# Potential Uses of AUSPIG in Commercial Pig Production

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## Summary

The AUSPIG model combines many of the production variables that interact in complex ways to predict not only the growth performance of pigs, but also minimum values of amino acids and energy that are required for maximum growth. A number of experiments and on-farm trials were conducted that used AUSPIG to evaluate the suitability of diets currently being fed, and to test the hypothesis that the supply of amino acid levels relative to energy could be reduced without adversely affecting growth and carcass quality, and hence increase profits. In all four experiments, feed costs could be reduced substantially by reducing amino acid levels to minimum requirements as predicted by AUSPIG. We also demonstrated how the model can be used to evaluate the effect of nutrition on tolerance to low environmental temperatures, and the 'true' consequence of formulating incorrect nutritive ingredient values on feed cost and growth performance, and subsequent production profitability.

## Introduction

The use of computer simulation models in agriculture is now becoming widespread as researchers, advisers and farmers become more interactive and the need to improve efficiency continues. By considering interactions that occur between many factors which influence growth and development, simulation models have the capacity to greatly simplify what is otherwise a large and complex biological system. Recent advancement in computer technology has provided the potential to increase the accessibility of research knowledge to a wider audience (Fortune, 1990).

There are many computer simulation models which have been developed to integrate data from research areas in pigs, poultry and ruminants and assist in the management of animals (Black et al., 1993). Simulation models such as AUSPIG (Black et al., 1986) allow the user to evaluate the complex interactions that influence the growth of the animal simultaneously. To be widely applied in commercial situations, simulation software programs need to be more than just a 'black box' of mathematical relationships. They need to be user-friendly and the output able to be interpreted. The pig industry has recognised the importance of the AUSPIG model in transferring research knowledge to the producer, as well as highlighting areas of research which require further study.

Since the commercial release of AUSPIG in 199 1, over thirty licences have been sold within Australia, with more than seventy users trained, including researchers, consultants, nutritionists, academics and pig producers. In this paper, we will present the results of a number of research and on-farm studies that have been conducted to demonstrate that AUSPIG, by predicting the nutrient requirements of the growing pig, can be used to improve the profitability of commercial pig enterprises. Other examples of how AUSPIG might be used to evaluate feeding and management strategies will also be described and discussed.

## AUSPIG Research Trials in Pig Nutrition

### *Evaluation of diets and the prediction of nutrient requirements*

Commercial diets are traditionally formulated using accepted minimum nutrient requirements (eg. Standing Committee on Agriculture - Pig Sub committee, 1990) or personal experience, with a 'safety margin' incorporated to be certain of meeting the requirements of all pigs in the herd. While some nutritionists calculate the amino acid requirements by empirical relationships, this method is time-consuming and can not take into account factors that may influence those requirements (eg. environment). Without conducting on-farm trials to measure the performance of animals against a range of nutrient levels, it is therefore difficult for nutritionists to have confidence in setting dietary specifications for individual herds.

Feeding diets that are over formulated may also occur due to a perception by producers and nutritionists that feeding a highly specified diet will lead to a better growth rate in the herd. All animals have a genetic potential which determines the maximum amount of body protein that can be deposited. Supplying dietary amino acids beyond the genetic potential of the animal does not result in an increase in protein deposition (Campbell et al., 1985; Thaler et al., 1986). The consequence of over-formulating diets is invariably a more expensive diet, an increase in feed:gain and a higher level of nitrogen in excreta and hence effluent. It must therefore be the objective of a good feeding strategy to first identify the genetic potential of pigs given the particular circumstances prevailing in that piggery, and to then design a diet that will maximise performance and/or profitability.

The AUSPIG computer simulation model uses a mechanistic approach to predict energy and amino acid utilisation for a pig growing under a defined set of physical and management conditions. AUSPIG simulates the growth performance of a pig from weaning to sale (eg. 100 kg live weight), with determining the nutrient requirement of the growing pig seen as the most important feature of the model amongst licensees to date.

AUSPIG integrates many of the complex factors that affect the feed intake and nutrient requirement of the pig independently, but more importantly in combination as occurs in commercial production. The model predicts the requirements for dietary amino acids and energy from information on housing conditions, environment, sex, live weight and genetic potential for feed intake, energy deposition and protein deposition. The AUSPIG program incorporates a nutrition data base within the feed formulation module, Feedmania. Existing diets that are currently being fed are entered into Feedmania with a nutrient composition derived from the data base. Simulation of the data set produces predicted values of amino acid and energy requirements on a daily or live weight basis. From the reporting facility, 'Evaluation of Diet Suitability', the user can evaluate the supply of individual amino acids as a proportion of the amount required for maximum growth. The minimum amino acid requirements predicted by AUSPIG are then transferred to Feedmania as dietary specifications which can then be re-formulated into a new ration.

## *Determining dietary specifications for grower and finisher pigs using A USPIG*

AUSPIG has been used successfully to reduce feed costs on commercial piggeries in Victoria (Mullan, 1992; Mullan, 1994) and Western Australia (Mullan, 1994; Smits, 1994; Smits, 1995) by predicting that the requirement for nutrients were less than what was currently being fed. In each case the model predicted that the supply of amino acids, relative to digestible energy, in the existing grower and finisher diets were between 20 and 40% more than was required. Major savings in feed costs, which account for approximately 55% of the overall cost of production (Ransley and Cleary, 1994), were predicted without any adverse effect on either growth rate, feed conversion or carcass quality. We present results from four of these studies in which the effect on performance and profitability of using dietary specifications calculated using AUSPIG are compared to the existing practice.

### *1. Research piggeries*

The production herd at the WA Department of Agriculture's Medina Research Centre was simulated and an experiment designed to compare dietary specifications determined by AUSPIG with those typically used in the industry for fmisher pigs (Mullan and Hooper, unpublished). AUSPIG predicted that for entire male pigs of the Medina genotype the existing finisher diet (0.57 g av. lys/MJ DE for pigs between 50 and 90 kg LWT) was over-supplying the first-limiting amino acid by approximately 30%. At a live weight of 50 kilograms, 226 growing pigs (117 entire males and 109 females) were randomly allocated to one of four dietary treatments which were formulated to supply either: 85, 100, 115 or 130% of requirement for the most limiting amino acid for entire male pigs. All diets were formulated to contain the same level of energy (13.5 MJ DE/kg) and used the same base ingredients (barley/wheat/lupins). Pigs were group housed and fed *ad libitum.*

**Table 1** The performance of finisher pigs fed diets formulated to provide either 85, 100, 115 or 130% of requirements for the first-limiting amino acid (Mullan and Hooper, unpublished).

| | 85 | 100 | 115 | 130[1] |
|---|---|---|---|---|
| Dietary Av. lysine (g/MJ DE) | 0.38 | 0.44 | 0.50 | 0.57 |
| Age at sale (d) $149^{a}$ | $145^{b}$ | $145^{b}$ | $147^{b}$ | |
| LWT at sale(kg) | 91.7 | 91.5 | 91.5 | 91.7 |
| Daily gain (g) 50-90 kg | $815^{a}$ | $879^{b}$ | $873^{b}$ | $875^{b}$ |
| Feed intake (kg/d) | 2.45 | 2.54 | 2.43 | 2.51 |
| Carcass weight (kg) | 62.0 | 62.0 | 61.7 | 62.0 |
| Backfat P2 (mm) | 15.2 | 15.1 | 14.6 | 15.0 |
| Feed cost ($/t) 203 | 208 | 215 | 232 | |
| Change in profit[2] ($/pig) | +2.86 | +3.78 | +3.99 | - |

Means with different superscripts significant ($P < 0.05$). [1] Typical finisher diet. [2] Gross income minus feed cost per pig.

The results support the predictions of AUSPIG that there was an oversupply of dietary amino acids for the Medina genotype and that dietary specifications could be reduced without any effect on performance (Table 1). A 30% reduction in dietary lysine (100 vs 130%) had no effect on growth rate or carcass quality, but the savings in feed costs equated to an increase in profitability of approximately $4 per pig. For a typical commercial piggery selling 20 pigs/sow/year, this would equate to a reduction in feed costs for the finisher herd of about $80/sow/year. The results of a similar experiment at the Research and Development Centre of Bunge Meat Industries (Campbell, 1993) also indicated that dietary available lysine could be reduced from 0.57 to 0.48 g/MJ DE without any effect on the performance of entire male finisher pigs.

In the experiment conducted at the Medina Research Centre, growth rate was significantly reduced when a diet supplying only 85% of requirements was fed (Table 1), again confirming the predictions of the AUSPIG model. While a reduction in growth rate would seem undesirable, it is interesting to note that profitability for this scenario was still greater than when the 130% diet, which cost $30 more per tonne, was fed.

## 2. *Commercial herds*

Although widely acclaimed by the national and international pig industry for its ability to simulate the growing pig given a range of dietary, environmental and genetic constraints, the use of AUSPIG is not widespread amongst Australian pig producers. This may partly be due to producers doubting that the results from experiments on research stations could be achieved on their own piggery. In an attempt to demonstrate to producers that the model can be used successfully in commercial practice, three separate on-farm studies have been conducted (Mullan, 1992; Smits, 1994; Smits, 1995) (Table 2). In all three farm studies we demonstrated that AUSPIG could accurately predict dietary requirements and that performance was not affected by the feeding of diets in which the supply of amino acids relative to digestible energy had been reduced. The savings in feed costs varied according to the price of ingredients, but the overall impact on profitability is substantial. For example, if it is assumed that each of these herds sells 20 pigs/sow/year, then annual feed costs for Kantara would be reduced by $2 1,000, Westpork by $39,000 and that for Berrybank by $168,000. In view of these savings it is even more surprising that many producers have not taken the opportunity to use AUSPIG to look at ways to reduce feed costs, especially following a year of soaring grain prices.

Each of the above herds had relatively good information on growth rates, carcass quality, environment and feed use. With continued monitoring and updating of the simulation data, fme-tuning of the genotype settings could be made with the possibility of reducing diet specifications further. There are many herds for which there is relatively little good data on which to base an AUSPIG simulation, but in these instances the tolerance level in setting dietary specifications can be adjusted to allow for a greater margin for error. Again, these simulations can be repeated and specifications refined as more accurate and reliable performance data is collected.

**Table 2** Summary of AUSPIG feeding trials at Berrybank, Westpork and Kantara comparing diets formulated to AUSPIG specifications supplying 105% of the most limiting amino acid for entire male pigs with existing diets used on each farm (Control)

| | Berrybank (Vic) 1200 sows | Westpork (WA) 1200 sows | Kantar(WA)[2] 120 sows |
|---|---|---|---|
| Diet cost[1] ($/t) | | | |
| Control | 235 | 246 | 300 |
| AUSPIG | 212 | 234 | 260 |
| Daily gain from birth (g/d) | | | |
| Control | 611 | 545 | 575 |
| AUSPIG | 620 | 545 | 580 |
| Backfat P2 (mm) | | | |
| Control | 14.8 | 13.0 | 12.7 |
| AUSPIG | 15.0 | 13.7 | 12.0 |
| Change to profit (vs Control) | | | |
| AUSPIG ($/pig) | +7.09 | +1.62 | +8.75[3] |

[1]Prices at the time of trial. [2]Data collected over 12 month period. [3]Based on savings to feed cost only.

## Setting dietary specifications for commercial herds using AUSPIG

When simulating a commercial herd the AUSPIG model simulates the average animal (either male or female) which is deemed to be representative of the pen. Therefore, the more performance data that has contributed to that 'average' then the more confident we can be in the predictions. Nevertheless, it is recognised that within a group of animals there will always be a proportion of animals that will have a greater genetic potential for lean deposition than the average, and these will have a higher minimum requirement for amino acids. Likewise, a proportion of the herd will have a lower genetic potential for lean growth and will require a lower level of amino acids. Assuming this, we could expect that if dietary requirements were set at 100% of requirements then the average performance of animals fed those diets would do marginally worse than their counterparts fed, for example, a diet formulated to 115%. The results in Table 1, however, do not support this hypothesis. Possible reasons for this are that there was an error in the genotype settings; that AUSPIG is overestimating the requirement for amino acids; and/or that the availability of amino acids in ingredients was greater than that assumed in the feed database.

The setting of dietary specifications above the 100% requirement for the average animal may ensure that the genetic potential of the 'best' animals will be reached. As we get to know more about the potential of commercial herds for lean growth, and have more accurate information on nutrient availability of ingredients the economic importance of formulating diet specifications to the top level of performance can be assessed (Davies, 1992). While it may be comforting to know that the best 5% of animals are growing at their potential, this may be less profitable if it means that the cost of diets are $10 per tonne more expensive. The only valid production target and measure of success on the pig unit should be to maximise profit. This may well be achieved by feeding cheaper diets that may not supply nutrients at a level necessary for maximum lean growth in every pig (Table 1). The pig industry now has the means, through the use of AUSPIG, to make such assessments.

## The use of Simulation Modelling in Practice

Growth modelling enables us to quantify the likely outcome of production variables that interact in complex ways. This enables us to solve 'what if questions that arise in management far easier than we would otherwise be capable of achieving using traditional methods of calculation. AUSPIG has been used in many exercises which evaluate production alternatives without the need for costly and time consuming experiments. Some of these simulations which investigated aspects of nutrition have been reported (Black and Davies, 1991; Bradley, 1992). It is important to communicate these simulations between users of AUSPIG to encourage a wider application of the model. The incorporation of 'industry standard' data sets in the model and production inputs using the PigStats reference book (Ransley and Cleary, 1994) facilitates the simulation of a number of production scenarios providing realistic comparisons between options.

### *Examples of simulated production options in nutrition*

*1. Predicting the effect of nutrition on temperature requirements in the growingpig*

AUSPIG was used to evaluate the growth performance and suitability of the diets fed to young pigs in a typical weaner facility. AUSPIG predicted that the animals required a greater supply of amino acids from the creep and weaner rations currently being fed. New diet specifications were formulated and growth and feed intake was simulated over 35 days for the housing conditions (Table 4). The simulated daily temperature at pig level was set at 22 - 27 °C. Wind speed was estimated at 0.12 m/second and relative humidity as 52%. A radiant heat lamp (200w) was simulated to supply 15w per pig for the first seven days. Stocking density was set at 0.2 $m^2$ per pig.

**Table** 4 Simulated weaner performance of pigs fed the either the current (Control) creep and weaner diets compared with feeding a highly specified weaner ration.

| | Control | Hi-Spec weaner |
|---|---|---|
| Simulated variable | | |
| Weaning weight (kg) | 7.0 | 7.0 |
| Weaning age (days) | 27 | 27 |
| Predicted performance | | |
| Live weight (kg) | 18.3 | 19.3 |
| Daily gain (g/d) | 323 | 350 |
| Feed : gain | 1.70 | 1.62 |
| Pen minimum temperature (°C) | 22 | 22 |
| % time below predicted LCT | 34 | 18 |

AUSPIG predicts the critical temperature range of the growing pig at hourly intervals, considering the animal's live weight and age, nutrition, floor type, stocking level and climatic conditions of ambient temperature, wind speed, humidity and radiant heat supply. The model predicted that at weaning, the lower critical temperature (LCT) at which the pig was in its zone of thermal comfort was 30 °C, considerably above the minimum temperature in the weaner room. As the animal grew and increased its feed intake, the predicted LCT declined. Feeding a diet with adequate amino acids and energy for maximum growth decreased the LCT (shifting the zone of thermal comfort to a lower ambient temperature) so that the weaner spent 50% less time below its zone of thermal comfort, and hence optimal growth environment, than the weaner fed inadequate protein (34% occupation period below LCT). AUSPIG demonstrated that by feeding a diet which supplied adequate nutrients to the young pig, their ability to withstand low shed temperatures increased. Furthermore, by simulating feed costs, the cost-effectiveness of increasing diet specifications was determined for the piggery resulting in a new weaner diet being used.

2. *The implications of using incorrect nutritive values when formulating rations*

The accuracy of AUSPIG in predicting nutrient utilisation in the pig depends on the input of correct nutritive values of ingredients. If inaccurate nutritive values are used the predicted growth performance can not be expected to be precise. A general lack of information on the nutritive value for some ingredients is a problem when attempting to predict the effects of nutrition'on growth. Variation in values between data bases can result from a small and select sample population being used to compose the data base; growing conditions that affect the nutrient value of the sample; and the techniques used in the analysis (van Bameveld *et al.*, 199 1; Mackintosh *et al.*, 1994). In addition, van Bameveld *et al.* have shown that the processing of raw ingredients during feed manufacture can also have a great influence on protein digestibility (van Bameveld *et al.*, 1993). We have used AUSPIG to investigate the implications of using incorrect values for energy and protein in lupins when formulating pig diets on a typical 100 sow piggery using production data from PigStats 1993 (Ransley and Cleary, 1994).

Three levels of crude protein and digestible energy were simulated in a 3 x 3 factorial design. Using the nutrient data base in AUSPIG we formulated nine protein diets and nine energy diets for each of the weaner, grower and finisher stages (Table 5) using narrow-leaf lupins at a fixed price of $180/tonne.

**Table** 5 Minimum nutrient specifications to which all diets were formulated

| | Weaner | Grower | Finisher |
|---|---|---|---|
| Digestible energy (MJ/kg) | 15.0 | 13.8 | 12.9 |
| Available amino acid (g MJ/DE) | | | |
| lysine | 0.70 | 0.58 | 0.46 |
| methionine | 0.20 | 0.17 | 0.14 |
| threonine | 0.45 | 0.36 | 0.30 |

A matrix of possible diet combinations was designed so that we formulated the diet assuming the lupin source contained one of three values of energy (12 MJ DE/kg; 13 MJ DE/kg; 14 MJ DE/kg) or crude protein (28%; 32%; 36%). As an interaction we supplied lupins containing three levels of energy or protein (Table 6). For example, Diet Ac was formulated assuming lupins contained 14 MJ DE/kg, but supplied only 12 MJ DE/kg. Diets that were correctly formulated to the energy / protein supplied are represented by Aa, Bb, Cc.

Formulating diets with lupins supplying 12 MJ DE/kg resulted in a substantial increase to the cost of the weaner (+$32/t) and the finisher (+$8/t) diet compared to the same diet formulated with lupins supplying 14 MJ DE/kg. This was due to the inclusion of tallow to meet the minimum energy requirement (Table 5). There was little change in the cost of the grower diet because wheat was substituted for barley at a similar price to supply the minimum energy require ment. The availability of a wide variety of protein sources reduced the effect of inadequate protein supply on diet cost from using lupins containing low levels of crude protein. The weaner diet formulated with low-protein lupins (28% CP) cost $9/t more due to higher inclusion of fish meal, full-fat soybean meal and threonine. The inclusion of more blood and fish meal forced the cost of the grower diet up by $1 l/t when formulated with lupins supplying 28% protein compared to lupins which supplied higher levels of protein.

However AUSPIG can do much more than simply evaluating the effect of nutrient supply from a variety of ingredients on least-cost diet formulation. By simulating diets with a certain nutrient value as well as the formulated diet costs, we can evaluate the 'true' effect on profitability accounting for the predicted effect on growth and feed intake.

Each diet combination described above was simulated for entire males and females from weaning (26 days; 6 kg) until sale at 168 days of age. Pigs were fed a weaner diet for 41 days, a grower for 49 days and a finisher for 52 days *ad libitum. The* genotype was set to represent average growth rates from birth of 520 g/d (Ransley and Cleary, 1994) with a backfat depth of 13 mm at a live weight of 92 kilograms.

When energy was the variable nutrient, underestimating the level of energy supplied in lupins (ie. the top-right triangle of values) resulted in an increase in net revenue of up to $8 per sow (Table 6a). This was associated with a greater efficiency of feed conversion. Formulating diets which overestimated energy levels in lupins (ie. the bottom-left triangle of values) resulted in a loss of up to $18 per sow. This loss in revenue was caused by a greater feed intake as a consequence of a lower dietary energy.

The effect of using incorrect values of protein on profitability was less pronounced (Table 6b). Underestimating the protein content of lupins resulted in only slight increases in revenue (top-right triangle). There was no difference in daily gain or feed intake between underestimated diets despite differences in the supply of amino acids indicating that the amino acid specification used in formulating the diets (Table 5) were set well above the minimum requirement for maximum lean growth. Overestimating the protein content (bottom-left triangle) resulted in a substantial loss in revenue. An increase in backfat and a lower growth rate suggest that these diets supplied inadequate amino acids for maximum growth.

Our simulated results which predicted the consequence of underestimating or overestimating the protein content of lupins support similar AUSPIG simulations that investigated the effect of overestimating the protein content of wheat (van Bameveld, 1993). Complex comparisons such as these described are very difficult without the use of simulation modelling. Not only does AUSPIG simulate the effect of using incorrect nutrient values on feed cost, it also predicts the consequences of nutrient supply from the same formulated diets on feed intake, daily gain and carcass backfat, predicting a 'true' effect on profitability.

**Table** 6 Predicted change in net revenue ($/sow/yr) from the optimal formulation (*) where (a) digestible energy and (b) crude protein is the variable nutrient value of narrow-leaf lupin ($1 80/t)

(a) Digestible Energy (MJ)

| | | | Actual level supplied A 12MJ | B 13MJ | C 14MJ |
|---|---|---|---|---|---|
| | a | 12MJ | * | +6 | +8 |
| Formulated level | b | 13MJ | -10 | * | +5 |
| | c | 14MJ | -18 | -8 | * |

(b) Crude Protein (%)

| | | | Actual level supplied A 28% | B 32% | C 36% |
|---|---|---|---|---|---|
| | a | 28% | * | 0 | +1 |
| Formulated level | b | 32% | -7 | * | +1 |
| | c | 36% | -45 | -6 | * |

* Formulation combination using correct energy and protein values supplied in lupins

## Future Roles of AUSPIG in Commercial Applications

### *1. Metabolic modifiers and other growth enhancers*

There are an increasing number of metabolic modifiers being developed and becoming available to pig producers (eg. betaine, porcine somatotrophin, enzymes). For those compounds where the mode of action is well documented, then it is conceivable that the effects on pig performance, and hence profitability, could be simulated using models such as AUSPIG. However, in the majority of cases there is insufficient known of their mode of action to incorporate into a simulation model and so the decision about their use will continue to rely on research results or on on-farm trials. Studies evaluating the effects on feed intake and growth using medication programs and growth enhancers, such as feed flavours, may also be simulated on AUSPIG provided there is accurate data on feed intake and growth. The cost-effectiveness of adopting a medication program or using a certain additive can then be evaluated.

### *2. Split-sex feeding and the development of phase-feeding diet specifications*

The nutrient requirement of the pig changes with live weight. We currently accommodate this change in requirement by having separate creep, weaner, grower and fmisher diets which vary in nutrient density and hence cost. However since the requirement of the growing pig changes progressively from birth to sale, it is conceivable that increasing the number of diets fed during this period has the potential to reduce feed costs and nitrogen excretion. The principles of phase feeding are well documented and feeding systems are available that will permit this strategy in commercial piggeries. With the development of simulation models it is now possible to accurately predict the nutrient requirements of pigs at any live weight between weaning and sale for a given genotype. The use of AUSPIG to set diet specifications in a phase-feeding production strategy is currently being investigated at the Research and Development Centre of Bunge Meat Industries.

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