Modelling Dose-Response Curves
Methionine in Broilers

feedtest
feeding trials - feed evaluation - consultancy

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I Introduction

The relationship between nutrient concentration (dose) and response in animal performance has been well studied for increasing concentrations up to maximal animal performance.

However, knowledge of dose-response relationship for nutrient dosage markedly exceeding maximal animal performance is poor.

II Objective

Investigate the dose-response relationship from a sub-optimal level to levels of excessive supplementation

Example: Methionine (Met) commonly deficient in natural protein of diet, supplementation by DL-Methionine

III Materials & Methods

Birds & Housing

840 male Ross broiler chickens
15 birds per pen (~1 m²)
Pelleted feed, nipple drinkers

Feed

Grower diet (days 12-25) based on wheat, SBM, peas, oil
Calculated to requirements for all nutrients except Met+Cys
Total Met+Cys: 6.25 g/kg; Stand. Ileal Digest. (SID) Met+Cys: 5.4 g/kg

Treatments

Supplementing DL-Met from 0 to 15 g/kg in 14 levels:
0 0.3 0.6 0.9 1.2 1.5 2.0 2.5 3 4 6 9 12 15 g/kg
4 pens (60 broilers) per treatment

Sigmoidal or exponential models

Commonly used for partial dose-response studies, describes either increase or decrease of performance. Therefore, two models necessary for complete dose-response relationship

Saturation kinetics model with inhibition (SKMI)

Single model, describing both increase and decrease of performance with increasing nutrient doses (Mercer et al., 1989, J.Nutr. 119: 1465-1471)

Definition Range of No Response (RNR): That range of nutrient concentration delimited by animal performance of 98% of maximum

IV Results & Discussion

Primary response to severe dietary amino acid imbalances (low / high SID Met+Cys levels): Reduction of voluntary feed intake (Figure 1) in order to avoid metabolic disturbances. As a direct result, growth will be limited (R^2=0.93; Figure 2).

Therefore, decrease of animal performance at excessive Met levels must NOT be interpreted as a toxic effect

Sigmoidal

$$y = bottom + \frac{top - bottom}{1 + e^{rate + slope \times x}}$$

Exponential

$$y = start_E + (asymptote - start_E) \times (1 - e^{slope \times x})$$

Extended SKMI

$$y = \frac{d * K_{0.5}{}^n + y_{max} * (x + shift)^n + \frac{d * (x + shift)^{2n}}{K_S{}^n}}{K_{0.5}{}^n + (x + shift)^n + \frac{(x + shift)^{2n}}{K_S{}^n}}$$

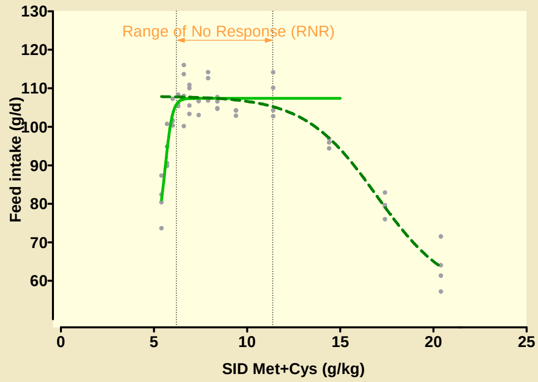

Figure 1: Feed intake in relation to SID Met+Cys concentration in the diet: two sigmoidal models fitted to describe ascending and descending animal performance

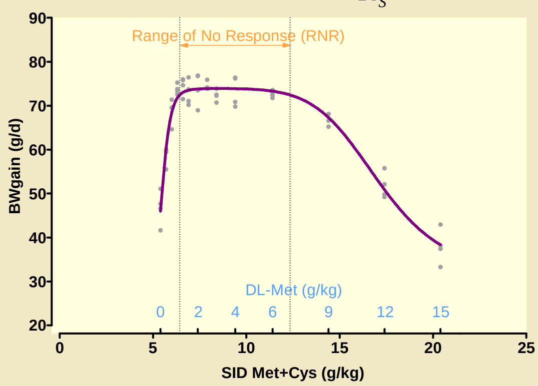

Figure 2: Body weight gain in relation to SID Met+Cys and DL-Met concentration in the diet: extended saturation kinetics model with inhibition fitted

Disadvantage sigmoidal/exponential models: Arbitrary cut-off of data points in descending and ascending parts to enable plateau estimation

Table 1: Range of No Response (g/kg SID Met+Cys) for parameters of animal performance determined either by pairs of sigmoidal/exponential models or by extended SKMI

Parameter	Sigmoidal (S) / Exponential (E)	Extended SKMI
Body weight	(S) 6.2 – 12.2	6.3 – 12.7
Body weight gain	(S) 6.2 – 11.7	6.4 – 12.3
Feed intake	(S) 6.2 – 11.4	6.4 – 11.7
Feed conversion	(E) 6.2 – 15.3	6.0 – 16.0

Original SKMI had to be extended to improve data fit

Inclusion of a parameter SHIFT to virtually move data points along x-axis.

Advantage extended SKMI: Estimated curves are identical independently from whether the chosen independent variable is total nutrient or supplemented nutrient concentration (Figure 2)

Feed intake and Body weight gain were most sensitive parameters to changing SID Met+Cys concentrations

Both types of models yield similar results in respect of the Range of No Response

V Conclusions

The extended saturation kinetics model with inhibition is an excellent tool to describe data of complete dose-response studies.

The Range of No Response allows assessment of the risk of performance impairment due to excessive concentrations of naturally occurring nutrients in practical diet formulation.

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