Establishment of nutrient intakes necessary to achieve maximal or near-maximal performance has long been a major topic for nutritional research in pigs. The results of such studies have been incorporated in tables of requirements which constitute the starting point for the formulation of most practical diets. However, the primary concern in feeding pigs is not the maximisation of animal performance but the optimisation of financial returns. For the latter purpose, knowledge of how change in nutrient intake affects performance is crucial, especially in respect of protein and energy which are the main determinants of feed costs. Conventional tables of nutrient requirements are of little help in this regard. Indeed, there is a dearth of experiments involving the wide range of levels of nutrient intake necessary to develop the relevant quantitative relationships between nutrient intake and animal performance.

Ability to predict animal performance from given intakes of protein and energy is clearly of great value in providing an objective basis for making sound management decisions concerning diets and feeding strategies. Current interest in the development of computer models which simulate animal performance has focussed attention on the lack of the requisite data and has stimulated work to remedy this situation. However, this is only one manifestation of a growing awareness of the need to make nutritional information more amenable to economic interpretation which is central to the feeding of commercial stock.

The series of papers here presented reflects this trend and depicts various aspects of the problem of determining optimal levels of dietary protein and energy for pigs at different stages of growth.

**PROTEIN AND ENERGY RELATIONSHIPS IN THE NUTRITION OF THE GROWING PIG**

I.H. WILLIAMS**

For growing lambs, the relationships between intakes of nitrogen (N) and energy and N retention have been established (Black and Griffiths 1975). These provide a basis for discussing the protein and energy nutrition of the growing pig.

**RELATIONSHIP BETWEEN NITROGEN INTAKE AND NITROGEN RETENTION**

When energy intake is constant for lambs of a given live weight, the relationship between nitrogen (N) retained and N intake consists of two linear phases provided the pattern of absorbed amino acids remains constant. In the initial phase, N retention is dependent on the intake of N and is independent of energy intake. The slope of the line is a direct measure of the biological value of the protein used, that is, the proportion of an increment in absorbed N which is retained. Weight and/or age do not appear to affect the biological value, thus the slope of the line describing the N-limiting phase is a constant for a given source of protein. It follows that less N from a protein of high biological value needs to be absorbed to achieve the same retention as that obtained with proteins of lower quality. However, as live weight increases the losses of

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endogenous N become larger and the line is displaced to the right while retaining the same slope (Fig. 1).

In the second phase, N retention is dependent on energy intake and live weight. At any given live weight, increases in N intake do not increase N retention unless additional energy is supplied.

INFLUENCE OF ENERGY INTAKE ON NITROGEN RETENTION

For pigs, there is insufficient information to describe the response of N retention to energy intake at all stages of growth. A number of alternative relationships can be proposed:

(a) a linear relationship between N retention and metabolizable energy (ME) from maintenance to ad libitum intake (Fig. 2a);

(b) a curvilinear relationship in which equal increments of ME from maintenance to ad libitum intake result in decreasing increments of N retained (Fig. 2b);

(c) a rectilinear relationship in which N retention only increases to some fraction of ad libitum intake of ME (Fig. 2c).

EXPERIMENTAL EVIDENCE FOR THE PROPOSED RELATIONSHIPS

Results from a number of studies on the effect of energy intake on N retention in pigs from 4 to 60 kg live weight are summarised in Table 1. In these experiments N intake was judged to be non limiting. The range of energy intakes used in each experiment is shown, together with these levels expressed as percentages of ad libitum intake. Values for ad libitum intakes of ME have been calculated from the empirical equations of Hodge (1974) and Cole et al. (1967). The results show that N retention is linearly related to ME within the range of 25 to 80% of ad libitum intake for pigs weighing 30 kg or less. The limited data for heavier pigs suggests a similar response. In young pigs weighing 4 kg this
TABLE 1 Effect of metabolizable energy (ME) intake on N retention of pigs of different live weights when N intake is not limiting

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Live weight (kg)</th>
<th>Estimated ad libitum intake of ME (kJ/kg(^{0.75})/d)</th>
<th>Range of ME intakes (kJ/kg(^{0.75})/day) (% of ad libitum)</th>
<th>Effect of ME intake on N retention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Williams (1976)</td>
<td>4</td>
<td>2156(\dagger)</td>
<td>1134 - 1890 (44 - 88)</td>
<td>Linear increase</td>
</tr>
<tr>
<td>Campbell# (1979)</td>
<td>4</td>
<td>2156(\dagger)</td>
<td>846 - 2151 (40 - 100)</td>
<td>Linear increase</td>
</tr>
<tr>
<td>Hodge (1974)</td>
<td>10</td>
<td>2376(\dagger)</td>
<td>1899 - 2376 (80 - 100)</td>
<td>None</td>
</tr>
<tr>
<td>Burlacu et al.</td>
<td>14.5</td>
<td>2380(\dagger)</td>
<td>878 - 1924 (37 - 61)</td>
<td>Linear increase</td>
</tr>
<tr>
<td>(1973)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hodge (1974)</td>
<td>25</td>
<td>2267(\dagger)</td>
<td>1863 - 2267 (80 - 100)</td>
<td>None</td>
</tr>
<tr>
<td>Close and Mount</td>
<td>30</td>
<td>2122(\dagger)</td>
<td>455 - 1655 (24 - 78)</td>
<td>Linear increase</td>
</tr>
<tr>
<td>(1976)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuller et al.</td>
<td>30</td>
<td>2122(\dagger)</td>
<td>420 - 1380 (20 - 65)</td>
<td>Linear increase</td>
</tr>
<tr>
<td>(1976)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>1699(\dagger)</td>
<td></td>
<td>420 - 1260 (20 - 75)</td>
<td>Linear increase</td>
</tr>
</tbody>
</table>

\(\dagger\) calculated from Hodge (1974)
\# calculated from Cole et al. (1967)
\# R.G. Campbell (unpublished data)
linear response continues to ad libitum levels of ME intake. For heavier pigs (10 - 25 kg live weight) ME intakes above 80% of ad libitum did not result in additional accretion of protein (Hodge 1974).

Black and Griffiths (1975) found a linear relationship between N retention and ME intake throughout the range of voluntary energy intake for lambs weighing from 3 to 38 kg. However, pigs are capable of consuming more energy than lambs. For example, Hodge (1974) found that between 10 and 50 days of age pigs consumed 55% more ME than lambs of similar weight and age.

The data presented here are limited but they are consistent with the hypothesis that N retention is linearly related to ME intake, but that, except in very young pigs, this relationship may only hold up to approximately 80% of ad libitum intake. However the data are insufficient to allow the pattern of response to be identified with confidence and more information is needed particularly at high energy intakes.

**SOME ECONOMIC CONSEQUENCES OF DIETARY PROTEIN/ENERGY RELATIONSHIPS IN THE FORMULATION OF DIETS FOR GROWING PIGS**

J.R. CARR*  

The previous paper illustrated the need to determine the form of the relationship between energy intake and N retention, as an initial step in the quantitative description of the pig’s growth and body composition response to protein and energy intake. This paper briefly outlines how such responses may be used to formulate diets to maximise profits.

**DERIVATION OF THE FUNCTIONS**

An experiment was conducted at Massey University (N.Z.) and the Ruakura Agricultural Research Centre (N.Z.) to estimate the production responses of pigs to variations in their daily digestible energy (DE) and protein intakes. The dietary treatments were arranged as a 4 x 4 factorial, the factors being average daily DE allowance (57, 68, 79 or 90% of voluntary intake) and average daily protein intake. The latter was formulated to contain the following proportions of amino acids relative to lysine at 100: methionine 28; methionine plus cystine 60; threonine 65; isoleucine 64; tryptophan 10. Protein intake was varied to provide daily lysine intakes ranging from 4 to 15 g at 20 kg and from 9 to 40 g at 100 kg live weight. The dietary treatments extended between 20 and 100 kg live weight, and involved 546 pigs, comprising equal numbers of entire males, castrated males and females, which were serially killed and the carcasses dissected at 20, 40, 80 and 100 kg live weight.

The first stage of data analysis involved fitting quadratic equations by least square regression to describe the within-sex relationships between various production characteristics (Y) and average daily lysine (X1) and DE (X2) intakes. A sample of these equations is presented in Table 2.

**USE OF THE FUNCTIONS FOR RATION FORMULATION**

The usefulness of the predictive equations in ration formulation was studied during a nine month period, beginning July 1979, under commercial conditions at Mayfair Farms, Bendigo, Victoria.

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Animal production in Australia

TABLE 2 The coefficients of equations for some characteristics ($Y$) of pigs growing from 20 to 80 kg live weight (average live weight $= 50$ kg), with average daily lysine ($X_1$) and DE intakes ($X_2$) as the independent variables ($X_1 = g; X_2 = MJ$)

<table>
<thead>
<tr>
<th>$Y$</th>
<th>Sex$^a$</th>
<th>$a$</th>
<th>$b_{X_1}$</th>
<th>$b_{X_2}$</th>
<th>$b_{X_1}^2$</th>
<th>$b_{X_2}^2$</th>
<th>$b_{X_1}X_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG (g/d)$^b$</td>
<td>G</td>
<td>-63.841</td>
<td>-1.8168</td>
<td>28.3850</td>
<td>-1.5745</td>
<td>-0.8192</td>
<td>2.4355</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>-410.961</td>
<td>-7.4791</td>
<td>63.5140</td>
<td>-1.0981</td>
<td>-1.3988</td>
<td>1.9033</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>-230.911</td>
<td>2.1492</td>
<td>45.0670</td>
<td>-1.9773</td>
<td>-1.4586</td>
<td>3.0405</td>
</tr>
<tr>
<td>K.O. (%)$^c$</td>
<td>G</td>
<td>62.134</td>
<td>-0.4392</td>
<td>1.6276</td>
<td>-0.0248</td>
<td>-0.0469</td>
<td>0.0456</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>50.656</td>
<td>-0.7662</td>
<td>2.7806</td>
<td>-0.0172</td>
<td>-0.0698</td>
<td>0.0466</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>53.544</td>
<td>-0.2969</td>
<td>2.2297</td>
<td>-0.0047</td>
<td>-0.0499</td>
<td>0.0128</td>
</tr>
<tr>
<td>C (mm)$^d$</td>
<td>G</td>
<td>1.424</td>
<td>-0.8282</td>
<td>1.5211</td>
<td>0.0432</td>
<td>0.0022</td>
<td>-0.0444</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>23.455</td>
<td>-0.9394</td>
<td>3.8152</td>
<td>0.0476</td>
<td>-0.0498</td>
<td>-0.0453</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>9.667</td>
<td>-1.0906</td>
<td>2.5606</td>
<td>0.0371</td>
<td>-0.0309</td>
<td>-0.0276</td>
</tr>
</tbody>
</table>

$^a$: G = gilt; B = barrow; E = entire male

$^b$: Average daily gain

$^c$: Killing out (dressing percentage)

$^d$: Fat depth taken 4 cm off mid-line at last rib on the warm carcass

The functions for growth rate, dressing percentage and carcass fatness were combined to construct a model to predict the intake and dietary concentration of protein (P opt.) to maximise profits (margin over feed cost/pig place/day) under conditions of ad libitum feeding. Apart from the daily intake of DE (derived from whole-of-farm records) the model also included functions relating dietary costs to protein and energy content, the prices received for pigs of different fat content, and the inventory value for a 20 kg pig. Capital investment was included as a constant. P. opt. was calculated monthly over the nine month period, and the study showed that for the Mayfair Farms operations:

(i) P opt. was 9 to 15% below the levels required to promote maximum rate and efficiency of gain, and resulted in an improvement of up to 5% in the margin over feed cost.

(ii) P opt. was found to vary from time to time, by up to 7%, with changes in such factors as the price of ingredients, the time of year and voluntary food intake. The use of a system which included changing values of P opt., as opposed to the use of a static value, increased margins over feed costs by up to 3%.

Bearing in mind the interim nature of these data it is concluded that functions describing the relationships between dietary energy and protein on the growth performance of the pig may have a valuable role in the formulation of diets designed to maximise profits.
EFFECT OF NUTRITION IN EARLY LIFE ON SUBSEQUENT GROWTH AND BODY COMPOSITION

R.G. CAMPBELL* AND A.C. DUNKIN*

There is some evidence that the rate and composition of weight gains in pigs during the grower and finisher stages are influenced by the animals' earlier nutrition. For example, pigs fed protein-deficient diets from 5 to 20 - 23 kg live weight and conventional diets thereafter grew faster and more efficiently during the latter stage than those fed protein-adequate diets prior to 20 - 23 kg (Zimmerman and Khajaern 1973; Campbell and Biden 1978). Similar compensatory responses have been reported following restriction of feed intake between 5 and 20 kg (Elsley 1963; Nielsen 1964).

However the factors which influence such compensatory responses and the magnitude of the latter are ill-defined. In particular, there is little information on the effect of protein/energy restriction during the first 3 - 4 weeks after birth when the animals weigh less than 5 kg. In this paper some results from our recent study of this question are presented and their significance in relation to feeding strategies is discussed.

EXPERIMENTAL METHODS

Pigs were weaned 24 - 36 hours after birth and were reared, in individual cages, on liquid diets containing varying proportions of ultra-filtered skim-milk powder, dextrose and butterfat/soybean oil. The initial treatments, which were designed to produce marked differences in growth rate and body composition, were imposed from 1.8 to 6.5, 10, 15 or 20 kg. Cereal-based dry diets replaced liquid diets from 10 - 11.5 kg in those experiments which were continued to heavier weights.

Representative animals were slaughtered at the beginning of experiments and at the end of each phase of the dietary treatments. The effect of various treatments were assessed in terms of rate and efficiency of weight gains and chemical composition of the empty body. The weight and DNA content of the M. adductor were also measured.

EFFECT OF FOOD RESTRICTION DURING EARLY DEVELOPMENT

A feature of the nutrition of naturally suckled piglets is the wide variation in individual feed intake during the first few weeks of life when practically all nourishment is derived from the sow. The results of two experiments illustrate the effect of differences in feed intake at this early stage on subsequent growth rate, nutrient utilisation and body composition.

In the first experiment, which was designed to examine carry-over effects in the phase immediately subsequent to the termination of initial treatments, the same protein-adequate diet containing 33% protein calories was fed at either twice (2 M) or five times (5 M) maintenance from 1.8 to 6.5 kg. Both groups were fed at the same level (4 M) from 6.5 to 11.5 kg. As expected, generous feeding during the initial phase resulted in much faster growth than restricted feeding. However, from 6.5 to 11.5 kg, animals previously restricted in food intake grew significantly (P<0.01) faster and more efficiently than those that had been fed generously throughout (Table 3).
The second experiment concerned the longer term effects of feed restriction in early life on growth rate and body composition at light bacon weight (75 kg). Pigs were fed either 2.8 M or 5.2 M from 1.8 to 20 kg; and at the same level (approximately 4 M) from 20 to 75 kg. Whereas feed restriction resulted in 33% slower growth prior to 20 kg, average daily gain from 20 to 75 kg was 13% greater (820 g vs 725 g) for animals previously restricted compared with that of pigs fed generously at both stages.

Overall, feed restriction to 20 kg increased the total time to reach 75 kg by 9%, but reduced the total feed required by 8% and the proportion of lipid in the carcass by 10.7%.

Comparison of changes in body composition between treatment groups showed that the magnitude of induced differences gradually declined as weight increased. The data also suggested that compensatory growth following removal of feed restriction was associated with enhanced retention of nitrogen and water. Muscle DNA content was unaffected by feed restriction in early life.

EFFECTS OF PROTEIN RESTRICTION IN EARLY LIFE

The effect of protein deprivation in early life on subsequent growth and development is of interest in two respects. (1) During the first few weeks of lactation sow's milk contains a substantially lower protein-energy ratio than that which has been shown to be optimal for maximum nitrogen retention and growth (Hencken et al. 1963); this unbalanced diet leads to a rapid increase in carcass fat content. Does an increase in protein intake at this stage improve subsequent performance and result in a leaner carcass at normal slaughter weights? (2) Conversely, can low protein, and therefore cheaper, early weaning diets be employed without detriment to age at slaughter or carcass leanness?

The results of two experiments indicated that, in contrast to the effect of feed restriction, feeding a low protein diet during early growth (1.8 to 6.5 or 15 kg) reduced muscle DNA content, the effect diminishing as weight increased. The extent of compensatory growth response following protein deprivation in the initial phase depended on the subsequent protein level. When a diet of moderate protein content (15%) was fed, pigs previously fed a low protein diet grew significantly faster to 45 kg than those fed initially a protein-adequate diet. However, when a high protein diet (22%) was fed during the later phase, animals...
previously receiving insufficient protein did not grow as fast as those which had received protein-adequate diets at both stages (Fig. 2). This suggested that potential for lean tissue growth had been impaired by protein insufficiency during the growth phase 1.8 to 6.5 kg. In support of this conclusion, animals at 45 kg fed a low protein diet prior to 6.5 kg contained more fat than those receiving a protein-adequate diet initially even though both groups received the same high protein diet thereafter. This difference, however, was no longer detectable by 75 kg.

PRACTICAL IMPLICATIONS

Confusion exists in the literature as to the extent of compensatory growth in the pig. This is due to differences between studies in such factors as the stage of growth during which restriction occurs, the magnitude of the difference between the imposed treatments, nutritional status during the subsequent period, and length of period over which the carry-over effects are assessed.

Our results indicate that the young pig subjected to feed restriction or fed a low protein diet has some ability to "catch up" in growth following improvement of its nutrition but, at least when ad libitum feeding is not permitted during the subsequent phase, compensation is usually not complete by 75 kg. The results also show that while an animal's body composition is influenced more by its nutrition in the more recent past, the effects of restricted protein and feed intake during early life are discernible at least to 45 and 75 kg respectively. In practice, feed restriction in early life is likely to have some beneficial effects on carcass quality, especially at light slaughter weights, and reduce the total amount of feed required, but may substantially increase age at slaughter. The use of low protein diets for young pigs is unlikely to enhance overall profitability unless high quality protein supplements are excessively costly.
AN EVALUATION OF DIFFERENT SCALES OF FEEDING FOR GROWER-FINISHER PIGS

L.R. GILES*

Recent test marketing programmes in Australia (Field 1977) have drawn attention to the production of fresh and cured pork products from a 65 kg carcass (or 'superporker') which has a backfat thickness of 14 – 18 mm measured at P2 (65 mm from the midline adjacent to the head of the last rib) (Pigmeat Promotion Advisory Committee (PPAC), 1979). The introduction of the superporker concept in Australia, the steady increase in slaughter weights, the marketing of entire males and the increased sales on weight and grade based on backfat thickness at P2, has focussed attention on the feed levels required to meet superporker carcass specifications.

The Agricultural Research Council's (ARC) (1967) recommendations of daily digestible energy (DE) intake are commonly used as the basis of feeding levels up to 90 kg live weight. While British workers (Davies and Lucas 1972) have pointed out that in practice feed levels need to be restricted below ARC (1967) recommendations to produce desirable carcasses, there is a lack of experimental data which relates daily DE intake to the commercial characteristics of average daily rate of liveweight gain and P2 backfat thickness. Accordingly an experiment was designed at Wollongbar to measure the influence of varying daily DE intake on growth rate and P2 backfat thickness with entire males and females slaughtered at various live weights.

EXPERIMENTAL

Ninety-six individually housed Large White pigs (48 entire male and 48 female) began the experiment at 25 kg live weight and were slaughtered at one of six live weights (45, 60, 75, 90, 105, 120 kg). All pigs were fed a wheat-soya bean diet (19.9% crude protein, 0.92% lysine and 14.0 MJ DE/kg) offered at one of four feed levels as defined below:

(i) ad libitum;
(ii) ARC (1967) recommended daily DE intake (C),
(iii) ARC (1967) daily DE intake minus 12.5% (C - 12.5%),
(iv) ARC (1967) daily DE intake minus 25% (C - 25%).

The measurements taken included:

(i) live weight (LW) measured one hour before slaughter after fasting for 18 to 20 hours;
(ii) average daily liveweight gain (DG) measured from 25 kg live weight until slaughter;
(iii) backfat thickness (P2) measured on the hanging, whole carcass using a Danish optical introscope within one hour of slaughter;
(iv) average daily DE intake (DE) measured from 25 kg live weight until slaughter; and
(v) feed conversion ratio (FCR), kg-feed consumed per kg liveweight gain.

The mean weekly minimum and maximum air temperatures, measured within the experimental building near floor level, ranged from 19.1 to 29.7°C and 23.3 to 30.8°C respectively.

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2480

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RESULTS

The DE achieved for each feed level with increase in live weight is shown in Table 4. The mean FCR for all 'ad lib' fed pigs was 2.8 compared to 2.6 for all pigs fed the 'C' feed level. There was no significant difference in FCR between the three restricted-fed treatment groups.

<table>
<thead>
<tr>
<th>Live weight (kg)</th>
<th>Feed level offered</th>
<th>Ad lib</th>
<th>C</th>
<th>C - 12.5%</th>
<th>C - 25%</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>24.5</td>
<td>18.9</td>
<td>16.9</td>
<td>14.2</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>30.1</td>
<td>21.6</td>
<td>18.7</td>
<td>16.5</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>28.3</td>
<td>24.8</td>
<td>21.7</td>
<td>18.5</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>31.0</td>
<td>26.2</td>
<td>23.9</td>
<td>20.6</td>
<td></td>
</tr>
<tr>
<td>105</td>
<td>29.5</td>
<td>27.7</td>
<td>25.5</td>
<td>22.3</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>27.0</td>
<td>29.7</td>
<td>27.0</td>
<td>24.4</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 4 Average digestible energy intakes (MJ/d) for each feed level with increase in live weight (from 25 kg)

Equations (1) and (2) indicate that a DE of 21.5 MJ/d was associated with an average P2 measurement of 18 mm and a DG of 577 g from 25 kg to 90 kg live weight.

Referring to Table 4 equation (2) indicates that it was possible to meet the PPAC (1979) superporker carcass specifications at 90 kg live weight with the 'C - 25%' feed scale.

Most of the variation not explained by the regression equations was attributable to the more variable performance of pigs slaughtered at 105 and 120 kg live weight. The inclusion of sex as a variable in the equations did not improve significantly their predictive value. However, compared with females, entire males showed an increase in DG of 64 g, an improvement in FCR of 0.2 and a reduction in P2 measurement of 1.6 mm.

DISCUSSION

In this study the C feed scale proved too high to achieve the trade specifications proposed by the PPAC (1979) of 14 to 18 mm P2 for a 65 kg carcass. These specifications were met, however, where DE was reduced by 25%, without deterioration in FCR.

The fact that the P2 measurements of pigs fed according to the C or C - 12.5% scales exceeded the specified limits may have been due to inferior genotype, or alternatively, to the effect of high environmental temperatures which have been reported to increase backfat thickness (Holmes 1971). The former possibility is
considered unlikely as the experimental animals came from a herd which uses only sires which have been selected for high growth rate and low backfat thickness. On the other hand, the high temperatures recorded during the experiment could have been a contributory factor.

In planning this experiment it was considered appropriate to use DE as a basis for predicting DG and P2 because relativity between feed scales remained constant throughout. However, it is recognised that in practice a variety of feed scales, which differ in their relative intensity of feeding at different stages of growth, may be employed. There is need therefore for further experiments to examine these effects on DG and P2.

The results of this experiment indicate that, at least under hot climatic conditions, restriction of DE intake to 25% less than that recommended by the ARC (1967) is one possible means of achieving the backfat specifications proposed for superporker carcasses. They also provide evidence of the superior growth performance and leaner carcass of entire males compared with females.

PROTEIN AND ENERGY INTAKES OF FINISHER PIGS IN RELATION TO FINANCIAL RETURNS

N.W. GODFREY*

Decreasing the level of digestible energy (DE) intake by the growing pig decreases carcass fat content while increasing crude protein (CP) intake increases carcass lean. Therefore variations in carcass composition may be achieved by manipulating both level of feed intake and dietary CP concentration.

However, restricting energy intake will also reduce growth rate and although an increase in CP intake improves carcass quality and growth rate, it is associated with higher feed costs. The effect of these changes on feed conversion ratio (FCR) depends on the level of intake at which the change is made.

The pig producer cannot afford to be concerned with carcass quality in isolation from growth rate and FCR since all three criteria influence the profitability of his enterprise. In addition to feed cost and carcass value, the optimum strategy will also depend on the value of growth rate, method of marketing and grading schedule. The results of the following experiment illustrate these various points.

EXPERIMENTAL

Seventy-two gilts and 72 castrates, which had been fed ad libitum to 40 kg live weight, were divided into groups of six and randomly allotted to four dietary treatments in a 2 x 2 factorial experiment in which the factors were high or low levels of DE intake (HE or LE) in conjunction with high or low levels of CP intake (HP or LP). The HP-LP treatment consisted of a 16% CP diet, based on meat meal, wheat and barley, fed to a scale which increased from 1.75 kg per pig daily at 40-50 kg live weight to 2.20 kg at 80-90 kg liveweight. The LE treatments reduced DE intake by 20% while the HP treatments increased CP intake by 20%. No attempt was made to equalise protein quality between treatments.

The requisite intakes of DE and CP on the four treatments were achieved by adjusting both feeding scale and CP concentration. The four diets contained 16.0,

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Animal production in Australia


There were no significant treatment interactions indicating that CP and DE acted independently in respect of the criteria examined.

TABLE 5 Effects of level of digestible energy and crude protein on the performance of finisher pigs (40 - 85 kg live weight)

<table>
<thead>
<tr>
<th>Dietary intake</th>
<th>Daily gain (g/d)</th>
<th>Feed conversion ratio</th>
<th>Carcass backfat (mm)</th>
<th>Eye muscle area (cm²)</th>
<th>Lean in ham (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Low</td>
<td>575</td>
<td>3.43</td>
<td>21.1</td>
<td>23.0</td>
<td>603</td>
</tr>
<tr>
<td>Low Low</td>
<td>471</td>
<td>3.45</td>
<td>18.4</td>
<td>25.5</td>
<td>639</td>
</tr>
<tr>
<td>High High</td>
<td>614</td>
<td>3.32</td>
<td>20.7</td>
<td>24.3</td>
<td>622</td>
</tr>
<tr>
<td>Low High</td>
<td>496</td>
<td>3.39</td>
<td>18.1</td>
<td>26.7</td>
<td>658</td>
</tr>
<tr>
<td>SEM</td>
<td>9</td>
<td>0.06</td>
<td>0.3</td>
<td>0.4</td>
<td>5</td>
</tr>
</tbody>
</table>

Significance DE *** NS *** NS *** NS

Significance CP NS NS NS NS

Significance DE x CP NS NS NS NS

NS, not significant (P>0.05), ** (P<0.01), *** (P<0.001).

Reducing DE intake depressed growth rate by 10%, had no significant effect on FCR, decreased backfat by 2.7 mm, and increased eye muscle area and lean content of the ham by 10.3 and 6.7% respectively (Table 5). The higher level of CP intake increased growth rate by 6%, had no significant effect on FCR or carcass backfat, and increased eye muscle area and lean content of the ham by 5.3% and 3.9% respectively. A significant proportion of high quality carcasses was achieved with the two LE treatments.

FINANCIAL CONSIDERATIONS

To assess the economic results, meat meal, barley and wheat were valued at $300, $80 and $115 per tonne respectively. The total feed cost to produce a 40 kg grower was estimated at $24 which was added to the cost of feed consumed during the experiment. The mean carcass value was determined from the calculated returns for individual carcasses graded according to two alternative commercial dead weight schedules, one of which (A) was more tolerant of fat cover than the other (B). For example, if the price was $1.28/kg for a carcass weighing 65 kg, a fat cover (P2) of between 18 and 22 mm was specified by Schedule A whereas Schedule B required a fat cover of 16 - 20 mm.

For the producer concerned primarily with producing baconer pigs at low feed cost, the HE-LP feeding regime might appear the most attractive although it produced the poorest carcasses. However, for producers selling on a grade and dead weight basis the greatest gross margin over feed cost was achieved by the LE-LP treatment on both price schedules. Differences between the schedules did not affect this result because although increasing CP intake increased carcass lean its effect on carcass backfat, on which the grading schedules were based, was not significant.

Additional to considerations of the carcass grades achieved and feed costs the intensive pig producer, with heavy capital investment in housing is also
TABLE 6  Effects of level of digestible energy and crude protein intake from 40 to 85 kg live weight on overall feed costs and returns

<table>
<thead>
<tr>
<th>Treatment</th>
<th>HE-LP</th>
<th>LE-LP</th>
<th>HE-HP</th>
<th>LE-HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total feed cost† ($)</td>
<td>44.47</td>
<td>47.04</td>
<td>45.66</td>
<td>49.19</td>
</tr>
<tr>
<td>Carcass value A($)</td>
<td>81.18</td>
<td>84.79</td>
<td>82.04</td>
<td>84.43</td>
</tr>
<tr>
<td>B($)</td>
<td>76.38</td>
<td>82.26</td>
<td>76.56</td>
<td>82.23</td>
</tr>
<tr>
<td>Gross margin over feed cost A($)</td>
<td>36.71</td>
<td>37.75</td>
<td>36.38</td>
<td>35.24</td>
</tr>
<tr>
<td>B($)</td>
<td>31.91</td>
<td>35.22</td>
<td>30.90</td>
<td>33.04</td>
</tr>
<tr>
<td>Gross margin per pig place per year +</td>
<td>70.52</td>
<td>66.89</td>
<td>71.78</td>
<td>63.68</td>
</tr>
<tr>
<td>A($)</td>
<td>61.30</td>
<td>62.40</td>
<td>60.96</td>
<td>59.70</td>
</tr>
</tbody>
</table>

† Including an allowance of $24 for feed used prior to 40 kg live weight.

Concerned with growth rate, the value of which, for comparative purposes can be expressed as gross margin per pig place per year, i.e.

\[
\text{(gross margin over feed cost x 365)} \div \text{(age at baconer weight in days)}
\]

In this case, the most profitable feeding regime depended on the grading schedule in that the highest gross margin per pig place per year was achieved with the HE-HP treatment for Schedule A and with the LE-LP treatment for Schedule B.

The results indicate that, although CP and DE intakes may be independently manipulated to produce various biological results in the growing pig, the most profitable strategy depends on method of selling, grading schedule and the value of growth rate.

CONCLUSIONS

A.C. DUNKIN

There is still uncertainty as to whether protein deposition continues to increase linearly as energy intake is increased to high levels; and whether the shape of the response curve alters at heavier weights. Information on these points obviously has important implications in relation to commercial feeding practices. It is essential to the development of a model that is capable of accurate prediction of the rate and composition of weight gains over the full range of growth up to heavy bacon weight under differing nutritional regimens. As relevant data become available the model can be further refined to take account of additional variables such as environmental temperature and the different potential rates of lean tissue growth of entire males, females and castrates.

Knowledge of the extent to which nutrition during one stage of growth influences subsequent performance and body composition is an important adjunct to the development of growth models. The results presented demonstrate that protein and energy nutrition in early post natal life can affect later performance; and that their respective effects differ. It is evident that in predicting growth and body composition account needs to be taken of earlier nutrition. Although the young, undernourished animal strives to return to the normal path of development when its nutrition is improved the scope for turning this to economic advantage is probably limited.
The last two papers provide examples of alternative feeding strategies which the producer may adopt in response to differing market situations. In the first case it is demonstrated that if the primary concern is to meet rigorous grading objectives this can be achieved by relatively severe feed restriction. However, the results of the second paper indicate that such a policy does not necessarily result in maximum profit and that producers need to review their feeding policies in the light of changes in market and production variables. This is a task of increasing complexity for which both better input/output information and improved methods of utilising it for economic purposes are needed in order to assist the producer in making rapid and cost-effective decisions.

As an example of the potential value of developments along these lines the adaption of growth response functions to allow formulation of "most profitable" commercial diets is presented. This approach, while still tentative and capable of considerable further refinement, is a notable advance on the formulation of diets on a "least cost" basis and foreshadows major developments in the use of nutritional information for management purposes.

Five years ago Whittemore and Elseley (1975) observed that 'it is possible that the science of animal nutrition will, over the next few years, move from an era of patient exploratory experimentation into one of simulation, model building and computerisation". While this may represent a somewhat exaggerated view there can be little doubt that in the near future what might be termed "economic nutrition" will assume a far more important role in pig production and in research orientation than it has been accorded in the past.

REFERENCES


PIGMEAT PROMOTION ADVISORY COMMITTEE (1979). "Superporker Cutting Instructions". (Sydney South, N.S.W.), Mimeograph.

