



A review on the lysine requirement of weaned piglets

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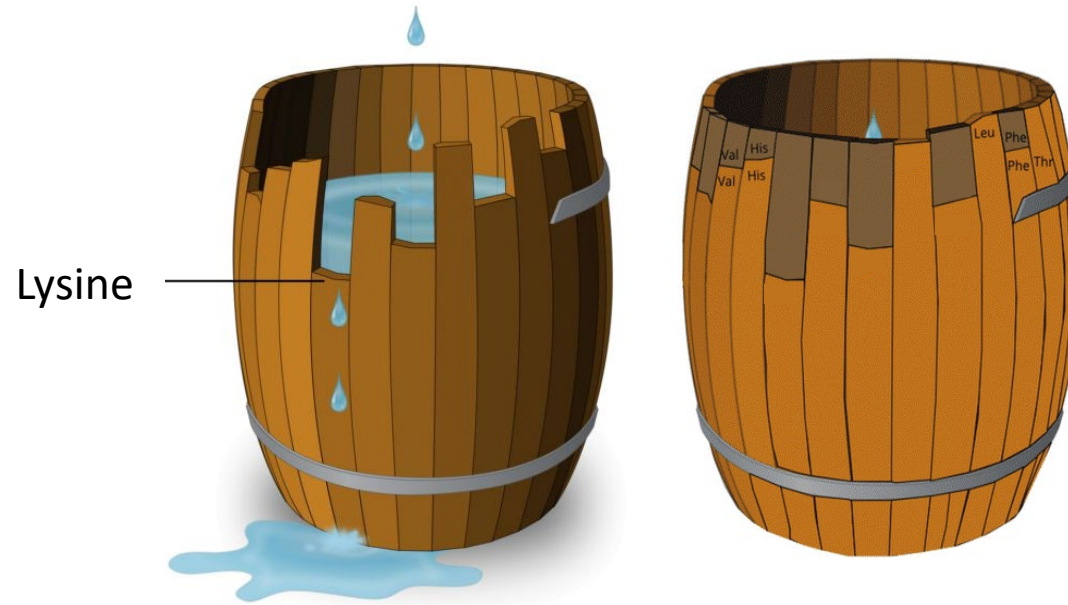
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PPS project 'Voeding op maat'

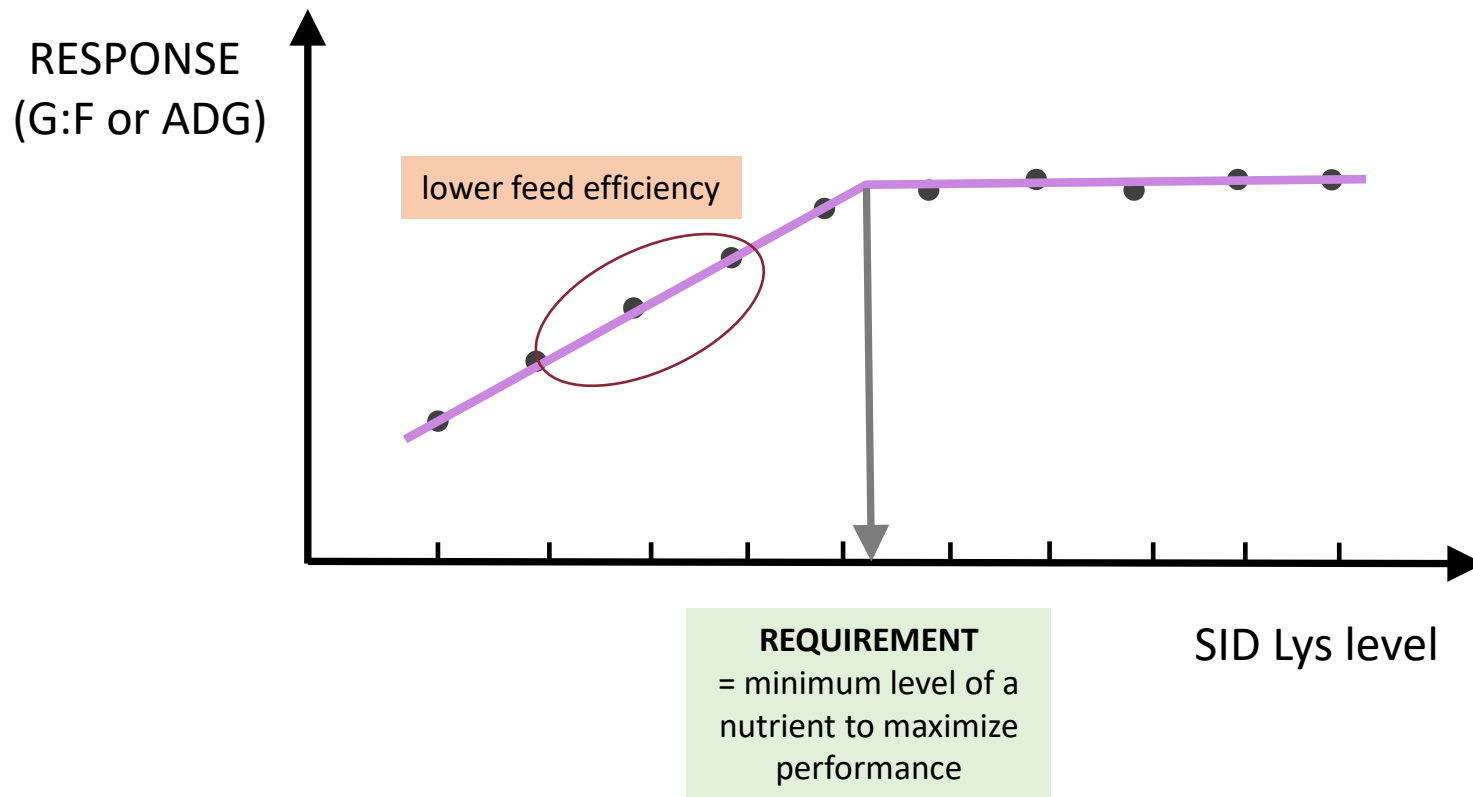


Background

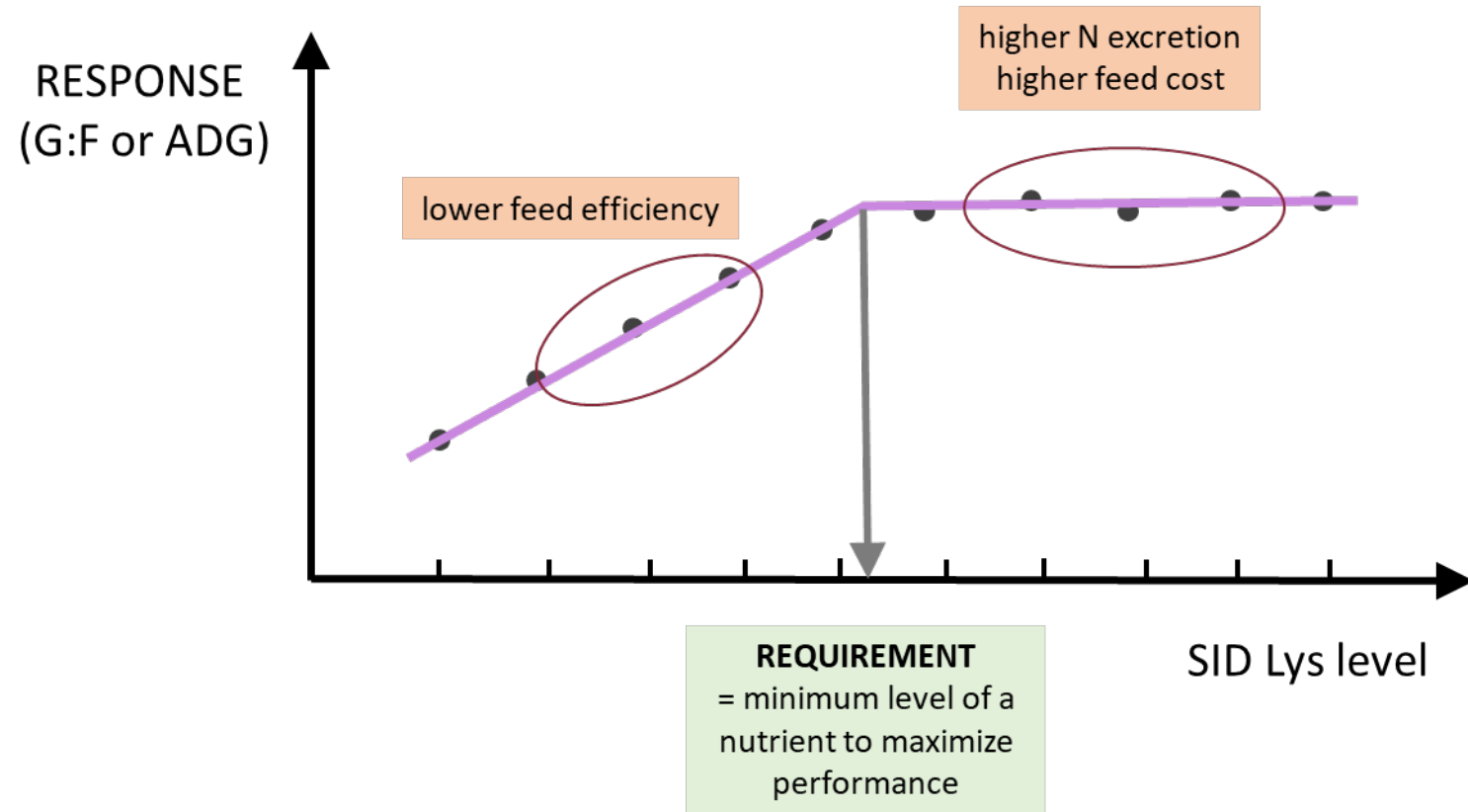


Lysine is typically the first limiting AA in pig diets → reference AA for other AA

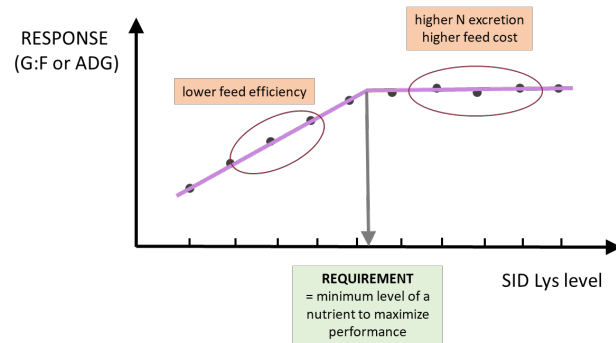
Background



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



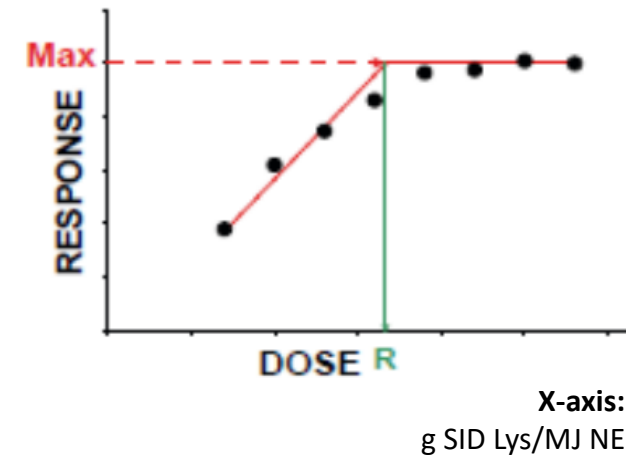
Literature review

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

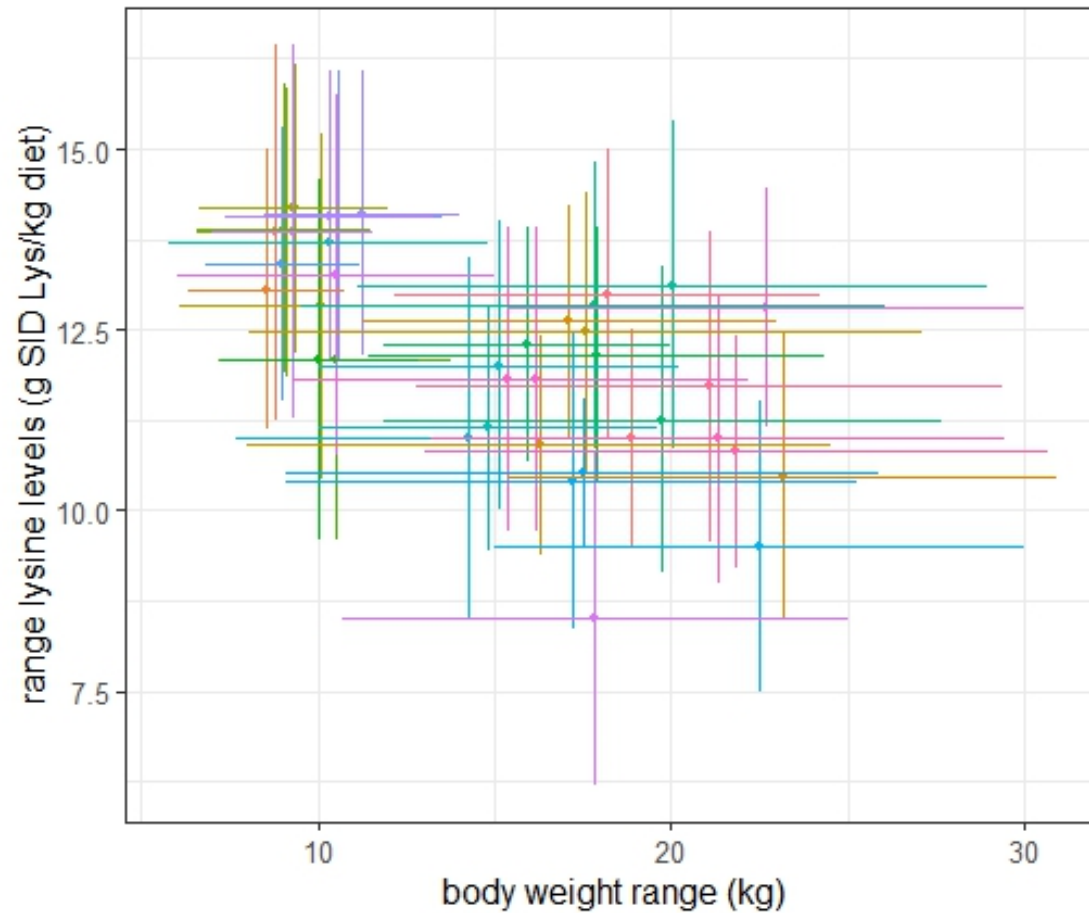
58 experiments

41 experiments

287 treatment means

206 treatment means

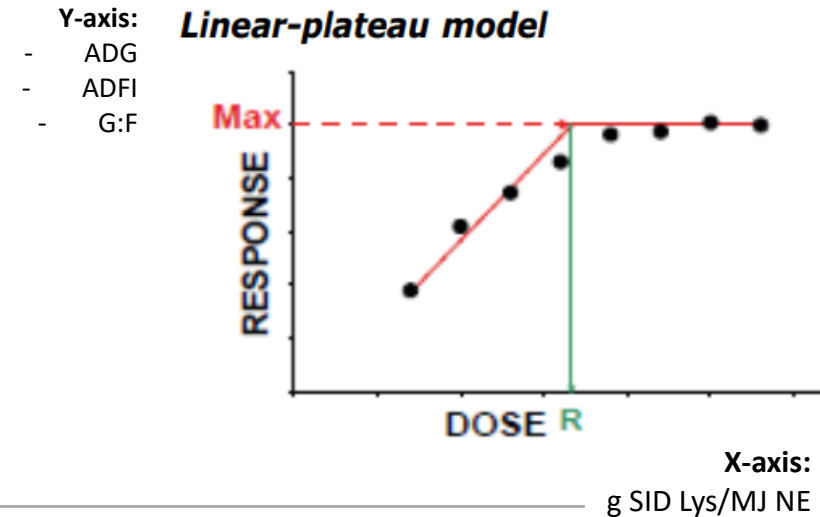
Results – study selection



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
Früge_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	

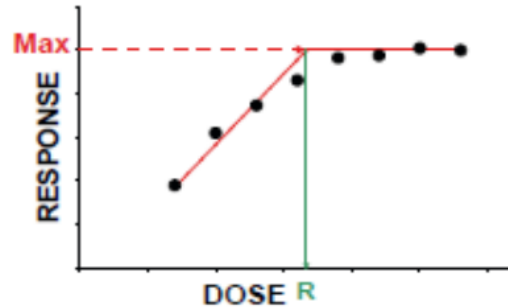
M&M - calculations



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

EXAMPLE

160 g CP in diet

SIDC CP = 85% (assumption)

160 g CP x 85% = 136 g SID CP

136 g SID CP in diet

max efficiency = 81%

136 g SID CP x 81% = 110 g SID CP

110 g SID CP will be incorporated in body protein

6.96% is the ratio of lysine in body protein

110 g SID CP x 6.96% = 7.66 g SID Lys

7.66 g SID Lys will be incorporated in body protein

Max efficiency = 72%

*7.66 g SID Lys/ 72% = **10.6 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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$$\frac{100}{0.81} \rightarrow \mathbf{123.5 \text{ g of digestible protein (SID CP)}}$$
$$\frac{6.96}{0.72} \rightarrow \mathbf{9.7 \text{ g of digestible lysine (SID Lys)}}$$

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

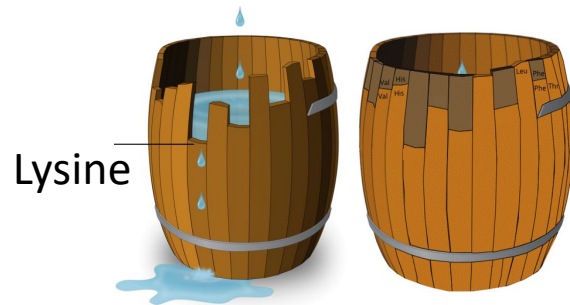
Theoretical max ratio of
SID LYS:SID CP?

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

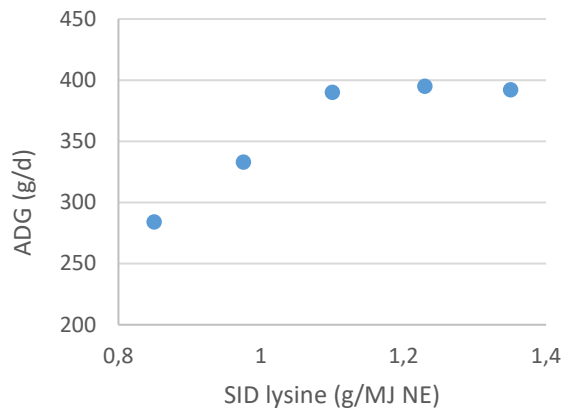
⇒ **Either or not in combination with the addition of constant or graded levels of one, two or more crystalline EAA**
a constant or varying (decrease) SID EAA/Lys ratio



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

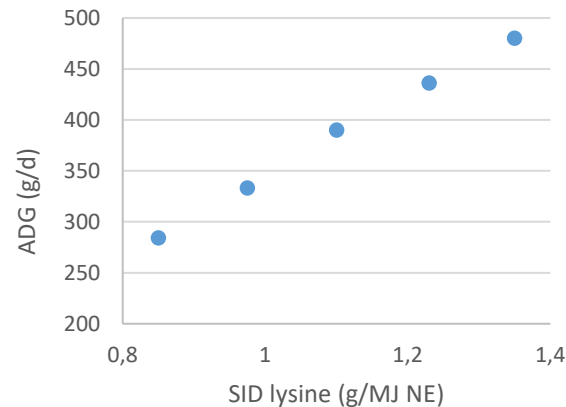
M&M – potential outcomes

Linear-plateau



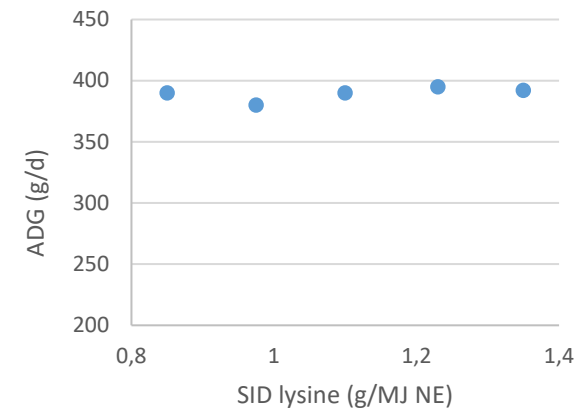
- Exceeding optimal lysine requirement; breakpoint = requirement?
- Other limiting factor?

Linear increase



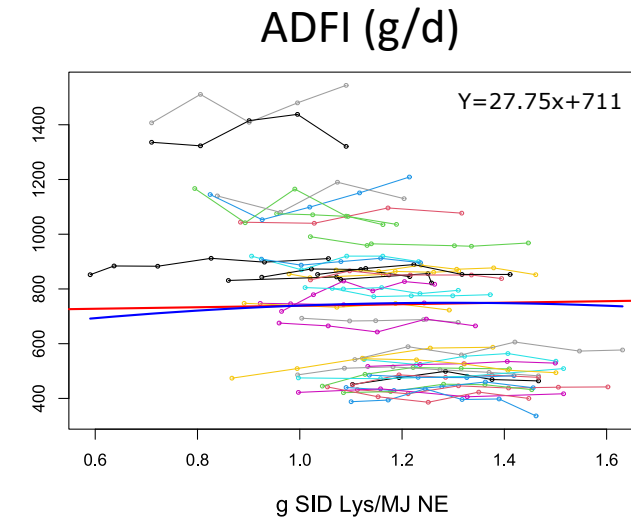
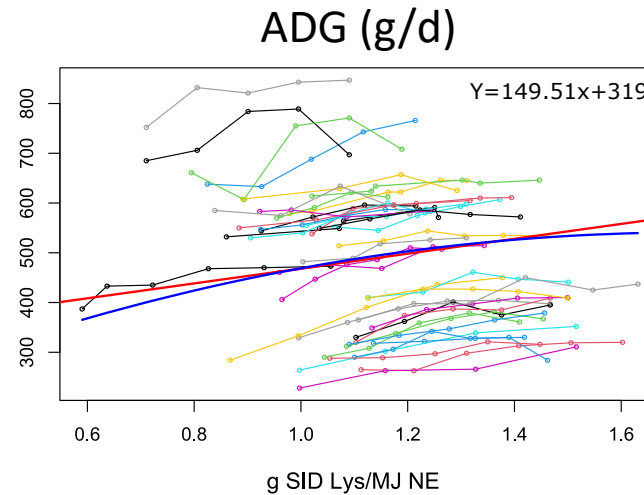
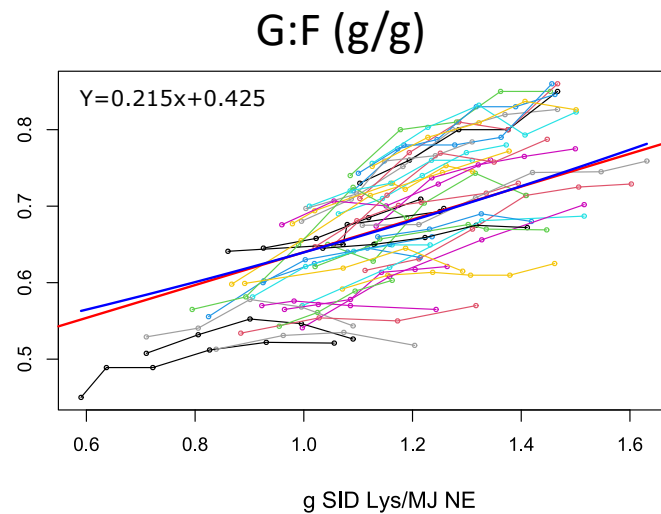
- Lysine requirement at least the highest tested Lys level?
- Other limiting factor?

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)

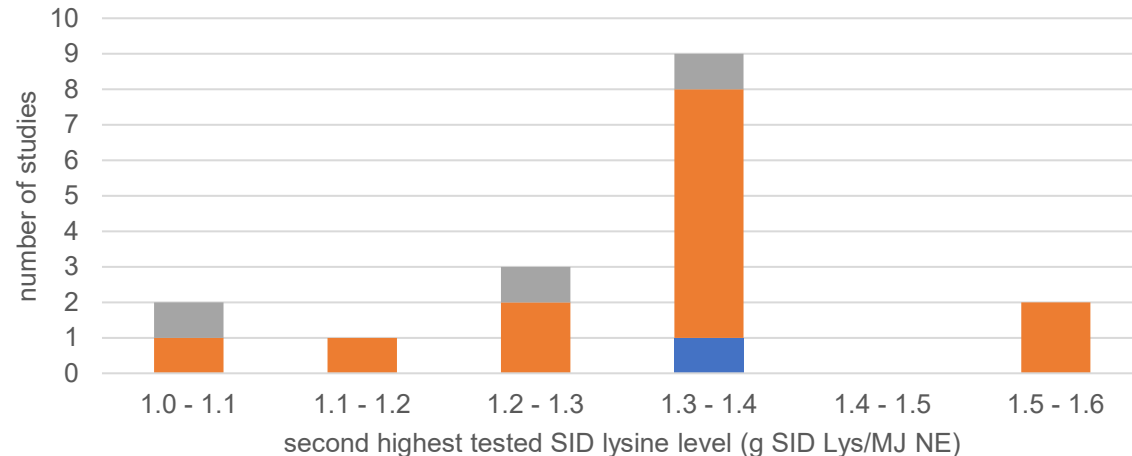
reference ^{1,2}	response ³	model parameters					estimated Lys requirement ⁴ (g SID Lys/MJ NE)
		linear	quadratic	linear-plateau			
		slope	term	slope	breakpoint	plateau	
Nieto_Exp1_2015	lin&quad&lin	0.14	-0.415	0.22	0.861	0.522	0.861
Fontes_Exp1_2005	lin&quad&lin	0.2	-0.896	0.36	1.048	0.639	1.048
Lenehan_P1_Exp1_2004	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
Nemechek_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
Nemechek_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
Nemechek_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	-&-&-	-	-	-	-	-	-
Nemechek_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%

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



FND
FEDERATIE NEDERLANDSE DIERVOEDERKETTEN



VDDN
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Diervoederspecialisten
Diergezondheidsproducten
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BFA
Belgian
Feed
Association



MVO



VICTAM



OPNV
Overleggroep Producenten Natte Veevoerders



HISFA



GMP+
International



Topsector
Agri &
Food



CVB
voor waardevolle voederwaarden

Thank you

Sophie Goethals, Sam Millet

Jordi Rijpert, Wouter Spek, Paul Bikker



ILVO



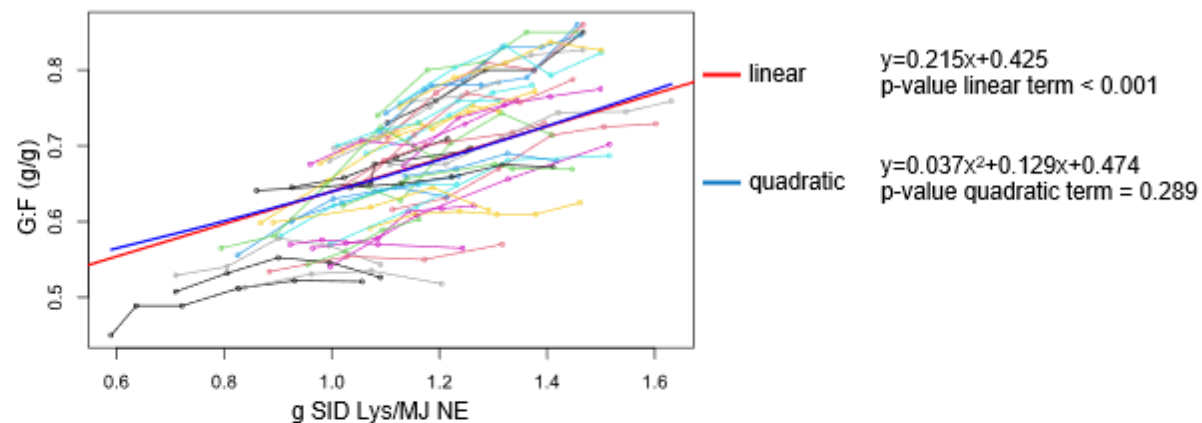
WAGENINGEN
UNIVERSITY & RESEARCH

Ad hoc group:

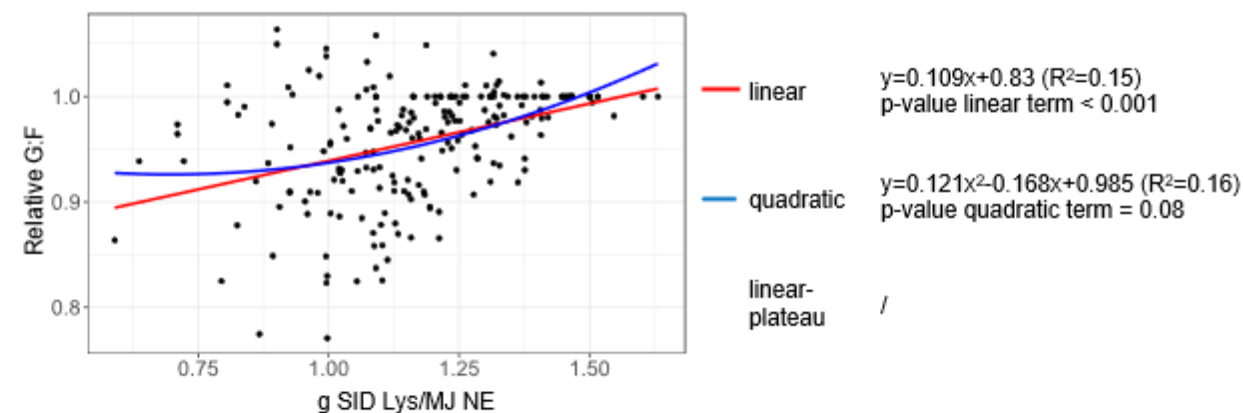
Jan Fledderus, Mario van Erp, Nestor Gutierrez Cespedes

For further comments and questions,
Please contact me at sophie.goethals@ilvo.vlaanderen.be

**mixed effects
linear and
quadratic models¹**



**linear, quadratic
and linear-plateau
models on
standardized
data²**



**linear and
quadratic models
for individual
studies**

