**20%**

Max. range: 27 g/j



Andretta et al., 2014

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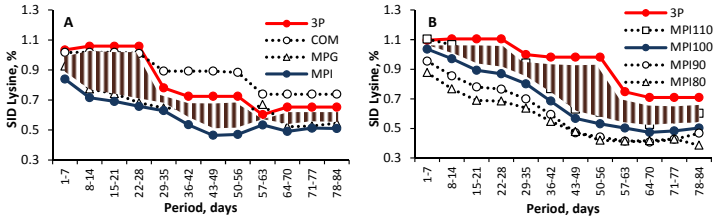
Validation trials: results

Dietary SID lysine level in trial 1 (A) and trial 2 (B)



Trial 1

3P *vs* MPI: -27%

Trial 2

3P *vs* MPI100: -26%

Andretta et al., 2014

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Validation trials: results

Table 1 – Performance, feeding costs and nitrogen balance of pigs fed in three-phase (3P), commercial (COM), daily-phase-group (MPG) and daily-phase-individual (MPI) feeding programs (trial 1)

Variable	Treatments[1]				SEM	P value
	3P	COM	MPG	MPI		
Daily feed intake, kg/day	3,05[b]	2,73[a]	3,07[b]	3,05[b]	0,04	<0,01
Daily weight gain, kg/day	1,11	1,07	1,11	1,10	0,01	0,58
Gain:Feed ratio, kg/kg	0,38[b]	0,40[a]	0,37[b]	0,37[b]	0,01	0,01
Daily protein gain, g/day	161	155	155	154	2,30	0,65
Daily lipid gain, g/day	343	326	366	369	9,11	0,16
Final BW, kg	134	131	135	136	1,12	0,24
Final backfat thickness, mm	19,1[a]	16,8[b]	19,5[a]	19,1[a]	0,50	0,03
Final loin muscle depth, mm	70,1	70,2	71,5	70,2	0,74	0,91
Daily crude protein intake, g/day	480[a]	433[b]	433[b]	405[b]	5,80	<0,01
Daily SID[2] lysine intake, g/day	23,8[a]	23,9[a]	19,7[b]	17,4[c]	0,42	<0,01
Nitrogen retention, kg/pig	2,17	2,08	2,08	2,06	0,02	0,64
Nitrogen excretion, kg/pig	4,04[a]	3,52[b]	3,54[b]	3,17[b]	0,07	<0,01
Feeding cost, $/pig	85,5[ab]	87,3[a]	82,7[b]	78,6[c]	0,94	<0,01
Feeding cost, $/100kg	92,4[ab]	97,7[a]	89,8[bc]	85,3[c]	0,01	<0,01

[1] Within a row, means without a common superscript differ ($P < 0.05$) according to Tukey's test.
[2] Standardized ileal digestible.

Andretta et al., 2014

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Validation trials: results

Table 1 – Performance, feeding costs and nitrogen balance of pigs fed in three-phase (3P), commercial (COM), daily-phase-group (MPG) and daily-phase-individual (MPI) feeding programs (trial 1)

Variable	Treatments[1]				SEM	P value
	3P	COM	MPG	MPI		
Daily feed intake, kg/day	3,05^{b}	2,73^{a}	3,07^{b}	3,05^{b}	0,04	<0,01
Daily weight gain, kg/day	1,11	1,07	1,11	1,10	0,01	0,58
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Final backfat thickness, mm	19,1^{a}	16,8^{b}	19,5^{a}	19,1^{a}	0,50	0,03
Final loin muscle depth, mm	70,1	70,2	71,5	70,2	0,74	0,91
Daily crude protein intake, g/day	480^{a}	433^{b}	433^{b}	405^{b}	5,80	<0,01
Daily SID[2] lysine intake, g/day	23,8^{a}	23,9^{a}	19,7^{b}	17,4^{c}	0,42	<0,01
Nitrogen retention, kg/pig	2,17	2,08	2,08	2,06	0,02	0,64
Nitrogen excretion, kg/pig	4,04^{a}	3,52^{b}	3,54^{b}	3,17^{b}	0,07	<0,01
Feeding cost, $/pig	85,5^{ab}	87,3^{a}	82,7^{b}	78,6^{c}	0,94	<0,01
Feeding cost, $/100kg	92,4^{ab}	97,7^{a}	89,8^{bc}	85,3^{c}	0,01	<0,01

[1] Within a row, means without a common superscript differ ($P < 0.05$) according to Tukey's test.
[2] Standardized ileal digestible.

Andretta et al., 2014

Validation trials: results

Table 1 – Performance, feeding costs and nitrogen balance of pigs fed in three-phase (3P), commercial (COM), daily-phase-group (MPG) and daily-phase-individual (MPI) feeding programs (trial 1)

Variable	Treatments[1]				SEM	P value
	3P	COM	MPG	MPI		
Daily feed intake, kg/day	3,05^{b}	2,73^{a}	3,07^{b}	3,05^{b}	0,04	<0,01
Daily weight gain, kg/day	1,11	1,07	1,11	1,10	0,01	0,58
Gain:Feed ratio, kg/kg	0,38^{b}	0,40^{a}	0,37^{b}	0,37^{b}	0,01	0,01
Daily protein gain, g/day	161	155	155	154	2,30	0,65
Daily lipid gain, g/day	343	326	366	369	9,11	0,16
Final BW, kg	134	131	135	136	1,12	0,24
Final backfat thickness, mm	19,1^{a}	16,8^{b}	19,5^{a}	19,1^{a}	0,50	0,03
Final loin muscle depth, mm	70,1	70,2	71,5	70,2		3P *vs* MPI
Daily crude protein intake, g/day	480^{a}	433^{b}	433^{b}	405^{b}		-16%
Daily SID[2] lysine intake, g/day	23,8^{a}	23,9^{a}	19,7^{b}	17,4^{c}		-27%
Nitrogen retention, kg/pig	2,17	2,08	2,08	2,06	0,02	0,64
Nitrogen excretion, kg/pig	4,04^{a}	3,52^{b}	3,54^{b}	3,17^{b}		-22%
Feeding cost, $/pig	85,5^{ab}	87,3^{a}	82,7^{b}	78,6^{c}		6,9 $/porc (8%)
Feeding cost, $/100kg	92,4^{ab}	97,7^{a}	89,8^{bc}	85,3^{c}	0,01	<0,01

[1] Within a row, means without a common superscript differ ($P < 0.05$) according to Tukey's test.
[2] Standardized ileal digestible.

Andretta et al., 2014

Validation trials: results

Table 2 – Performance, feeding costs and nitrogen balance of pigs fed in three-phase program (3P) or daily-phase-individual program (MP) considering 110%, 100%, 90% ou 80% of the estimated nutritional requirements (trial 2)

Variable	Traitements[1]					SEM	P value
	3P	MP110	MP100	MP90	MP80		
Daily feed intake, kg/day	2,44	2,43	2,53	2,57	2,33	0,03	0,52
Daily weight gain, kg/day	1,05^{a}	1,05^{a}	1,03^{a}	1,00^{ab}	0,93^{b}	0,01	<0,01
Gain:Feed ratio, kg/kg	0,43	0,43	0,41	0,39	0,40	0,01	0,05
Daily protein gain, g/day	167^{a}	167^{a}	166^{a}	158^{ab}	148^{b}	3,10	<0,01
Daily lipid gain, g/day	256	263	245	256	235	2,74	0,55
Final BW, kg	119^{a}	118^{a}	116^{ab}	114^{ab}	108^{b}	1,21	0,02
Final backfat thickness, mm	15,6	17,0	15,5	16,1	15,2	0,36	0,37
Final loin muscle depth, mm	72,4^{a}	74,1^{a}	69,7^{ab}	64,6^{b}	64,6^{b}	0,87	<0,01
Daily crude protein intake, g/day	380^{a}	331^{b}	318^{b}	302^{bc}	262^{c}	4,00	<0,01
Daily SID[2] lysine intake, g/day	22,4^{a}	18,1^{b}	16,5^{bc}	15,0^{c}	12,5^{d}	0,38	<0,01
Nitrogen retention, kg/pig	2,25^{a}	2,24^{a}	2,24^{a}	2,13^{ab}	1,99^{b}	0,01	<0,01
Nitrogen excretion, kg/pig	2,66^{a}	2,04^{b}	1,87^{bc}	1,78^{bc}	1,41^{c}	0,02	<0,01
Feeding cost, $/pig	80,5^{a}	74,8^{ab}	72,8^{b}	72,8^{b}	68,0^{c}	0,33	0,01
Feeding cost, $/100kg	89,7^{a}	84,4^{b}	84,6^{b}	84,8^{b}	86,3^{ab}	1,21	0,04

[1] Within a row, means without a common superscript differ ($P < 0.05$) according to Tukey's test.
[2] Standardized ileal digestible.

Validation trials: results

Table 2 – Performance, feeding costs and nitrogen balance of pigs fed in three-phase program (3P) or daily-phase-individual program (MP) considering 110%, 100%, 90% ou 80% of the estimated nutritional requirements (trial 2)

Variable	Traitements[1]					SEM	P value
	3P	MP110	MP100	MP90	MP80		
Daily feed intake, kg/day	2,44	2,43	2,53	2,57	2,33	0,03	0,52
Daily weight gain, kg/day	1,05^{a}	1,05^{a}	1,03^{a}	1,00^{ab}	0,93^{b}	0,01	<0,01
Gain:Feed ratio, kg/kg	0,43	0,43	0,41	0,39	0,40	0,01	0,05
Daily protein gain, g/day	167^{a}	167^{a}	166^{a}	158^{ab}	148^{b}	3,10	<0,01
Daily lipid gain, g/day	256	263	245	256	235	2,74	0,55
Final BW, kg	119^{a}	118^{a}	116^{ab}	114^{ab}	108^{b}	1,21	0,02
Final backfat thickness, mm	15,6	17,0	15,5	16,1	15,2	0,36	0,37
Final loin muscle depth, mm	72,4^{a}	74,1^{a}	69,7^{ab}	64,6^{b}	64,6^{b}	0,87	<0,01
Daily crude protein intake, g/day	380^{a}	331^{b}	318^{b}	302^{bc}	262^{c}	4,00	<0,01
Daily SID[2] lysine intake, g/day	22,4^{a}	18,1^{b}	16,5^{bc}	15,0^{c}	12,5^{d}	0,38	<0,01
Nitrogen retention, kg/pig	2,25^{a}	2,24^{a}	2,24^{a}	2,13^{ab}	1,99^{b}	0,01	<0,01
Nitrogen excretion, kg/pig	2,66^{a}	2,04^{b}	1,87^{bc}	1,78^{bc}	1,41^{c}	0,02	<0,01
Feeding cost, $/pig	80,5^{a}	74,8^{ab}	72,8^{b}	72,8^{b}	68,0^{c}	0,33	0,01
Feeding cost, $/100kg	89,7^{a}	84,4^{b}	84,6^{b}	84,8^{b}	86,3^{ab}	1,21	0,04

[1] Within a row, means without a common superscript differ ($P < 0.05$) according to Tukey's test.
[2] Standardized ileal digestible.

Validation trials: results

Table 2 – Performance, feeding costs and nitrogen balance of pigs fed in three-phase program (3P) or daily-phase-individual program (MP) considering 110%, 100%, 90% ou 80% of the estimated nutritional requirements (trial 2)

Variable	Traitements[1]					SEM	P value
	3P	MP110	MP100	MP90	MP80		
Daily feed intake, kg/day	2,44	2,43	2,53	2,57	2,33	0,03	0,52
Daily weight gain, kg/day	1,05^{a}	1,05^{a}	1,03^{a}	1,00^{ab}	0,93^{b}	0,01	<0,01
Gain:Feed ratio, kg/kg	0,43	0,43	0,41	0,39	0,40	0,01	0,05
Daily protein gain, g/day	167^{a}	167^{a}	166^{a}	158^{ab}	148^{b}	3,10	<0,01
Daily lipid gain, g/day	256	263	245	256	235	2,74	0,55
Final BW, kg	119^{a}	118^{a}	116^{ab}	114^{ab}	108^{b}	1,21	0,02
Final backfat thickness, mm	15,6	17,0	15,5	16,1	15,2	0,36	0,37
Final loin muscle depth, mm	72,4^{a}	74,1^{a}	69,7^{ab}	3P *vs* MPI100		37	<0,01
Daily crude protein intake, g/day	**380^{a}**	331^{b}	**318^{b}**	**-16%**		00	<0,01
Daily SID[2] lysine intake, g/day	**22,4^{a}**	18,1^{b}	**16,5^{bc}**	**-26%**		38	<0,01
Nitrogen retention, kg/pig	2,25^{a}	2,24^{a}	2,24^{a}	2,13^{ab}	1,99^{b}	0,01	<0,01
Nitrogen excretion, kg/pig	**2,66^{a}**	2,04^{b}	**1,87^{bc}**	**-30%**		02	<0,01
Feeding cost, $/pig	**80,5^{a}**	74,8^{ab}	**72,8^{b}**	**7,7 $/porc (10%)**		53	0,01
Feeding cost, $/100kg	**89,7^{a}**	84,4^{b}	**84,6^{b}**	84,8^{b}	86,3^{ab}	1,21	0,04

[1] Within a row, means without a common superscript differ ($P < 0.05$) according to Tukey's test.
[2] Standardized ileal digestible.

Validation trials: **conclusion**

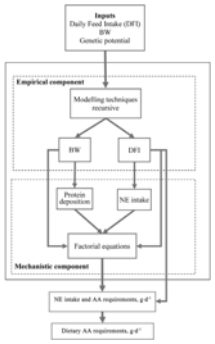
Feeding growing pigs individually with daily tailored diets may be a key element to optimize the sustainability of pig farming systems

According to the current findings, precision feeding technique is an effective approach to improve nutrient efficiency, to reduce nutrient excretion, to decrease raising costs and to improve economic profitability in pig industry

Precision feeding: **final remarks**

Feeding pigs individually with daily tailored diets formulated based on its own real-time patterns of feed intake and growth represents a **fundamental paradigm shift** in pig feeding

Nutrient requirements are no longer a static population characteristic, but a **dynamic process** that evolves independently for each animal



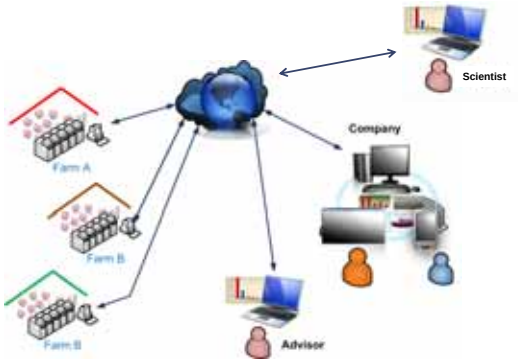
Precision feeding: **final remarks**

Empirical and factorial methods, as well as the models implementing these methods

- ✓ Must be calibrated, ***a priori***,
- ✓ Using data collected from **bygone reference populations**

Precision feeding: **final remarks**

In a context of **precision livestock farming**, feeding interventions are at different levels,



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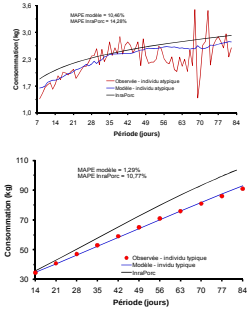
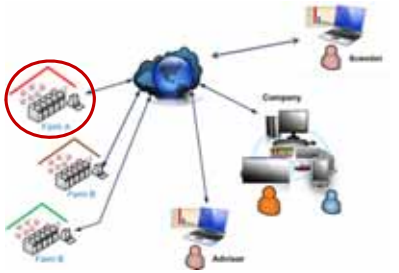
Precision feeding: **final remarks**

In a context of **precision livestock farming**, feeding interventions are at different levels,

At the farm:





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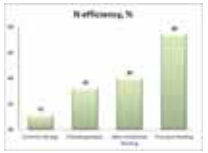
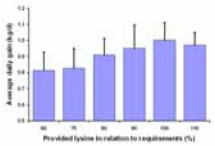
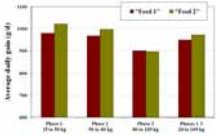
Precision feeding: **final remarks**

In a context of **precision livestock farming**, feeding interventions are at different levels,

At the office:







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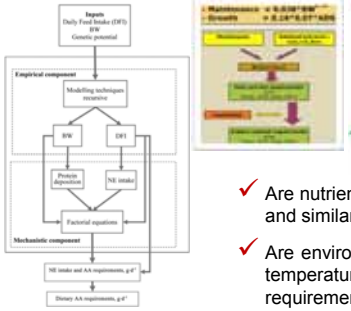
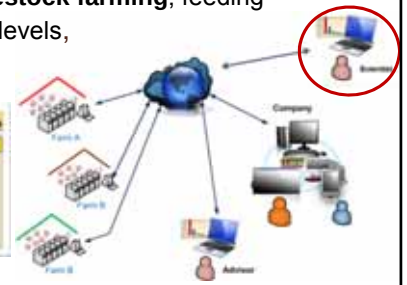
Precision feeding: **final remarks**

In a context of **precision livestock farming**, feeding interventions are at different levels,

For the scientist:





- ✓ Are nutrient efficiencies constant over weight and similar between animals?
- ✓ Are environmental stressors (i.e., deceases, temperature, space allowances) modifying requirements?

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Thank you