Feed efficiency in growing pigs – what's possible?

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Summary

Improving the efficiency with which growing pigs utilise feed is a high priority for the pork industry because the cost of feed is by far the major component contributing to the cost of production. There are relatively few accurate estimates of feed conversion ratios in commercial piggeries, but results from experiments conducted over the past 30 years have shown that there has been a substantial improvement in feed efficiency. In particular, recent research conducted by the Department of Agriculture and Food in Western Australia to determine the lysine requirements of grower and finisher pigs has recorded levels of efficiency not previously reported in Australia. In this paper, some of the factors that may have contributed to this improvement are discussed.

Introduction

High feed prices are fast becoming the norm, and pork producers cannot assume that the price for their product will rise accordingly. As the cost of feed is by far the greatest input cost in pork production (65–75%), anything that can be done to improve the efficiency with which feed is used will have a positive impact on profitability. The Pork Co-operative Research Centre (CRC) has for the past 6 years focussed on improving the international competitiveness of the Australian industry, and as such has supported several research projects aimed at improving the feed efficiency of the growing pig or the whole herd. This paper reports some of the results of research supported in part by the Pork CRC in which feed to gain ratio has been measured, and then speculates on possible reasons why we have observed improvements in feed conversion far greater than that thought to be the case in industry.

What is feed efficiency at present?

There are very few accurate records of feed efficiency, otherwise referred to as feed to gain ratio or feed conversion ratio (FCR), on commercial farms. The best estimate available is from the Pork CRC benchmarking project, which was undertaken with a relatively small number of farms between 2008 and 2010 and indicates that FCR from weaning to sale is 2.45. It may seem surprising that every producer does not have accurate records for FCR, given its importance and its simplicity of calculation (total amount of feed consumed divided by the total increase in weight). Before the introduction of all-in, all-out production systems it was difficult to track the performance of a discrete batch of pigs because pigs were continually being added to or removed from groups. In theory, it would have been possible to track a pen (or 'focus' pens) of pigs, but this would have involved measuring the feed allocated to that particular pen, which is labour intensive. Furthermore, how representative that particular pen (or group of pens) was of the rest of the pigs could also be questioned.

Even when the industry changed to all-in all-out production systems, it was still more difficult than many thought to measure FCR. For example, although the name suggests that all pigs are sold at the same time, in reality they are sold over a 2 to 4 week period to take into account the range in live weight at the end of the growing period, unlike the poultry industry. Therefore, pigs for sale are mixed with pigs from other units to fill transport vehicles, making it more difficult or in some cases impossible to measure slaughter weight for a particular group. Although most producers have systems for weighing pigs as either individuals or groups, it is still a labour intensive activity and other tasks are often given a higher priority. Measurement of feed consumption is also difficult, often relying on the scales on feed delivery trucks as the only measure of total feed delivered. Another important consideration is the potential variation in energy content of diets between different production systems, thus adding error to a comparison of FCR on a per kg basis.

The most accurate measures of FCR are derived from research, in which accurate measurement of feed intake and weight gain is critical. The extent of improvement in FCR can be estimated by comparing the results of recent research with those of similar research conducted 10 to 20 years ago.

Results from recent research

The formulation of diets for growing pigs relies on accurate knowledge of the energy and amino acid requirements of a particular genotype. With regard to amino acids, most attention is focussed on the requirement for lysine because this is referred to as the first limiting amino acid. As it has been some time since the lysine requirements of grower and finisher pigs has been determined, two experiments were conducted by Moore and Mullan (2010) at the Department of Agriculture and Food of Western Australia's (DAFWA) Medina Research Centre. This research involved sourcing weaner pigs from high-health status commercial herds and rearing them in groups in straw-based shelters until they reached the target starting live weight. The genotype chosen was from the Pig Improvement Company because it accounts for a significant proportion of the pigs currently grown in Australia. Two experiments were conducted to measure the responses of entire male and female pigs, reared in groups of seven, during the grower (20–50 kg live weight) and finisher (50–100 kg live weight) phases. Entire males and females were chosen because they represent the biggest difference in nutrient requirements, whereas it is acknowledged that from an eating quality perspective, entire males should be either physically castrated or immunocastrated.

In the first experiment, pigs were fed diets ranging from 0.6 to 1.0 g available lysine per MJ DE over a live weight range of 22–53 kg. There was no significant effect of treatment on feed intake (1.45 kg/d for males and 1.62 kg/d for females), but there was a significant effect on growth rate and hence feed to gain ratio (Figure 1). The response in feed to gain ratio indicates that the requirement for females, corresponding to the point of inflexion at which feed to gain ratio is a minimum, is 0.75 g available lysine per MJ DE, whereas that for entire males is at least 0.80 g available lysine per MJ DE. The difference in requirement for lysine between the two sexes is primarily due to the greater potential of entire males for protein deposition.

The difference in FCR between entire males and females is of similar magnitude to that reported by O'Connell et al. (2005) from research conducted in Ireland (pooled values of 1.80 vs 1.86 for entire males and females, respectively, from 20 to 40 kg). In that experiment, the optimum FCR of 1.72 was for 0.77 g available lysine per MJ DE, similar to the value for females in the experiment of Moore and Mullan (2010). In research conducted in the USA, Main et al. (2008) also reported a similar requirement for females (0.79 g available lysine per MJ DE) between 35 and 60 kg but with a higher FCR (2.10) than in either of the other two studies. The results of our research indicate that many commercial diets may not be formulated to meet the requirements of current genotypes, and the extremely low values for feed to gain ratio recorded are particularly noteworthy.

In the second experiment with pigs from 50 to 103 kg live weight, differences in feed to gain ratio between entire males and females were similar to those observed in the grower phase, and the optimum requirement for entire males was also higher than that for females (0.75 vs 0.65 g available lysine per MJ DE, respectively; Figure 2). The absolute values for feed to gain ratio were extremely good and the results from both experiments indicated that from this perspective, Australian genetics are capable of achieving results that compare favourably with other genotypes worldwide (R. Campbell pers. comm.). O'Connell et al. (2006) reported a similar difference in FCR between entire males and females, and although their data are difficult to interpret because their performance results were pooled for the two sexes versus treatment, the FCR values for the experiment conducted in Australia were approximately 0.2 points lower than their values. The calculated requirement of 0.67 g available lysine per MJ DE from the Irish experiment for pigs between 60 and 90 kg is similar to that for females in the Australian experiment.

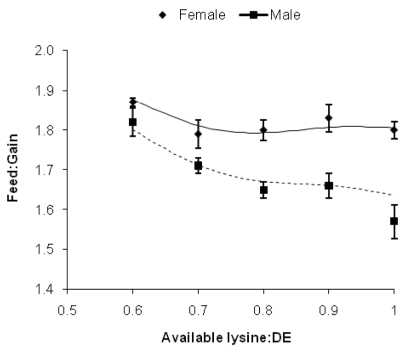

Figure 1. Effect of available lysine (g available lysine per MJ DE) on feed to gain ratio for females and entire males (± SEM) from 22 to 53 kg live weight (Moore et al., 2010).

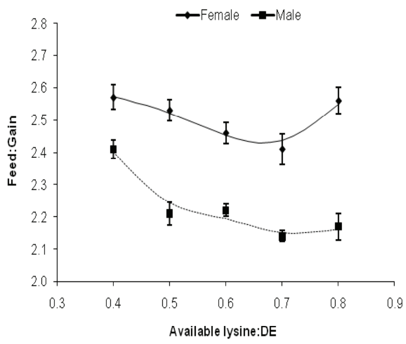

Figure 2. Effect of available lysine (g available lysine per MJ DE) on feed to gain ratio for females and entire males (± SEM) from 50 to 103 kg live weight (Moore et al., 2010).

How do the values for feed to gain ratio compare?

There are many factors that can have an effect on feed efficiency, and it is difficult to accurately compare the results of one experiment with those of another when they were conducted 10 or more years apart, often with different genotypes and in different facilities. In the mid-1980s Campbell et al. (1988) conducted experiments similar to that of Moore and Mullan (2010) to determine the lysine requirements of male and female pigs. The results for finisher pigs (50–90 kg live weight) are shown in comparison to the results of Moore and Mullan (2010) in Figure 3. A substantial improvement in feed to gain ratio has taken place over this time: average values decreased by about 0.5 (from 2.70 to 2.20 for males and from 2.90 to 2.40 for females). Growth rates in the experiments conducted in the 1980s were between 700 and 800 g/day, compared with 1100 g/day in the more recent experiments. Although we suspect that much of this difference is due to improvements in genotype, the experiments were also conducted under quite different environments and conditions, and hence it is impossible to proportion the degree of improvement in feed efficiency to particular variables.

Two experiments conducted approximately 10 years previous to the experiments of Moore and Mullan (2010), in the same facility and also with pigs sourced from commercial herds that used breeding stock from the Pig Improvement Company, provide a better means of assessing how performance has changed over time. In one experiment conducted from 25 to 106 kg live weight, an FCR of 2.67 was recorded for entire male pigs (Mullan et al., 1999), and in a second experiment that included female pigs and a similar weight range (22 to 103 kg live weight), the FCR was 2.99 (Mullan et al., 2000). Whereas the difference between females and entire males is of similar magnitude to that shown in Figure 2 for finisher pigs, the 30% improvement in FCR over a relatively short period of time is quite outstanding. Some of this improvement can be attributed to genetic improvement, but a number of other changes were made over that period, which could also have contributed to the improvement in FCR. It is worthwhile discussing each of these changes and, more importantly, speculating as to how they may have had a positive impact on feed efficiency.

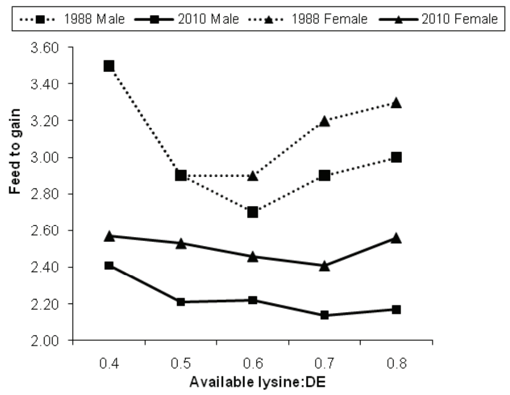

Figure 3. Feed to gain ratio in response to dietary lysine concentration for entire male and female pigs in experiments conducted approximately 30 years apart (Campbell et al., 1988; Moore et al., 2010).

What has contributed to the improvement in FCR?

1. Genotype

Some of the improvement in FCR can be attributed to genetic selection for growth rate and depth of back fat as well as for FCR. Regarding entire males, in the early experiment (Mullan et al., 1999), pigs had an average daily gain from 25 to 106 kg live weight of 863 g/d, whereas between 48 and 104 kg live weight in the more recent experiment, growth rates of 1070 g/d were recorded (Moore and Mullan, 2010). At the same time, there was a reduction in the depth of back fat (P2) of approximately 2 mm, indicating the improvement in lean meat deposition that has occurred over time.

2. Health status

It is well known that health status can affect the partition of nutrients and in particular, the proportion of nutrients used for maintenance. The Medina Research facility is operated on an all-in all-out basis, often with a break of several weeks between batches of pigs together with a thorough cleaning protocol. Even so, a combination of events led to an outbreak of porcine dermatitis and nephropathy syndrome (PDNS) in 2009, which necessitated an even more thorough cleaning and disinfection protocol. Although impossible to measure, this would have meant that the hygiene level of the facility was as good as possible. Since there were no pigs on the same site for a period of approximately one month, this would also have helped achieve a standard of cleanliness that many other research groups, and particularly commercial herds, could never achieve unless they were building new facilities on a green field site. In addition, all recent pigs have been vaccinated against circovirus, which may have had a sub-clinical impact on pig performance in previous years.

Another factor that affects FCR, but which is often overlooked, is mortality rate. Payne (unpublished) calculated that reducing the mortality rate in a grower-finisher herd from 4% to 2% could reduce feed usage by 1%, on the assumption that, on average, pigs would have eaten 100 kg of feed before dying. Mortality rates are typically lower in experiments conducted in facilities such as Medina than in commercial research or production facilities, and this would explain some of the difference in reported values for FCR.

To demonstrate the potential impact of a disease challenge on nutrient requirements, in a recent experiment conducted for the Pork CRC, Dr Jae Kim and colleagues from DAFWA examined the hypothesis that heightened immune stimulation increases the requirement for sulphur-containing amino acids. Although it is too early to draw conclusions, if the hypothesis were supported, it could mean that a proportion of pigs in commercial herds are being fed diets that under-supply some amino acids because of the likely challenge to their immune system, which would in turn affect FCR. This research reflects the growing interest in the role of health status on pig performance, and in particular feed efficiency.

3. Measurement of feed disappearance

One of the changes that has occurred at the Medina Research Station in recent years has been the installation of the Feedlogic feed delivery system. Feedlogic is a fully integrated feed dispensing and management system comprised of a self-contained feed delivery unit suspended from an overhead rail, a charging and loading station and a wireless network connected to an off-board computer in a nearby office. The system has the ability to automatically deliver multiple diets to specific feeders and provide real-time data on feed disappearance. While it would not influence pig performance per se, it has certainly improved the accuracy with which feed allocation to pens is measured and hence has probably contributed in a small way to the improvement in feed efficiency that has been recorded.

4. Feeder design and access

Associated with the installation of Feedlogic at the Medina Research Station was the installation of new single-space feeders. These replaced single-space feeders that had been in place for about 20 years and in some instances, feed wastage was high due to the difficulty of adjusting feeders to control the flow of feed. At the same time, the number of pigs per feeder (7) is less than that suggested by the manufacturer, meaning that pigs have ready access to feed at almost any time of day. Morrison et al. (2003) compared the performance of entire male growing pigs with either nine or 15 pigs per feeding space, and reported a significant increase in feed to gain ratio from 10 to 23 weeks of age (2.46 to 2.64 for 9 and 15 pigs per feeder space, respectively, $P < 0.05$). Competition for feed and periods when feeders run empty are certain to contribute to the higher values for FCR found on many commercial piggeries. The space allowance for pigs at Medina is typically 0.9 m^2 per pig, substantially higher than the code of welfare recommendations (0.68 m^2 for a 105 kg live weight pig), which would also allow the pig to exhibit its genetic potential.

5. Environment

Climatic factors such as ambient temperature and humidity can have a significant impact on FCR. While they do not explain the change in FCR between successive experiments at Medina, pigs in that facility have a close to optimal climatic environment at most times, which is better than that in many commercial facilities. Hugh humidity is rare and spray cooling systems, programmed to switch on at 22 °C, together with excellent airflow and a large air space per pig, all contribute to good conditions for efficient growth.

6. Nutrition

The impact that feeding under-specified diets to growing pigs can have on FCR is clearly shown in Figures 1 and 2. Unfortunately, it is often difficult to feed pigs in commercial piggeries to their exact specifications. For example, because variation in live weight is often large, if diet specifications are set according to the average live weight of the group, a proportion of pigs will be fed diets that limit their capacity to grow to their genetic potential and an increase in FCR will result. On the other hand, feeding diets that meet the requirement of all pigs in the group would be expensive and result in significant waste of nutrients by pigs of lower genetic potential.

What might be possible?

Weaner nutrition

In the research reported previously (Figures 1 and 2), no special attention was given to what piglets were fed from weaning to 20 kg live weight. Pigs were sourced from a commercial farm at weaning, reared in straw-based shelters and fed standard commercial diets. A recent weaner study demonstrated that, compared with a wheat-soybean meal-based control diet, supplementation of 50 g spray-dried plasma protein per kg of diet improved FCR by 39% in the first week after weaning (Hernandez et al., 2010). Although the effect diminished during weeks 2 and 3 post-weaning, use of spray-dried plasma protein is an efficient strategy to reduce the post-weaning growth check and contributes to an overall improvement in herd feed conversion efficiency. This is just one example of how diet composition during the weaner phase might be used to improve overall feed efficiency of the growing pig.

Feeding systems

In the research experiments described previously, the same diets were fed to pigs from, for example, 20 to 50 kg or from 50 to 100 kg. Figure 4 shows the theoretical requirement for a particular genotype. Note that as the live weight of the pig increases, the requirement for dietary lysine declines to a point around 100 kg live weight, where it probably becomes constant. As the level of lysine declines, so too does the cost of the diet. In the example shown in Figure 4, which depicts a three-diet feeding program, each diet is set at the level of the

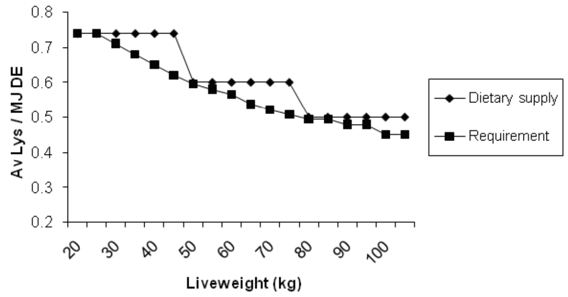

Figure 4. Requirement for lysine versus that supplied in a three-phase feeding program.

theoretical requirement, but as live weight increases, there is a period at which the diet supplies excess amino acids before the next diet is introduced. This is called phase feeding, as the diets are theoretically matching the different phases of growth and hence amino acid requirements of the pig.

Some feeding systems now incorporate blending of two or more diets, enabling the diet of pigs to be changed on a weekly basis. In this way, the supply of nutrients is better matched to the pigs' requirements. Blend feeding has been shown to save AUS $3 per pig in feed costs (Mullan et al., 1997), but as this does not take into account the cost of installing the necessary feed system or the cost of ingredients, the cost benefit will be better in some years than in others. It is unclear as to how much of this saving is attributable to improvements in FCR vs savings in the cost of feed per tonne.

Particle size

It is well-recognised that mechanical grinding of grains and legumes improves nutrient digestibility and hence feed efficiency. Grinding generally increases nutrient digestibility by releasing encapsulated nutrients and by increasing surface area, which facilitates contact between nutrients and digestive enzymes. Therefore, reducing particle size has minimal effects on growth rate but improves feed efficiency. On the other hand, excessive grinding can cause stomach ulcers, increase digesta viscosity, which reduces feed intake and nutrient digestibility, and increase the cost of milling due to the extra power required to drive machinery.

A grower pig study conducted at the Medina Research Station examined the effect of lupin particle size on ileal energy and amino acid digestibility. The results showed that for every 100 μm increase in lupin particle size over 567 μm, ileal digestible N and energy content were reduced by 2.2 g/kg and 0.53 MJ/kg, respectively (Kim et al., 2009). In the same experiment, every 100 μm increase in particle size of lupins over 567 μm reduced the standardised ileal digestible lysine, methionine, threonine, isoleucine, leucine, valine and total amino acid content by 0.5, 0.1, 0.5, 0.6, 0.9, 0.6 and 10.5 g/kg, respectively. These results collectively demonstrate that sub-optimal grinding, in this case of lupins, increased undigested energy and protein at the terminal ileum, which would in turn have an impact on feed efficiency.

However, a grain by particle size interaction was observed in an experiment with grower pigs in which ground wheat and sorghum were passed through a hammermill fitted with a 2 mm screen or a 3 mm screen (Murphy et al., 2009). The results showed that reducing the particle size of wheat from 640 μm to 550 μm decreased FCR by 5% (2.00 vs 1.89, respectively), whereas decreasing the particle size of sorghum from 650 μm to 600 μm did not influence FCR. The authors suggested that reducing the particle size of sorghum was deleterious for pellet quality and increased the percentage of fines from 1% to 4%, which may have nullified the beneficial effect of small particle size in the sorghum diet.

Conclusions

Recent results from two experiments conducted at the DAFWA Medina Research Station have highlighted what is possible with current genotypes maintained under close to ideal conditions. We know that many factors influence FCR, and although we can assume that many of these have additive effects, it is difficult to assign values to each. It is perhaps more important to identify factors that can be implemented on-farm than to spend valuable resources accurately measuring the relevant impact of each component. There is certainly no excuse for not adopting modern genetics and adjusting diet specifications using the most recent information available, but other influences such as health status might be more difficult, more transient and more expensive to improve in commercial piggeries. An added advantage of the results of the research conducted at the Medina Research Station is that the Australian pork industry has a new benchmark to aim for, which will hopefully focus attention on this important factor.

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