



A review on the lysine requirement of weaned piglets

Sophie Goethals¹, Paul Bikker², Jordi Rijpert², Bart Ampe¹, Wouter Spek², Sam Millet¹

¹*Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Belgium*

²*Wageningen University & Research, the Netherlands*

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Studienamiddag diervoeding

PPS project 'Voeding op maat'

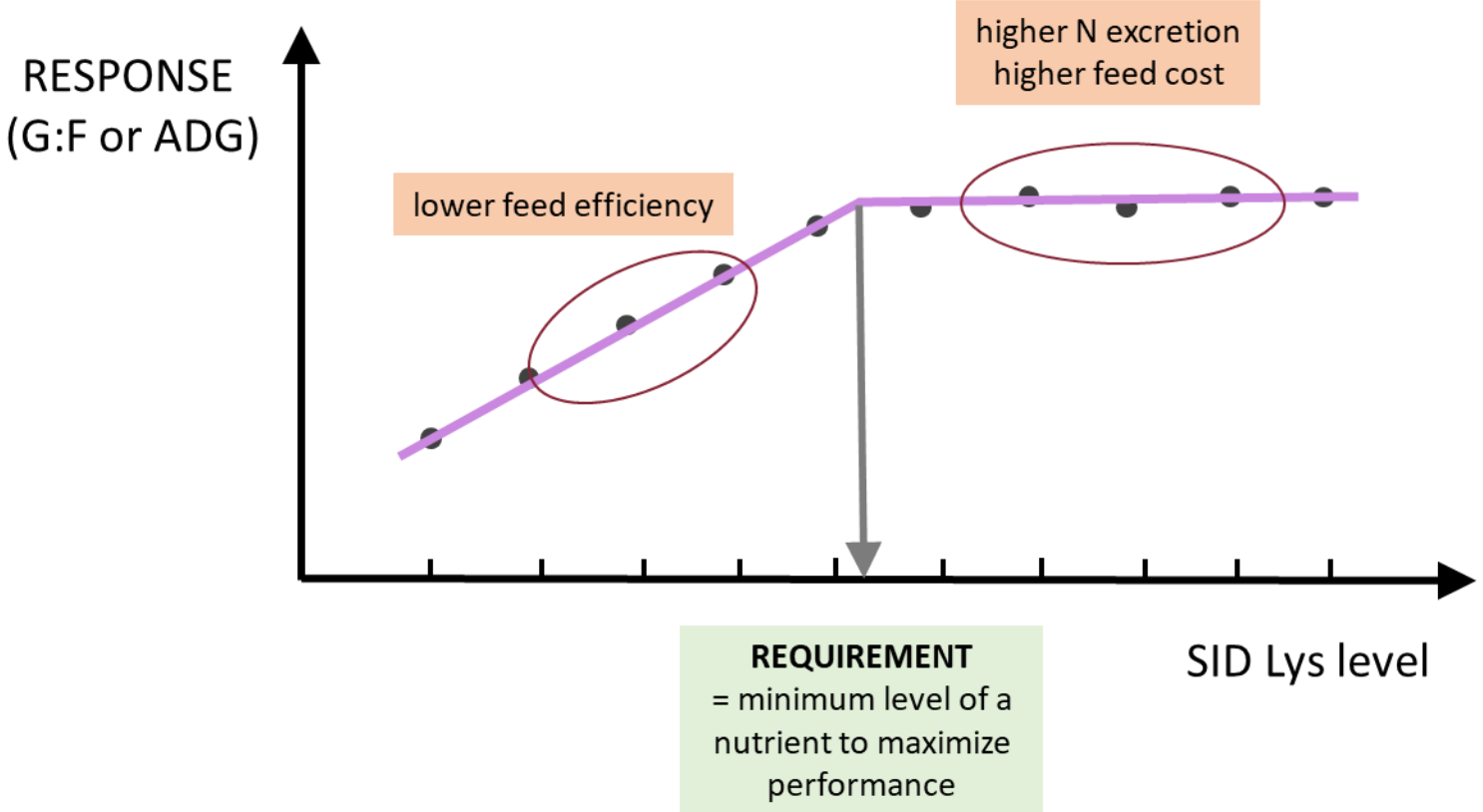


Background

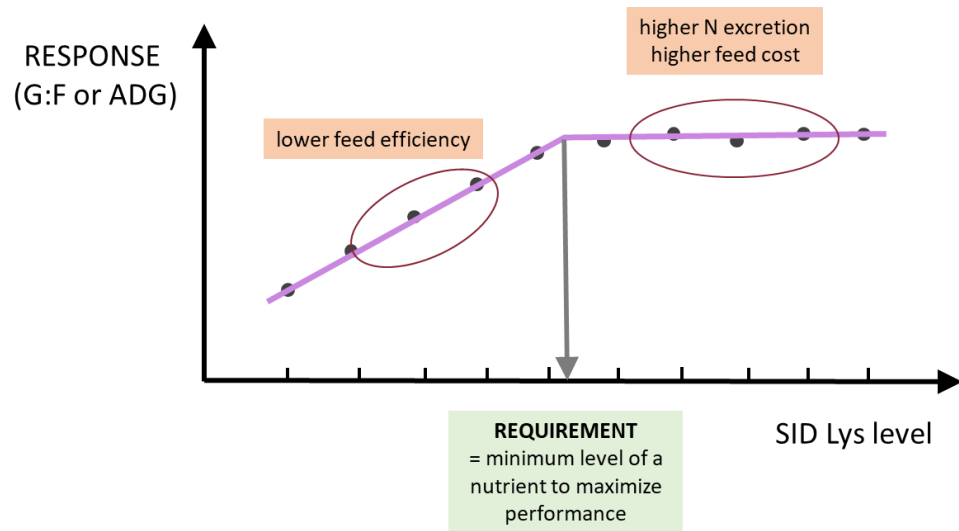


Lysine is typically the first limiting AA in pig diets → reference AA for other AA

Background



Background



Reported values for the lysine requirement in weaned piglets: 9.8 to >16 g SID Lys/kg

Requirement estimates can vary

- Statistical approach
- Performance parameter
- Feed evaluation system to estimate AA content and digestibility

REQUIREMENT

- feed intake capacity
- protein deposition capacity
- genotype, sex, age
- health status
- individual variation



OBJECTIVE

- ➔ Estimate the Lys requirement for maximal growth performance in weaned piglets
- ➔ Address the sources of variation influencing this requirement

M&M – study selection



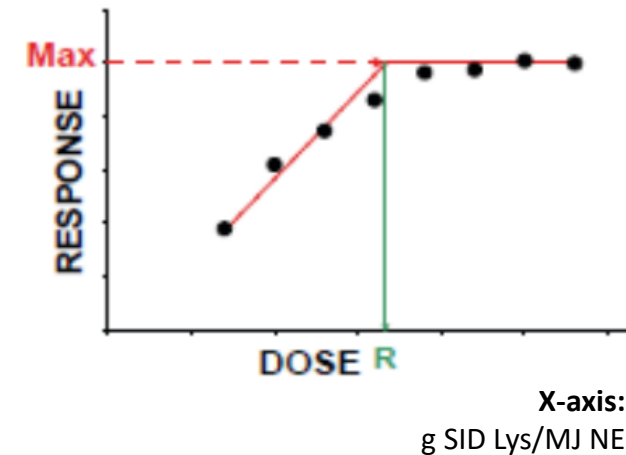
Literature review

Selection criteria:

- Dose-response technique: at least 4 levels of lysine
- Animal performance response criteria (ADG, ADFI, FCR or G:F)
- Feed ingredient/nutrient composition of diets
- BW range: 5-30 kg
- Lysine should be first limiting nutrient

- Y-axis:
- ADG
 - ADFI
 - G:F

Linear-plateau model



keywords → abstracts selection → full text selection → final dataset

344 papers

86 papers

37 papers

24 papers

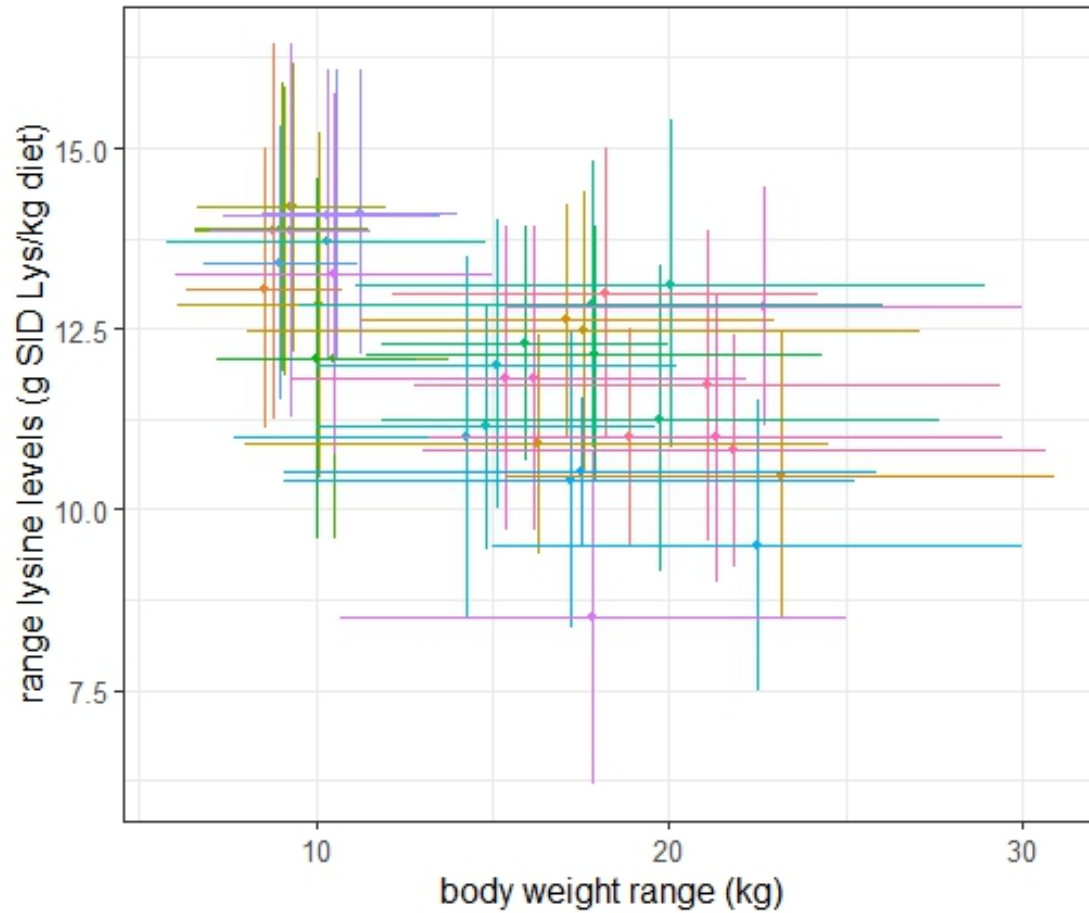
58 experiments

41 experiments

287 treatment means

206 treatment means

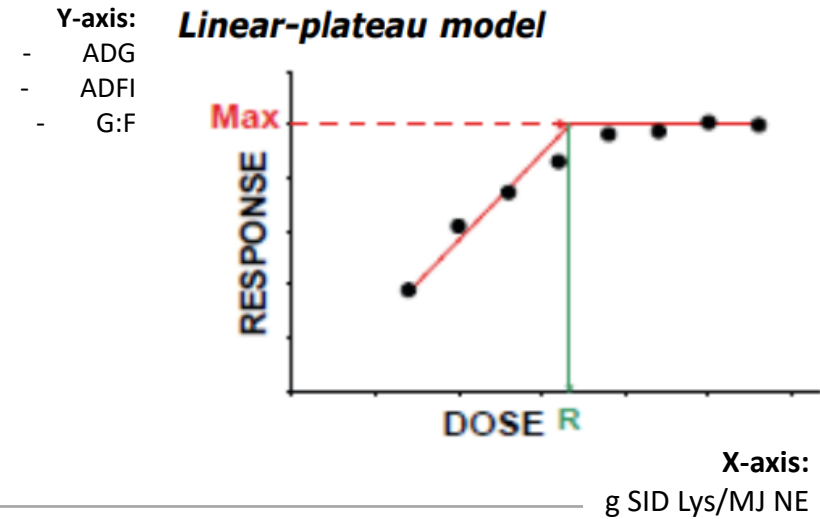
Results – study selection



Experiment_ID

- | | | |
|---------------------|---------------------|-----------------------|
| —●— Braga_overall | —●— Kendall_Exp1 | —●— Nemechek_Exp2 |
| —●— Clark_Exp1 | —●— Kendall_Exp2 | —●— Nemechek_Exp3 |
| —●— Dean_Exp1 | —●— Kendall_Exp3 | —●— Nemechek_Exp4 |
| —●— Fontes_Exp1 | —●— Kendall_Exp4 | —●— Nichols_Exp1 |
| —●— Fruge_Exp1 | —●— Kendall_Exp5 | —●— Nieto_Exp1 |
| —●— Gatel_Exp1 | —●— Kim_overall | —●— Nunes_Exp1 |
| —●— Gatel_Exp2 | —●— Lenehan_P1_Exp1 | —●— Oliveira_P2_Exp1 |
| —●— Jin_Exp1 | —●— Lenehan_P2_Exp1 | —●— Schneider_P1_Exp1 |
| —●— Jones_Exp1 | —●— Millet_Exp1 | —●— Schneider_P1_Exp2 |
| —●— Jones_Exp2 | —●— Moretto_Exp1 | —●— Urynek_Exp1 |
| —●— Jones_Exp3 | —●— Moretto_Exp2 | —●— Urynek_Exp2 |
| —●— Jones_Exp4 | —●— Nam_Exp1 | —●— Urynek_Exp3-4 |
| —●— Kahindi_P1_Exp1 | —●— Nam_Exp2 | —●— Yi_Exp1 |
| —●— Kahindi_P1_Exp2 | —●— Nemechek_Exp1 | |

M&M - calculations



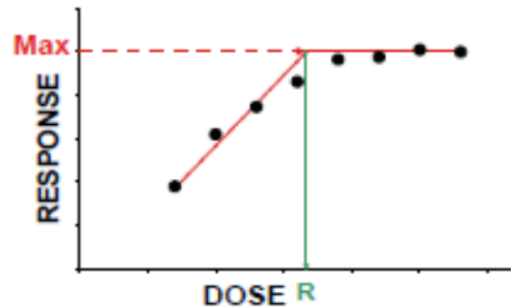
energy DE, ME, NE, EW -> **NE**
 based on conversion factors (Noblet et al., 2022)

Lys SID, AID, analyzed total, calculated total -> **SID Lys**
 based on total Lys levels reported in the paper and CVB SID digestibility coefficients

CP calculated or analyzed CP -> **SID crude protein**
 based on total CP level reported in the paper and CVB SID digestibility coefficients

M&M – dose-response studies

Linear-plateau model



- ⇒ Lysine is increased by graded levels of L-lysine HCL and/or protein rich feed materials a varying (increase) or constant SID Lys/CP ratio
- ⇒ Either or not in combination with the addition of constant or graded levels of one, two or more crystalline EAA a constant or varying (decrease) SID EAA/Lys ratio

⇒ Lysine must be first limiting factor, other nutrients should be non-limiting

M&M – Lys as first limiting factor

⇒ **Lysine is increased by graded levels of L-lysine HCL and/or protein rich feed materials**
 a varying (increase) or constant SID Lys/CP ratio



Item	Content in body protein ^d	Maximum efficiency (k_{AA}) ^e
Protein	1.0000	0.81
Lysine	0.0696	0.72
Methionine	0.0188	0.64
Cystine	0.0103	n.a.
Methionine + cystine	0.0291	0.51
Threonine	0.0370	0.61
Tryptophan	0.0095	0.57
Isoleucine	0.0346	0.60
Leucine	0.0717	0.76
Valine	0.0467	0.71
Phenylalanine	0.0378	0.82
Tyrosine	0.0286	n.a.
Phenylalanine + tyrosine	0.0664	0.75
Histidine	0.0279	0.93
Arginine	0.0626	1.54

Van Milgen et al., 2008

160 g CP in diet

SIDC CP = 85% (assumption)
 $160 \text{ g CP} \times 85\% = 136 \text{ g SID CP}$

136 g SID CP in diet

max efficiency = 81%
 $136 \text{ g SID CP} \times 81\% = 110 \text{ g SID CP}$

110 g SID CP will be incorporated in body protein

6.96% is the ratio of lysine in body protein
 $110 \text{ g SID CP} \times 6.96\% = 7.66 \text{ g SID Lys}$

7.66 g SID Lys will be incorporated in body protein

Max efficiency = 72%
 $7.66 \text{ g SID Lys} / 72\% = 10.6 \text{ g SID Lys}$

10.6 g SID Lys in diet is required to make optimal use of the 160 g CP provided by the diet for protein accretion

In a diet with a CP content of 160 g/kg diet

- Lys is limiting protein accretion up to a level of 10.6 g SID Lys/kg
- When SID Lys level > 10.6 g/kg diet => Lys is probably not used as essential AA

M&M – Lys as first limiting factor

⇒ **Lysine is increased by graded levels of L-lysine HCL and/or protein rich feed materials**
 a constant or varying (increase) SID Lys/CP ratio

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Van Milgen et al., 2008

$$\frac{100}{0.81} \rightarrow \mathbf{123.5 \text{ g of digestible protein (SID CP)}}$$

$$\frac{6.96}{0.72} \rightarrow \mathbf{9.7 \text{ g of digestible lysine (SID Lys)}}$$

$$\frac{9.7}{123.5} = \mathbf{0.0783}$$

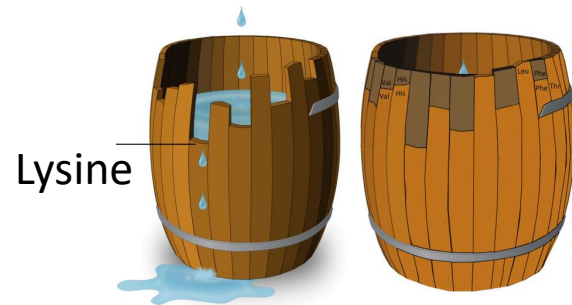
Theoretical max ratio of SID LYS:SID CP?

SID Lys:SID CP ratio

- > 0.0783, NEAA or nitrogen itself could be first limiting
- Ratio < 0.0783 is selection criterium
- For 41 of 58 experiments, all dietary treatments had a ratio < 0.0783

M&M – Lys as first limiting factor

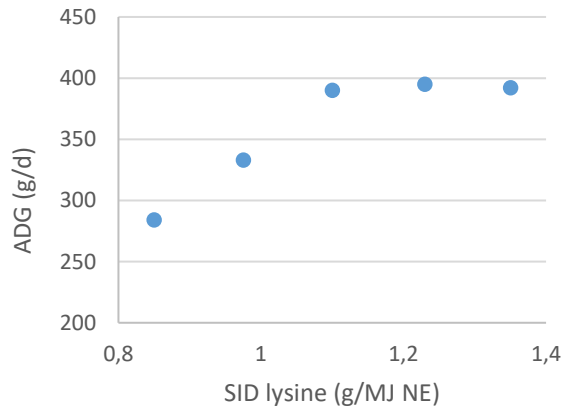
⇒ **Either or not in combination with the addition of constant or graded levels of one, two or more crystalline EAA**
a constant or varying (decrease) SID EAA/Lys ratio



- Estimation of AA profile requires many assumptions
- Very few studies (17) have assumed ideal protein profile
- No selection criterium as such

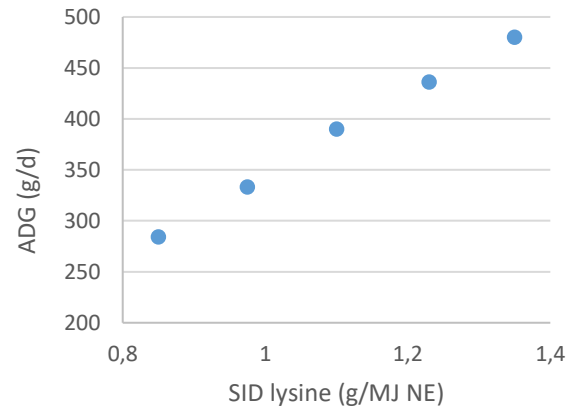
M&M – potential outcomes

Linear-plateau



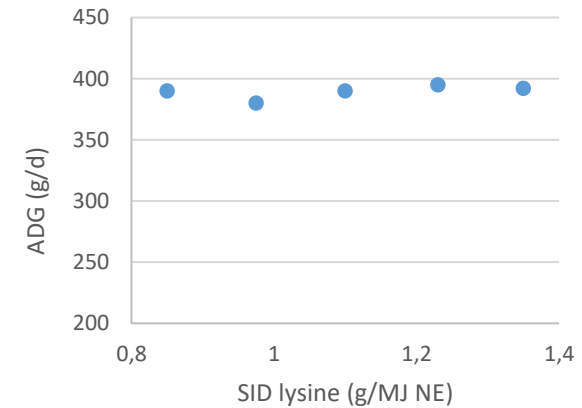
- Exceeding optimal lysine requirement; breakpoint = requirement?
- Other limiting factor?

Linear increase



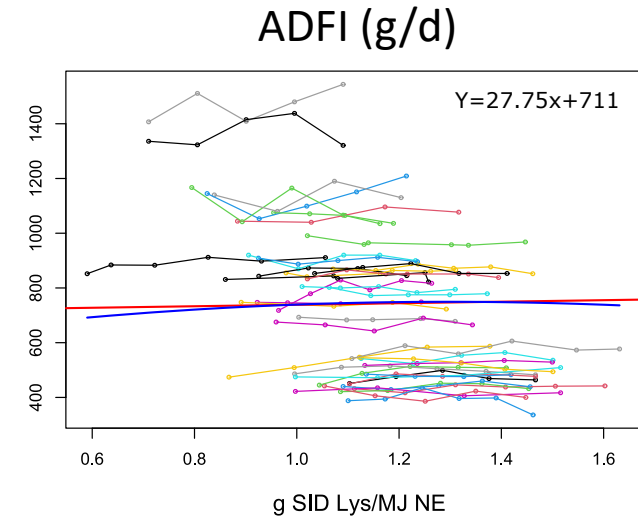
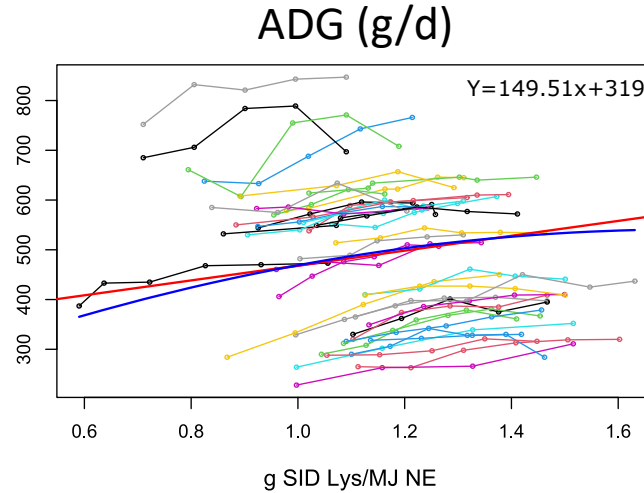
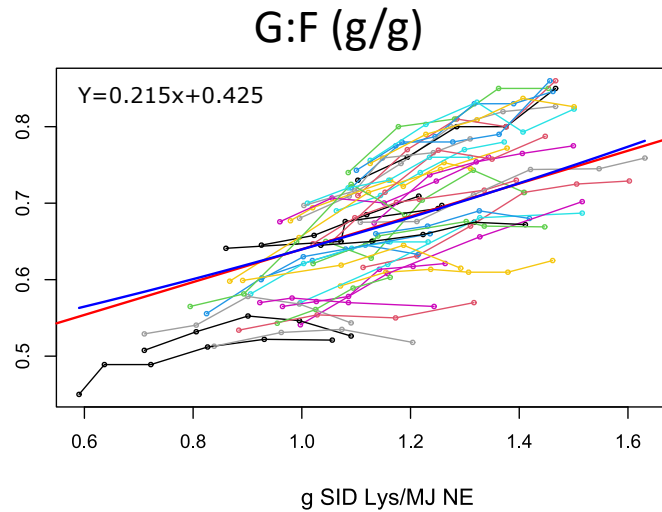
- Lysine requirement at least the highest tested Lys level?
- Other limiting factor?

Constant



- Tested lysine levels above limiting lysine concentration?
- Other limiting factor?

Results – combined data



— Linear — Quadratic

G:F and ADG

No linear-plateau model fit
Response: mainly linear increase

ADFI

Not considerably affected by
lysine content

Results – individual experiments

Individual experiments (17 of 41 experiments assumed to have ideal protein profile)

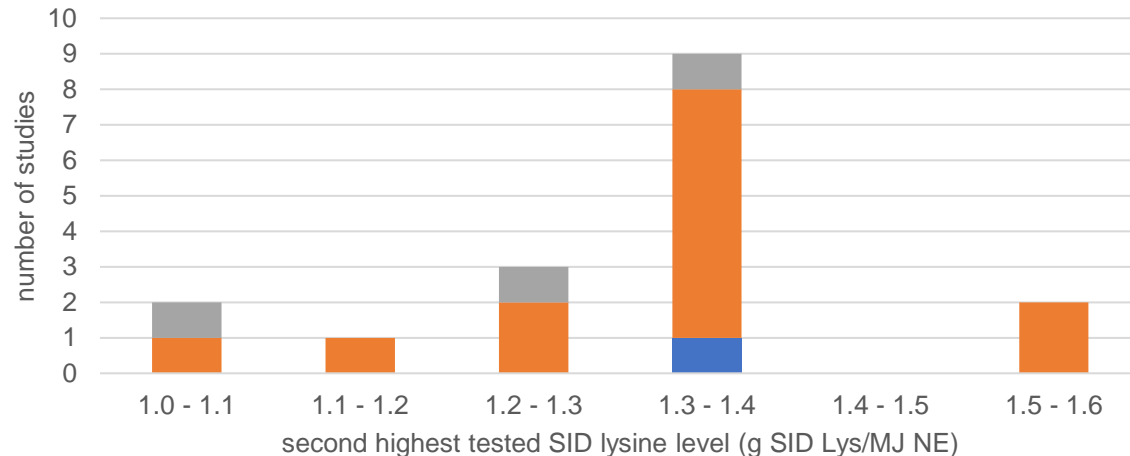
reference ^{1,2}	response ³	model parameters					estimated Lys requirement ⁴ (g SID Lys/MJ NE)
		linear	quadratic	linear-plateau			
		slope	quadratic term	slope	breakpoint	plateau	
Nieto_Exp1_2015	lin&quad&lin	0.14	-0.415	0.22	0.861	0.522	0.861
Fontes_Exp1_2005	lin&quad&lin	0.2	-0.896	0.36	1.048	0.639	1.048
Lenehan_P1_Exp1_2004	lin&quad&lin	0.21	-0.825	0.32	1.108	0.649	1.108
Kendall_Exp5_2008	lin&quad&lin	0.11	-0.531	0.29	1.197	0.672	1.197
Nemeček_Exp3_2012	lin&quad&lin	0.26	-0.91	0.43	1.342	0.770	1.342
Nunes_Exp1_2008	lin&quad&lin	0.32	-1.007	0.39	1.37	0.787	1.370
Nemeček_Exp4_2012	lin&quad&lin	0.21	-0.67	0.29	1.389	0.832	1.389
Oliveira_P2_Exp1_2006	lin&-&-	0.39	-	-	-	-	>1.091
Nam_Exp2_1994	lin&-&-	0.3	-	-	-	-	>1.094
Braga_overall_2018	lin&-&-	0.23	-	-	-	-	>1.119
Schneider_P1_Exp1_2010	lin&quad&-	0.18	-0.473	-	-	-	>1.158
Nam_Exp1_1994	lin&-&-	0.07	-	-	-	-	>1.172
Gatel_Exp1_1992	lin&-&-	0.22	-	-	-	-	>1.205
Schneider_P1_Exp2_2010	lin&-&-	0.21	-	-	-	-	>1.235
Kendall_Exp2_2008	lin&-&-	0.29	-	-	-	-	>1.242
Lenehan_P2_Exp1_2003	lin&-&-	0.2	-	-	-	-	>1.247
Kendall_Exp3_2008	lin&-&-	0.14	-	-	-	-	>1.251
Millet_Exp1_2020	lin&quad&-	0.34	-0.378	-	-	-	>1.255
Kendall_Exp1_2008	lin&-&-	0.22	-	-	-	-	>1.262
Früge_Exp1_2017	lin&-&-	0.31	-	-	-	-	>1.299
Yi_Exp1_2006	lin&-&-	0.08	-	-	-	-	>1.317
Kahindi_P1_Exp2_2014	lin&quad&-	0.31	-0.244	-	-	-	>1.327
Kahindi_P1_Exp1_2014	lin&-&-	0.24	-	-	-	-	>1.327
Kendall_Exp4_2008	lin&quad&-	0.2	-0.506	-	-	-	>1.336
Jones_Exp3_2014	lin&-&-	0.29	-	-	-	-	>1.362
Jones_Exp4_2014	lin&-&-	0.32	-	-	-	-	>1.363
Jin_Exp1_1998	lin&quad&-	0.34	-0.433	-	-	-	>1.37
Jones_Exp1_2014	lin&-&-	0.31	-	-	-	-	>1.376
Jones_Exp2_2014	lin&-&-	0.36	-	-	-	-	>1.376
Nemeček_Exp1_2012	lin&quad&-	0.29	-0.437	-	-	-	>1.39
Clark_Exp1_2017	lin&-&-	0.26	-	-	-	-	>1.506
Nichols_Exp1_2018	lin&-&-	0.18	-	-	-	-	>1.547
Moretto_Exp1_2000	-&quad&-	-	-0.943	-	-	-	-
Moretto_Exp2_2000	-&quad&-	-	-0.911	-	-	-	-
Urynek_Exp3-4_2003	-&quad&-	-	-0.581	-	-	-	-
Dean_Exp1_2007	-&-&-	-	-	-	-	-	-
Gatel_Exp2_1992	-&-&-	-	-	-	-	-	-
Kim_overall_2011	-&-&-	-	-	-	-	-	-
Nemeček_Exp2_2012	-&-&-	-	-	-	-	-	-
Urynek_Exp1_2003	-&-&-	-	-	-	-	-	-
Urynek_Exp2_2003	-&-&-	-	-	-	-	-	-

Linear: 32

Linear & quadratic: 13

Linear & quadratic & linear-plateau: 7

Most studies showed linear increase (without reaching plateau) in tested lysine range



- number of studies for which no linear-plateau, nor linear model could be fitted
- number of studies for which a linear, but no linear-plateau model could be fitted
- number of studies for which a linear-plateau model could be fitted

Results – Lys requirement

- **Not possible to determine an accurate value** for the SID lysine requirement of weaned piglets to achieve maximal growth performance
- Analysis of **pooled data** and **individual** dose-response experiments predominantly showed continuous **linear increase in G:F and ADG** within the tested SID lysine range
- The results indicate that the **SID lysine requirement is at least 1.3 g SID lysine/MJ NE or higher.**

Results – Lys recommendations

Requirement is > **1.3 g SID lysine/MJ NE**

$$\frac{9.7}{123.5} = 0.0783$$

Max ratio of SID LYS:SID CP?

$$\frac{\text{optimal lysine level} \left(\frac{\text{g SID lysine}}{\text{MJ NE}} \right) * \text{energy content} \left(\frac{\text{MJ NE}}{\text{kg diet}} \right)}{\text{optimal crude protein level} \left(\frac{\text{g crude protein}}{\text{kg diet}} \right) * \text{SID coefficient crude protein} (\%)} * 100 = \text{optimal SID lysine to SID crude protein ratio} (\%)$$

ASSUMPTIONS	85%	10 MJ NE/kg	7.83%
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Optimal crude protein level in relation to lysine level

Optimal lysine level in relation to crude protein level

Scenario 1: 1.50 g SID Lys/MJ NE => 225 g CP/kg diet

Scenario 2: 170 g CP/kg diet => 11.3 g SID Lys/kg diet

Conclusions

- The SID lysine requirement for maximal growth performance seems higher than the level tested in most dose-response studies (> 1.3 g SID Lys/MJ NE)
- Sources of variation in the lysine requirement could not be studied
- Lysine levels (recommendations) should be considered in relation to crude protein levels. Piglets are probably fed below the AA and CP requirement for maximum performance

Future research perspectives

- Determine SID lysine requirement in dose-response studies using a higher SID lysine range
- Determine optimal SID lysine to SID CP ratio



Nevedi



BFA
Belgian Feed Association



OPNV
Overleggroep Producenten Natte Veevoeders



FND
FEDERATIE NEDERLANDSE DIERVOEDERKETTEN



MVO



HISFA



VDDN
Vereniging
Diervoedspecialisten
Diergezondheidsproducten
Nederland



VICTAM



GMP+
International



Topsector
Agri &
Food



CVB
voor waardevolle voederwaarden

Thank you

Sophie Goethals, Sam Millet

Jordi Rijpert, Wouter Spek, Paul Bikker



ILVO



WAGENINGEN
UNIVERSITY & RESEARCH

Ad hoc group:

Jan Fledderus, Mario van Erp, Nestor Gutierrez Cespedes

Goethals et al., 2024

