Modelling the lysine requirements of weaned piglets using a factorial growth model

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Outline

- Goal and overview of the model
- Model mechanisms
- Validation of the model
- Application of the model

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Scope of the project

PPS project 'Voeding op maat'

reduce nitrogen emission in production animals through improved nutrition

Estimation of lysine requirement of weaned piglets based on:

- Published literature (presentation Sophie Goethals)
- A factorial growth model

Goal:	to design a spreadsheet model as a predictive tool for the SID lysine requirements of weaned piglets over time
Boundary:	model outputs are representative of a healthy piglet (5-30kg) housed in neutral climate conditions

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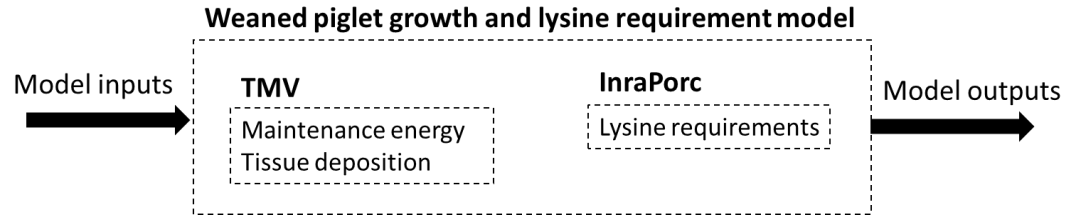
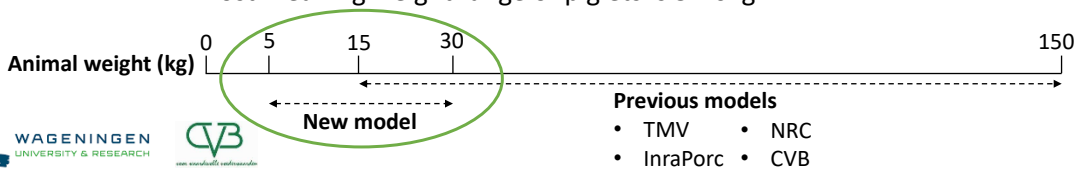
Model mechanisms are adapted from previous pig growth models



- Model mechanisms and parameters are adapted (where possible) to be representative of weaned piglets
  - Previous pig growth models focus on growing-finishing pigs in the 15-150 kg bodyweight range
  - Post-weaning weight range of piglets is 5-10kg



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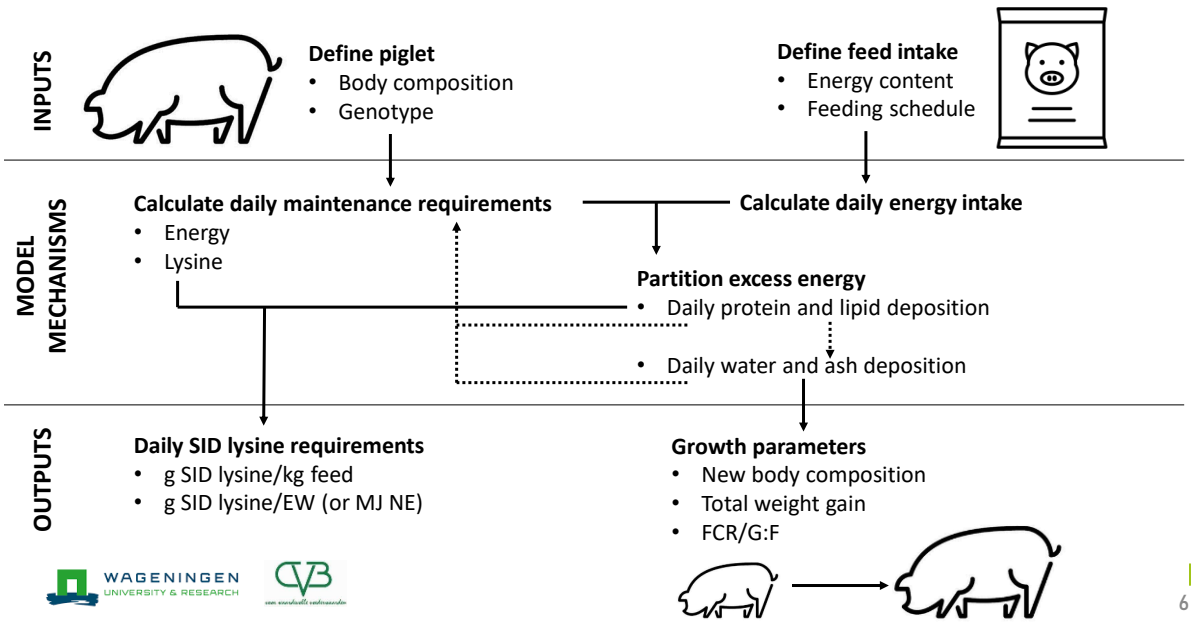
Schematic flowchart of the model



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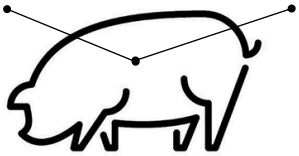
Outline

- Goal and overview of the model
- **Model mechanisms**
  - Default piglet composition and maintenance
  - Feed intake
  - Protein/lipid deposition
  - Water deposition
  - Lysine requirement
- Validation of the model
- Application of the model

Default[1] piglet composition and energy maintenance

(Empty) body composition[2]
15.5% protein
10.5% fat
2.9% ash
71.1% water



Daily energy maintenance
1.012 MJ ME/kg$^{0.6}$/day
x
Bodyweight (in kg$^{0.6}$)

- Bodyweight and body composition are updated per day of simulation as a result of tissue deposition (or degradation)
- Maintenance energy is linked to energetic efficiency of protein and lipid deposition -> no such dataset exists for piglets, used values are for pigs

[1]All input values can be changed in the model
[2]Based on (Piétrain x hybrid) with 95% empty body weight

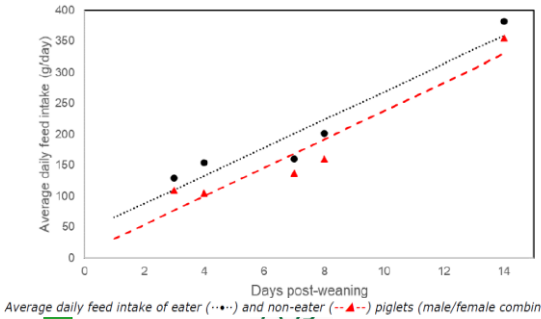
Body composition
Warnants ea 2006 (*Infonamiddag ILVO-DIER:35-50)*
Jones ea 2012 (*J. Anim. Sci. 90(11):4072-4080)*

Energy maintenance
Everts ea 2015 *(CVB-Documentation Report nr. 57)*

Feed intake function

It is possible to provide up to five different (linear) feeding periods as input, where input consists of:

- Feed period duration (days)
- Total feed intake per period (kg feed) → **Calculate daily feed intake**
- Energy content of the feed (MJ NE/kg or EW/kg) → **Calculate daily energy intake**



Average daily feed intake of eater (···•···) and non-eater (--▲--) piglets (male/female combined)

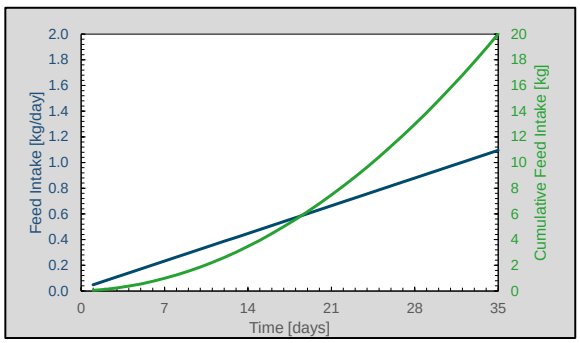
- Initial post-weaning feed intake is highly variable
- Linear increase in daily feed intake post-weaning
- **Assumption:** initial feed intake = **48 g/day**

Initial and total feed intake over a period of known length allows a linear feed intake function to be formed for the model

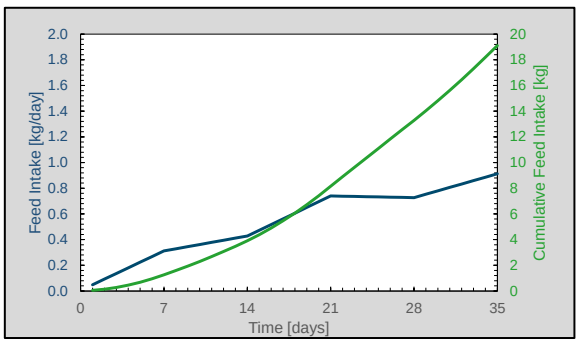
Bruininx ea 2002 (*J. Anim. Sci. 80(6):1413-1418)*
Bruininx ea 2004 (*Anim. Sci. 78:67-75)*
Carstensen ea 2005 *(Vet. Microbiol. 110:113-123)*
Sulabo ea 2010 *(J. Anim. Sci. 88(9):3153-3162)*

Feed intake function - Examples

Feed intake						
Feeding periods	◉ 1	○ 2	○ 3	○ 4	○ 5	
Duration [days]	35					
Total feed intake [kg]	20.000					
Energy content [MJ NE/kg]	10.2					MJ NE

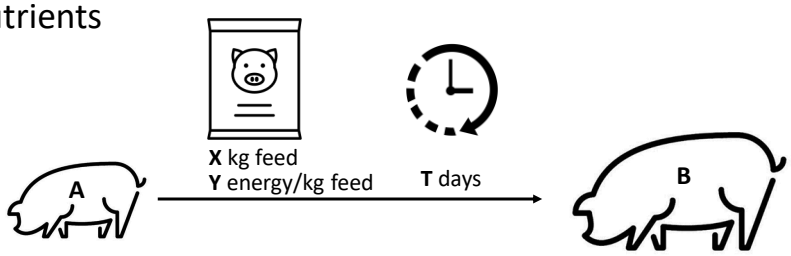


Feed intake						
Feeding periods	○ 1	○ 2	○ 3	○ 4	◉ 5	
Duration [days]	7	7	7	7	7	
Total feed intake [kg]	1.260	2.649	4.243	5.127	5.830	
Energy content [MJ NE/kg]	10.2	10.3	10.4	10.5	10.2	MJ NE



Feed is represented as having an 'ideal' composition

- Energy content is the only defining factor of the diet
- Feed is assumed to contain non-limiting amounts of macro- and micronutrients



Implication on model output

If piglet **A** has grown into piglet **B** while consuming **X** kg of feed with **Y** energy per kg of feed over **T** days, it **would have had** a SID lysine requirement of ...

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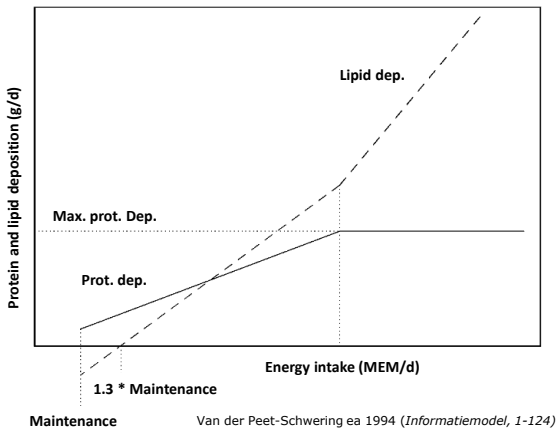
Protein and lipid deposition depend on energy intake

- Excess energy: net protein and/or lipid deposition
- Marginal ratio describes ratio between protein and lipid deposition
  - Older animals tend to deposit more fat than younger animals

Adapted from TMV

Maximum protein deposition is present in the model, but not realistically reached by weaned piglets (limited by consumption of feed)



Van der Peet-Schwering ea 1994 (*Informatiemodel, 1-124)*

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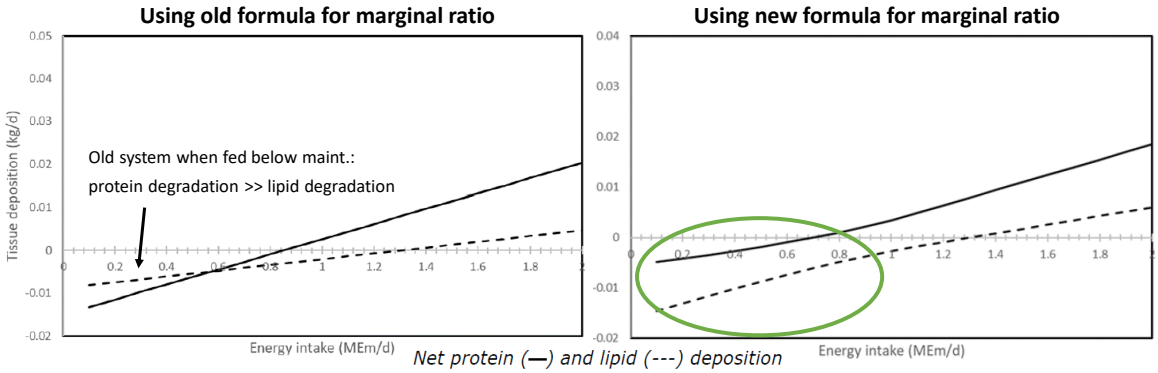
Protein and lipid deposition when fed below maintenance has been adapted to be reflective of *in vivo* observations

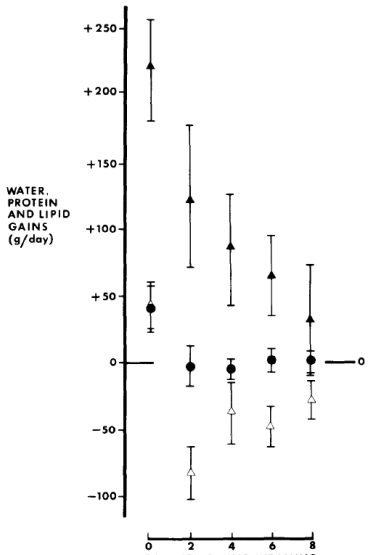


Net protein (—) and lipid (---) deposition

Literature: at low energy intake, piglets will aim to preserve protein tissue at the expense of lipid tissue

Water deposition is partially linked to protein deposition

- Growing-finishing pigs, standard formula with values dependent on pig genotype:
  $Water\ deposition = 5.20 * protein\ deposition^{0.855}$
- Weaned piglets have been observed to deposit excessive amounts of water
  - Bodyweight remains relatively constant as fat seems to be 'replaced' by water
  - Current hypothesis is that this is an effect of insulin resistance as a result of the sudden switch of diet
- System has been implemented in the model that 'compensates' fat loss with water gain during the first week post-weaning



Daily gains of water (▲), protein (●) and lipid (△) of pigs following weaning (±s.d.). Day 0 gains refer to the suckled control pigs.

De Lange ea 2003 (*J. Anim. Sci. 81(14):E159-E165*)
Whittemore ea 1981 (*Anim. Prod. 32:203-210*)

Daily SID lysine requirements are calculated based on amino acid maintenance, feed intake and growth of the piglets

Adapted from InraPorc

$$Lysine\ required\left[\frac{g\ SID\ Lys}{day}\right] = \overbrace{(turnover + integument)}^{\text{Maintenance}} + \overbrace{endogenous}^{\text{Feed intake}} + \overbrace{\frac{prot.deposition}{efficiency}}^{\text{Protein deposition}}$$

$$Lysine\ required\left[\frac{g\ SID\ Lys}{day}\right] = 0.0284 \cdot BW^{0.75} + 0.313 \cdot 0.89 \cdot FI + \frac{0.0696 \cdot 1000 \cdot PD}{0.72}$$

InraPorc reports values that are valid for a pig weighing 55 kg, we assume these values are also applicable to piglets of our weight range

Van Milgen ea 2008 (*Anim. Feed Sci. Technol.* 143(1-4):372-386)

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Validation studies overview

Average daily gain

Author	Starting bodyweight	Energy content diet	Duration	ADG	SID lysine req.
	(kg)	(EW/KG)	(days)	g/day	g/kg feed
Bikker ea 2018	7.56	1.12	35	216-494	-
Bikker ea 2020	8.08	1.15-1.17	42	252-823	-
Bikker ea 2021	8.77	1.19	35	283-656	-
Millet ea 2020	7.93	1.16	35	122-547	-
Millet ea 2021	7.70	1.23	35	379	-
Lysine requirement					
Kahindi ea 2016	7.13	1.18	21	386	13.0
Zhou ea 2019	8.10	1.19	28	458	13.2
Lee ea 2019	6.51	1.23	21	417	13.1

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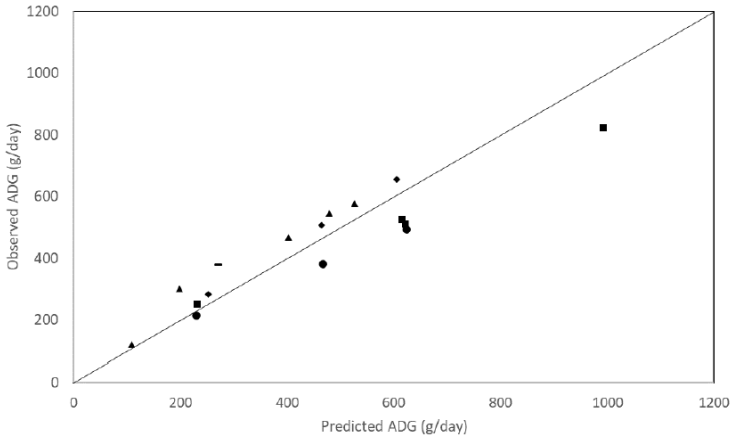
ADG is consistently over- or underestimated



(●) Bikker et al. (2018)
(■) Bikker et al. (2020)
(♦) Bikker et al. (2021)
(▲) Millet et al. (2021)
(-) Millet et al. (2020)

Implies that model mechanisms are adequate, but that piglets between different studies are not properly represented by chosen parameters

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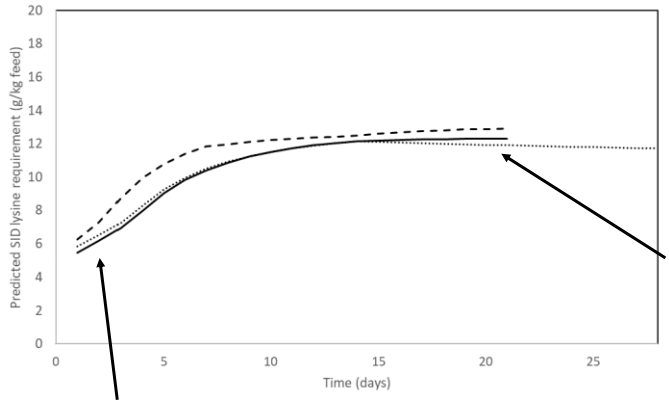
Daily SID lysine requirement follows an expected pattern



(—) Kahindi et al. (2017)
(⋯) Zhou et al. (2020)
(---) Lee et al. (2021)

Stable after a certain period, where ADG and feed intake also have become more stable

Initial lysine requirement is low, which is consistent with low initial protein deposition and low initial feed intake

= low in the initial period

$$Lysine\ required\left[\frac{g\ SID\ Lys}{day}\right] = \overbrace{(turnover + integument)}^{\text{Maintenance}} + \overbrace{endogenous}^{\text{Feed intake}} + \overbrace{\frac{prot.deposition}{efficiency}}^{\text{Protein deposition}}$$

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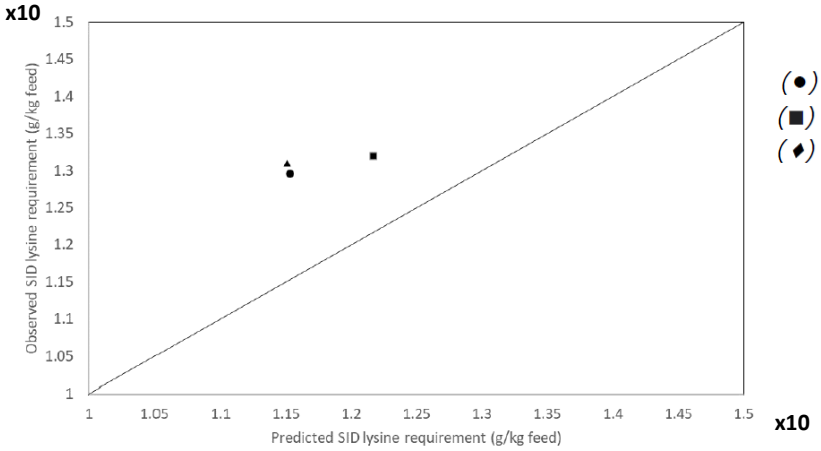
SID lysine requirement is underestimated



(●) Kahindi et al. (2017)
(■) Zhou et al (2019)
(♦) Lee et al. (2021)

This also applies when comparing model outputs to the results of the meta-analysis (presentation Sophie Goethals)

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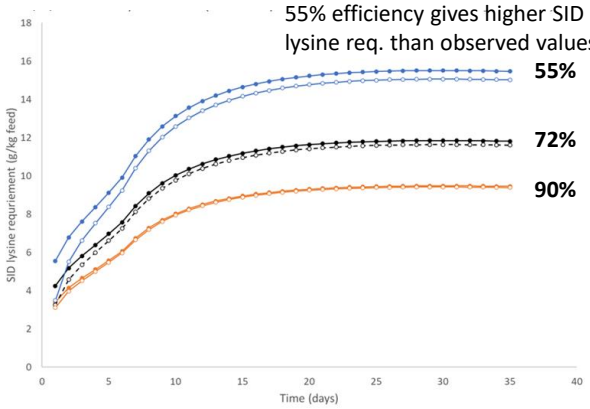
Efficiency of lysine deposition may have been overestimated

$$Lysine\ required\left[\frac{g\ SID\ Lys}{day}\right] = \overbrace{(turnover + integument)}^{\text{Maintenance}} + \overbrace{endogenous}^{\text{Feed intake}} + \frac{\overbrace{prot.deposition}^{\text{Protein deposition}}}{efficiency}$$

Value for efficiency of AA utilization: 72% (Van Milgen et al., 2012), but also values of 55% (Susenbeth et al., 1995) or 90% (Ceron et al., 2013) have been reported

Higher efficiency = less lysine required and vice versa

55% efficiency gives higher SID lysine req. than observed values



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There are other possibilities that might explain the discrepancy

- SIDC for growing pig might differ from piglets, e.g. current SIDC CP of 92.4% for soybean meal, Engelsmann et al. (2022) reported SIDC CP of 15% to 81% for piglets between 7-28 days after weaning.
- (Over or under)-estimation of maintenance energy
- Ratio between protein/lipid deposition
- Other...?

The current model uses a mixture of parameters from both piglet and pig studies. Homogenizing it to use only piglet parameters would increase the robustness of its predictions -> lack of (current) studies

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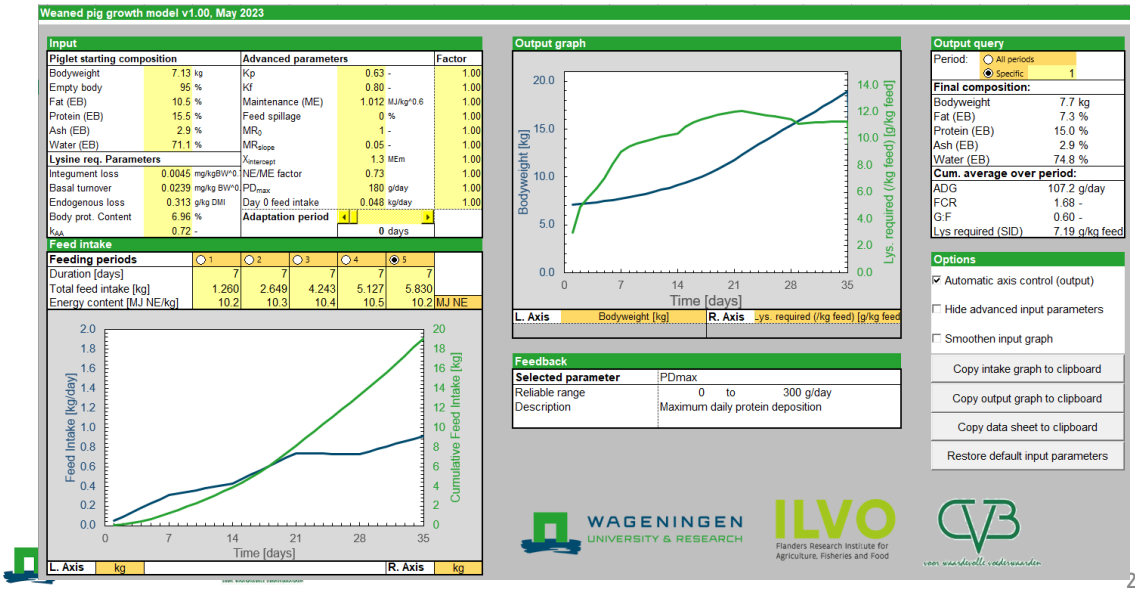
The model has been translated into a spreadsheet



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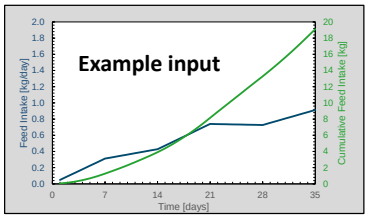
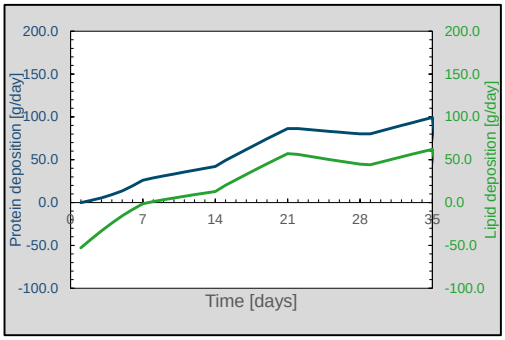
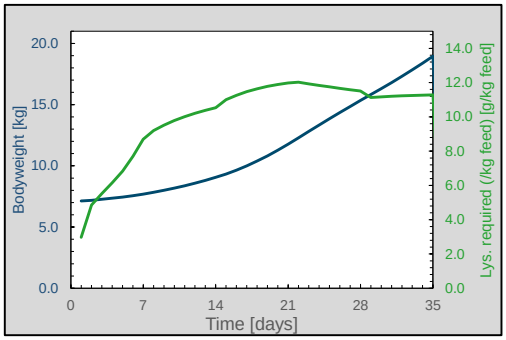
Example of a model output

Visual output showing bodyweight and SID lys. Req. over the simulated period. Every model output can be visualized.







Concluding remarks

- The model shows promising results when using average input parameters
  - SID lysine requirements are lower than observed values, but consistently so
  - When the model is calibrated to a certain piglet genotype/growth range + feed intake, output will likely be more reflective of *in vivo* circumstances
- Updated data to obtain piglet parameters for the model might (drastically) improve model performance
  - Focus on combination of maintenance energy and efficiency of protein/lipid deposition
  - Also the efficiency of lysine deposition

Thank you!

Uitvoerenden:
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