# LYSINE REQUIREMENTS OF PIGS FROM 20 TO 100 KGS LIVEWEIGHT

## Report prepared for the Co-operative Research Centre for an Internationally Competitive Pork Industry

**Project 2A-104**
**Experiment 2 and 3**


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# Executive Summary


Through genetic selection pigs now deposit relatively more protein and less fat than they did twenty years ago, primarily because of the pressure from consumers to reduce the amount of subcutaneous fat on pork products. As a consequence, the requirement for amino acids relative to energy has slowly increased over this time. It has been several years since experiments to determine the requirement for amino acids relative to energy have been conducted. The aim of this experiment was to determine the optimal available lysine per MJ dietary energy ratios for entire male and female pigs from 20 to 100 kg liveweight.

Two experiments were conducted, one from 20 to 50 kg and the other from 50 to 100 kg liveweight, to determine the lysine requirements of entire male and female pigs of the Australian PIC genotype. From 20 to 50 kg liveweight entire males had a lower daily gain, reduced feed intake and improved feed to gain compared to females, while from 50 to 100 kg LW entire males had a higher daily gain, similar feed intake and improved feed to gain compared to females.

Entire males had a higher lysine requirement than females from 20 to 100 kg LW. Generally it has been assumed that entire males and females have a similar lysine requirement from 20 to 50 kg liveweight and the difference in requirement found in this experiment suggests that potentially there may be some feed cost savings in separating male and female pigs in this weight range. The results from this experiment have established the lysine requirements for a current Australian genotype which may be higher than the levels currently used by the Australian industry.

# Table of Contents

# 1. Introduction

In broad terms pigs have a nutritional requirement for energy (digestible energy or DE) and amino acids, as well as minerals and vitamins. The requirement for each of the essential amino acids follows a concept referred to as ideal protein, where the ratio of each amino acid is expressed relative to lysine. Lysine is the first limiting amino acid and it is common to include synthetic lysine in the diet of pigs to meet their requirement. Lysine requirement is discussed in terms of available lysine rather than total lysine, since this accounts for the actual amount of lysine, that the pig can digest, absorb and deposit as protein.

There are strong and well established relationships between the requirement for energy versus amino acids, such that amino acids will only be utilised and deposited as protein if there is also sufficient energy available. Therefore, when diets are formulated the amino acid specifications are expressed in terms of the level of lysine relative to energy, or more specifically the ratio of available lysine per MJ digestible energy (DE). This allows lysine requirements to be suitable and easily adjusted across a range of dietary energy levels (Main *et al.* 2008). Hereafter we will refer to the level of available lysine per MJ DE (Av Lys/MJ DE) as being the requirement for amino acids, but it assumes that all other amino acids are in the correct ratio as per the ideal protein concept which is used by all nutritionists world-wide.

There are many factors that influence the amino acid requirements of growing pigs with the major factors being genotype, sex, feed intake and liveweight (LW). Through genetic selection pigs now deposit relatively more protein and less fat than they did 10 years ago, primarily because of the pressure from consumers to reduce the amount of subcutaneous fat. As a consequence, the requirement for amino acids relative to energy has slowly increased over this time.

It has been several years since experiments to determine the requirement for amino acids relative to energy have been conducted. Many of the early studies were conducted with pigs in individual pens, yet we know that feed intake of pigs in individual pens is higher than when they are housed in groups and so the results of these studies need some degree of interpretation (Campbell *et al.* 1984). We have also relied on simulation models such as AUSPIG (Black *et al.,* 1986) to predict the requirement of growing pigs for amino acids, but we have no way of knowing if these predictions are accurate. The current specifications of Av Lys/MJ DE used in pig diets is 0.75 for pigs from 20-50 kg LW and 0.55 for pigs from 50-100 kg LW (Mullan, pers com). Recent studies by van Barneveld (unpublished), however, have indicated that the lysine requirements of today's pigs are higher than currently included in diets. It is crucial to provide the optimum dietary lysine requirement to ensure lean growth is maximised and feed costs are minimised.

Therefore the aim of this study was to determine the optimal available lysine/MJ digestible energy ratio for a major Australian genotype from 20 to 100 kg LW.

## Hypothesis

Pigs will respond to increasing levels of amino acid supply per unit of digestible energy by having an increased growth rate and reduced feed conversion ratio, until a plateau is reached at their genetic potential.

# 2. Methodology

The experiments were conducted at the Department of Agriculture and Food Western Australia's (DAFWA) Medina Research Centre. The experimental protocols used were approved by the DAFWA Animal Research Committee and by the Animal Ethics Committee. The animals were handled according to the Australian code of practice for the care and use of animals for scientific purposes (NHMRC, 2004).

### Experiment 1

*Animals and Experimental Design*

A total of 350 Large White × Landrace × Duroc entire male and female pigs were used in this experiment. The experiment was a 2 x 5 factorial with the main treatments being:

i) sex (entire males and females) and;

ii) available lysine to MJ digestible energy (Av Lys/MJ DE) ratio (0.6, 0.7, 0.8, 0.9 and 1.0 g available lysine/MJ DE).

*Allocation and housing*

Pigs were sourced at weaning (21 days, average 6.2 kg LW) from a high health status commercial herd whose bloodlines were sourced from the Pig Improvement Company. In order to obtain the required number of piglets it was necessary to bring the pigs to Medina Research Centre in three groups, over a three week period. All pigs were housed in weaner accommodation and fed the same creep and weaner pelleted diets which were formulated to standard industry specifications. All pigs had *ad libitum* access to feed and water for the entire period of the experiment.

Upon arrival at Medina piglets were identified individually with ear tags, inoculated with Enterisol® Ileitis (Boehringer Ingelheim, United Kingdom) and weighed. Piglets were then weighed fortnightly thereafter. When the pigs reached 7 weeks of age (or approximately 17 kg LW) they were stratified on a weight basis and the heaviest pigs were randomly allocated to treatment. This procedure was repeated with the remaining pigs from each group in the following week. The heaviest pigs were allocated earlier to ensure that all of the groups commenced the experiment at approximately the same LW. The pigs were housed in groups of 7 in a naturally ventilated grower-finisher facility. The experiment was conducted in January and February 2009. The average maximum temperature in the facility in this period was 31°C while the average minimum temperature was 21°C.

*Diets*

The experimental diets were fed from 22.3 to 53.1 kgs LW. The composition of the diets and the ratios used to attain the blended diets using the Feedlogic system are given in Tables 1, and 3, respectively. The diets were submitted for quantitative amino acid analysis (Australian Proteome Analysis Facility, Sydney) and the results are given in Table 2.

Table 1: The composition of the diets for the two extreme lysine levels.

| **Diet** | **Diet 1 (Low)** | **Diet 2 (High)** |
|---|---|---|
| **Ingredients (g/kg)** | | |
| Wheat | 746 | 558 |
| Soya-bean meal | 82.5 | 272 |
| Canola meal | 20 | 20 |
| Meat and bone meal | 100 | 97 |
| Tallow | 43.5 | 39.5 |
| Alimet | 0.55 | 2.9 |
| Choline chloride | 0.13 | 0.13 |
| Salt | 1.65 | 1.70 |
| L-lysine HCL | 2.35 | 4.65 |
| L-threonine | 0.49 | 1.80 |
| Vitamins and minerals[a] | 2.50 | 2.50 |
| | | |
| **Nutrient Composition**[b] | | |
| DE (MJ/kg) | 14.6 | 14.6 |
| Crude protein (%) | 19.0 | 26.1 |
| Available lysine:DE (MJ/kg) | 0.60 | 1.00 |

[a] Each kilogram of vitamin and mineral premix contains 7 MIU Vitamin A, 1.4 MIU Vitamin $D_3$, 20 g Vitamin E, 1 g Vitamin K, 1 g Vitamin $B_1$, 3 g Vitamin $B_2$, 1.5 g Vitamin $B_6$, 15 mg Vitamin $B_{12}$ 12 g niacin, 10 mg pantothentic acid, 0.19 g folic acid, 30 mg biotin, 10.6 g Calcium pantothenatic, 60 g iron, 100 g zinc, 40 g manganese, 10 g copper, 0.2 g cobalt, 0.5 g iodine, 0.3 g selenium, and 20 g antioxidant.

[b] Calculated composition.

Table 2: Quantitative amino acid analysis of the two basal diets.

| **Amino acid (mg/g)** | **Diet 1** | **Diet 2** |
|---|---|---|
| Hydroxyproline | 2.60 | 2.74 |
| Histidine | 4.55 | 6.21 |
| Serine | 9.55 | 12.7 |
| Arginine | 12.1 | 17.2 |
| Glycine | 13.1 | 15.8 |
| Aspartic acid | 14.5 | 22.6 |
| Glutamic acid | 45.6 | 53.9 |
| Threonine | 7.45 | 10.8 |
| Alanine | 9.45 | 12.3 |
| Proline | 16.3 | 18.3 |
| Lysine | 10.6 | 16.7 |
| Tyrosine | 4.29 | 6.20 |
| Methionine | 2.72 | 3.34 |
| Valine | 9.21 | 12.2 |
| Isoleucine | 7.33 | 10.3 |
| Leucine | 139 | 18.7 |
| Phenylalanine | 8.92 | 12.1 |

Table 3: The blend ratios (%) of the two basal diets to produce the five dietary treatments.

| Treatment | Diet 1 | Diet 2 | MJ DE/kg | Av. Lys/MJ DE |
|---|---|---|---|---|
| 1 | 100 | 0 | 14.6 | 0.6 |
| 2 | 75 | 25 | 14.6 | 0.7 |
| 3 | 50 | 50 | 14.6 | 0.8 |
| 4 | 25 | 75 | 14.6 | 0.9 |
| 5 | 0 | 100 | 14.6 | 1.0 |

*Measurements*

Individual pig weight was recorded on the same day and at approximately the same time each week, and feed disappearance was recorded daily using the Feedlogic system. The feed to gain ratio was calculated on a per pen basis by dividing the total weight of feed eaten by the LW gain in the same period.

**Experiment 2**

*Animals and Experimental Design*

A total of 420 Large White × Landrace x Duroc entire male and female pigs were used in this experiment. The experiment was a 2 x 5 factorial with the main treatments being:

i) sex (entire males and females) and;

ii) available lysine to MJ digestible energy (Av Lys/MJ DE) ratio (0.4, 0.5, 0.6, 0.7 and 0.8 g available lysine/MJ DE).

*Allocation and housing*

As described for Experiment 1. This experiment was conducted from July to September 2009. The average maximum temperature on the research station for this period was 18°C while the average minimum temperature was 9°C. Temperature data is given for the research station rather than in the facility due to a technical problem with the temperature logger.

*Diets*

The experimental diets were fed from 49.6 to 103 kgs LW. The composition of the diets and the ratios used to attain the blended diets using the Feedlogic system are given in Tables 4 and 6, respectively. The diets were submitted for quantitative amino acid analysis (Australian Proteome Analysis Facility, Sydney) and the results are given in Table 5.

Table 4: The composition of the diets for the two extreme lysine levels.

| Diet | Diet 1 (Low) | Diet 2 (High) |
|---|---|---|
| **Ingredients (g/kg)** | | |
| Wheat | 50 | 50 |
| Wheat seconds | 45 | 45 |
| Mill mix | 50 | 50 |
| Groats | 113.5 | 30 |
| Barley | 569 | 473 |
| Soya-bean meal | 40 | 185 |
| Canola meal | 20 | 52.5 |
| Meat and bone meal | 55.5 | 50 |
| Tallow | 40.5 | 40.5 |
| Alimet | 0.3 | 2.45 |
| Choline chloride | 0.13 | 0.13 |
| Limesand | 9 | 10 |
| Salt | 2.35 | 2.40 |
| Porzyme | 1.0 | 1.0 |
| L-lysine HCL | 0.65 | 3.10 |
| L-threonine | 0.40 | 1.92 |
| Vitamins and minerals[a] | 2.50 | 2.50 |
| | | |
| **Nutrient Composition**[b] | | |
| DE (MJ/kg) | 13.5 | 13.5 |
| Crude protein (%) | 14.1 | 20.5 |
| Total lysine (mg/g) | 6.93 | 12.8 |
| Available lysine:DE (MJ/kg) | 0.4 | 0.8 |

[a] Each kilogram of vitamin and mineral premix contains 7 MIU Vitamin A, 1.4 MIU Vitamin $D_3$, 20 g Vitamin E, 1 g Vitamin K, 1 g Vitamin $B_1$, 3 g Vitamin $B_2$, 1.5 g Vitamin $B_6$, 15 mg Vitamin $B_{12}$ 12 g niacin, 10 mg pantothentic acid, 0.19 g folic acid, 30 mg biotin, 10.6 g Calcium pantothenatic, 60 g iron, 100 g zinc, 40 g manganese, 10 g copper, 0.2 g cobalt, 0.5 g iodine, 0.3 g selenium, and 20 g antioxidant.

[b] Calculated composition.

Table 5: Quantitative amino acid analysis of the two basal diets.

| **Amino acid (mg/g)** | **Diet 1** | **Diet 2** |
|---|---|---|
| Hydroxyproline | 1.46 | 1.62 |
| Histidine | 3.50 | 5.08 |
| Serine | 7.01 | 10.2 |
| Arginine | 9.42 | 14.0 |
| Glycine | 9.28 | 11.8 |
| Aspartic acid | 11.2 | 18.2 |
| Glutamic acid | 31.7 | 41.5 |
| Threonine | 5.89 | 9.60 |
| Alanine | 7.34 | 9.89 |
| Proline | 12.6 | 14.7 |
| Lysine | 7.66 | 13.4 |
| Tyrosine | 3.42 | 5.22 |
| Methionine | 2.17 | 2.82 |
| Valine | 7.49 | 10.2 |
| Isoleucine | 5.51 | 8.28 |
| Leucine | 10.7 | 15.2 |
| Phenylalanine | 7.06 | 9.80 |

Table 6: The blend ratios (%) of the two basal diets to produce the five dietary treatments.

| Treatment | Diet 1 | Diet 2 | MJ DE/kg | Av. Lys/MJ DE |
|---|---|---|---|---|
| 1 | 100 | 0 | 13.5 | 0.4 |
| 2 | 75 | 25 | 13.5 | 0.5 |
| 3 | 50 | 50 | 13.5 | 0.6 |
| 4 | 25 | 75 | 13.5 | 0.7 |
| 5 | 0 | 100 | 13.5 | 0.8 |

Measurements are as described for Experiment 1. In addition, when pigs were 100 kg LW or above they were individually tattooed, removed from feed overnight and transported to a commercial abattoir (approx. 90 minute transport time). The pigs were stunned using a carbon dioxide, dip-lift stunner set at 85% $CO_2$ for 1.8 minutes (Butina, Denmark). Exsanguination, scalding, dehairing and evisceration were performed using standard commercial procedures. Hot carcass weight (AUSMEAT Trim 13; head off, fore trotters off, hind trotters on; AUS-MEAT Ltd, South Brisbane, Qld, Australia) and P2 backfat depth, 65 mm from the dorsal midline at the point of the last rib (PorkScan) were measured approximately 35 minutes after exsanguination, prior to chiller entry (2$^{o}$C, airspeed 4 m/second).

***Statistical analysis***

Two-way analysis of variance (ANOVA) was performed with the Genstat 12 program to analyse the main effects of sex and diet for Experiment 1 and 2. Position within the shed was used as a block in the analysis. A level of probability of less than 0.05 was used to determine statistical difference between treatments. To estimate lysine requirements from 20 to 50 kg LW and from 50 to 100 kg LW a spline model was fitted to the data (Auldist *et al.* 1997). Lysine requirements were estimated at either 95% (for ascending curves) or 105% (for descending curves) of the high-lysine plateau (King *et al.* 2000).

Response curves were also fitted to the data using treatment means and the curves were used to predict the optimum dietary lysine concentration for maximum daily gain and minimum feed to gain for the weight ranges 20 to 35 kg, 35 to 50 kg, 50 to 65 kg, and 65 to 80 kg LW. Cubic and quadratic curves were fitted to the data with cubic models selected as most representative of the data. The cubic curves were fitted using $y=ax^3+bx^2+cx+d$, where y=either daily gain or feed:gain, x= available lysine:DE and a, b, c and d are representative components of the equation. Linear-by-linear and quadratic-by-linear curves were also fitted. The quadratic-by-linear model ($y=a+b/(1+dx)+cx$) showed the best fit and an estimate of the optimum lysine level to achieve maximum daily gain and minimum feed to gain was made.

# 3. Outcomes

***Experiment 1***

Pigs were an average of 22.3 kg LW and 59 days of age at the start of the experiment. There was no significant difference in start weight between lysine treatments (P=0.754), however the females were significantly heavier than the males (P<0.001). The experiment ceased when the pigs were an average of 53.1 kg LW and 94 days of age. At this time the females were heavier than males, and pigs on the lowest level of lysine were lighter than those on the higher levels of lysine (P<0.001) (Table 7).

The entire males had a lower average daily gain (P=0.036), reduced feed intake (P<0.001) and improved feed to gain (P<0.001) compared to the females (Table 7, Figure 1 and 2).

Pigs that received the lowest level of Av Lys/MJ DE (0.6 g) grew slower and had a reduced feed to gain ratio compared to those on the higher levels (P<0.001, Table 7). Male pigs that received 1.0 g Av Lys/MJ DE also had an improved feed to gain compared to those on the other treatments (P<0.001, Table 8). There were no significant differences (P = 0.243) in feed intake between any level of dietary lysine level (Table 7).

There was a significant interaction between the lysine level and sex for the feed to gain ratio (P=0.011). Entire males continued to decrease their feed to gain as the level of lysine increased while the feed to gain of females reached a plateau as the lysine level increased. Therefore, lysine requirements were determined separately for females and entire males.

Using the respective plateaus for daily gain and feed to gain ratio the lysine requirements were determined. The lysine requirement to ensure 95% of plateau daily gain was 0.76 g Av Lys/MJ DE for entire males and 0.74 g Av Lys/MJ DE for females while the lysine requirement to ensure 105% of plateau feed to gain was 0.84 g Av Lys/MJ DE for entire males and 0.78 g Av Lys/MJ DE for females.

The overall performance of pigs on this experiment was excellent by industry standards. Of the 350 pigs that commenced on the experiment, one was euthanased for health reasons.

Table 7: Growth performance for male and female pigs fed varying levels of available lysine to DE from 22.3 to 53.1 kg (n=5).

| | Treatment (g Av Lys/MJ DE) | | | | | SED[a] | P-value | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | | Level | Sex | LxS |
| *Initial LW (kg)* | | | | | | | | | |
| Male | 21.6 | 22.2 | 21.6 | 22.3 | 21.8 | 0.509 | 0.754 | <0.001 | 0.409 |
| Female | 22.9 | 22.5 | 22.6 | 22.8 | 23.2 | | | | |
| *Final LW (kg)* | | | | | | | | | |
| Male | 49.3 | 52.7 | 52.6 | 53.0 | 53.9 | 1.05 | <0.001 | <0.001 | 0.607 |
| Female | 52.2 | 54.2 | 53.7 | 55.1 | 54.7 | | | | |
| *ADG (g)* | | | | | | | | | |
| Male | 791 | 870 | 885 | 888 | 920 | 23.1 | <0.001 | 0.036 | 0.180 |
| Female | 838 | 906 | 887 | 924 | 900 | | | | |
| *Feed Intake (kg/d)* | | | | | | | | | |
| Male | 1.44 | 1.49 | 1.46 | 1.45 | 1.44 | 0.044 | 0.243 | <0.001 | 0.467 |
| Female | 1.57 | 1.62 | 1.59 | 1.69 | 1.62 | | | | |
| *Feed to gain* | | | | | | | | | |
| Male | 1.82 | 1.71 | 1.65 | 1.66 | 1.57 | 0.036 | <0.001 | <0.001 | 0.011 |
| Female | 1.87 | 1.79 | 1.80 | 1.83 | 1.80 | | | | |

[a] SED for treatment x sex

Table 8: Contrast matrix analysis conducted for the feed to gain ratio.

| Source of variation | df | p-value |
|---|---|---|
| Block stratum | 4 | |
| Sex | 1 | <0.001 |
| 0.6 g Av Lys/MJ DE vs rest (a) | 1 | <0.001 |
| Sex . a vs rest | 1 | 0.013 |
| 0.6 vs rest . 0.7,0.8,0.9 vs 1 (b) | 1 | 0.010 |
| Sex . b | 1 | 0.021 |
| b . 0.7,0.8,0.9 | 2 | 0.549 |
| Sex . b . 0.7,0.8,0.9 | 2 | 0.263 |
| Residual | 36 | |

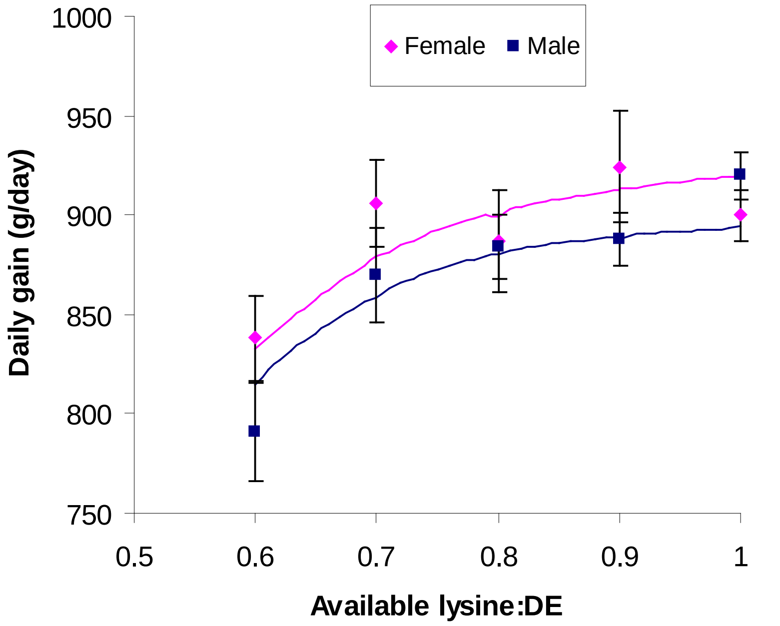


Figure 1: Effect of available lysine on average daily gain (ADG) for males and females (± SE) from 22.3 to 53.1 kg LW.

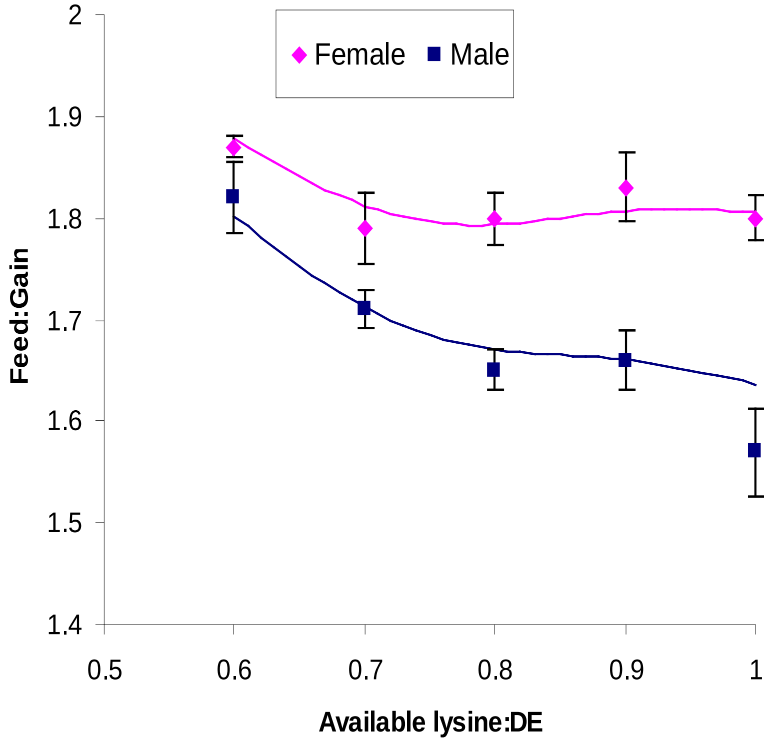


Figure 2: Effect of available lysine on feed to gain ratio for females and males (± SE) from 22.3 to 53.1 kg LW.

***Experiment 2***

Pigs were an average of 49.6 kg LW at the start of the experiment. The females were significantly heavier than the males at the commencement of the experiment (P<0.001), however, they were also approximately one week older than the males. Males were significantly heavier than females (P=0.019) when the experiment ceased and there was no difference between males and females in the number of days on the experiment (P=0.214). The entire males had a higher average daily gain (P=<0.001), similar feed intake (P=0.208), improved feed to gain (P<0.001), lighter carcass weight (P=0.056), lower dressing percentage (P<0.001) and a similar depth of backfat (P=0.120) compared to the females (Table 9, Figure 3 and 4).

There was no significant difference in start weight and final liveweight between lysine treatments (P=0.844 and P=0.065, respectively). Pigs that received the lowest levels of lysine grew slower (P<0.001) and had a higher feed to gain (P<0.001) compared to pigs that received the higher levels of lysine. There were no differences in carcass weight, dressing percentage and depth of backfat between lysine levels (P>0.05).

There was a significant interaction between the lysine level and sex for the feed to gain ratio (P=0.005, Table 9). The feed to gain of entire males reached a plateau as the level of lysine increased while the feed to gain of females increased at the highest lysine level. Therefore, lysine requirements were determined separately for females and entire males.

Using the respective plateaus for daily gain and feed to gain ratio the lysine requirements were determined. The lysine requirement to ensure 95% of plateau daily gain was 0.60 g Av Lys/MJ DE for entire males and 0.60 g Av Lys/MJ DE for females while the lysine requirement to ensure 105% of plateau feed to gain 0.70 g Av Lys/MJ DE for entire males and 0.66 g Av Lys/MJ DE for females.

The overall performance of pigs on this experiment was excellent by industry standards. Of the 420 pigs that commenced on the experiment, 2 pigs were removed because of prolapses, and 2 were removed for health reasons.

Table 9: Growth performance and carcass characteristics for male and female pigs fed varying levels of Av Lys/MJ DE from 49.6 to 103.2 kg (n=6).

| | Lysine level (g Av Lys/MJ DE) | | | | | SED[a] | P-value | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | | Level | Sex | LxS |
| *Initial LW (kg)* | | | | | | | | | |
| Male | 47.8 | 48.2 | 47.8 | 47.9 | 47.5 | 1.19 | 0.844 | <0.001 | 0.994 |
| Female | 51.2 | 51.8 | 51.5 | 51.7 | 50.6 | | | | |
| *Final LW (kg)* | | | | | | | | | |
| Male | 103.1 | 104.2 | 104.3 | 103.8 | 103.0 | 0.799 | 0.065 | 0.019 | 0.721 |
| Female | 102.4 | 102.4 | 104.1 | 103.0 | 102.3 | | | | |
| *Days on experiment* | | | | | | | | | |
| Male | 58.6 | 53.7 | 52.5 | 52.5 | 52.7 | 2.07 | 0.002 | 0.214 | 0.789 |
| Female | 59.1 | 53.7 | 53.6 | 54.2 | 56.2 | | | | |
| *Daily gain (g)* | | | | | | | | | |
| Male | 949 | 1056 | 1086 | 1066 | 1069 | 24.9 | <0.001 | <0.001 | 0.446 |
| Female | 879 | 952 | 988 | 966 | 931 | | | | |
| *Feed Intake (kg/d)* | | | | | | | | | |
| Male | 2.29 | 2.33 | 2.41 | 2.27 | 2.32 | 0.063 | 0.020 | 0.208 | 0.756 |
| Female | 2.26 | 2.41 | 2.43 | 2.33 | 2.39 | | | | |
| *Feed to gain* | | | | | | | | | |
| Male | 2.41 | 2.21 | 2.22 | 2.14 | 2.17 | 0.043 | <0.001 | <0.001 | 0.005 |
| Female | 2.57 | 2.53 | 2.46 | 2.41 | 2.56 | | | | |
| *Carcass weight (kg)* | | | | | | | | | |
| Male | 68.9 | 69.7 | 70.2 | 70.7 | 69.4 | 0.488 | 0.056 | <0.001 | 0.702 |
| Female | 71.1 | 71.0 | 71.8 | 71.5 | 70.6 | | | | |
| *Dressing percentage* | | | | | | | | | |
| Male | 66.8 | 66.9 | 67.3 | 67.4 | 67.2 | | 0.436 | <0.001 | 0.371 |
| Female | 69.5 | 69.4 | 69.0 | 69.5 | 67.3 | | | | |
| *Backfat (mm)* | | | | | | | | | |
| Male | 12.3 | 12.5 | 12.5 | 11.1 | 11.8 | 0.468 | 0.519 | 0.120 | 0.360 |
| Female | 12.8 | 12.4 | 12.5 | 12.7 | 12.2 | | | | |

[a] SED for level × sex

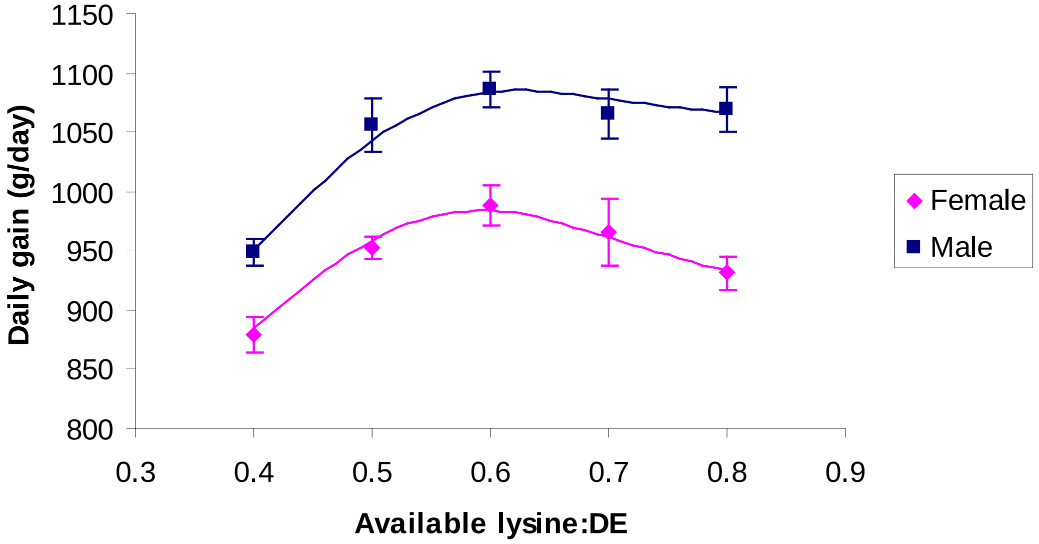


Figure 6: Effect of available lysine on daily gain for females and males (± SEM) 49.6 to 103.2 kg LW.

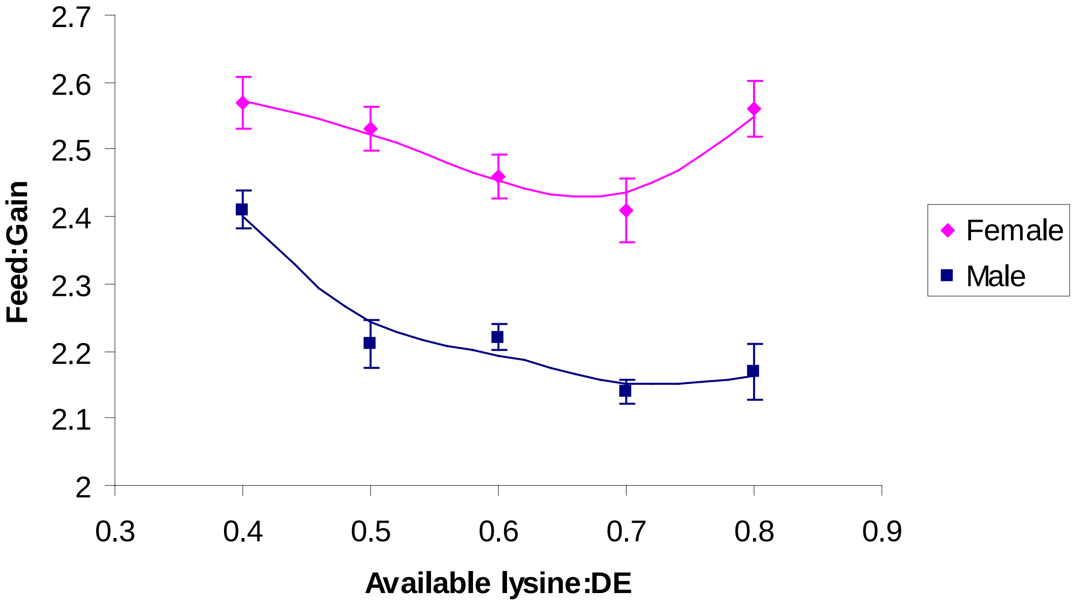


Figure 7: Effect of available lysine on feed to gain for females and males (± SEM) 49.6 to 103.2 kg LW.

***Combined results***

The cubic regression equations that were used to predict the dietary lysine concentration to achieve maximum daily gain and the minimum feed:gain are given in Tables 10 and 11. Figures 8, 9, 10 and 11 show the cubic response curves of daily gain and feed:gain against lysine concentration. The predicted lysine requirements are given separately for entire males and females as there was a lysine level x sex interaction. From 20 to 35 kg the optimum lysine level for maximum daily gain was 1.00 and 0.90 g Av Lys:DE, and for minimum feed:gain was 1.00 and 0.84 g Av Lys:DE for entire males and females, respectively. From 35 to 50 kg the optimum lysine level for maximum daily gain was 0.80 and 0.79 g Av Lys:DE, and for minimum feed:gain was 0.81 and 0.72 g Av Lys:DE for entire males and females, respectively. From 50 to 65 kgs the optimum lysine level for maximum daily gain was 0.60 and 0.56 g Av Lys:DE, and for minimum feed:gain was 0.80 and 0.55 g Av Lys:DE for entire males and females, respectively. From 65 to 80 kg the optimum lysine level for maximum daily gain was 0.61 and 0.69 g Av Lys:DE, and for minimum feed:gain was 0.69 and 0.69 g Av Lys:DE for entire males and females, respectively. From 80 to 95 kg the optimum lysine level for maximum daily gain was 0.56 and 0.52 g Av Lys:DE, and for minimum feed:gain was 0.63 and 0.48 g Av Lys:DE for entire males and females, respectively.

Table 10: Cubic response equations used to predict the optimum available lysine:DE ratio for males for maximum daily gain or minimum feed conversion.

| | Cubic equation | $R^2$ | Optimum lysine level |
|---|---|---|---|
| **Daily gain (g/day)** | | | |
| 20-35 | $y = 4583x^3 - 11014x^2 + 9017x - 1697$ | 0.940 | 1.00 |
| 35-50 | $y = 6000x^3 - 16000x^2 + 14090x - 3200$ | 0.940 | 0.80 |
| 50-65 | $y = 12000x^3 - 22929x^2 + 44454x - 2016$ | 0.998 | 0.60 |
| 65-80 | $y = 10083x^3 - 20971x^2 + 14340x - 2133$ | 0.9997 | 0.61 |
| 80-95 | $y = 10500x^3 - 20986x^2 + 13598x - 1761$ | 0.961 | 0.56 |
| | | | |
| **Feed:gain (kg/kg)** | | | |
| 20-35 | $y = -5.83x^3 + 12.9x^2 - 9.91x + 4.29$ | 0.888 | 1.00 |
| 35-50 | $y = -10.8x^3 + 29.1x^2 - 25.8x + 9.20$ | 0.936 | 0.81 |
| 50-65 | $y = 13.3x^3 + 24.9x^2 - 15.8x + 5.38$ | 0.977 | 0.80 |
| 65-80 | $y = -2e^{-12x3} + 4.43x^2 - 6.11x + 4.220$ | 0.978 | 0.69 |
| 80-95 | $y = 2.64x^2 - 3.32x + 3.40$ | 0.369 | 0.63 |

Table 11: Cubic response equations used to predict the optimum available lysine:DE ratio for females for maximum daily gain or minimum feed conversion.

| | Cubic equation | $R^2$ | Optimum lysine level |
|---|---|---|---|
| **Daily gain (g/day)** | | | |
| 20-35 | $y= 1583x^3 - 5414x^2 + 5827x - 1138$ | 0.718 | 0.90 |
| 35-50 | $y= 2750x^3 - 7529x^2 + 6748x - 1048$ | 0.973 | 0.79 |
| 50-65 | $y= 16333x^3 - 32650x^2 + 21162x - 3499$ | 0.956 | 0.56 |
| 65-80 | $y= -12917x^3 + 20786x^2 - 10199x + 2414$ | 0.903 | 0.69 |
| 80-95 | $y= 13417x^3 - 26079x^2 + 16260x - 2281$ | 0.867 | 0.52 |
| | | | |
| **Feed:gain (kg/kg)** | | | |
| 20-35 | $y= -5x^3 + 14.7x^2 - 14.1x + 6.07$ | 0.760 | 0.84 |
| 35-50 | $y= -14.2x^3 + 34.8x^2 - 28.1x + 9.28$ | 0.462 | 0.72 |
| 50-65 | $y= -31.7x^3 + 61.9x^2 - 39.4x + 10.5$ | 0.893 | 0.55 |
| 65-80 | $y= 40x^3 - 67.6x^2 + 36.1x - 3.54$ | 0.957 | 0.69 |
| 80-95 | $y= -29.2x^3 + 52.7x^2 - 30.4x + 8.28$ | 0.685 | 0.48 |

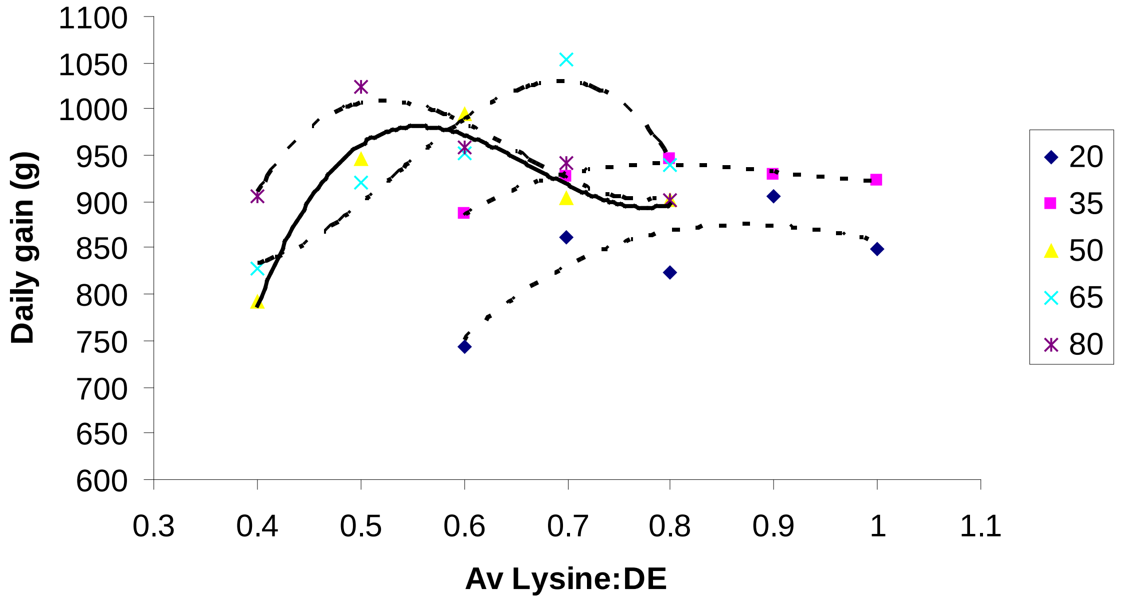


Figure 8: Cubic response curves fitted for the daily gain of females at 20, 35, 50, 65 and 80 kg LW.

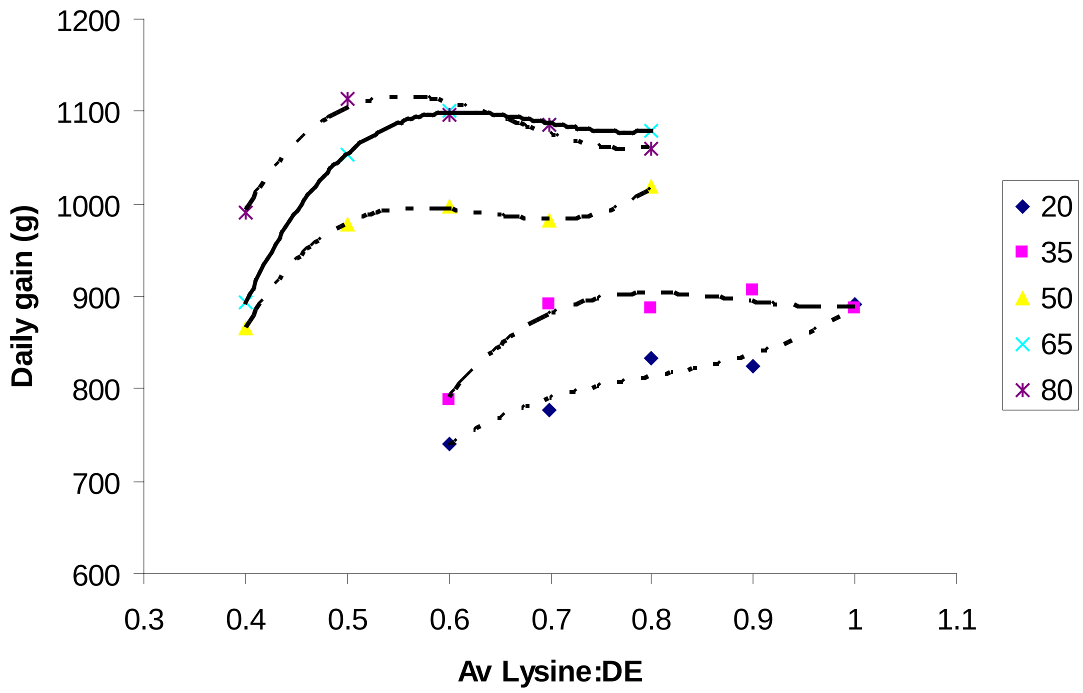


Figure 9: Cubic response curves fitted for the daily gain of males at 20, 35, 50, 65 and 80 kg LW.

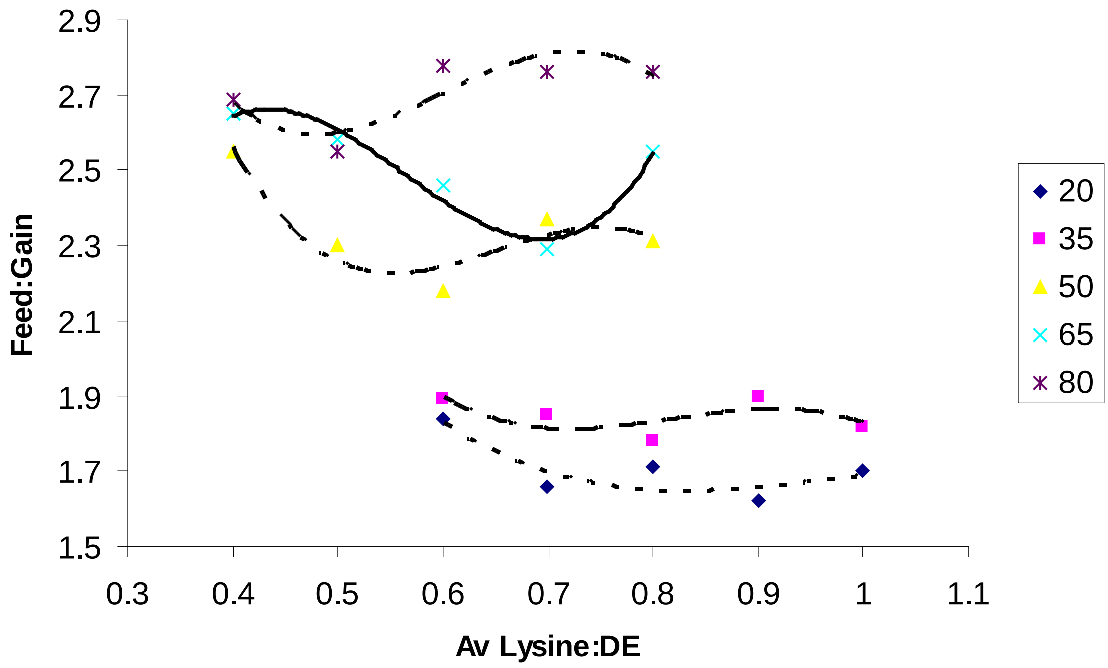


Figure 10: Cubic response curves fitted for the feed to gain of females at 20, 35, 50, 65 and 80 kg LW.

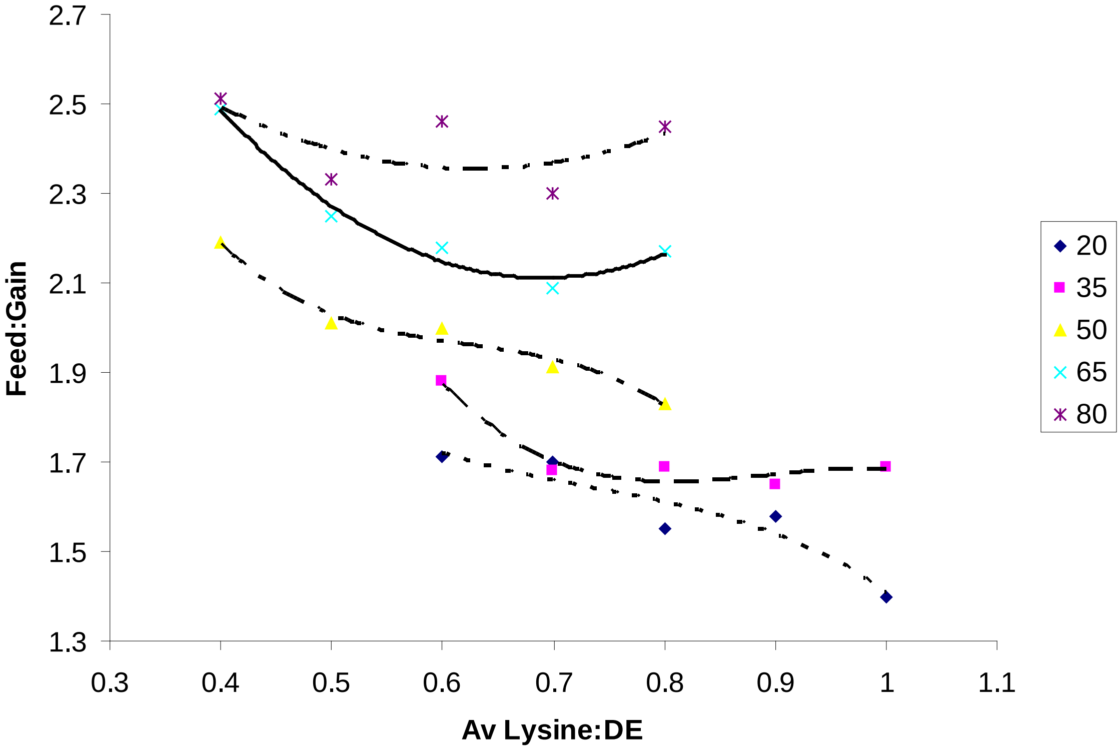


Figure 11: Cubic response curves fitted for the feed:gain of males at 20, 35, 50, 65 and 80 kg LW.

The response curves for quadratic-by-linear were also fitted to the data to estimate the optimum lysine level. The curves are given in Appendix A and the estimated lysine requirements to achieve maximum daily gain and minimum feed:gain are given in Table 12. From 20 to 35 kg the optimum lysine level for maximum daily gain was 1.00 and 0.72 g Av Lys:DE, and for minimum feed:gain was 0.80 and 0.70 g Av Lys:DE for entire males and females, respectively. From 35 to 50 kg the optimum lysine level for maximum daily gain was 0.77 and 0.78 g Av Lys:DE, and for minimum feed:gain was 0.77 and 0.76 g Av Lys:DE for entire males and females, respectively. From 50 to 65 kg the optimum lysine level for maximum daily gain was 0.60 and 0.60 g Av Lys:DE, and for minimum feed:gain was 0.62 and 0.58 g Av Lys:DE for entire males and females, respectively. From 65 to 80 kg the optimum lysine level for maximum daily gain was 0.58 and 0.70 g Av Lys:DE, and for minimum feed:gain was 0.70 and 0.70 g Av Lys:DE for entire males and females, respectively. From 80 to 95 kg the optimum lysine level for maximum daily gain was 0.50 and 0.50 g Av Lys:DE, and for minimum feed:gain was 0.50 and 0.50 g Av Lys:DE for entire males and females, respectively.

Table 12: The estimated lysine requirement (g Av Lys:DE) to achieve maximum daily gain and minimum feed:gain for each weight category using quadratic-by-linear fit curves.

| Weight (kg) | Male | | Female | |
|---|---|---|---|---|
| | Daily gain | Feed:gain | Daily gain | Feed:gain |
| 20 | 1.00 | 0.80 | 0.72 | 0.70 |
| 35 | 0.77 | 0.77 | 0.78 | 0.76 |
| 50 | 0.60 | 0.62 | 0.60 | 0.58 |
| 65 | 0.58 | 0.70 | 0.70 | 0.70 |
| 80 | 0.50 | 0.50 | 0.50 | 0.50 |

# 4. Application of Research

The aim of this study was to determine the optimal available lysine/MJ DE ratio for the Australian PIC genotype from 20 to 100 kg LW. It has been several years since the lysine requirements of pigs have been determined, and it is likely that the lysine requirement of today's genotypes have increased because of increased rate of protein deposition and feed efficiency from improved genetics (Schneider *et al.* 2010). This experiment found that the lysine requirements of entire males and female pigs from 20 to 100 kg LW were higher than what is possibly currently used in the Australian feed industry. However, the optimum available lysine to DE ratio required to ensure maximum daily gain or minimum feed conversion depended on the model which was fitted to the data. Several models were used to calculated lysine requirements including quadratic and cubic response curves or linear-by-linear and quadratic-by-linear fit curves. Cubic response curves and quadratic-by-linear fit curves were the best representatives of the data. Smoothing splines were also used to predict overall requirements from 20 to 50 kg and 50 to 100 kg LW.

It is concluded that the optimum Av Lys/MJ DE ratio for pigs from 20 to 50 kg LW was 0.74 g for females and 0.8 g for males. This is higher than currently used in grower diets in Australia for this genotype. It is common practice to feed grower pigs (20 to 50 kg LW) similar diets because based on previous research the nutrient requirements of females and entire males do not differ significantly. Therefore the result from this experiment has indicated that there is a difference in the nutrient requirements between the two different sexes in this range and so feeding standards may need to be adjusted accordingly. This result contrasts with O'Connell *et al.* (2005) who found no difference in the requirements of entire males and females from 20 to 40 kg. However, Campbell *et al.* (1988) found that entire males and females had a small difference in lysine requirement from 20 to 50 kg.

The optimum Av Lys/MJ DE for pigs from 50 to 100 kg LW was 0.63 g for females and 0.65 g for males. In this range entire males grew faster than females and were also more efficient which is in agreement with other studies (O'Connell *et al.* 2006; Campbell *et al.* 1988). Most recent studies have found no difference in the lysine requirement between entire males and females in this range although studies conducted in the 1980's suggested that entire males have higher lysine requirements than females (Dunshea, 2009). In addition, the results from this experiment suggest that perhaps entire males are using amino acids more efficiently than previously and also with greater efficiency than females. Females also appear to be more sensitive to oversupply of lysine than entire males, as once the requirement of females was exceeded their performance appeared to be depressed.

The performance figures obtained in this experiment, in particular the figures for feed:gain from 20 to 50 kg LW, demonstrate that under the conditions of this experiment Australian genetics are capable of achieving results that compare favourably with other genotypes world wide (Campbell pers comm.). The results also support previous evidence that within these LW ranges entire males are more efficient compared to females (O'Connell *et al.* 2005; O'Connell *et al.* 2006).

# 5. Conclusion

It has generally been thought that the lysine requirements for males and females between 20 and 50 kg LW are the same, however this experiment shows that males have a higher requirement for lysine than females in this weight range. This suggests that potentially there may be some feed cost savings in separating male and female pigs in this weight range.

The requirements for both entire males and females from 50 to 100 kg LW are also higher than currently recommended for this genotype and confirm that males have a higher lysine requirement than females in this weight range.

## 6. Limitations/Risks

The successful implementation of the results from this experiment relies on having a good knowledge of the genetic potential of pigs in a commercial situation because the results from the current experiment have set the new benchmark. Producers may also not be able to feed different diets to entire males and females over the 20-50 kg weight range, but that will be an economic decision that they can make based on the potential savings in feed costs.

## 7. Recommendations

The results from this study have established the lysine requirements for a current Australian genotype which may be higher than the levels currently used by the Australian industry. The suggested available lysine requirements per MJ DE for entire male and female pigs at various bodyweights are given in Table 13. It is important that the results of this experiment be provided to the main nutritionists around Australia for discussion and possible implementation. Appropriate adjustments to the recommended values should be made based on factors such as genetics, temperature, pen size and feed intake.

Table 13: Suggested available lysine per MJ DE requirements for entire male and female pigs at different bodyweights.

| Body weight (kg) | Entire male | Female |
|---|---|---|
| 20 | 0.80 | 0.78 |
| 35 | 0.77 | 0.76 |
| 50 | 0.65 | 0.60 |
| 65 | 0.60 | 0.55 |
| 80 | 0.53 | 0.50 |

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Schneider, J.D., Tokach, M.D., Dritz, S.S., Nelssen, J.L., DeRouchery, J.M., & Goodband, R.D., (2010). Determining the effect of lysine:calorie ratio on growth performance of ten- to twenty-kilogram of body weight nursery pigs of two different genotypes. *Journal of Animal Science* **88**, 137-146. doi:10.2527/jas.2008-1204.

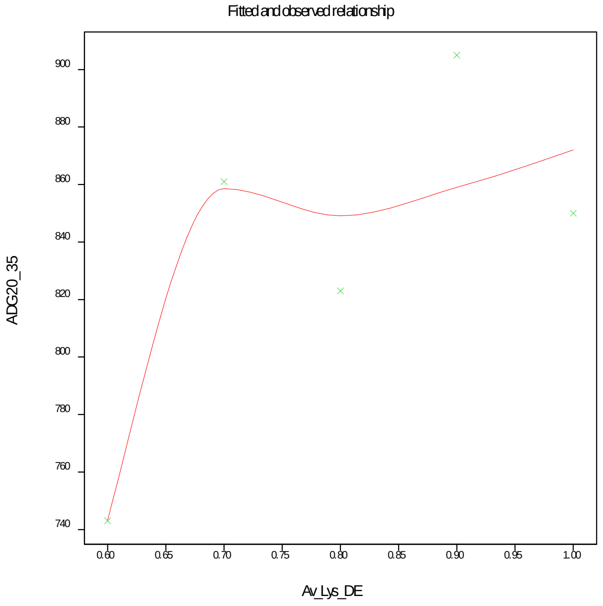
# Appendix 1

## Daily gain (g/day)

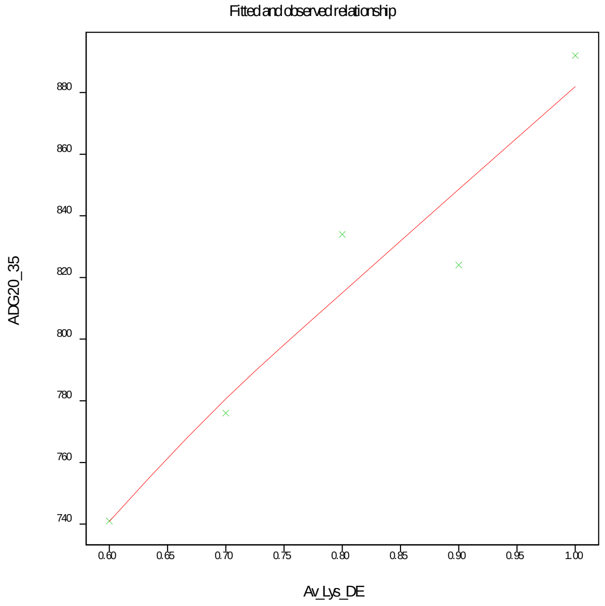
## Quadratic-by-linear

### Female

### ADG20-35




### Male

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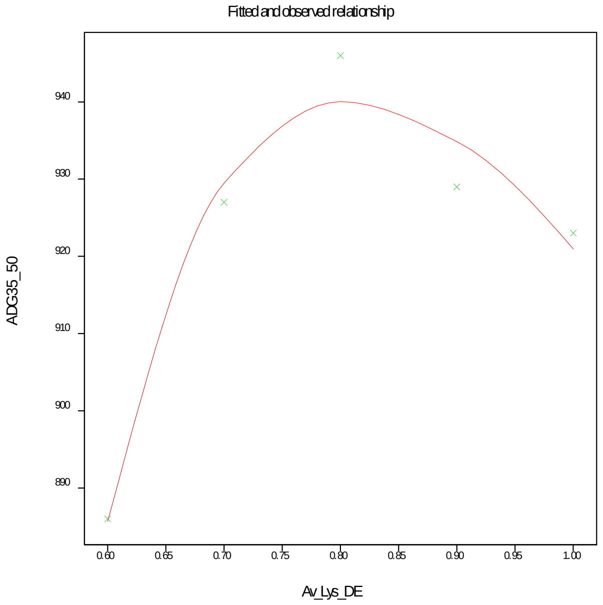


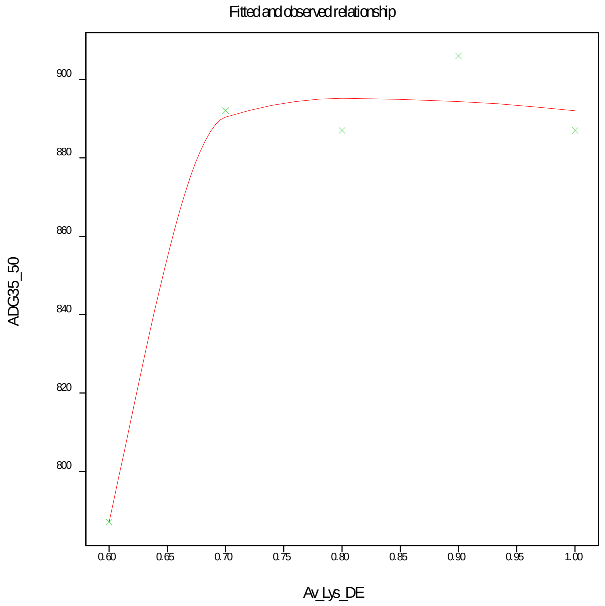

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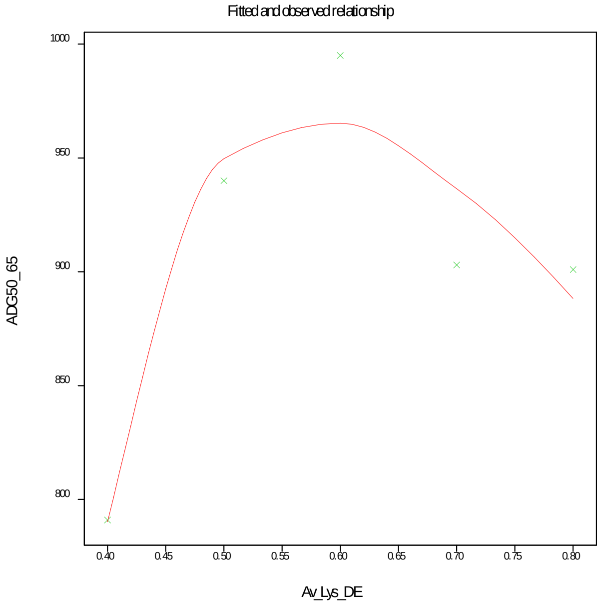


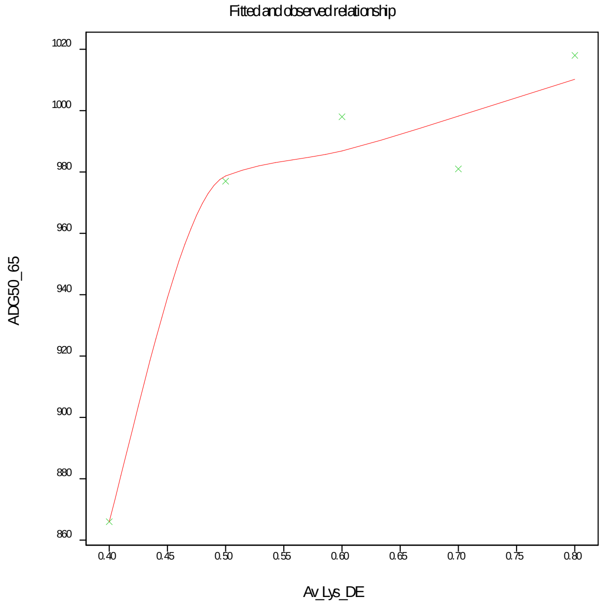


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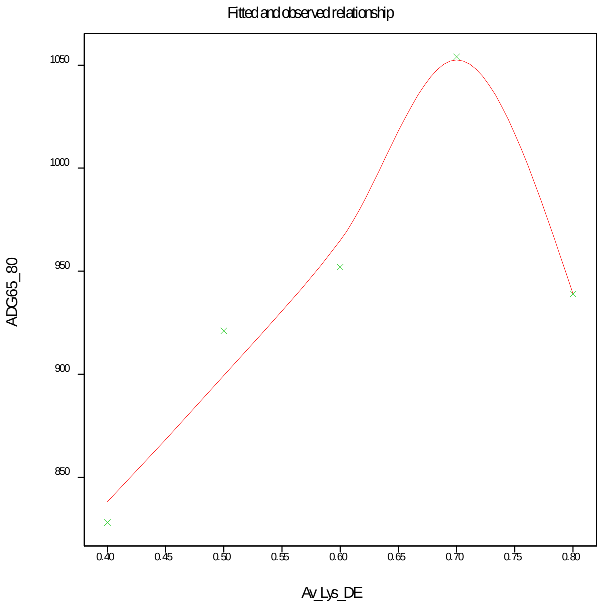


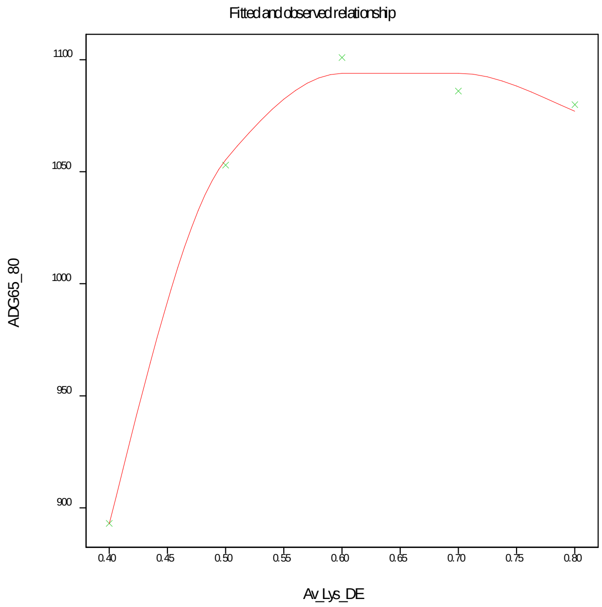


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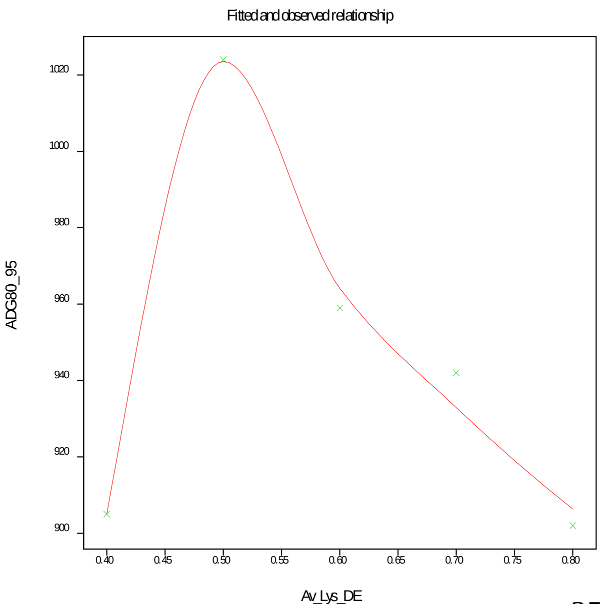
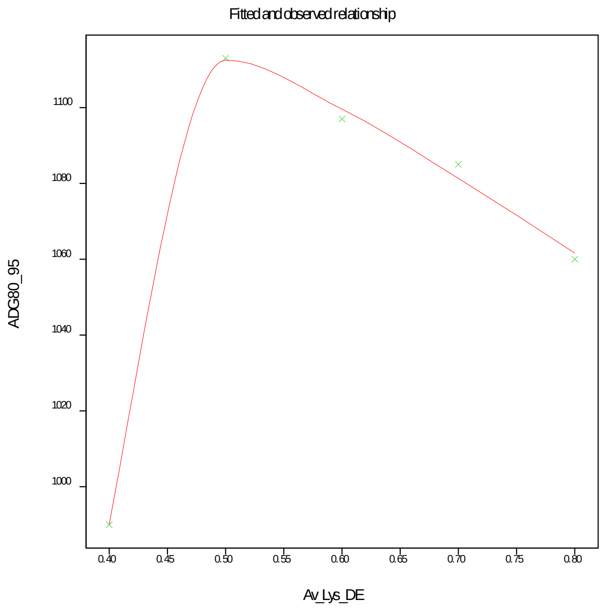


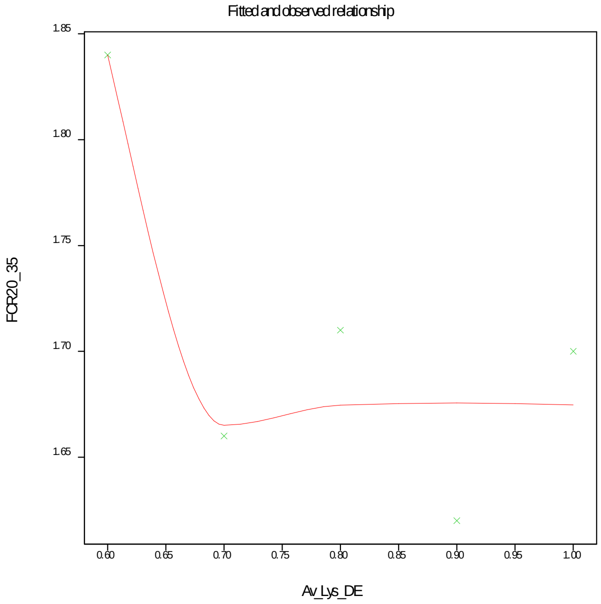



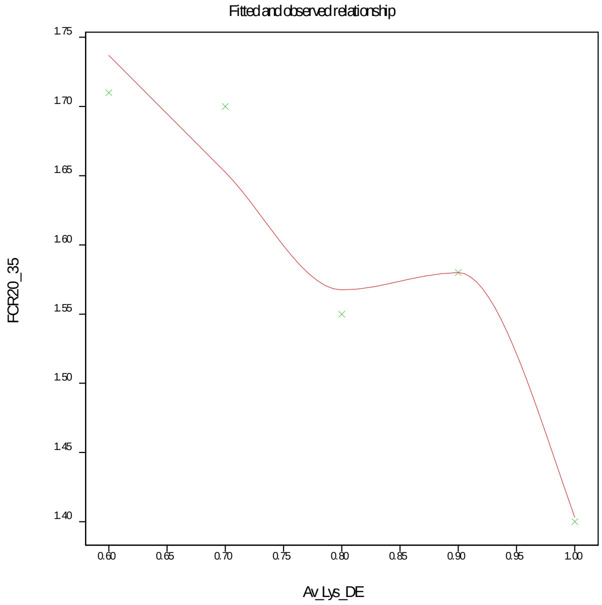
## Feed:Gain

## Quadratic-by-linear

### Females / Males

### FCR20-35

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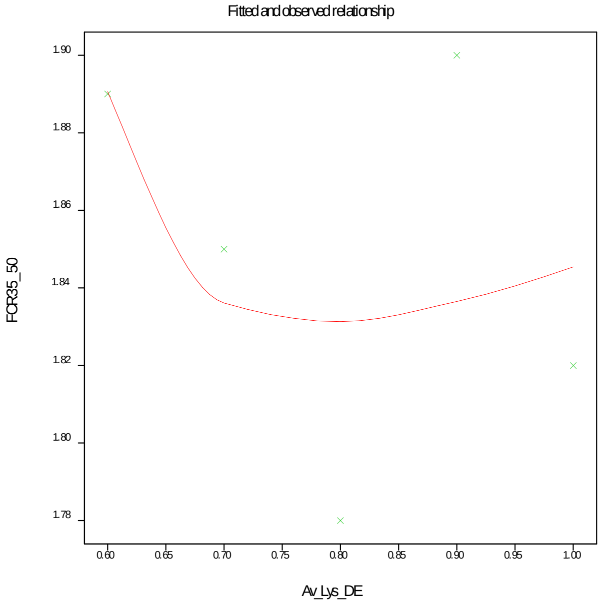


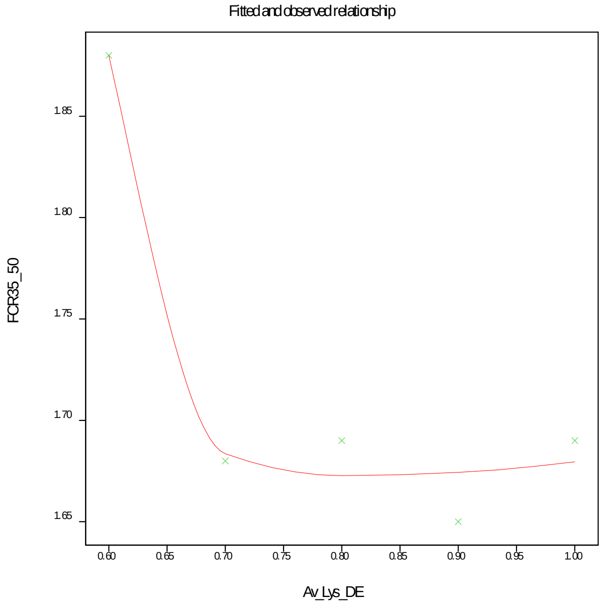

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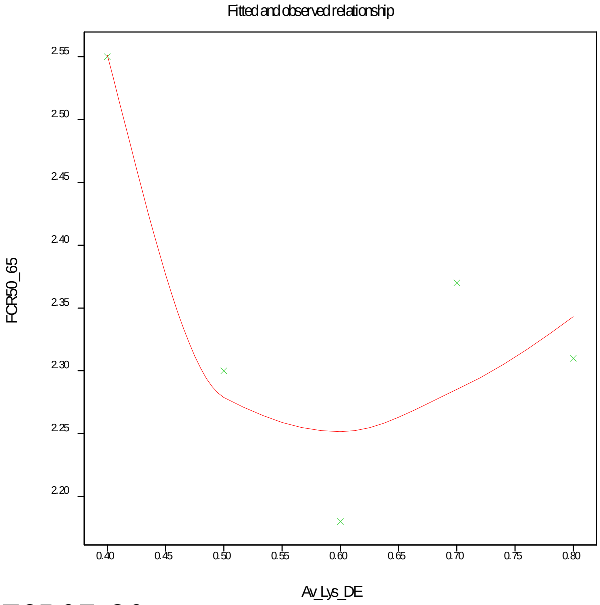


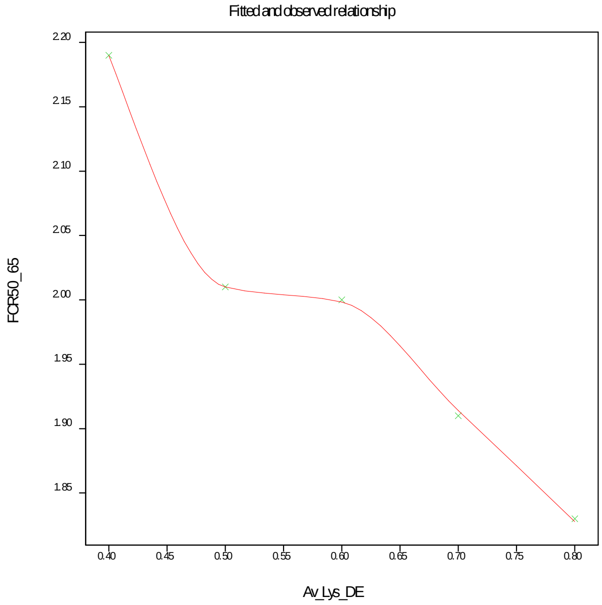


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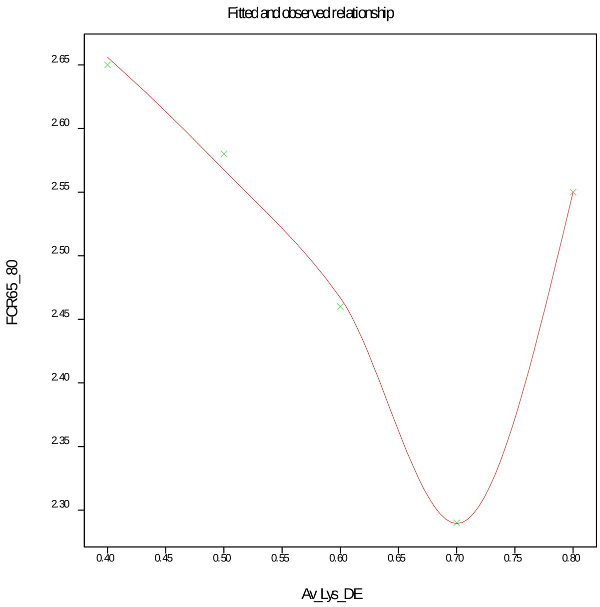


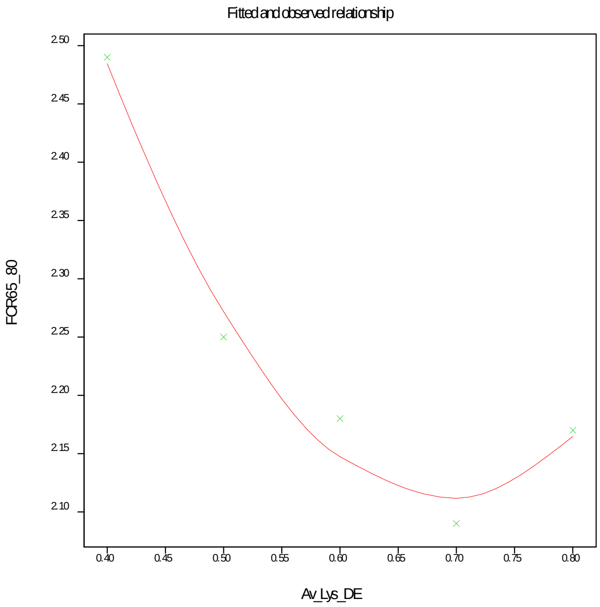


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