AUSTRALIAN PORK LIMITED

Producers' Guide to Pig Production & Nutrition

2017



PROJECT TITLE:

Producers' Guide to Pig Production & Nutrition 2017

PROJECT NUMBER:

2011/2211

ACKNOWLEDGEMENTS

Australian Pork Limited (APL) gratefully acknowledges the authors, Robert van Barneveld, Bruce Mullan, Jo Slade (authors) and Jane Fergusson (editor), who contributed to the "Weaning to Sale – Volume 1" manual (1998). APL also gratefully acknowledges the authors, Robert van Barneveld, Tony Edwards, Bruce Mullan, Joanna Slade (authors) and Jane Fergusson (editor), who contributed to the "Producers' Guide to Pig Nutrition – Volume 2" manual (1998). Their contributions are acknowledged and thanked as much of the information included in the earlier publication has been retained in this publication.

In this current publication, APL gratefully acknowledges the authors, Megan Edwards, Tony Edwards, Chris Cameron and Harun Rashid.

Many thanks to the scientists, producers and others who provided their ideas and comments, including Emalyn Loudon, Bruce Mullan, Ashley Norval, Ray King, Heather Channon, Darryl D'Souza, Pat Mitchell, Elzet Vermeulen, Roger Campbell, Barry Lloyd, Christine Clark, David Reu, Grant Kelly, Mark McLean, Tom Smith, Jeff Braun and Graeme Crook.

AUSTRALIAN PORK LIMITED

Producers' Guide to Pig Production & Nutrition

2017

Acknowledgements

This publication is effectively Edition II of two earlier PRDC publications which were the "Weaning to Sale – Volume 1" and "Producers' Guide to Pig Nutrition – Volume 2" manuals. The authors, editor and other contributors did a tremendous job as much of their very useful information included in the earlier publication has been retained in this publication.

Australian Pork Limited (APL) consequently, gratefully acknowledges the authors and editor of "Weaning to Sale – Volume 1" manual, produced by The Pig Research and Development Corporation, 1998. The team behind the "Weaning to Sale" manual were: Robert van Barneveld, Bruce Mullan and Jo Slade (authors), Jane Fergusson (editor).

APL also gratefully acknowledges the authors and editor "Producers' Guide to Pig Nutrition – Volume 2" manual, produced by The Pig Research and Development Corporation, 1998. The esteemed team behind this manual were; Robert van Barneveld, Tony Edwards, Bruce Mullan, Joanna Slade (authors), Jane Fergusson (editor).

Other valued contributors to both manuals were Neil Gannon, Virginia Falls, John Vercoe, Vaughan Chenoweth, and Bruce Muirhead.

In this current publication, APL gratefully acknowledges the editors, Megan Edwards, Tony Edwards, Chris Cameron and Harun Rashid.

In addition, many thanks are also due to the scientists, producers and others who provided their ideas and comments, including Emalyn Loudon, Bruce Mullan, Ashley Norval, Ray King, Heather Channon, Darryl D'Souza, Pat Mitchell, Elzet Vermeulen, Roger Campbell, Barry Lloyd, Christine Clark, David Reu, Grant Kelly, Mark McLean, Tom Smith, Jeff Braun and Graeme Crook.

Table of Contents

List of Tables

List of Figures

Chapter One

Introduction

1 Introduction

The Producers' Guide to Pig Production and Nutrition replaces the previous *Wean to Sale* and *Pig Producers' Guide to Nutrition* manuals published by the Pig Research and Development Corporation in 1998.

Pig farming can be a very rewarding experience when it is profitable. Whilst all the factors affecting profitability of the pig business (world grain prices, pork prices, etc.) cannot be controlled, you can endeavour to make pig production as efficient as possible.

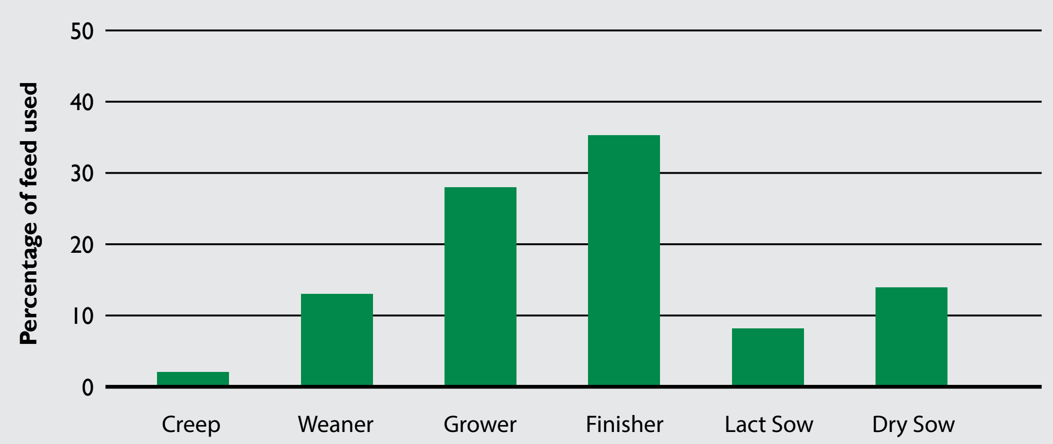
The Producers' Guide to Pig Production and Nutrition is designed to assist you in making your business as efficient as possible and remain viable by adopting modern production technologies and making the best use of recent research outcomes. The guide aims to assist in determining your current performance, identifying areas for improvement, providing advice on how to maximise profits for every kilogram of pig meat sold and using methods which are efficient, humane and sustainable.

Production costs can be lowered by improving:

1. Feed conversion efficiency
2. Feed prices
3. Growth rates
4. Productivity (pigs/sow/year, weaner/grower/finisher mortality)
5. Dressing percentage.

The weaning to sale period has the most impact on these production factors as this period accounts for roughly 76% of the herd feed usage (Figure 1.1). Production improvements in the weaning to sale period, however small, will assist with reducing costs.

FIGURE 1.1 Example of proportion of feed used in each phase of pig production (ACE Livestock Consulting Pty Ltd)

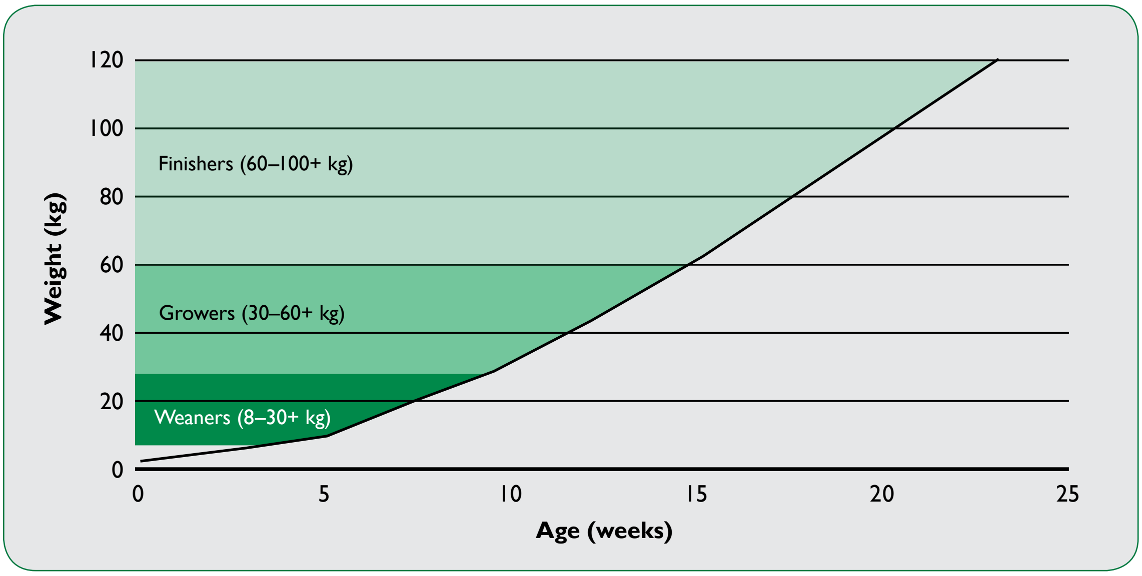


CHAPTER 1 INTRODUCTION

This guide describes pigs as weaners, growers or finishers, but producers can define them to suit their own circumstances. For some it will depend on movement of pigs between housing, whilst others will classify groups according to age or weight, with the latter giving the best indications of the pigs' maturity and nutritional requirements.

Figure 1.2 can be used as a guide to categorise pigs. Throughout the guide, the terms 'weaner' (from weaning at about 7–8 kg liveweight up to 30 kg liveweight), 'grower' (30–60+ kg liveweight), and 'finisher' (60–100+ kg liveweight or the point of sale) will collectively be referred to as the 'growth phase'.

FIGURE 1.2 Defining weaners, growers and finishers



The Producers' Guide to Pig Production and Nutrition focuses heavily on nutrition as feed costs account for more than 60% of total pig production costs. Getting nutrition right presents the greatest opportunity to improve the profitability of your business. Producers should therefore try to understand nutrition and how it can affect herd performance.

The trick is to examine the whole production process, focus on the final product, and relate nutrition to a simple, everyday process. When this becomes habit, nutrition – and its value – is more clearly understood.

2 The Final Product – Pork

Pork is a lean meat product which consists of protein, fat, water and bone.

Protein

Protein is basically a string of amino acids arranged in a pre-determined sequence exactly the same for all pigs, regardless of genotype, origin or diet. It is genetically fixed in the same way that pigs have four legs and two eyes.

Fat

Pigs are fed to achieve a low fat content in the meat, which may not improve pork's taste, but satisfies consumer demand for low fat due to the risk of heart disease. Some intramuscular fat however is needed to make the meat flavoursome.

Water

About 75% of lean meat is water.

Bone

Bone is the frame on which the muscles are attached and consists mainly of calcium and phosphorus.

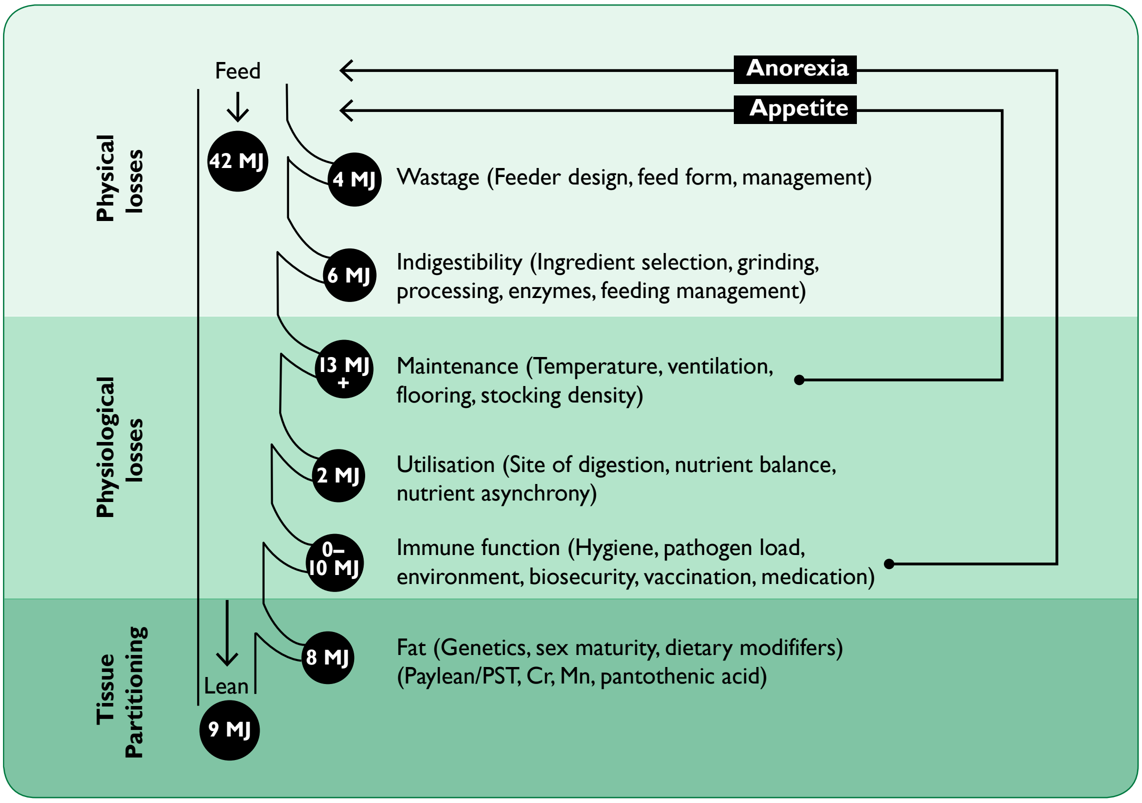
3 How is Pork Produced?

Pork meat is comprised of 75% water, 20% protein and 5% fat and carbohydrates. The main objective when producing pork is to provide pigs with the necessary amino acids to generate the desired protein (or lean meat) content. This process is metabolically costly and requires other nutrients including energy, water, vitamins and minerals from the feed, as well as hormones and enzymes from the animal, to achieve efficient protein production.

When providing nutrients to the pig for growth, we first need to meet the maintenance requirements of the pig. These nutrients are required to support the immune and metabolic demands of the pig to maintain its bodyweight. Beyond this, nutrients can be used for fat and lean tissue growth.

The key to efficient pork production is to minimise the maintenance requirement of the pig so that tissue growth can be maximised. Figure 1.3 shows how physical losses, physiological losses and tissue partitioning of nutrients contributes to how energy is utilised in a finisher pig. The energy cost of supporting the immune system (up to 25% of total energy consumed) can be a significant variable and can ultimately be a major determinate of efficiency. Minimising the cost of the immune system is essential to maximising lean meat production. Healthy pigs = healthy business.

FIGURE 1.3 Example of the potential losses of energy occurring in a finisher pig consuming 42 MJ of gross energy (ACE Livestock Consulting Pty Ltd, 2011)



4 Capacity and Efficiency of Pork Production

The capacity for lean meat production is determined genetically and is mediated by hormones. As a result, males and females, and pigs of differing genetic merit, have different production capacities. As these affect the composition of the final product, inputs to the system need to be adjusted accordingly.

With pigs, energy units must be matched to the animal's capacity to produce protein after maintenance commitments have been met. If suboptimal energy is consumed, the pig will not deposit as much protein as it otherwise could. If excess energy is consumed, above that required for maintenance and deposition of protein, this will be stored as fat rather than the specified product – lean meat. It takes five times as much energy to make fat as it does to make lean meat, so not having the correct balance of energy and protein in the diet leads to inefficiencies.

Protein deposition must be maximised, while as few resources as possible are applied to maintenance.

5 The Amino Acid Balance

A fixed amount of each amino acid is needed to produce muscle protein. If one amino acid is in short supply, the pig cannot make protein and the manufacturing process stops. On the other hand, amino acids are wasted if over-supplied, as the pig cannot store them and it is metabolically costly to excrete them.

In addition to supplying pigs with protein and energy, they also require micro-nutrients like vitamins and minerals from the feed, and their own hormones and enzymes to ensure lean meat deposition is efficient. Additional enzymes are often supplied in the feed to supplement the pig's own capacity to digest feed.

The challenge in pig production is to determine what nutrients are needed by your pig to grow to its potential, and to supply these in the most efficient way. This guide will help you achieve this.

Chapter Two

Stockpersonship

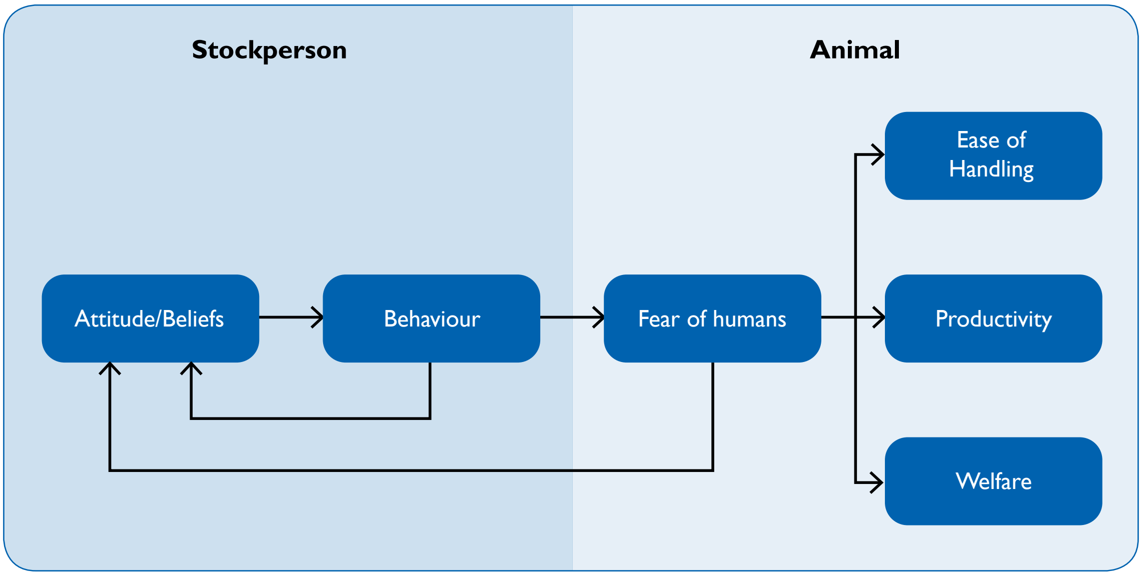
1 Introduction

This chapter outlines the key attributes of a successful stockperson and how they can best assess the piggery environment.

Stockpersonship is recognised internationally as the most important factor to ensure good animal welfare. Good stockpeople focus on the welfare of animals in their care, ensuring the pigs' health and productivity by responding quickly to their changing needs.

The relationship between the stockperson and the pig is a crucial driver of welfare, productivity and enterprise success (Figure 2.1).

FIGURE 2.1 Relationship between stockperson and animal and the implications the relationship can have on handling, productivity and welfare (ProHand®)



The weaning to sale period is sometimes perceived as a 'cruise control' time when stockmanship or stock sense may be relaxed, but nothing could be further from the truth. Lack of attention in this phase can adversely affect growth rate, feed conversion, mortality and the quality of the meat produced.

2 Know the Value of Good Stock Sense

Good stock sense can markedly improve the productivity of pigs. For instance, the effects of unpleasant (forcing pigs away) or inconsistent handling (stroking pigs sometimes and forcing them away at other times) of individual animals can reduce growth rate by as much as 50 g/day (Table 2.1). A growing pig handled badly could weigh about 4.5 kg less at slaughter than its potential, resulting in profound profit losses. Unpleasant and inconsistent handling can result in poor human-animal relationships, chronic stress responses, and depressed growth performance and feed conversion. Table 2.1 also highlights how negative performance is correlated with increased levels of the stress hormone corticosteroid. The elevation of corticosteroid is linked with an increase in gluconeogenesis (the generation of glucose from non-carbohydrate sources) that subsequently limits the potential for protein deposition and efficient lean growth.

TABLE 2.1 Influence of handling on the growth performance and corticosteroid concentration of female grower pigs from 7–13 weeks of age (Hemsworth et al., 1987)

	Unpleasant	Pleasant	Inconsistent	Minimal
ADG, g	404[a]	455[b]	420[ab]	458[b]
FCR, F:G	2.62[b]	2.46[a]	2.56[b]	2.42[a]
Corticosteroid conc, ng/ml	2.5[a]	1.6[b]	2.6[a]	1.7[b]

The difference between an effective, enthusiastic employee and one who is just satisfactory could be worth thousands of dollars per year to the producer. If stock sense makes such a difference, how can it be learned?

A good stockperson has:

- A sound basic knowledge of the animals and their needs;
- Patience, attachment to the stock and the skill to communicate and form a good 'relationship' with pigs;
- The dedication to make each animal as comfortable and contented as possible;
- The interest, sensitivity and observational skills to notice slight behavioural changes in individual animals or groups;
- An ability to comfortably handle large adult animals;
- An understanding of the pigs' behaviour and ability to manage moving them;
- Ability to organise the workload efficiently;
- Appreciation of priorities and the instinct to set aside routine duties to deal with pressing needs; and
- An ability to effectively communicate with supervisors.

Different sections of the farm require stockpeople with different characteristics. For instance, while it is hard to recognise individual animals in the growing section, a good stockperson will notice abnormal signs, take prompt action and continue to monitor the affected pig.

3 Stockperson Training and the Welfare Acts

Those who work with stock must strive to develop their skills. Employees should be trained (either undergo formal off-site training or on-the-job training) and assessed within six months of commencing employment to ensure that they have good animal handling skills.

The welfare needs and requirements of pigs in Australia are outlined within the *Model Code of Practice for the Welfare of Animals (Pigs) 3rd Edition (2008)*. A copy can be found on CSIRO's website at http://www.publish.csiro.au/Books/download.cfm?ID=5698.

The competency requirements of stockpeople are regulated within each state and territory. For further information about the pig welfare regulation in your state visit Australian Pork Limited's (APL) website http://australianpork.com.au/industry-focus/animal-welfare/training/. Contact APL for more information on staff training opportunities, including ProHand®, a training program targeting key attitudes and behaviours of stockpeople known to have a direct effect on pigs' fear of humans and subsequent productivity.

Details of the current (as at 2016) principal Welfare Act for each state and territory are listed in Table 2.2.

TABLE 2.2 State and Territory Acts being administered for regulation of pig welfare (APL)

State/ Territory	Principal Act	State Pig Welfare Regulations	Administering Department
NSW	Prevention of Cruelty to Animals Act 1979	The Animal Welfare Code of Practice – Commercial Pig Production is enforceable under the Act	NSW Department of Primary Industries
VIC	Prevention of Cruelty to Animals Act 1986 Livestock Management Act 2010	The Victorian Standards and Guidelines for the Welfare of Pigs, based on the Model Code, has been regulated under the Livestock Management Act	Department of Environment and Primary Industries
ACT	Animal Welfare Act 1992	No domestic pigs farmed in the ACT	Territory and Municipal Services
QLD	Animal Care and Protection Act 2001	The Model Code has been regulated under the Animal Care and Protection Regulation 2012	Department of Agriculture and Fisheries
SA	Animal Welfare Act 1985	The Model Code has been regulated and is embedded in the Animal Welfare Regulations 2012	Department of Environment, Water and Natural Resources

TAS	The Animal Welfare Act 1993	The Model Code has been regulated under the Animal Welfare (Pigs) Regulations 2013	Department of Primary Industries, Parks, Water and Environment
WA	Animal Welfare Act 2002	The Model Code standards have been regulated under the Animal Welfare (Pig Industry) Regulations 2010	Department of Agriculture and Food Western Australia
NT	Animal Welfare Act March 2000	No domestic pigs farmed in the NT	Department of Primary Industry and Fisheries

The Australian pig industry has determined that a stockperson can be considered 'suitably qualified' in accordance with regulations if they meet one or more of the following criteria:

1. Is a veterinarian;
2. Holds a Certificate III in Agriculture (Pork Production) or equivalent;
3. Has completed the Stockperson Skill Set or has been assessed by a Registered Training Organisation (RTO) to have completed units of competence (either through training or recognition of prior learning) in at least the following areas:
   – Move and handle pigs;
   – Care for the health and welfare of pigs;
   – Comply with industry animal welfare requirements; and
   – Administer medication to livestock.

APL also recommends that stockpeople undertake the euthanasia module, but this is not compulsory; and/or

1. Has 12 months experience caring for pigs in a commercial establishment and must have had on the job training and experience in at least the following areas:
   – Moving and handling pigs;
   – Inspecting and assessing the health and wellbeing of pigs;
   – Carrying out vaccinations, health treatments and elective husbandry procedures;
   – Humane destruction of pigs suffering an incurable disease, untreatable injury or painful deformity; and
   – Maintaining records of inspections and assessments of pigs.

This can be proven through either recognition of prior learning or through appropriate farm records, such as quality assurance records, that show that the stockperson has competently carried out these tasks.

4 Applying Stock Sense

Stock sense develops with time and experience and must become second nature. Good stockpeople are able to take care of all pigs in a large group as if they were individuals, provide individual attention suited to the requirements of a specific pig and automatically use a mental checklist when they have contact with pigs. When they enter any pig facility, they pay attention to the following points (note that new staff may find a copy of this checklist useful).

4.1 First Impressions

The following factors are used by a stockperson to obtain a first impression of the pigs and their environment.

Noise	Can you hear distressed pigs or coughing pigs?
Odour	Are there foul smells or high levels of ammonia?
Temperature	Is it excessively hot or cold?
Lighting/visibility	Is there a large amount of dust in the air?
Humidity	Is the room comfortable?
Shutter settings	Does the ventilation suit the type of day?
General tidiness	Is there rubbish or equipment lying around?
Shed maintenance	Is there broken penning or equipment in need of repair?

4.2 Detailed Inspection

Having given a preliminary assessment, the general surroundings should be inspected in more detail. The stockperson should walk slowly through the shed or pig housing, focusing on the following but still paying attention to individual animals:

Water

- Is it flowing from each drinker and at the correct rate?
- Is the temperature right? (Pigs won't drink hot water.)
- Is the water fresh and clear? Does it smell?
- Are medication or acidifiers being used and accurately dosed?

Feed

- Should there be feed in the feeder?
- Is the feed fresh? Does it smell pleasant?
- Is the right feed getting to the right pigs?
- Is the feed flowing?
- Is there significant wastage?
- Does the feed show signs of separation?

Environment

- What is the room temperature?
- Is there too much airborne dust?
- Is there too much ammonia?
- Are the spray coolers working?
- Are shutters or environment control systems working?
- Is there enough air movement or does the room feel stuffy?
- Is there too much air movement or are areas of the shed subject to draughts?
- Are the pens clean?
- Are the drains full?

Pig behaviour

- How are the pigs lying? Huddled or spread out?
- Do the pigs have sufficient space or do they seem overcrowded?
- Are the pigs fighting, biting tails, ears or flanks?
- Are the pigs suddenly dirtying pens that are normally clean?
- Is an individual pig behaving abnormally?

Health

- Are any pigs dead?
- Are there any pigs which are acting differently to the others? (e.g. looking hairy, lying apart, coughing, lame, scouring.)
- Are any pigs scratching?
- Do all the pigs get up to eat?
- What is the faeces consistency?
- Are there pigs which need to be transferred into or out of a hospital pen?
- Have all sick pigs been treated, correctly identified and recorded?

Everyone who works with animals needs good stock sense. A good stockperson will be aware of all aspects of a pig's environment and will recognise what is 'normal' and what is not. They will identify any problems and take immediate steps to correct them.

To summarise: observe, investigate, take action and record!

5 References

Hemsworth, P.H., Barnett, J.L. & Hansen, C. (1987) Influence of inconsistent handling by humans on the behaviour, growth and corticosteroids of young pigs. *Applied Animal Behaviour Science* Vol. 17. pp. 245-252.

Chapter Three

The Weaner Pig

1 Introduction

This chapter details the management, care, housing and nutritional requirements of the weaner phase, allowing producers to identify practices which could make production of pigs during the weaner phase inefficient. The main objectives at weaning are to minimise stress, provide the best possible environment, maximise pig health and hygiene, and provide a carefully balanced diet to support the immune and digestive development of the immature pig. The chapter also incorporates research findings from recent Australian Pork Limited (APL) and Pork Cooperative Research Centre (Pork CRC) funded research into weaner production.

Weaning is a critical event in a pig's life. Weaning involves the removal of piglets from the sow with the objective of trying to safeguard both the sow's reproductive performance as well as the piglets' growth rate, health and welfare. The ability of the young pig to cope with the weaning transition can influence their potential for future growth and development. The overall objective should be to:

- Minimise stress at weaning
- Provide a good, climate-controlled environment
- Ensure optimal hygiene and health
- Feed a highly digestible, functional and nutritious diet.

Maximising weaning weights of piglets ensures that the piglet has the body condition it needs to cope with the challenges of weaning. Growth rates of 220 g/day are acceptable for suckling pigs in commercial production systems, however, it is important to remember that this is only approximately 40% of their potential of 550 g/day. Hodge (1974) was able to achieve growth rates of 571 g/day between 10 and 30 days of age for pigs that were weaned at two days of age and fed reconstituted cow's milk. Other factors affecting the growth of suckling pigs are sow milk quality and yield, competition from other litter mates for available milk, a poor environment, and stress from disease. It is difficult to change milk quantity and quality of sows through her diet, but alternative strategies can be implemented to improve suckling pig growth. They are:

- Selecting sows for high milk yield (12+ L/day)
- Use protein rich milk replacers and/or high quality creep feed in addition to sows' milk
- Provide a comfortable growing environment
- Ensure high health and hygiene standards in the farrowing house.

2 Understanding the Growth Check

In the wild, weaning is a gradual process which occurs between 10–20 weeks of age. In commercial practice, weaning is an abrupt process which generally occurs between 17–32 days of age. Almost all pigs experience some degree of poor or negative growth in the immediate post-weaning period, which is commonly referred to as the post-weaning 'growth check'. To ensure that the severity and longevity of any growth check is minimised it is important to have a clear understanding of the weaning process and the changes that occur. With this knowledge you will be in a better position to help your piglets adapt and adjust to the weaning transition, minimising checks to growth and the risk of predisposing young pigs to disease.

3 When to Wean

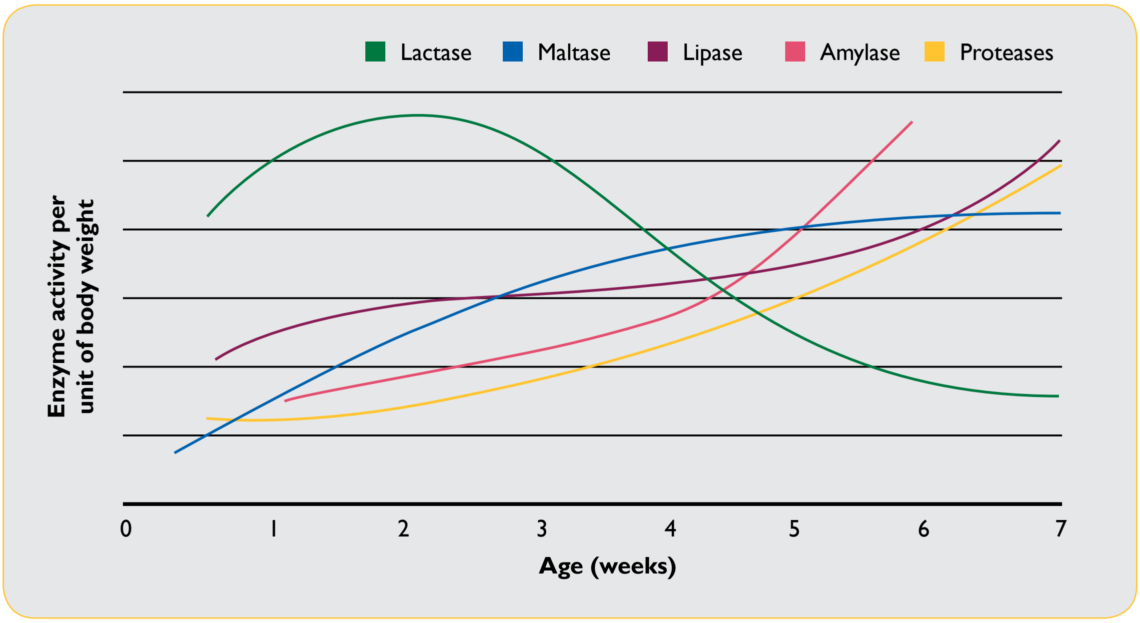
There is no set age for the removal of piglets from the sow and timing can vary between production systems. There are substantial changes in the metabolic, physiological and immunological circumstances in the piglet that occur as a result of weaning, and these can result in considerable stress if not managed well. When determining the appropriate weaning age for your production system, the following five areas should be considered.

3.1 Physiological Constraints

Sows' milk contains more than simple nutrition for the suckling pig. The withdrawal of sows' milk removes a range of bioactive compounds (anti-infectious agents, digestive enzymes, hormones, growth factors, etc.) from the piglet's diet that regulate digestive and immune development as well as provide passive immune protection.

Digestive system – The enzyme profile required to utilise cereal-based diets is different from the profile required to utilise sows' milk. The dominant sources of energy in sow's milk are lipids (fats) and lactose, as the major carbohydrate, whilst the dominant energy source in cereal-based diets is carbohydrate (starch). Figure 3.1 illustrates the changes in digestive enzyme secretion over time in the young pig. By delaying the weaning age you can improve the performance of piglets offered solid feed, as the digestive tract is better developed. If the enzyme secretion of the pig is insufficient to cope with the solid diet, there is a risk of undigested raw material passing into the large intestine, resulting in diarrhoea and scouring. A range of nutrition tools/principles which can be applied to minimise this risk are discussed later in this chapter.

FIGURE 3.1 **Digestive enzyme development in the piglet (Kidder & Manners, 1978)**



Piglet immunity – At birth, as the piglet's immune system is immature, they rely on maternally-derived or passive immunity, initially through sows' colostrum and then through her milk. The piglet's own immune system matures in distinct phases over the initial six to seven weeks of life. This development requires specific stimulatory inputs and is regulated by bioactive compounds in sows' colostrum and milk.

Weaning in commercial piggeries occurs at a critical period when the passive immune protection from the sow is declining and the active immunity of the pig is not fully functional.

3.2 Sow Factors

Milk yield – Sow milk yield peaks between days 14–21 of lactation and this level is then maintained for approximately 14 days. Milk yield is influenced by litter weight, with the effect being most pronounced in early lactation where the potential for mammary tissue growth is greatest.

Milk composition – Glutamine is an amino acid which plays an important role in immune cell function and is needed for intestinal development. Sows' milk is a rich source of glutamine/glutamic acid. Whilst milk production peaks around day 14 of lactation, the glutamic acid concentration in sows' milk increases throughout lactation, peaking at day 28.

Sows in heat – Weaning at 21–28 days usually triggers the heat cycle unless the sows are in poor body condition.

Subsequent litter size – Subsequent litter size tends to be higher in sows weaned at 21–28 days compared to those sows weaned at 14–21 days.

Sow condition – The sow's body condition can be reduced by loss of appetite during lactation, or insufficient feed intake to meet milk output demands. Poor body condition delays her return to oestrus, reduces the size of her next litter, and, may necessitate early weaning.

Optimal use of infrastructure – Increasing weaning age can increase the capital costs required (due to the need for more farrowing crates) and farrowing crates may not be large enough to house large litters of older weaners.

3.3 Environmental Constraints

Housing costs – The earlier pigs are weaned, the higher the cost of housing them after weaning.

Housing availability – Early weaning may be necessary because of insufficient housing in the farrowing shed.

Temperature – The older that piglets are weaned, the better their ability to cope with cooler or fluctuating temperatures, as they have higher body fat reserves and are consuming more solid food.

3.4 Feed Constraints

Feed costs – Starter feeds for pigs vary greatly in quality and price. When pigs are weaned at very young ages, high quality and expensive feed ingredients may need to be used to support the weaning transition. Like sows' milk, some raw materials used in starter feeds contain bioactive compounds that can be useful in compensating the newly weaned pig. If you decide not to invest in high quality starter feeds you may be better off weaning at an older age.

Dietary antigens – The immature immune system of the piglet can result in inappropriate, transient hypersensitivities to dietary antigens (e.g. soya bean meal). This can cause damage to the villi within the gut and limit the piglet's ability to absorb nutrients. Careful selection of diet ingredients, gradual introduction of raw materials and pre-weaning exposure of piglets to raw materials can limit the harm associated with dietary antigens.

3.5 Other Constraints

Labour – Early weaning requires more labour and stock sense. If good quality, reliable labour is not available then delayed weaning to 28 days of age may be a better option.

Herd health status – Depending on the diseases within your herd and the weaning system used, weaning age may be influenced by disease control procedures. If your piglets are transferred to a segregated site at weaning, younger weaning ages may limit the contamination of endemic (e.g. *Actinobacillus pleuropneumoniae*) and enteric diseases (e.g. Parvovirus) from sow to piglet. Developing a disease control procedure with your veterinarian is recommended when determining the ideal weaning age for your herd.

Routine medication – Delayed weaning generally results in decreased use of routine medications due to a more mature immune system.

4 Promoting Feed Intake

One of the most important targets in the management of weaners is to ensure that feed intake in the immediate post-weaning period is maximised. Maintaining sufficient feed intake is an essential part of maintaining the intestinal integrity of the newly weaned pig. A healthy gut reduces the risk of disease and poor nutrient utilisation benefiting feed conversion. Strategies to promote feed intake in newly weaned pigs include:

- Offer creep feed pre-weaning to allow familiarisation
- Feed little and often. Frequent small meals help the piglet maintain a healthy gut and avoid the risk of undigested feed reaching the small intestine and causing diarrhoea
- Avoid abrupt diet changes. Offer the same feed pre and post-weaning to limit nutritional stress
- Use starter diets containing spray-dried plasma products or glutamic acid/MSG (Mono-Sodium Glutamate)
- Avoid the use of bitter feed ingredients (e.g. some in-feed medications, high levels of canola meal) as feed intake can be reduced
- Ensure water supply is plentiful and of high quality.

5 Weaning Systems

The most common style of weaning has been the continuous flow system which is cheap and easy to manage, however, all-in/all-out systems are superior and are best practice for weaner management. The following section looks at three weaning systems.

5.1 Continuous Flow

Groups of pigs are regularly moved into weaner or grower-finisher accommodation as older groups are moved out to the next stage of production, or to market. Younger pigs are continually exposed to older pigs in the same airspace, increasing risks of possible infection, and making it harder to prevent or control disease. Housing large numbers of pigs together can trigger disease (particularly respiratory disease) and make disease eradication difficult.

Advantages

- Continuous flow systems cost less than all-in/all-out systems.
- Pig movement is unrestricted so they are easier to wean, shortening sow weaning to service intervals and increasing litter size.

Disadvantages

- Preventing and controlling disease is very difficult.
- Thorough cleaning is impeded as weaning facilities are rarely vacant.
- Medication costs increase.
- Lower growth rates, higher feed conversion ratio (FCR) and poorer air quality are associated with continuous flow systems.
- It is harder to maintain the right temperature (environment) for a wide range of age groups.

5.2 All-in/All-out

In this system, pigs are weaned in batches according to their age. Pigs whose age differs by no more than two weeks (and preferably, one week) are grouped in weaning kennels or rooms.

Each batch of pigs remains grouped from birth to market. As they are moved to the next production stage, the vacated pens are cleaned and disinfected before the next batch enters.

Advantages

- Disease prevention is much easier as piglets are not exposed to older infected pigs.
- Environment and nutrition can be tailored to a single age group.
- Phase feeding is possible.
- Air quality in sheds can be improved (temperature and ventilation).
- Growth is better when fewer pigs share a single airspace.
- Facilities can be cleaned between each batch.

Disadvantages

- Pigs may not all grow at the same rate.
- Irregular sizes can make it hard to adhere to the batch system. It requires tight breeding management.
- If regular cleaning is not already practiced, more labour may be needed until system management becomes routine.

5.3 Segregated Early Weaning (SEW) and Multi-site Production

Segregated early weaning (SEW) involves weaning pigs at an 'early age', usually at less than 18 days, and removing them from the breeding herd immediately after weaning as a means of eliminating or reducing disease load being transferred to piglets from sows. They are reared in all-in/all-out management systems in separate buildings or farms.

Weaning age

The weaning age used will depend on the disease status of the breeding herd. While 21 day weaning deters many pathogens, ten day weaning is needed to eliminate Enzootic Pneumonia. Some diseases can be eliminated with 18 day weaning, including Pleuropneumonia and Leptospirosis. SEW can also aid in the control (but not elimination) of other diseases including Greasy Pig, Proliferative Enteritis and Glässers Disease (*Haemophilus parasuis*), however, if a disease outbreak occurs the outbreaks tend to be acute rather than chronic, with severe losses.

Housing

Flat deck weaner rooms are commonly used. These facilities are spot heated and equipped with mats over the mesh to improve feeding and sleeping areas for very young pigs. Water is provided through 'bite-type' nipple drinkers which drip to encourage early recognition of the water source. Piglets are moved in batches to rearing sites.

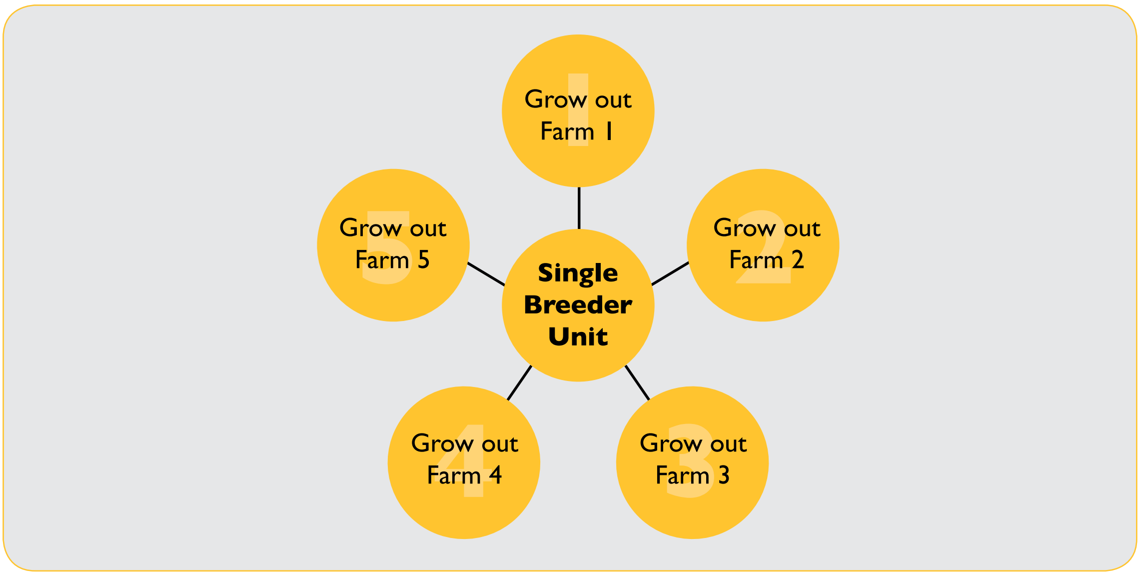
SEW works best with multi-site production of weaners, growers and finishers. It is best to house only one batch of weaners or growers at any one site, or in sheds far enough apart to minimise any biosecurity risks. When they are moved, the accommodation must be cleaned prior to the entry of the next batch of pigs.

SEW structure

SEW is ideal for a group of producers working together, one being the breeder and the others growing batches of pigs to market weight (Figure 3.2). Another producer group option is to establish a new breeding herd and use existing facilities to house weaners or growers.

SEW systems are also well suited to integrated contracting, where large companies contract smaller farms to grow pigs from about four to eight weeks old. The grower receives a fee in return for labour, power, water and housing. The owner usually pays for feed and medication if required.

FIGURE 3.2 Possible producer structure utilising a single breeder site to supply producers on a rotation to maintain throughput and herd health



Advantages

- Pleuropneumonia and Enzootic Pneumonia, Swine Dysentery and Glässers Disease can be controlled, if not eliminated.
- Disease breakdowns become temporary and manageable rather than hard to control, relative to a continuous flow system.
- SEW has the potential to improve air quality in sheds for both pigs and people because of the controlled nature of the system.
- Average daily gain is usually higher than in continuous production systems.
- Medication costs can be lower.
- It is easier to introduce phase feeding systems.
- SEW enables staff to specialise and improve their skills and performance.
- Alliances formed between producers for SEW production may provide family farms with additional options to remain involved in pig production.

Disadvantages

- Weaners need extra care to minimise post-weaning mortality.
- Transport between sites may be stressful and is costly.
- Diet programs may need adjusting.
- Flexible selling arrangements are required, e.g. sale of underweight pigs.
- Acute disease outbreaks may occur.
- SEW finisher gilts selected for breeding may be naive to respiratory diseases that are endemic to the herd, so special consideration must be given to getting them used to herd diseases during quarantine.

6 Meeting Weaning Objectives

The four main objectives at weaning are to:

- Minimise stress at weaning;
- Provide a good, climate-controlled environment;
- Ensure optimal hygiene and health; and
- Feed a highly digestible, functional and nutritious diet.

6.1 Minimising Stress

If not managed properly, weaning may be stressful for piglets as they are mixed with unfamiliar pigs, moved to new accommodation, and are fed a grain-based diet rather than a milk-based diet.

The younger the piglet, the greater the risk of stress. Stress impacts on piglet welfare, slows the growth of weaners and makes them more susceptible to disease.

Mixing pigs

High stress occurs when pigs are mixed and forced to form new social groups. Most piggeries create large groups at weaning (e.g. >100) so pigs are forced to interact with those from different litters.

The main reason for fighting is to seek dominance within the pen hierarchy, rather than to compete for food and water. Therefore, giving pigs extra feeder and drinker spaces will make little difference.

Fighting is worst in the first four hours after mixing. After a couple of days, the order of dominance will be established and social stability attained. Stress at weaning is inevitable, but good management can certainly reduce it. Strategies to minimise the stress of mixing unfamiliar pigs include:

- Form groups as young as possible and maintain them (e.g. avoid remixing)
- Try to move all pigs into the unfamiliar pen simultaneously or within as short a time frame as possible
- Try to mix relatively equal-sized groups or animals with similar bodyweights
- Allow extra space if possible
- Spray pigs with a common scent.

Pre-weaning

One option in farrowing houses is to allow free piglet access to adjacent farrowing crates prior to weaning, by removing the farrowing pen boards separating litters and allowing litters to mix. This practice is known as multiple suckling. Most piglets will, however, return to their own mother for milk. Only litters of similar bodyweight should be mixed to avoid bigger piglets 'stealing' more milk than their share. Although this practice can greatly reduce stress post-weaning, few farrowing units are designed to practice such a program.

Sorting pigs

Sort pigs (chosen from the least possible number of litters) into weaner pens on the basis of liveweight and sex. This avoids mixing heavy, dominant piglets with those needing special care and attention.

This process also means that feeding strategies can be adapted to suit the requirements of particular pens (e.g. keeping smallest pigs on first stage weaner diets for longer). Separating male and female pigs at weaning will save doing so later when grower-finisher pigs of different sexes need different diets or feeding programs.

Light and medium weight weaners can benefit (i.e. produce more profit at slaughter) when fed complex creep feeds. Research by Morrison et al. (2009) showed that pigs above 8 kg liveweight at 27 days of age performed just as well from weaning to slaughter on a second stage nursery diet for the initial 14 days post-weaning. However, pigs below 8 kg liveweight (medium and light) at weaning benefited from being offered a more complex (and costly) first stage nursery diet in the initial 14 days post-weaning. This resulted in greater profit per pig, especially in the light weight group (Table 3.1). It was concluded that sorting pigs by weight at weaning and developing a feeding program based on weaning weight can help improve profitability.

TABLE 3.1 **Influence of weaning weight (W) at day 27 and feeding program (FP) in the initial 14 days post-weaning on weight at slaughter (day 123) and economic returns (Morrison et al., 2009)**

Weaning Weight Group	Light		Medium		Heavy			P value	
Feeding Program	Com	Sim	Com	Sim	Com	Sim	SED	FP	W
Weaning wt (kg)	5.51	5.47	7.27	7.25	9.54	9.59	0.115	0.61	<0.01
Slaughter wt (kg)	91.2	88	98.5	95.6	101.1	101.4	1.10	0.06	<0.01
Carcase wt (kg)	66.0	64.5	71.8	71.1	75.8	77.4	1.71	0.40	<0.01
Total Feed cost ($/pig)	76.5	75.0	83.6	78.8	86.4	85.0			
Feed cost/kg gain ($/kg)	0.89	0.91	0.92	0.89	0.94	0.93			
Return of carcase ($)	211.1	206.4	229.7	227.5	242.5	247.7			

Com = Complex diet containing cooked cereals, skim milk powder, soy protein isolate and 28% whey powder
Sim = Simple diet containing wheat, lupin kernels, canola and 8% whey powder
Both diets contained 15.1 MJ DE/kg and 0.90 g available lysine/MJ DE. Both diets contained meat meal, fish meal, blood meal and soya bean meal

Accommodation

To reduce stress levels, avoid overcrowding weaner pens and clean the pens well between batches to avoid disease. Create the right environment and ready access to feed and water.

Stress can be lower if pigs remain in farrowing crates for the week after weaning, but this will not compensate for inefficient accommodation use. It is best to move pigs at weaning and use the farrowing crate for its right purpose.

Background noise (like a radio) will divert the pigs' attention from disruptions caused by slamming doors and staff noise. Pig 'toys', such as chains and rubber buoys, can help reduce aggression and tail biting.

Moving pigs

To minimise stress at weaning, use a purpose-built trolley to move pigs from the farrowing crate to the weaner shed or load-out area. Make sure it is easy to manoeuvre, load and unload, and also that there are no sharp edges to minimise risk of injuries.

If transporting pigs to their weaner accommodation via truck or trailer, ensure there is protection from the sun in hot weather and cold draughts during winter. Make the trip as smooth as possible in the way the vehicle is driven and by maintaining private roads – making them free of potholes and sharp bends.

If you are walking piglets to their new accommodation, use stock-boards to steer them in the right direction and have doorways properly latched to prevent them taking the wrong path.

Remember to handle weaners carefully and if you need to pick them up do so by grasping them gently around their middle or picking them up carefully by their back legs.

Feeders

Single-space feeders are designed to protect individual pigs while feeding, but newly weaned pigs prefer to feed in groups and need a conventional feeder designed to feed several pigs at once.

Management

To reduce stress, carefully observe piglet behaviour and respond quickly when necessary.

Ensure that all pigs get up when disturbed, and treat sick pigs promptly. Most aggressive behaviour should stop within 48 hours post-weaning after mixing, so resist intervening before this time as this may delay the settling-down process. If all seems well, leave the pigs alone.

6.2 Providing the Best Environment

Housing pigs well gives them an environment which will maximise performance (e.g. growth rate, feed conversion) and enable effective stock management. These need to be achieved without high costs.

Management and environment have more influence on producing good weaners than nutrition and genetics, and successful producers know how environmental factors affect pig behaviour and performance.

It is vital to be aware of the pig's response to its conditions, recognise inadequacies, and strive to adapt husbandry and management to meet the pig's needs. These include external factors such as temperature, feeding level and floor type.

Pigs housed in sheds have little opportunity to select their own environment. Their needs during the growth phase need to be considered, and decisions made on fulfilling these needs within the restraints of cost, labour, power and water.

The most expensive housing systems are not necessarily the best. Without skilled labour, well-housed pigs may not reach their potential.

Temperature

Temperature is of vital importance in post-weaning performance. Just after weaning, energy intake falls as the piglet learns to eat dry food at irregular intervals instead of drinking milk hourly. This energy loss makes the piglet feel cold, so it is essential to keep it warm during the first week after weaning.

If the pig is in its thermal comfort zone (i.e. within the temperature range in which it feels best) it will retain its energy, eat well and meet its growth potential. Changes to this zone occur as the pig's weight and energy intake changes, and can be affected by air movement, stocking density, floor type, etc. For example, pigs reared on fully slatted floors have a greater heat requirement than those housed in straw bedded accommodation (Table 3.2).

TABLE 3.2 Recommended minimum temperature (°C) for piglets post-weaning (Meat and Livestock Commission, 2004)

	Floor type		
Weight	**Straw bedded**	**Solid insulated concrete**	**Fully slatted**
6 kg (day of weaning)	27	28	30
6 kg (once started eating)	26	27	29
8 kg	24	26	28
10 kg	21	23	25
15 kg	19	20	23
20 kg	15	17	21

As pig behaviour will change according to its thermal comfort, stockpeople should observe pig behaviour carefully and take necessary action to assist the pig to remain in its thermal comfort zone (Table 3.3). A cold pig will huddle with others, avoid contact with the floor, eat more and shiver. A hot pig lies away from others, increases contact with the floor, has a higher body temperature, pants, eats and drinks less, and fouls the pen by splashing and wallowing.

TABLE 3.3 Influence of temperature extremes on pig behaviour and response strategies to optimise performance

	Too hot	Too cold
Pig Behaviour	Pigs will lie apart and try to maximise contact with flooring Pigs will use dunging area for lounging around/cooling themselves Pigs will attempt to create wallows and/ or foul pens Pigs will display irritable and aggressive behavior Pigs will pant Pigs will decrease feed intake and may increase water consumption Pigs will have high body temperatures	Pigs will huddle together and avoid contact with the floor Pigs will burrow into bedding if available Pigs will increase feed intake Pigs may shiver Extremities (ears and tails) may show signs of frost bite in extreme cases
Stockperson Response	Increase space allowance Wet concrete flooring Increase airflow (both volume and speed) Spray pigs with water Insulate buildings Provide evaporative cooling Offer diets containing higher levels of fat to reduce heat increment Offer betaine in the diet as an osmoregulator	Increase stocking density to allow pigs to huddle Reduce draughts Provide additional bedding, compositing bedding packs or covers to allow pigs to create their own environment Provide supplemental heating for very young pigs Insulate buildings/flooring Offer high energy diets (>15 MJ DE/kg) and maximise feed intake Increase entry weights (smaller/lighter pigs are more susceptible to cold temperatures)

Not only is it important to ensure the optimal temperature is maintained in the nursery, it is also important to limit the level of fluctuation throughout the 24 hour period. Wide fluctuations in temperature can have the same outcome as pigs being exposed to low temperatures.

Monitor ambient temperature on a daily basis and record readings. A delay in adjusting the weaner room temperature, if needed, can have drastic effects on the health status and performance of young pigs. Relative humidity has little effect on pig performance except when high humidity and high ambient temperatures occur simultaneously.

A maximum-minimum thermometer should be used in the weaner accommodation. Place it at pig level, in a position where staff can read it. A thermometer higher up the wall is unreliable as temperature at this level could be 4 °C higher than at pig level. The temperature at mid-morning may feel okay to you, but temperature extremes do most damage to pig performance.

Maximum-minimum thermometers will not show how long extreme temperatures have persisted, but temperature data loggers (e.g. Tiny Talk monitors, automatic controllers) can and are very useful in monitoring temperature. Use one for an accurate assessment of the weaner

environment at pig level. Modern data loggers (ranging in price from $300–$600) can record both temperature and humidity on a regular basis. This data can be downloaded to a computer or connected to an alarm, allowing you to get a good understanding of the fluctuation of conditions and allowing prompt action when temperatures become sub-optimal.

Careful observation of piglet behaviour is important. Pigs which huddle to keep warm make fewer visits to the self-feeder. If temperatures fluctuate within a pen, pigs will move around more and disrupt the group's social structure. There is no substitute for carefully recorded observation, followed by prompt action.

Air movement

A slight draught of 0.15 m/sec is equivalent to a 3 °C drop in air temperature, while a draught of 0.50 m/sec matches an 8 °C drop. An air speed of no more than 0.15 m/sec is recommended except when cooling is needed.

Lighter pigs in a room with lower ambient temperatures are most affected by draughts. It is inefficient to provide radiant heat when it escapes through a crack in the wall. The use of a smoke-gun to study air movement within the weaner accommodation can help identify necessary changes to minimise unwanted draughts. The young pig's housing conditions will have a big effect on its performance and the profitability of the whole enterprise.

Given a choice, young pigs prefer changes in air temperature during the day, and providing this may improve feed intake, however, the risk of post-weaning diarrhoea increases with large variations (more than ±5 °C) in daytime ambient temperature, especially in the first week after weaning.

Lower night-time temperatures and exposure to draughts triggers coughing, sneezing and slower growth, and so ambient temperature should be maintained within a narrow a range as possible (e.g. ±2 °C). Protect piglets from cold when the building is opened to fresh air.

Bedding

Plentiful bedding can help the pig create a micro-environment which reduces heat loss, but while it is essential for weaner huts and eco-shelters, it should not be used in intensive weaner sheds due to issues with waste disposal. Common materials used for bedding include straw, rice hulls and wood shavings, with straw having the best insulating properties.

Measuring air quality

Poor air quality can cause health problems, reduced feed intake and slower growth rates. Gases including ammonia, hydrogen sulphide, carbon dioxide and carbon monoxide affect air quality, as does dust and bacteria.

Ventilation systems remove water vapour, dust and harmful gases, and help to control temperature. To protect both stock and staff, good shed design and proper management is necessary.

Occupational health and safety organisations, and some government departments, may supply portable devices to monitor ammonia and carbon dioxide levels, total respirable dust and bacteria load. If air quality in your sheds is not what it should be, consult an agricultural engineer or a pig specialist. Table 3.4 summarises gas, dust and bacteria targets.

TABLE 3.4 **Targets for gas, dust and bacteria levels**

Risk factor	Gas			Total dust	Respirable dust	Bacteria
	Ammonia	Hydrogen sulphide	Carbon dioxide			
Target levels	Less than 10 ppm (20 ppm maximum)	Less than 5 ppm	Less than 3 000 ppm (aim for less than 1 500 ppm)	2.4 mg/m^3	0.23 mg/m^3	100,000 CFUs/m^3

CASE STUDY: Converting to an all-in/all-out (AIAO) system to improve air quality and production

The original system

- 500 sow farrow to finish production unit.
- Has specialised (AIAO) weaner rooms for pigs from 4–10 weeks of age.
- Had naturally ventilated grower and finisher sheds for pigs from 10–16 weeks and 16–23 weeks, respectively.

The new system

- Grower and finisher sheds were partitioned to each house 260 pigs (2.8m^2 airspace per pig).
- Sections were cleaned between batches by hosing walls, ceilings and floors.
- Pigs were housed in a section from 10 weeks to about 22 weeks old.

What happened?

- The average daily gain increased by 12.1% (560–620 g/day).
- Grower-finisher mortality decreased by 50% (from 7–3.5 deaths/week).
- There was 35% less dust.
- Bacterial particles dropped by 50%.
- Pleurisy was reduced by only 4.3% (9.8%–5.6%), but grade 2 lesions fell from 67% to 36%. Projections showed that within nine months the herd would have a pleurisy risk of 3.3%, with only a quarter of lesions grade 2.
- The average lung score increased from 5.3–8.5 but abscesses from Actinobacillus pleuropneumoniae dropped from 4.4% to 0.25%.
- Medication dosage plunged from 100 pigs/week injected with antibiotics before the changes, to 1.5 pigs/week.

The results demonstrate the value of converting continuous flow facilities into all-in/all-out management systems. Pigs can be reared in defined age groups away from older pigs and protected from infection. Pens can be cleaned between batches to improve air quality, reduce disease, increase growth rates, maximise profits and be safer for piggery staff.

Dealing with gases

Ammonia

- Levels should be less than 10 ppm. Above 20 ppm should be avoided.
- Use gas tubes to measure ammonia concentration. Humans can smell 5 ppm.
- Ammonia is lighter than air, so measure levels about 20 cm above the floor, at the edge of slats or at an open drain.
- Improve effluent disposal and ventilation.
- To slow ammonia production, flush pits or cover dung in pits or drains with water. Yucca-based products like Deodorase© or Microaid© may help to bind unwanted ammonia.

Carbon dioxide

- Levels above 3000 ppm are too high. Aim for less than 1500 ppm.
- Use gas tubes to measure carbon dioxide concentration.
- Carbon dioxide levels are a measure of ventilation rates. On a cool, breezy day, carbon dioxide levels in an open, well-ventilated shed will be 400–500 ppm. Levels in an over-stocked, closed shed may reach 5000 ppm.

Hydrogen sulphide

- Levels should be lower than 5 ppm. Humans can smell 1 ppm.
- Hydrogen sulphide smells like rotten eggs and can be toxic to humans.

Reducing dust

- Total dust levels should be lower than 2.4 mg/m^3.
- Levels of respirable dust (smaller particles breathed into the lungs) should be lower than 0.23 mg/m^3.
- Respirable dust increases when humidity is lower than 30%.
- Dust can be reduced by using granular feeds with higher levels of dietary fat, rather than powdery feeds.

Beating bacteria

- A bacterial load of 100,000–120,000 colony forming units (CFU)/m^3 is acceptable, but lower is better.
- Bacteria attach to dust and other airborne particles.
- Both dust and bacteria can be lessened by fogging the shed with products like Virkon S®.
- In-water acidifiers are an effective way of reducing the introduction of bacteria into the pigs' environment, whilst also limiting the build-up of micro-film in the lines. In-feed acidifiers are also beneficial in reducing the level of bacteria in feed as well as in the stomach and faeces of the pig.

Protecting piggery staff

- The recommended exposure levels of some air pollutants are lower for humans than for pigs (Table 3.5).
- Reducing air pollutants to levels recommended for human health will help improve both stockperson and pig health.

TABLE 3.5 Recommended human and pig maximum exposure levels for various air pollutants found in pig sheds (Murphy, 2011)

Pollutant	Human health	Pig health
Ammonia (ppm)	7.0	11.0
Carbon dioxide (ppm)	1540	1 540
Total dust (mg/m^3)	2.4	3.7
Respirable dust (mg/m^3)	0.23	0.23
Endotoxin (g/m^3)	0.08	0.15
Total bacteria (CFU/m^3)	1.0×10^5	1.0×10^5

6.3 Stocking Density and Group Size

An ideal group size is 10–15 weaners per pen. These small groups enable same-sized pigs to be kept together and problems to be spotted sooner.

Grouping larger numbers saves penning costs but competing for food could lower growth rates unless more feeding space is provided. Large groups make it harder to observe individual piglets and identify problems. Higher stocking densities can increase stress, trigger disease and lower performance.

How much space?

Pigs understocked at weaning are often overstocked before they move to the next shed. When assigning pigs to a pen, you need to ensure that enough space is available so that they won't be overstocked at the end of their stay in that pen. Less space is needed on slatted than on solid floors, particularly if the pigs have easy access to feed and water. Minimum and recommended space allowances are shown in Table 3.6.

TABLE 3.6 Minimum and recommended space allowances for weaner pigs in conventional pens and deep litter housing

	Pens with 1/3 slatted, 2/3 solid floor		Deep litter housing
Pig weight (kg)	**Minimum space allowance (m^2/pig)***	**Recommended space allowance (m^2/pig)^**	**Minimum space allowance (m^2/pig)* [1]**
6	0.10	0.16	0.13
8	0.12	0.19	0.16
10	0.14	0.22	0.18
12	0.16	0.25	0.21
14	0.18	0.28	0.23
16	0.19	0.30	0.25
18	0.21	0.33	0.27
20	0.22	0.35	0.29
22	0.24	0.37	0.31
24	0.25	0.40	0.33
26	0.27	0.42	0.35
28	0.28	0.44	0.36
30	0.29	0.46	0.38

Source * *Model Code of Practice for the Welfare of Animals (Pigs) 3rd Edition (2008)*
Source ^ *Pigs RSPCA Approved Farming Scheme Standards August 2011*
[1]Higher space allowances may be necessary for optimal litter management

Begin with the end in mind

Stocking rates, feeder spacing, water access points etc., should be determined using the exit weight as the determinant. The following equations can be used to determine the ideal stocking rate for your piggery.

For conventional pens (one third slatted, two thirds solid floor)

Minimum space requirement = 0.03 x liveweight at exit $(kg)^{0.67}$

Recommended space requirement = 0.047 x liveweight at exit $(kg)^{0.67}$

For deep litter housing systems (eco-shelters)

Minimum space required = (0.03 x liveweight at exit $(kg)^{0.67}$) x 1.3

If your pigs are not reaching their target exit weights (e.g. >30 kg at ten weeks of age), it is likely that floor space, feeder space and/or water access is a limiting factor. Use your target exit weight (rather than your current exit weight) in the above equations to determine the appropriate stocking rate.

When pigs are weaned into eco-shelters, temporarily partitioning off some of the shelter furthest from the feeders (e.g. using straw bales) can help pigs maintain temperature and condition. The partition can be removed to accommodate the increasing space required by older or heavier pigs.

Preventing dirty pens

Pens can often be dirty, even with the highest standard of management. The reasons could be:

- Incorrect stocking rates (too many or too few)
- Poor ventilation
- Pens which do not encourage dunging in one area
- Insufficient slatted area
- Rough floors which encourage pigs to sleep on the 'smooth' slatted area and to dirty solid areas.

Rectify the problems by:

- Placing sawdust on the 'clean' area before pigs move in
- Improving the shed environment
- Placing sprinklers over the slatted area
- Giving easy access to food and cool water
- Providing 'toys' for pigs
- Mixing familiar pigs only.

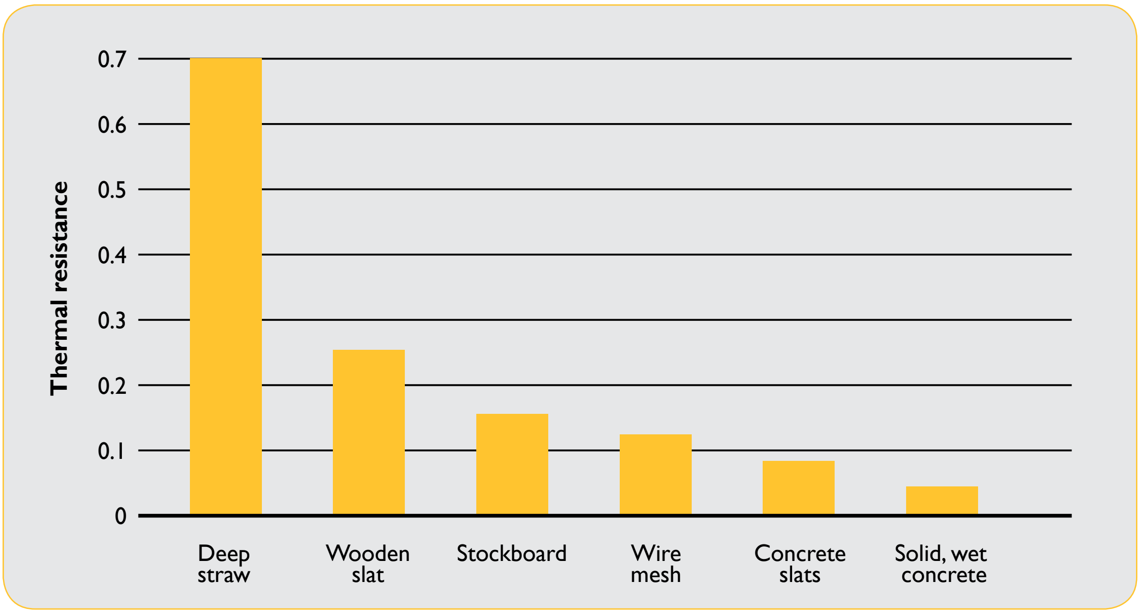
7 Weaner Housing

Weaners should be housed in a separate building or section. This means that temperature and ventilation can be set for their specific requirements, and it protects their health by isolating them from farrowing and grower sheds. In an all-in/all-out system, keep them away from other groups of weaners.

Floor type is very important. Flooring must be easy to clean, enable faeces to be cleared, be warm enough, and prevent foot lesions. Deep bedding will retain heat much better than a concrete floor because of its superior thermal properties (Figure 3.3). Rubber matting will minimise heat loss and can easily be removed for cleaning before new pigs move in.

After weaning, piglets prefer to lie on solid floors and against solid walls. Growth rates are improved by covering a third of a wire mesh floor with wood, stockboard or rubber matting. Floor type seldom affects pig performance, but floors that limit access to feed and water because they are slippery, have wide gaps or are not well maintained, certainly will.

FIGURE 3.3 Insulating properties of flooring materials



There are many weaner accommodation designs covering the needs of various management systems. The one chosen must take into account the minimum age/weight of pigs at weaning, as the smallest piglet is the most susceptible to a poor environment. The following describes three examples of housing common in the industry, and highlights important principles of weaner housing.

7.1 Environmentally Controlled Weaner Sheds

This accommodation automatically controls the environment. The weaner pens have fully slatted floors with a solid area (e.g. rubber matting) sometimes provided for newly weaned pigs. Larger units may have several weaner rooms that are completely de-stocked and cleaned between batches.

Advantages

- The temperature can be set to meet the pig's exact requirements.
- The shed makes feeding easy.
- It improves pig observation and inspection.
- It reduces the risk of scours by separating the pig from its dung.
- It makes it easier to install water medication systems.

Disadvantages

- It is expensive to operate and build.
- Every part of the control system must work correctly, so it requires careful monitoring.
- A backup system may be needed to cater for power failures.
- Inadequate ventilation may result from trying to maintain a constant ambient temperature.
- Pigs do not have the opportunity to select their own micro-climate.
- Need for alarms to alert issues and temperature control.

7.2 Weaner Kennels

Weaner kennels offer the pig a choice of environments. An enclosed insulated sleeping section is provided, with a minimally controlled outside area for feeding. Some are straw-based, some are not, and portable kennels can be moved to a clean site when batches are changed over.

Advantages

- The system is less sophisticated, so it is cheaper to build and operate than environmentally controlled weaner sheds.
- The kennels rely less on automatic control and give the pig more choice.
- Straw bedding can be used.

Disadvantages

- It is harder to observe the pigs.
- Weaners may be less inclined to go to the feeder if it is located outside the kennel thereby reducing feed intake.
- It is harder to move pigs to the next pen type.
- It may not be suitable for pigs weaned at less than two weeks old.
- Dust levels are high.

7.3 Eco-shelters

Eco-shelters (or barns) have become a common housing option for newly weaned pigs. Eco-shelters are an open plan deep litter flooring system (using rice hulls, straw, wood shavings or similar).

Advantages

- The system is less sophisticated, so is cheaper to build and operate.
- Eco-shelters rely less on automatic control and give the pig more choice.
- Bedding can be used.
- Pigs have more control of managing their micro-climate.

Disadvantages

- Large numbers of pigs make it more difficult to provide individual pigs with extra care or to manage disease outbreaks.
- Bedding can be a source of contamination (e.g. mycotoxins, pollutants).
- Greater variation in growth rate within a batch.
- Bedding can be expensive and needs to be topped up continuously.

Contact commercial suppliers for more information on weaner accommodation options.

8 Health and Hygiene

To maintain health status (the range and prevalence of specific diseases in a herd), it is first essential to identify the diseases present (or absent). High health status herds have few diseases and these are well controlled; in contrast, low health status herds have many diseases that are under poor control.

Disease outbreaks are usually caused in two ways:

- An introduction via contaminated stock, vehicles, people, dogs, rodents, birds or other living creatures; or
- When a change of routine or management allows an existing disease to flourish.

Most diseases are spread between pig farms by pigs. People, rodents, feral animals, domestic pets and wind can also be culprits. Prevention is better than cure, and the following methods are effective:

Isolation

Maintain a minimum buffer of three kilometres around the piggery to guard against windborne infection from other pigs. Make sheds bird-proof, keep pets and feral animals out, and control rodents.

Movement control

When buying in breeding stock, consult your veterinarian and 'disease match' your herd with that of the supplier's (i.e. only buy from herds with a similar or better health status than your own). Never let pigs return to the herd from the loading area, make sure that trucks entering your farm are clean and empty of pigs, and burn or bury all dead animals. For more information visit Animal Health Australia http://www.animalhealthaustralia.com.au/ or the Farm Biosecurity website www.farmbiosecurity.com.au/.

Manage gilts

Increased exposure of gilts to endemic farm pathogens will improve their potential for passive immune transfer to their progeny. Exposure strategies need to be devised in accordance with current state swill feeding restrictions. Work with your veterinarian to develop and document an effective gilt immunity program.

Quarantine

It is recommended for every farm to have quarantine facilities. A quarantine shed is used to keep the new stock separated from the existing stock for a suitable period (e.g. preferably 60 days or more) to monitor disease outbreak. This will help the farm prevent the introduction of new disease. Ideally the quarantine facility should be at least three kilometres from the breeder site. For more information on quarantining gilts visit fact sheets on APL's website.

Control of people and vehicles

Limit non-essential visitors' entry to the farm and supply boots and overalls for those who do enter. Do not employ staff who have contact with other pigs and do not allow staff to own pigs or come into contact with any other pigs (including feral pigs). Place a minimum isolation time before visitors in contact with other pigs can enter. If there is any doubt, extend the isolation time or have them take a shower.

Management controls to maintain good herd health

It requires careful management to maintain good herd health. Remember that stocking rates, hygiene, water pressure, ventilation and shed temperature have as much impact on the pig as the pathogen. These four steps will maximise weaner hygiene and control existing diseases:

1. Organise throughput carefully

Badly regulated pig flow can lead to overstocking, put pressure on facilities, and make complete cleaning routines very difficult.

2. Use an all-in/all-out management system

Completely empty a room, or preferably a building, to enable thorough cleaning, reduce disease transfer between younger and older pigs, and improve air quality. The basic principle is to keep the 'same age animal' under the same airspace. If it is not possible, at least keep the age gap between batches as narrow as possible.

3. Clean and disinfect pens thoroughly between batches

Take out all movable items such as feed troughs and clean them separately. Remove all loose dung and other organic materials from the pen walls and floor. Hose down walls and ceilings to remove dust and soak pen with water and detergent. Soak very dirty pens for 24 hours. Pressure clean, using a minimum of 1000 psi. Take care not to chill piglets and weaners in adjacent pens. A removable shower curtain can be a useful barrier to prevent splashing and spray drift. Spray the roof, walls and floor with a good disinfectant (used at recommended dilutions), making sure that all electrical leads/points are covered. It is advisable to alternate the disinfectants used.

4. Take care when re-populating cleaned pens and houses

Ensure that all surfaces are completely dry and no disinfectant remains, that the room is at the right temperature, and feed and water are readily available.

9 Preventing Weaner Deaths

The majority of deaths in the growing herd tend to occur in the weaner phase. For every 1% increase in mortality rate, returns drop by $10/sow/year. Take urgent action if weaner deaths exceed 1.5%.

Weaner health can be improved if this routine is followed daily:

- Check weaners and ensure they get up and feed
- Keep the water flow rate at 0.5 litres/minute minimum
- Check sick pigs and note their symptoms
- Move all sick pigs to a hospital pen
- Treat sick pigs immediately
- Consider the pigs' welfare and euthanase non-viable pigs
- Examine or post-mortem all dead weaners
- Ensure vaccination routines are maintained and carried out properly
- Check levels of Vitamin E and selenium in sow and weaner diets to ensure that they are adequate.

10 Weaner Diseases

Common diseases that can affect weaners include:

- Colibacillosis (haemolytic/non-haemolytic)
- Porcine Circovirus Type 2 (PCV2)
- Oedema Disease
- Salmonellosis
- *Streptococcus* Meningitis and Arthritis
- Glässers Disease
- Mulberry Heart Disease
- Skin diseases such as Greasy Pig Disease, Mange and Swine Pox.

10.1 Weaner Scours *(Colibacillosis)*

Weaner scours is an industry problem requiring urgent action on-farm. *E. coli* is the main cause of scouring, particularly in the three weeks after weaning. Up to 50% of pigs can scour and about 25% of affected pigs may die. *E. coli* scours can increase death rates by 3–6% and lower growth rate and subsequently reduce profits by $50–$100/sow/year.

Cause

Pathogenic strains of *E. coli* bacteria are responsible for colibacillosis. They are able to attach to the intestinal wall where they can also produce toxins. Both of these properties of *E. coli* can cause diarrhoea in young piglets.

Signs

Watery clear diarrhoea is the signal of colibacillosis. The colour may vary from white to yellow depending on ingesta and duration of the disease. Body temperature is often subnormal, and shivering may be noticed. If diarrhoea continues, there is progressive dehydration and hair coat becomes roughened. Piglets die due to severe dehydration and septicaemia.

Diagnosis

Clinical signs and post-mortem lesions are useful but not definitive. For confirmatory diagnosis a sample of fresh diarrhoeal fluid, rectal swabs, or intestine with contents can be sent to a diagnostic laboratory. This should be done in consultation with your veterinarian.

Treatment

Treating clinically ill piglets is not always a useful option. Supportive treatments with electrolytes in drinking water might be helpful. Husbandry and management to minimise the likelihood of infection are more important than treatment.

Control and prevention

As many as possible of the following measures should be taken for control and prevention:

- Ensure piglets are getting enough colostrum after birth
- Keep weaner accommodation warm and dry
- Maintain a constant temperature with less than 2 °C fluctuation
- Wean from 21–28 days old, and at more than 6 kg liveweight
- Feed highly digestible creep diets before weaning
- Avoid diet changes in the immediate post-weaning period
- Use all-in/all-out weaner systems
- Mix litters before weaning
- Reduce stocking rates
- Provide clean, fresh water
- Provide electrolytes for scouring piglets
- Vaccinate weaners if *E. coli* is involved
- Ensure diets have a low acid-binding capacity
- Acidify the water supply and creep/starter feed
- Include inorganic zinc (e.g. ZnO at 3 kg/T or potentiated ZnO at 300 g/T) in the diet or an effective alternative
- Consider temporary use of low protein creep/starter diets.

10.2 Porcine Circovirus Type 2 (PCV2)

Porcine Circovirus Type 2 is a viral disease which is common in most pig herds globally. PCV2 is an immunosuppressive disease which means an infected pig becomes immune-compromised and, as a result, is at a greater risk of developing other diseases.

Cause

PCV2 is caused by a very small DNA virus. Transmission is believed to occur via oral and nasal routes, and possibly as an aerosol.

Signs

The symptoms of PCV2 in pigs vary greatly from high levels of mortalities, poor growth and weight loss (progressing to the level of severe weakness between 5–14 weeks of age) to absolutely no symptoms whatsoever. Other symptoms include enlarged lymph nodes, skin rashes, difficulty breathing, jaundice, fever, stomach ulcers, diarrhoea or sudden death. Most pigs are infected with some level of PCV2, whilst not all exhibit clinical signs. In Australian farms, mortality and morbidity of the disease are usually undetected, however, subclinical conditions of the disease may be evident by severe reductions in performance.

Diagnosis

As the clinical signs can be highly variable, the method of diagnosis needs to be discussed with your veterinarian and is likely to include herd examination, several autopsies, and tissue and blood sample collection for diagnosis of PCV2 and any associated diseases.

Treatment

Treatment is generally focused on the secondary disease which has been caused by the immune-suppression arising from PCV2. Treatment options should be discussed with your veterinarian on a case by case basis.

Control and prevention

Effective vaccination programs should be developed with your veterinarian. Maintaining high levels of immunity will help reduce the potential for clinical PCV2 to develop within a herd. Any steps taken to improve hygiene and reduce stress will help reduce the impact of PCV2 on a herd and include:

- Cleaning and disinfecting pens prior to use
- Lowering stocking densities
- Using solid partitions between pens, especially between pigs of different ages
- Allowing adequate space for feed and water
- Avoiding out-of-feed events at all times
- Managing air quality and temperature
- Minimising mixing events.

10.3 Oedema Disease

Oedema disease usually occurs one to four weeks post-weaning. It kills healthy, fast-growing pigs up to 12 weeks of age. The disease is much less common than *E. coli* scours but occurs sporadically in some herds, sometimes with post-weaning scours.

Cause

Oedema disease is an acute, often-fatal, enterotoxaemia caused by a few serotypes of *E. coli*. These *E .coli* produce a powerful toxin which damages blood vessels including those found in the brain.

Signs

Key signs are sudden death in fast-growing pigs, sudden nervous onsets (related to lesions in the brain), and apparent blindness. Pigs have trouble standing and end up on their sides, convulsing. Also expect swollen eyelids and a high pitch squeal.

Diagnosis

It is often characterised by fluid retention in the stomach wall and in tissue around the large intestine. Excess fluid in body cavities is common. Collect sections of small intestine as per your veterinarian's instructions from dead pigs for laboratory examination. It is necessary to rule out *E. coli* scours, Mulberry Heart Disease and heliotrope poisoning as causes of sudden death. *Streptococcus suis* Meningitis and Glässers Disease also cause nervous signs.

Treatment

Little can be done to treat affected pigs.

Control and prevention

Controlling oedema disease can be frustrating. No prevention method is universally accepted or successful. The following general strategies should be considered for control in the affected herd:

- Minimise environmental stresses (e.g. temperature variation, damp conditions, draught, limited mixing and movement)
- Use all-in/all-out systems
- Nutritional considerations including creep feeding, feeding small quantities at regular intervals directly after weaning
- Acidifiers added to water and/or feed
- Decreased protein in the diet while still feeding adequate levels of amino acids, and the addition of extra zinc, plasma protein or fibre to the diet
- Antimicrobial intervention to find the sensitive agents acting against the bacteria
- Introduction of genetically disease resistant pigs
- In consultation with your veterinarian, vaccinate sows and/or suckers.

10.4 Salmonellosis

Cause

Salmonellosis is a disease caused by any of more than 2000 *Salmonella* serotypes. Only few serotypes cause disease in pigs. Pigs can be affected at any stage from nursery to grower-finisher.

Signs

Morbidity is usually low to moderate. Acute illness with marked depression and fever (up to 41.6 °C) is common and death occurs within 24–48 hours in a group of apparently thrifty pigs. Inappetence and weakness may also be observed. Nervous signs may occur in pigs; these animals may also suffer from pneumonia. Mortality may reach 100%. Diarrhoea is not common but nursing pigs may develop diarrhoea, and usually succumb to generalised septicaemia. Red to purple discolouration of skin of the extremities is developed due to septicaemia. Weaner or grower-finisher pigs show signs of a fever and have liquid faeces that may be yellow and contain shreds of necrotic debris.

Diagnosis

The history, clinical signs and typical post-mortem lesions might be adequate for tentative diagnosis. Laboratory diagnosis is recommended for confirmatory diagnosis. Salmonellosis has to be differentiated from other coliform Enteritis, Proliferative Enteritis, Trichuriasis (whipworm) and Swine Dysentery.

Treatment

Medication with antibiotics may reduce the mortality as well as severity of the disease. Antibiotics should be used judiciously and selected cautiously because many have lost efficacy due to bacterial resistance.

Control and prevention

Controlling Salmonellosis is important not only for pig production but also for human health. Pigs may serve as a source of *Salmonella* infection to humans via contaminated pork products, so efforts to reduce *Salmonella* in the food chain are a high priority for the industry. Good husbandry practices are essential. Standard biosecurity and hygiene protocols, and a vaccination program, should be in place. Sourcing stock from a single source is advisable. Stress due to transport, low or high temperature, overcrowding etc., should be minimised. Feed can be tested to reduce *Salmonella* contamination.

10.5 *Streptococcus* Meningitis and Arthritis

This is the most important streptococcal infection of pigs and is usually seen in nursing or recently weaned piglets. Meningitis is inflammation of the tissue lining of the brain.

Cause

Streptococcus Meningitis is caused by a bacterium called *Streptococcus suis*. These bacteria also cause arthritis, serositis and pneumonia. The disease is most prevalent in four to ten week old weaners, and is rarely seen in older pigs. Annual deaths from the disease are low (0.1–0.3% in infected herds). More than 70% of herds contain pigs that harbour *Streptococcus suis* in their tonsils.

Outbreaks of *Streptococcus* Meningitis often follow periods of stress like sudden temperature fluctuations, cold weather, regrouping and moving. Many die suddenly during an outbreak. Overstocking, high humidity, poor ventilation, and dirty and dusty sheds also contribute to outbreaks, which are more common in continuous flow production systems where pigs of different ages mix in the same space.

Signs

Signs are trembling, a staggering walk, unable to stand, and pigs lying on their side and paddling. A few may die suddenly. Pigs deteriorate rapidly, stop eating and have an elevated body temperature (up to 42 °C). Signs of incoordination (unable to walk properly) are followed by paralysis (unable to stand), paddling (lying on side moving legs back and forth), tetanic spasms (violent movements when disturbed) and death.

Pigs with Meningitis usually squeal when picked up and they do not always fall over to the same side like pigs with middle ear infections. Pigs with arthritis have swollen joints and are lame.

Diagnosis

Tentative diagnosis can be made on the basis of clinical signs and post-mortem lesions. Confirmation should be made by laboratory diagnosis. This bacterium can infect humans, so care should be taken when handling infected pigs. Whilst *Streptococcus suis* is the most common cause of arthritis in weaner pigs, other bacteria (e.g. *Actinobacillus suis, Haemophilus parasuis, E. coli*, *staphylococci* and *Mycoplasma hyosynoviae*) can also be the cause.

Treatment

Treat early to aid recovery. Discuss a treatment program with your veterinarian. Treat affected pigs two to three times a day for three days. Anti-inflammatory drugs may assist recovery.

In herds with a chronic problem, check if penicillin-resistant strains are present. North American surveys have found resistant strains on up to 28% of farms. Affected pigs should be held up to a nipple drinker or given water from a hose twice a day.

Control and prevention

Control Meningitis of weaner pigs by:

- Avoiding high stocking rates
- Strict sanitation of facilities
- Ventilating the shed adequately
- Avoiding unnecessary moving and mixing of pigs
- Maintaining an even temperature in the weaner house (limit fluctuations to 2 °C per 24 hours)
- Reducing high humidity levels
- Operating an all-in/all-out weaner system
- Cleaning pens thoroughly between batches
- Supplying adequate, fresh and clean water containing medium chain fatty acids
- Treat as per your veterinarian's recommendation.

10.6 Glässers Disease

An infectious disease of pigs occurs sporadically in herds, usually observed in pigs from three weeks of age up to four months of age.

Cause

Glässers Disease is caused by the bacterium *Haemophilus parasuis*. Neonatal pigs are exposed to the bacterium but are usually protected by antibodies present in sows' colostrum.

Signs

Onset of Glässers Disease is usually sudden. Signs may include tremors, incoordination and posterior paresis or lateral recumbency. A low appetite, high body temperature, swollen joints and respiratory distress may also be noticed. Sudden death may occur at any age group.

Diagnosis

A tentative diagnosis can be made on the basis of history, clinical signs and post-mortem lesions. Confirmatory diagnosis is made by culture of *H. parasuis* from the sample of serous membrane, cerebrospinal fluid, joints or other tissue. It must be differentiated from other nervous system signs, septicaemia or arthritis.

Treatment

The course of the disease is often short and many of the sick pigs will die if untreated. Sick animals should be treated promptly with antimicrobials. Sensitivity of the drug should be checked if possible.

Control and prevention

Prevention can be achieved by following sound husbandry, control of primary diseases, and prophylactic use of antimicrobials and vaccination. Acclimatisation and vaccination of breeding stock has been of some benefit on some farms. Minimising stressors associated with weaning and the nursery environments should be emphasised.

10.7 Mulberry Heart Disease

Mulberry Heart Disease kills growing pigs between 4–16 weeks old, but can occur at two to three weeks. The condition is named after the mottled appearance of the heart muscle in affected pigs.

Cause

Mulberry Heart Disease has been traditionally associated with Vitamin E deficiency. Although outbreaks have been recorded in pigs with Vitamin E-deficient diets, and pigs with low levels of Vitamin E in heart muscle, cases have occurred when adequate diet levels are fed.

This disease is more common in faster growing pigs and appears more prevalent in certain blood lines. The level of polyunsaturated fatty acids (PUFA) and peroxidases in diets plays a role. Death patterns vary between herds but sporadic deaths are more likely than large numbers.

Signs

Pigs are often not eating, are unable to stand and have severe breathing difficulties. Most affected pigs die, but for those that survive the carcase is usually in good condition.

Diagnosis

It is best to use a post-mortem to obtain a diagnosis. Body cavities (chest, stomach cavity and heart sac) contain excess fluid. The heart sac fluid may clot, and the heart has areas of haemorrhage (bleeding) which look like paint brush marks or mulberries (a massive bleed). Haemorrhages may not be obvious, but small areas of the heart muscle look paler than surrounding areas.

Provide the laboratory with sections of heart muscle in normal saline and fresh heart muscle and liver. Check diets for selenium, Vitamin E, PUFA and peroxidases, and pigs for selenium, Vitamin E and lipid peroxidation levels. This will help diagnosis and indicate a course of action.

Treatment

Individual treatment is not always effective. Correction of the diet on the basis of diagnosis would be helpful in preventing further cases.

Control and prevention

Ensure that dietary levels of Vitamin E and selenium are adequate in dry and lactating sow diets, weaner diets and grower diets. Sow diets are important as the level of Vitamin E in sows' milk determines the level of Vitamin E in pigs at weaning.

Recommended Vitamin E levels vary from herd to herd. Levels of 35 g/T (or higher) in sow and weaner diets will be beneficial. For grower diets, use 20–25 g/T or higher if more than 5% oil is used. Diets with 0.3 ppm selenium are recommended for pigs during the two weeks post-weaning, reducing to 0.1 ppm by market weight.

The level of PUFA in the diet depends on ingredients used. The recommended ratio of Vitamin E to peroxidisable PUFA (mg/g) is greater than six, so PUFA level increases should be matched by increases in Vitamin E levels. The level of peroxidases in feed will also increase the requirement for Vitamin E. Your veterinarian or nutritionist can arrange for the correct assays needed to check these factors.

10.8 Skin Diseases

Greasy Pig Disease is caused by the bacterium *Staphylococcus hyicus* and is highly infectious. The toxins produced by this bacterium can result in damage to the liver and kidneys of the pigs and subsequently reduce growth rates and cause deaths. The outbreak can be triggered by humid weather, Mange, fighting or skin abrasions coupled with low supplies of sows' milk. The inflamed skin is damp, oily, crusty or dirty, and dehydration is common.

Mange is a parasitic disease caused by one of two mites, *Sarcoptes scabiei* or *Demodex phylloides*, with the former being the most common cause. Mange affects the production of growing pigs, with mild forms reducing growth rates by 5%, and severe forms by as much as 25%. Rubbing and scratching are the most common signs.

Swine Pox is a viral disease from the Poxviridae family. It shows as small, round, crusty lesions often confused with insect bites. Lesions are most common along the abdomen, inside the legs and in the inguinal areas (crotch). Outbreaks of swine pox may accompany Mange and Greasy Pig Disease.

Control skin diseases in weaners by:

- Treating sows pre-farrowing for Mange
- Checking crates and weaner pens for damaged floors or sharp objects which could injure weaner pigs
- Checking piglets, weaners and growers for red pimples and rubbing
- Providing good ventilation (below 65% humidity) to avoid Greasy Pig Disease
- Ensuring teeth are properly clipped after birth
- Maintaining the recommended stocking rate.

11 The Best Creep and Weaner Diets

Diets for weaned pigs are aimed at:

- Maximising growth (aim to produce pigs of 30 kg liveweight at 70 days of age);
- Providing adequate nutrients;
- Developing the digestive enzyme and acid systems so that piglets can make a smooth transition to solid feed without stress;
- Supporting the developing immune system of the young pig for long term gain; and
- Minimising risk of post-weaning scours.

Here are seven steps which will help you meet these objectives:

1. Give creep feed;
2. Provide sufficient nutrients;
3. Feed for higher intake and fewer post-weaning scours;
4. Supply plenty of fresh water;
5. Use the highest quality ingredients;
6. Use the right feeders; and
7. Use feed additives.

11.1 Give Creep Feed

Creep feed is dry, solid feed given to suckling pigs before weaning. It gets piglets accustomed to eating dry feed and supplements the nutrients contained in the sows' milk to encourage growth. Creep feed intake is highly variable both within and between litters.

Benefits of creep feeding are often hard to detect. Creep feeding is more beneficial when weaning later than 21 days of age and/or when sows are supporting larger litters (>12 pigs). Gilts tend to maintain smaller litters (both in terms of weight and number) and these may therefore consume less creep feed, however, the potential benefits to the immune system are likely to be greater in gilt progeny.

Creep feed can be a source of bacterial and feed antigens. An antigen is a substance which when consumed can cause the body to make antibodies (i.e. stimulate an immune response). Providing creep feed allows for the piglets' immune system to develop appropriate immune responses to these antigens whilst still protected by maternal antibodies present in sows' milk.

Hypersensitivity can cause detrimental changes to the pig's intestine. Anti-nutritional factors including trypsin inhibitors, tannins and lectins can also limit protein digestibility and result in unfavourable changes to the microflora; increasing the risk of post-weaning diarrhoea. To avoid the risk of hypersensitivities, raw materials and milling processes should be selected carefully.

Creep feeds generally contain high quality raw materials and is the most expensive diet in the whole piggery. Creep feed wastage can also be considerable, however, in the overall cost of production, creep feed contributes less than 1% of the total production costs (including sow feed costs).

Factors affecting the intake of creep feed include:

- Stage of lactation (peak milk yield is generally around day 14–18)
- Season (extreme summer temperature can limit sow milk output)
- Length of exposure to feed (it generally takes around three days for pigs to become accustomed to creep feed)
- Litter size (larger litters (>10 pigs) have a higher total nutrient demand)
- Sow age (first litter sows and older sows, i.e. greater than parity five or six, can be less efficient at partitioning nutrients into milk production).

Growth performance benefits arising from creep feeding are often questionable, however, for piglets weaned later than 21 days, creep feeding of larger litters (especially in summer) can improve weaning weight, growth rates and health post-weaning, and reduce stress at weaning. It helps the older piglet maintain good growth as the sows' milk starts to taper off, and it stimulates the digestive system.

During the first few weeks of life the piglet's ability to convert sows' milk/feed into gain (lean meat) is at its most efficient. The young pig has the potential to achieve a feed conversion of 1:1 or better, i.e. for every 100 g of feed consumed 100 g of weight gain will be achieved. So even though feed intake may be low and seem insignificant, the conversion into gain is very efficient.

Research conducted by Edwards et al. (2011) showed that by offering creep feed for eight days prior to weaning at day 28, total removals in the nursery between day 28 and day 68 could be reduced by about 50% (P=0.07), with the greatest advantage seen in the progeny of gilts (Table 3.7). The immune competence of gilt progeny is inferior to sow progeny. Exposing piglets to creep feed appears to enhance the immune competence and reduce the disease susceptibility of pigs. Creep feeding should be adopted as an investment strategy to assist in the maturation of the intestinal immune system.

TABLE 3.7 Influence of dam parity and pre-weaning creep feed exposure (day 19–day 27) on mortality and morbidity within the nursery phase (day 28–day 68) (Edwards et al., 2011)

	Progeny	Mortality	Morbidity	Total removals*
Not Creep Fed	Gilt	10	5	15
	Sow	2	4	6
Creep Feed for 8 days	Gilt	8	0	8
	Sow	0	3	3

* Pigs which were removed from the experiment due to either mortality or morbidity

Introducing creep feed

Give piglets their first creep feed 10–12 days prior to weaning, about two hours after the sow has eaten and the piglets are not asleep or suckling. Offer them small amounts on a clean, dry section of the floor (or on a wooden board if floors are slatted). Do not offer more than 20 g/litter/day for three or four days until the pigs are obviously eating, then use a small feeder which allows several pigs to feed together.

A heavy, shallow, circular trough is ideal, as a fairly large litter can use it and the creep feed is both visible and accessible. Feeding frequency and the amount of feed offered should be increased throughout lactation. Creep feeding is labour intensive, but has important long term benefits.

Keep it fresh

Little and often is the rule. Creep feed must be supplied every day so that it is fresh and its regular arrival stimulates the piglets' curiosity and encourages them to eat it. Creep feeds should only contain high quality raw materials and should not be stored for long periods (e.g. less than two months). The inclusion of antioxidants, acidifiers, mould inhibitors and mycotoxin binders in the creep feed can help maintain the integrity of the feed.

How to present creep feed

Piglets tend to prefer crumbled creep feed or short pellets (2.5 mm diameter or less), eating more and wasting less than they do with conventional pellets. Feeding a mash diet is not advisable for pigs younger than five weeks of age. Keep the feeder away from the side of the pen so piglets are less likely to dung in it. Fouling and wastage is lessened if the feeder is raised 10 cm from the floor.

Water access

Piglets need water as well as sows' milk when creep feeding. Place 'bite-type' nipple drinkers in the farrowing pen. Use similar types of nipple drinkers in the weaner accommodation. This also allows piglets to become familiar with the drinkers and their use by the time they are weaned. Also make sure the drinkers are located at a level that all pigs can reach comfortably.

Creep feed composition

The feed should be very digestible and palatable. It should contain a broad range of raw materials at low to moderate inclusion rates. Ideally, high quality milk products (e.g. skim milk powder, whey powder, buttermilk, lactose) should be included, as well as energy-rich cooked cereals (e.g. groats, biscuit meal). Table 3.8 outlines some recommended inclusion limits of different raw materials used in creep diets. The level of complexity and expense will be related to the weaning age, weaning weight, parity profile and disease status on your farm. Raw material availability and pricing will also dictate how closely the recommendations are followed.

TABLE 3.8 **Recommended inclusion rates of raw materials in creep feed diets**

Ingredient type	Examples	Young weaning age (<28 days), light weaning weight (<8 kg) or high proportion of gilt progeny or high disease risk	Older weaning age (>28 days), heavier weaning weight (>8 kg) or low proportion of gilt progeny or low disease risk
Grains	Wheat Barley Triticale Oats Maize Sorghum	Wheat is the preferred grain. Barley inclusion at 7–15% can provide addition fibre related benefits. Other cereals can be included at low (<5%) levels if necessary.	Wheat is the preferred grain. Barley inclusion at 7–15% can provide addition fibre related benefits. Low inclusion levels (<10%) of other grains is recommended especially if they are used in the weaner diet.
Milk products	Skim milk powder Whey powder Lactose Casein Buttermilk	15–20%	5–10%
Cooked cereals	Biscuit meal Groats Extruded wheat	15–30%	10–20%
Pulses	Peas Lupins Lentils Chickpeas	Peas only, maximum 10%	Peas preferred but maximum total legume should not exceed 10%
Plant proteins	Soya bean meal Full fat soya Soy protein concentrate Soy protein isolate Canola meal	Canola meal should be avoided. Soya bean meal should be limited to 5–8%. FFS and SPC/SPI are preferred.	Canola meal maximum 3%. Soya bean meal maximum 8%
Grain by-products	Mill mix Rice pollard	Best avoided	Minimise inclusion
Animal proteins	Meat meal Blood meal Fish meal Plasma protein	Meat meal and fish meal minimum inclusion 3% each. Blood meal maximum 2%. Plasma protein recommended at 3–5%. N.B. Blood + plasma protein should not exceed 5% total.	Meat meal and fish meal minimum inclusion 3%. Blood meal maximum 2.5%. Plasma protein recommended at 2–4%. N.B. Blood + plasma protein should not exceed 5% total.
Enzymes	NSP enzyme Phytase enzymes Protease enzymes Lipase enzymes	Include enzymes at the recommended rate. Phytase enzyme should be included when phytate bound phosphorous >0.17%	Include enzymes at the recommended rate. Phytase enzyme should be included when phytate bound phosphorous >0.17%

Because intake is low, nutrient levels should be concentrated (0.95 g available lysine/MJ DE; 15 MJ DE/kg). It is important to ensure bitter or unpalatable raw materials are avoided or their use minimised.

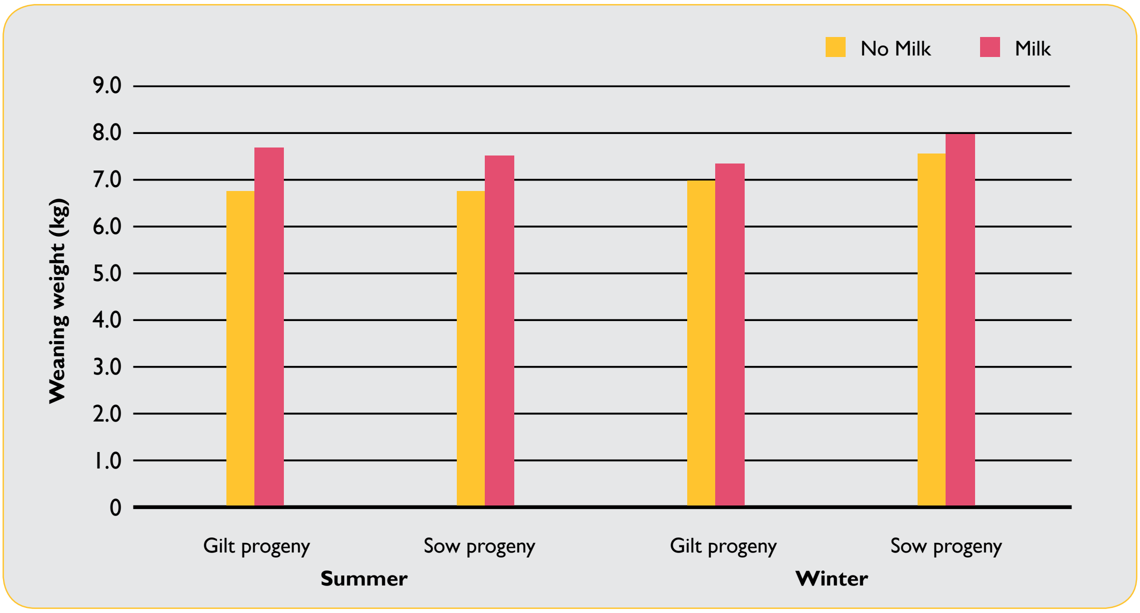
The same creep feed should continue to be offered for at least five to seven days post-weaning. Maintaining the same diet will eliminate the stress of having to cope with a nutritional adjustment as well as all the other challenges associated with weaning.

Research by Wilkinson et al. (2013) has shown that the dietary balance of omega-6 (n-6) to omega-3 (n-3) is important in the diets of pigs including weaning pigs. A high ratio of n-6:n-3 has been shown to cause appetite suppression in weaner pigs, causing reduced performance. Ideally diets should be formulated with the n-6:n-3 ratio included in the specification. The recommended ratio is 10:1 or less. Fish oil or algal products can be added to diets to improve the ratio.

Using milk as a supplement

The decision to use supplemental milk needs to be evaluated carefully from an economic and labour stand point. Miller et al. (2012) showed that supplemental milk can have a greater impact on piglet weaning weight during summer compared to winter (Figure 3.4).

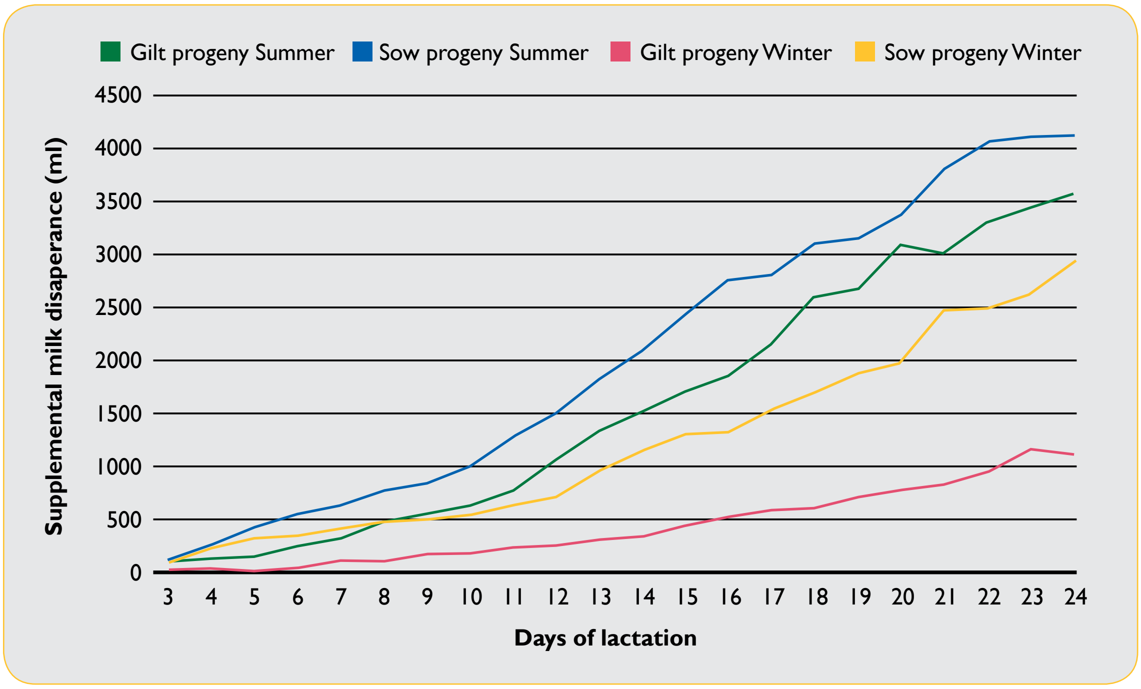
FIGURE 3.4 Influence of supplemental milk (day 3 to day 28) on the weaning weight at day 28 of gilt and sow progeny during summer and winter (Miller et al., 2012)



Supplemental milk disappearance was also greater during summer (Figure 3.5) with litters consuming up to 4 L of milk per day at day 28 of lactation.

CHAPTER 3 THE WEANER PIG

FIGURE 3.5 Average daily supplemental milk disappearance (apparent intake) per litter (mL/litter/day) among gilt and sow litters in winter and summer (Miller et al., 2012)



Make sure the milk is fresh and not allowed to sour. Preservatives, e.g. a 3% solution of hydrogen peroxide, added at a rate of 10 ml/L, can improve the milk's shelf life. Piggeries close to a dairy may be able to buy whole milk cheaply, but skim milk in powder form is easy to store and can be mixed at higher concentrations to give piglets a brew rich in solids.

Before adding supplementary milk, evaluate the cost. Assume:

- Each 0.8 kg increase in liveweight at weaning is worth 5 kg of carcase weight
- Milk contains 12% solids and converts at an efficiency of 0.8:1
- If a litter of 10 piglets is offered 3.2 L per day for 21 days, this equates to 6.7 L/pig or 67 L per litter. Assuming 20% wastage (6.7*0.8 = 5.36 L) this would convert to 0.8 kg liveweight. ((5.369 x 0.12) / 0.8) = 0.8 kg
- If you assume 9.5 piglets survive to market, the extra carcase value equates to:
  - 5 kg x 9.5 pigs x $2.40 net value ($3.20 carcase minus $0.80 feed costs) = $114
  - The breakeven value of the milk then is $114/67 L = $1.70/L or in other words, the supplemental milk (and associated labour and handling costs) should cost no more than $1.70/L.

CASE STUDY: Using artificial rearing systems to prevent pre-weaning losses

In smaller piggery operations where labour is often limiting and holding back sows can be challenging, the use of an artificial rearing system may help producers to limit financial losses. Each newborn piglet costs between $55–65. The greatest opportunity to capture profit is to increase performance of the bottom 30% of piglets. Whilst there are additional costs involved in rearing piglets artificially, the system will ultimately reduce piglet mortality, improve uniformity and increase the number of pigs sold. These systems can also help limit disease by allowing producers to wean pigs of a similar age.

A 500 sow unit in Victoria has installed two artificial rearing systems (Birthrite Deck™) in the piggery to use when numbers of fall-back piglets do not warrant holding back a sow or when crates are in short supply. Piglets are fostered into the crate (minimum of two days of age) and offered high quality creep feed and supplemental milk (both containing spray-dried porcine plasma). Most piglets are in the crate for a limited period of time, with some being returned to the sow prior to weaning.

The use of the artificial rearing system has allowed the piggery to keep up their all-in/all-out batching system, helping maintain their high health status, and reducing mortality and weaning weight variation. It was estimated that the pigs reared artificially are probably sold at breakeven costs after taking the cost of labour into account, however, this was considered better than not selling the piglet and losing $65 each time.

11.2 Provide Sufficient Nutrients

Following weaning, it is up to the producer to supply all of the pig's nutrient needs. As modern pigs grow fast and lean, the diet must provide plenty of amino acids and energy.

Digestible energy

High energy weaner diets (>15.0 MJ DE/kg) will cost more but will improve the performance of weaner pigs, enhance the feed conversion ratio, and have little impact on overall feed costs. Feed eaten by pigs between weaning and a weight of 20 kg is less than 6% of the total eaten by the herd.

Available lysine and other amino acids

Lysine is the first limiting amino acid for pigs. The pig's need for lysine is influenced by liveweight, energy intake, genotype (Table 3.9), environmental conditions and health status. When formulating a weaner diet, the first decision to make is its energy content. In ideal conditions modern lean genotypes have a high requirement for lysine to support optimal lean protein deposition.

TABLE 3.9 Influence of genetics on the optimum lysine/digestible energy (DE) (g MJ-1) ratio in pigs less than 25 kg bodyweight (van Lunen & Cole, 1996)

Genetics	Castrates	Gilts	Boars
Unimproved	0.78	0.80	0.83
Average	0.85	0.85	0.88
High	0.88	0.90	0.93

When pigs are under an immunological challenge (e.g. housed in less than optimal conditions) their lysine requirement is decreased as the partitioning of nutrients is shifted away from lean protein deposition and towards immunity (Williams et al., 1997). To ensure feed is used as efficiently as possible, minimise the risk of immune challenges through hygiene and health management. The newly weaned pig has the potential to convert feed at an efficiency of close to 1:1. Take the opportunity to capitalise on this ability.

Research by Kim et al. (2012) showed that the sulphur amino acid (methionine + cysteine) requirement for grower-finisher pigs was elevated by 20% in the presence of *E. coli* lipopolysaccharide challenge, established to mimic an immune challenge similar to that experienced by pigs in a commercial environment. A weaner pig study also showed 27% higher sulphur amino acid requirement when the pigs were experimentally infected with enterotoxigenic strain of *E. coli* (Capozzalo et al., personal communication). Similarly, Capozzalo et al. (2012) reported 28% increased requirement for dietary tryptophan relative to lysine in newly weaned pigs housed in commercial conditions. In addition, threonine requirement is also known to be increased by 10% when pigs are challenged by an immunological challenge, as production of threonine-rich mucus in the intestine is increased to reduce pathogen invasion.

11.3 Feed for Higher Intake and Fewer Post-weaning Scours

Sudden changes of environment and diet at weaning make *E. coli* proliferate in the gut and cause scours. If the weaned pig fails to eat, then overeats when hungry, the digestive system cannot cope and scours may result.

If protein passes undigested into the hind gut of the weaner pig and is fermented, the risk of diarrhoea is increased. Pepsin is the enzyme responsible for protein digestion in the stomach. Pepsin works best when the stomach is an acidic environment (pH 2.0–3.5). The acid binding capacity (ABC) of feed is a measurement of the feed's ability to neutralise feed/stomach acid.

To ensure the stomach remains acidic and protein is rapidly digested:

- Ensure the ABC of the diet is low (<700 milli-equivalents/kg at pH 3)
- Include acidifiers with low ABC (e.g. formic, fumaric or orthophosphoric acid)
- Avoid raw materials with high ABC (e.g. limestone, zinc oxide, sodium bicarbonate)
- At sites where persistent scours occurs and mortality is high, consider the temporary use of a low protein (<18.5%) diet.

Nutritional strategies to promote feed intake in the immediate post-weaning period may include:

- Use of spray-dried porcine plasma or bovine plasma
- Use of Mono-Sodium Glutamate (MSG) as a source of glutamic acid
- Acidification of the drinking water
- Limit use of limestone in the first stage weaner diet and reduce calcium to 0.7%
- Offer semi-moist extruded creep feeds (if available).

Nutritional strategies to limit post-weaning scours may include:

- Use of spray-dried plasma proteins
- Use of zinc oxide in the diet
- Use of in-feed acidifiers
- Use of functional feed ingredients to limit binding of pathogenic bacteria and stimulation of the immune system (such as mannan-oligosaccharides, mannan-rich bioactive fractions, spray-dried porcine plasma, beta-glucans)
- Limit dietary protein level in first stage weaner diet (e.g. maximum 19% crude protein) in situations where post-weaning diarrhoea is a common problem and/or where highly digestible animal proteins are not readily available
- Consider use of probiotics in sow and piglet diets prior to weaning to encourage a favourable gut microflora.

Use three diets to achieve best performance from weaning to 25–30 kg: a special starter diet (preferably the same as your creep diet), a first stage weaner diet and a second stage weaner diet. An example is provided in Table 3.10.

TABLE 3.10 Diet specifications for a three-stage weaner feeding regime (ACE Livestock Consulting Pty Ltd)

Name	Weeks after weaning*	DE (MJ/kg)	Available lysine (g/MJ DE)
Special starter	0–1	15.4+	0.95–1.00
First stage	2–3	14.8–15.2	0.85–0.88
Second stage	4–6	14.2–14.5	0.78–0.85

* NB: Use as a guide only, diet changes should be based on piglet bodyweight rather than age (e.g. approximately 7–9 kg, 10–14 kg and 15–30 kg respectively)

As well as reducing costs, feeding three diets between weaning to 25–30 kg helps pigs cope with early weaning and allows the changing digestive and immune needs of the pig to be met.

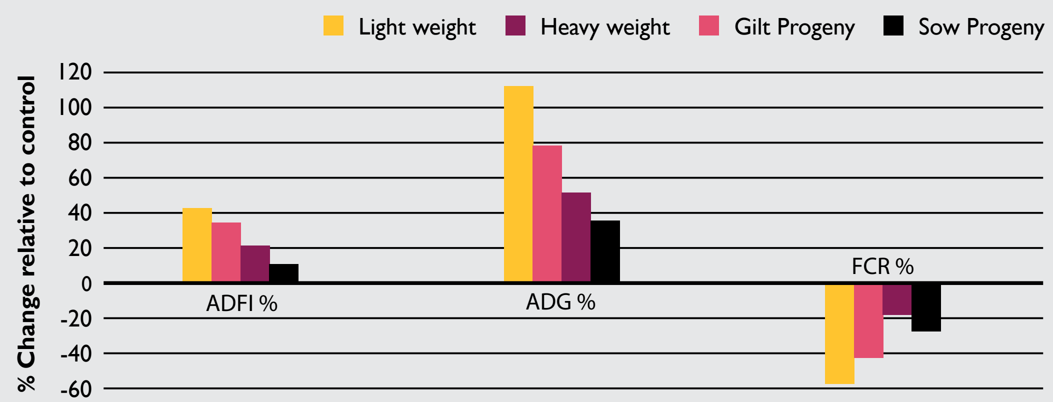
The three diet system is flexible. If weaning is early (e.g. 15–18 days) the special starter diet can be used longer, or if piglets are weaned at 28 days aim to provide 1 kg/pig of the special starter diet (which should be consumed in four to five days). The feeding program should be customised for your farm. Diet changes should be based on actual bodyweight rather than weaner age or target weights. The program should be monitored regularly and adjusted accordingly. For example, if you know weaning weights are lower during the summer months, then it would pay to offer the special starter for longer during summer to help piglets compensate.

In modern genotypes, sex differences become apparent in the period from weaning at 5.5 kg to 13 kg at 20 days, but are more obvious from then on. Males and females/surgical castrates can be fed separate diets to further improve growth performance.

Using spray-dried porcine plasma in starter feeds to improve performance

Two independent studies (Hernandez et al., 2010 & Edwards et al., 2013) showed significant improvements in newly weaned pigs offered diets containing 5% spray-dried porcine plasma. Average daily feed intake, average daily gain and feed conversion efficiency were consistently improved in both light and heavy piglets (housed under research conditions) as well as gilt and sow progeny (housed under commercial conditions) during the initial week post-weaning (Figure 3.6).

FIGURE 3.6 Relative changes in growth performance of pigs offered diets containing 5% spray-dried porcine plasma in the initial seven days post-weaning (adapted from Hernandez et al., 2010 and Edwards et al., 2013)



11.4 Supply Plenty of Fresh Water

Use 'bite-type' nipple drinkers in weaner facilities (and in farrowing pens also, so piglets can get used to them). In conventional housing allow one drinker for every five to six pigs, with a minimum of two drinkers per pen. When housing pigs in larger groups (100+) allow one drinker for every ten pigs.

Drinkers should be adjusted as the pigs grow. Table 3.11 outlines water requirements for weaners throughout the nursery phase. Drinkers in conventional housing should be positioned over a slatted floor at an angle of 45–70 °. Drinkers should be checked daily. As a general rule, weaners will consume three times more water than feed.

TABLE 3.11 Water requirements, height settings and flow rates for weaner pigs using nipple drinkers (Premier Pig Program, 2009)

	Liveweight	Water requirement	Drinker height	Water flow rate
	(kg)	(L/day)	(m)	(L/min)
First stage weaner	6–10	0.7–1.4	0.3	0.5
Second stage weaner	10–25	1.4–3.8	0.45	1.0

Check the flow rate so the pigs get what they need and the drinker functions properly. Water flow rate can be measured by timing flow into a bucket of known volume. Weaners need 0.5–1.0 litres/minute and water must be cool (16–18 °C), but not cold. Pigs only spend a few minutes each day at the drinker, so flow rates need to be adequate to meet their requirements. Extra drinkers/electrolytes may be useful in the first week post-weaning.

Water systems can be useful to deliver medications and other feed additives (e.g. acidifiers, plant extracts). Ensure the header tank is covered and the water system is flushed regularly. Low water intake can lead to dehydration. One test of dehydration is to pinch a fold of skin just behind the front limb. If the fold remains elevated for more than a few seconds, it is a sign of dehydration. Even minor dehydration can lead to reduced feed intake, lower daily gains and poorer feed conversion.

Inclusion of flavours or additives (e.g. citric acid, sugar, MSG, water acidifiers) can help promote water intake compared to non-supplemented water. High levels of salt in drinking water can limit intake.

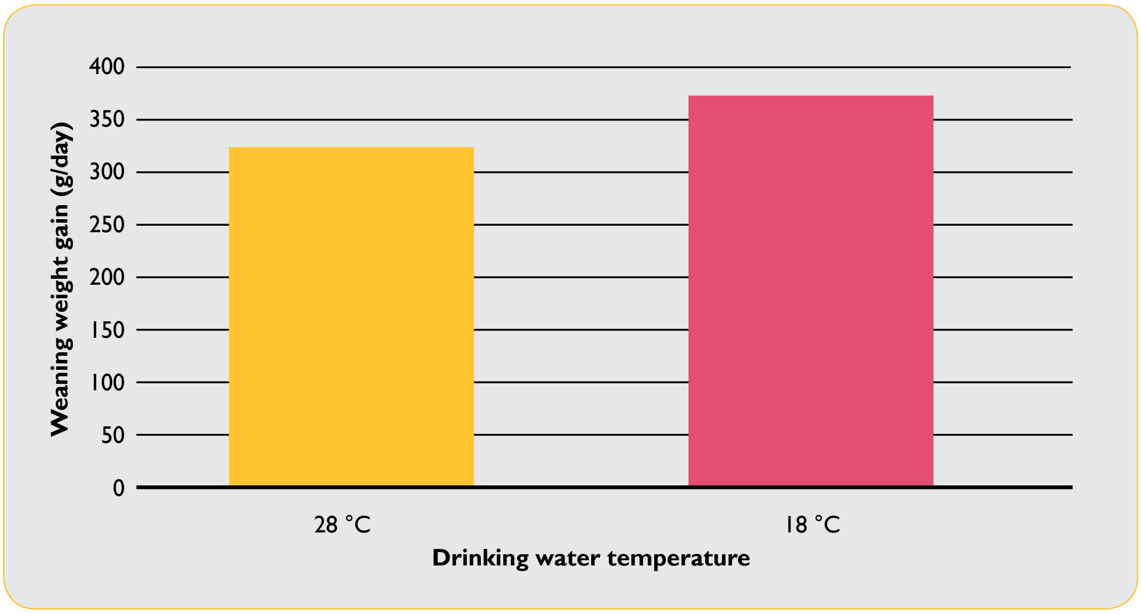
Water should be tested for contaminants, microbes and minerals (including salt). Water high in soluble salts or contaminated by faeces or other materials should not be used, but all classes of pigs tolerate water with less than 4000 mg/L of total dissolved ions. Water quality can be improved by the use of in-water acidifiers. Check drinkers daily, especially if additives (e.g. flavours or organic acids) have been added to the water supply. Additives like organic acids may dislodge bio-film in the pipes and block drinkers. Lines should be flushed when water acidification commences.

For information on how and where to have your water tested and how to interpret water test results, refer to *Chapter Seven: Water.*

Effect of drinking water temperature on weaner pig performance

A study by Banhazi et al. (2000) showed that during summer months when drinking water temperatures increase, the growth performance of pigs can be impaired. A 13% drop in growth rate was experienced in weaner pigs when water temperatures increased from 18 °C to 28 °C (Figure 3.7).

FIGURE 3.7 Influence of drinking water temperature on average daily gain on group housed weaners (adapted from Banhazi et al., 2000)



11.5 Use the Highest Quality Ingredients

Base weaner diets on high energy grains and digestible protein sources. Wheat, maize, naked oats (groats) and raw sugar are good energy sources.

Soy bean products, fish meal, blood meal, plasma proteins and high quality meat meal are excellent sources of highly digestible protein and amino acids. Soya bean meal should be limited in young pig diets to avoid ingredient hypersensitivity, however, soya bean isolates and concentrates together with full fat soya products can be used more generously. Weaned pigs will also benefit from soybean oil, coconut oil, corn oil, peanut oil, canola oil, salmon oil or a mixture of these included in the diet.

Keep acid buffering ingredients like ground limestone to a minimum. A level of 0.7% to 0.9% calcium in the starter diet is adequate. Diets should be formulated to an acid binding capacity below 700 Meq (at pH 3) or 70 Meq (at pH 4). Formulate diets to an omega-6:omega-3 fatty acid ratio of 5:1 to limit oxidative stress on the piglet.

11.6 Use the Right Feeders

Feed weaners to 30 kg liveweight in troughs or multi space self-feeders. Do not use single space wet and dry feeders for pigs lighter than 15 kg liveweight.

High levels of animal proteins in weaner diets makes feed become stale quickly, so feeders should be filled with only one day's supply. Three 150 mm feeding spaces are adequate for up to 12 pigs. Short trough lengths help prevent fouling and feed wastage.

11.7 Use Feed Additives

First consider the cost-effectiveness of feed additives for weaners. They may make a pig grow faster without increasing the profit from pig meat sold. The value of additives should be measured by the kilograms of pork meat produced per batch of pigs rather than on nursery performance alone.

Organic acids, probiotics, prebiotics, antibiotics, flavours, enzymes and B group vitamins all improve weaner pig performance under certain conditions, and zinc oxide can stem the impact of *E. coli.* Feed additives can be used to not only assist in meeting the nutrient requirements of the pig, but also to support the immune and digestive function of the immature pig.

Using feed additives to support weaner performance

A range of feed additives/raw materials are available for inclusion in weaner diets and a summary of the possible performance/immune benefits achieved by the use of particular supplements is provided here.

Yeast derived protein meals

- Reduced variation in growth and liveweight in the first three weeks post-weaning.
- Improved immune function in weaner pigs at three to six weeks post-weaning.
- Improved feed conversion efficiency in the nursery (especially in the later nursery phase).
- Improved villous height in the duodenum of pigs at three weeks post-weaning.

Glutamate/glutamic acid/MSG

- Reduced variation in growth weight in the first three weeks post-weaning.
- Improved immune function in weaners at three weeks post-weaning.

Spray-dried plasma protein

- Improved feed intake in the week immediately post-weaning.
- Improved feed conversion efficiency in the week immediately post-weaning.
- Improved villous height in the jejunum at six days post-weaning.
- Lower immune-pathology scores along the intestine at six days post-weaning.

12 Performance Targets for Weaner Pigs

The modern pig has a high capacity for lean growth and it is achievable to expect a bodyweight of 30 kg at 70 days of age. Table 3.12 suggests some performance targets and is intended as a guide. It may be useful for you to identify times when your pigs' performance deviates from the expected performance. Until 25 kg liveweight, there is very little difference in performance between males and females.

TABLE 3.12 Performance targets for weaner up to 30 kg liveweight (ACE Livestock Consulting Pty Ltd)

Age (days)	Liveweight (kg)	Growth rate (g)	Feed intake (g)	Feed: Gain (g:g)	Mortality (%)
21–28	6–8	275	275	1.00	<3.0
28–42	8–13	340	420	1.24	<1.5
42–56	13–20	470	700	1.49	<1.0
56–70	20–30	650	1100	1.69	<1.0
Overall	6–30	490	740	1.51	<2.0

13 Weaning Flow Chart

Split the weaning process into three phases (stages):

1. **Preparation:** Decide which batch of piglets will be weaned and prepare accommodation for them.
2. **Problems:** The critical phase lasting for about seven days after weaning, during which scouring, low food intakes, fighting, loss of bodyweight and deaths occur. The pigs' adjustment to this phase dictates how long they remain in the weaner room or their liveweight at exit.
3. **Conclusion:** The post-critical/final period, when pigs begin to grow at their potential. There is little chance that a growth set-back during the previous phase will be compensated for.

Two days before weaning	One day before weaning	Day of weaning	Daily routine
• Clean and disinfect weaner accommodation. • Inspect floors, walls, feeders and drinkers for breakages. • Empty and clean feeders, making sure that they are dry before use.	• Choose which piglets will be held back and which sows will be used as foster mothers. • Is medication needed and is everything ready?	• Pre-heat the weaner room to the optimum level. • Move piglets to weaner room (a good time to split sex groups as it saves mixing later). • Keep a recording sheet handy. • Feed a handful per pig at least three times a day. • Notice piglets not eating and force feed. • Check for scouring twice daily and any behaviour which calls for environment adjustment.	• Look for signs of huddling, poor growth or excessive fighting. • Make sure there is adequate, clean feed. • Check water supply and medication system if in use. • Check the condition of pen walls and feeders. • Ensure temperature is within the right range. • Remove sick piglets promptly, transfer to a hospital pen and start a medication program. • Monitor air quality and adjust ventilation if required.

14 References

Banhazi, T., Cargill, C., Zane, H., Wegiel, J. & Glatz, P. (2000) The effects of adverse environmental and drinking water temperatures on pig production. Available from APL.

Capozzalo, M.M., Kim, J.C., Htoo, J.K., de Lange, C.F.M., Mullan, B.P., Hansen, C.F., Resink, J.W., Stumbles, P.A., Hampson, D.J. & Pluske, J.R. (2012) An increased ratio of dietary tryptophan to lysine improves feed efficiency and elevates plasma tryptophan and kynurenine in the absence of antimicrobials and regardless of infection with enterotoxigenic *Escherichia coli* in weaned pigs. *Journal of Animal Science* Vol. 90 Supp. 4. pp. 191-193.

Edwards, M.V., Choct, M. & Campbell, R.G. (2011) Weaner survival is influenced by dam parity and pre-weaning exposure to creep feed. *Recent Advances in Animal Nutrition.* Eds. P. Cronje. pp. 147.

Edwards, M.V., Campbell, R.G., Chapman, T., Brouwers, H., Pierzynowski, S.G., Weström, B.R., Prykhod'ko, O., Gabor, L. & Choct, M. (2013) Spray-dried porcine plasma and yeast derived protein meal influence the adaption to weaning of primiparous and multiparous sow progeny in different ways. *Animal Production Science* Vol. 53. pp. 75-86.

Hodge, R. M.W., 1974. Efficiency of food conversion and body composition of the preruminnat lamb and the young pig. British Journal of Nutrition 32: 113-126.

Kidder, D.E. & Manners, M.J. (1978) *Digestion in the pig*. Bath: Scientechnica Bristol.

Kim, J.C., Mullan, B.P., Frey, B., Payne, H.G. & Pluske, J.R. (2012) Whole body protein deposition and plasma amino acid profiles in growing and/or finishing pigs fed increasing levels of sulphur amino acids with and without *Escherichia coli* lipopolysaccharide challenge. *Journal of Animal Science* Vol. 90. Supp. (4). pp. 362-365.

Meat and Livestock Commission (2004) Environmental management for healthy pig production. Available online at http://pork.ahdb.org.uk/media/39675/environmental-management-for-healthy-pig-production.pdf.

Miller, Y.J., Collins, A.M., Smits, R.J., Thomson, P.C. & Holyoake, P.K. (2012) Providing supplemental milk to piglets improves the growth but not survival of gilt progeny compared with sow progeny. *Journal of Animal Science* Vol. 90. pp. 5078-5085.

Morrison, R., Pluske, J.R., Smit, R., Henman, D. & Collins, C. (2009) The use of high cost weaner diets to improve post weaning growth performance. Pork CRC Project 2B-103. Available online at http://www.porkcrc.com.au/2B-103-_Final_Research_Report-Hign_Cost_Weaner_diets_.pdf.

Murphy, T.W. (2011) Effect of individual and combinations of airborne pollutants on feed intake, immune function and physiology of the pig. *PhD thesis*. University of Adelaide. Available online at http://digital.library.adelaide.edu.au/dspace/handle/2440/72151.

Premier Pig Program Technical Manual (2009) Alltech Inc., Kentucky, USA.

Wilkinson, S.J., Downing, J.A., Thomson, P.C. & Newman, R.E. (2013) Dietary fatty acids affect the growth, body composition and performance of post weaning gilt progeny. *Animal Production Science* Vol. 54. pp. 339-346.

Williams, N.H., Stahly, T.S. & Zimmerman, D.R. (1997) Effect of chronic immune system activation on the rate, efficiency, and composition of growth and lysine needs of pigs fed from 6 to 27 kg. *Journal of Animal Science* Vol. 75. pp. 2463-2471.

Van Lunen, T.A. & Cole, D.J.A. (1996) The effect of lysine/digestible energy ratio on growth performance and nitrogen deposition of hybrid boars, gilts and castrated male pigs. *Journal of Animal Science* Vol. 63. pp. 465-475.

Chapter Four

The Grower-Finisher Pig

1 Introduction

This chapter describes grower-finisher management and their nutritional requirements. The objective for pigs in their final production phase is to optimise the amount of meat sold for the highest possible profit. This chapter outlines practices and research outcomes which deliver the highest meat quality, the best environment for the animals, and which optimise health and nutrition. There is also a strong focus on feed management and minimising feed wastage.

This guide defines 30–60 kg liveweight animals as growing pigs, and defines those from 60–100+ kg liveweight, or at point of sale, as finishers. The greatest difference between the two groups is their nutritional needs.

Growers and finishers consume more than 60% of the piggery's feed, so attention to nutrition means large savings and more profit. It is important to know how growers and finishers respond to dietary nutrients so we can optimise growth rate, feed efficiency and carcase quality to maximise profits. Feed management and performance monitoring are key to a successful grower-finisher phase.

This chapter discusses the factors which affect the performance of grower-finisher pigs. It is important to remember that we need to feed pigs with multiple objectives in mind:

- To maintain their welfare;
- To achieve efficient lean meat yield;
- To achieve quality pork meat; and
- To maintain profitable, sustainable and viable production.

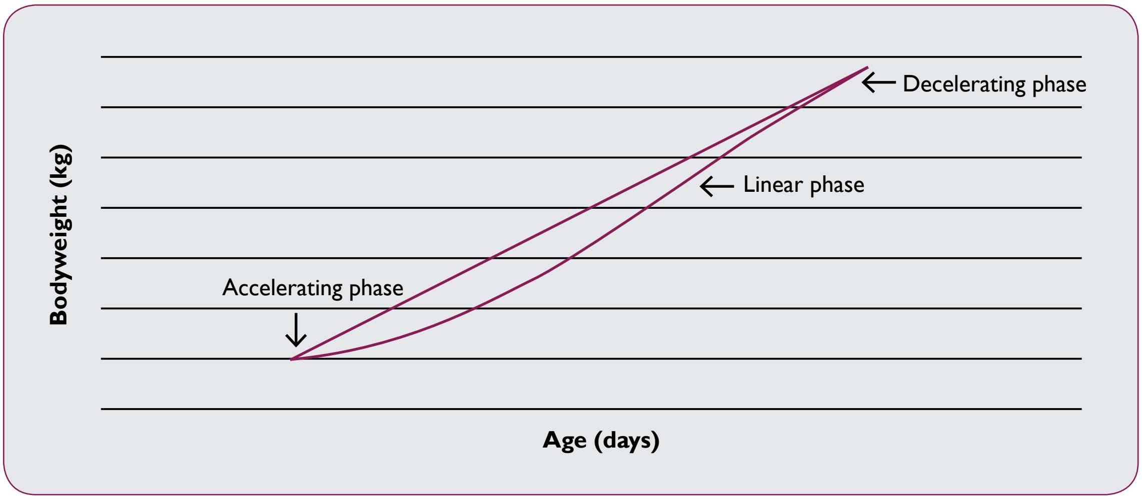
To ensure these objectives are met we first need to appreciate the science and physiology behind the growth of grower-finisher pigs.

2 Understanding Growth in Grower-Finisher Pigs

The typical growth curve of a pig is shown in Figure 4.1. Young pigs have the potential for very rapid growth (accelerated growth). As the pig ages the rate of gain is essentially constant (linear phase), and finally as the pig approaches maturity the rate of gain slows (decelerated growth).

Over the past 15–20 years, genetic selection has enabled significant improvement in the grower-finisher pig performance in Australia. The average backfat of the modern pig has been reduced by 0.8–2.0 mm and the average daily gain has increased by 40–100 g/day. These achievements have been reached through both genetic and non-genetic factors. The nutrition and management of these pigs must also evolve to ensure their growth is optimised.

FIGURE 4.1 Typical growth curve of a pig (ACE Livestock Consulting Pty Ltd)



When pig diets contain sufficient protein and amino acids, the rate at which they produce lean meat depends on the level of energy consumed. The more energy growing pigs consume, the faster they grow, until they reach their genetic potential. Feed conversion also improves with increased energy consumption, without excessive deposition of backfat until the genetic potential for protein deposition is finally reached.

In the past, high energy intakes by finishing pigs increased fat deposition and lowered feed conversion ratios. However, recent Australian research has shown that in modern genotypes with higher muscle growth capacity, performance can still be limited by energy intake and therefore these pigs require high energy diets to express their full potential.

3 Factors Affecting Growth

The sex and genotype of finishers influence how much energy is needed for lean muscle growth. Providing male and female pigs with different diets, or applying separate feeding programs during this phase, will maximise lean meat sold and reduce feeding costs.

Amino acids and energy create lean meat. Pigs need a proper level and balance of individual amino acids, ten of which are indispensable for growing and finishing pigs. Amino acid requirements are generally expressed in terms of grams of available lysine (or standard ileal digestible lysine) per megajoule of digestible energy. The balance of secondary amino acids is expressed as a proportion of (or ratio to) the lysine value. The dietary requirement depends on liveweight, energy intake, sex, genotype, immune status and environmental conditions. Research has shown that during periods of chronic immune system activation the requirements for the sulphur amino acids (methionine and cysteine) relative to lysine, must increase from 0.55 to 0.75 in grower pigs if growth performance is to be maintained (Kim et al., 2012).

During the finisher stage, entire males have a higher capacity for muscle growth than females or castrates, so their amino acid needs are greater. The connection between energy and muscle growth means that dietary amino acids (e.g. lysine) need to be expressed in relation to dietary energy concentration (e.g. grams of available lysine/MJ DE). Recent Australian research has redefined the lysine requirements of grower-finisher pigs.

The genetic standard of Australian pigs has greatly improved in recent years. Modern genotypes have more lean meat and less fat, and therefore need more lysine per unit of energy. Their capacity to deposit lean meat is likely to extend further into the finisher phase than it does with unimproved or unselected stock.

4 Establishing Targets

4.1 Production Targets

The biology of pork production, tissue synthesis, and the cost of nutrients are well understood. Therefore it is possible to define the biological potential for pig production and set realistic targets to achieve it (Table 4.1). Meeting production targets that are suggested in this table will be easier if producers adhere to the recommendations in this chapter. Performance improvements are possible, with little extra cost, by using an accurate monitoring system.

TABLE 4.1 Practical production targets and profit

Indicator	Possible (target)	Comment
Average pigs sold/sow/year	25–30	
Average sale liveweight (kg)	100–110	Depends on market
Average carcase weight (kg)	75–85	Depends on market
Average age at sale (weeks)	19–22	Depends on final weight
Average growth rate – birth to sale (ADG, g/d)	700–750	Depends on final weight
Total feed used/pig sold (kg)	250–300	Includes breeder feed and depends on pigs sold and market weight
Herd feed conversion ratio (HFCR; carcase weight)	3.2–3.5	
Average cost of feed/tonne ($)	400.00	Highly variable
Cost of production (COP; $/kg HSCW)	2.30–2.80	Depends on feed cost, HFCR, kg sold etc.
Average net price received ($/kg)	2.80–3.20	Highly variable
Average margin/pig ($)	+36.00^	
Average profit/sow/year ($)	+990.00^	

^ Based on median values (i.e. 27 pigs sold/sow/year, 105 kg sale liveweight, 80 kg carcase weight, 21 weeks sale age, 714 g/d ADG, 3.35 HFCR, $2.55 COP and $3.00/kg for pork)

4.2 Performance Targets

Based on your genotype, facilities and health status you should be able to establish a realistic set of performance targets. Table 4.2 outlines potential performance targets for pigs grown under good commercial conditions.

TABLE 4.2 Suggested performance targets for grower-finisher pigs under good commercial conditions (ACE Livestock Consulting Pty Ltd)

Age (days)	Bodyweight (kg)	Feed intake (kg/d)	Growth rate (kg/d)	FCR (kg/kg)
70–87	30–45	1.72	0.875	1.96
87–103	45–60	1.92	0.915	2.10
103–125	60–80	2.19	0.935	2.34
125–145	80–100	2.52	1.000	2.52
Overall	30–100	2.11	0.935	2.26

Once you have established realistic performance targets the next step is to monitor performance and to identify areas which require attention. There are significant extra costs involved in suboptimal growth. Table 4.3 outlines the influence that growth rate of grower-finishers has on the cost of production.

TABLE 4.3 Cost of growth rate from 30 to 100 kg liveweight (adapted from Premier Pig Program, 2009)

Feed (kg/d)	ADG (g/d)	Days	Feed (kg)	Extra feed (kg)^	Extra feed value ($)*	Extra over-head ($)**	Total extra cost ($)
1.80	717	97.6	175.7	18.4	7.36	4.54	11.90
1.90	790	88.6	168.3	11.0	4.40	2.74	7.14
2.00	864	81.0	162.0	4.70	1.88	1.22	3.10
2.10	935	74.9	157.3	-	-	-	-

^ Comparisons are made with a pig growing at 935 g/d and having a mean feed intake of 2.1 kg/d
* Cost of feed $400/tonne
** Each extra day costed at $0.20/pig

5 Optimising Nutrition

5.1 Nutrient Requirements

The nutrient requirements of growing and finishing pigs are published in many forms. It is difficult to identify what your own herd needs because of variations caused by genotype, environment, feeding methods and market requirements (e.g. carcase weight, backfat penalties). Table 4.4 highlights that the lysine requirement differs not only between sexes but also by performance indicator (e.g. daily gain or FCR). Select diet specifications which maximise profit rather than maximise performance or optimise feed conversion.

TABLE 4.4 Estimated dietary lysine (g available lysine:MJ DE) requirement to achieve maximum daily gain and minimum feed:gain (FCR) for each weight category (Moore et al., 2012)

Liveweight	Entire Males		Females	
(kg)	Daily gain	FCR	Daily gain	FCR
	Estimated dietary lysine requirements g available lysine/MJ DE			
20–35	1.00	1.00	0.90	0.86
35–50	0.87	0.87	0.84	0.85
50–65	0.72	0.80	0.67	0.64
65–80	0.67	0.69	0.63	0.66
80–95	0.63	0.63	0.58	0.40

When determining the practical lysine level required to maximise profit, there are numerous judgements which need to be applied which involve consideration of formulation cost pressures, population variation, variable change points and final carcase quality.

Grower diets routinely contain an available lysine content of about 0.65–0.70 g/MJ DE and a digestible energy content of about 14.0–14.2 MJ/kg. Finisher diets routinely contain 0.52–0.60 g available lysine/MJ DE and a digestible energy content of about 13.2–14.0 MJ/kg. A good nutritionist can fine-tune these specifications based on your herd performance and save you considerable costs in feed.

First and foremost the maintenance requirements of the pig must be met before lean growth or fat deposition can occur. The maintenance requirement is dependent on the immune status of the animal, the environmental conditions that the animal is housed in, and liveweight. The energy and protein requirements for growth change as the pig's bodyweight increases. The energy requirements for pigs can be broken down into requirements for protein gain, fat gain and maintenance. Table 4.5 shows how the requirements change with increasing bodyweight.

TABLE 4.5 **Energy requirements for maintenance, protein and fat gain in pigs from 30 to 100 kg liveweight (adapted from Premier Pig Program (2009) by ACE Livestock Consulting Pty Ltd)**

Body weight (kg)	ADG (g/d)	Protein gain (g/d)	Fat gain (g/d)	Energy requirement (MJ DE/d) for:			
				Maintenance	Protein gain	Fat gain	Total
30–45	875	160	115	7.5	8.3	5.8	21.6
45–60	915	180	128	9.8	9.4	7.0	26.2
60–80	935	180	150	12.1	9.4	8.3	29.8
80–100	1000	190	180	14.6	9.9	9.9	34.4
Mean	936	179	144	11.3	9.3	7.8	28.4

It is interesting to note from Table 4.5 that:

- Requirements for maintenance use about 40% of total dietary energy when pigs are housed in ideal conditions. To maximise gain, the maintenance requirement must be minimised, therefore pigs should be housed in optimal climatic conditions with minimal immune challenge; and
- The energy requirement for protein and fat gain are similar, however, lean protein deposition is far more energy efficient than fat deposition.

Lysine is the first limiting amino acid for pigs. The pig has a relatively small maintenance requirement for lysine. The maintenance requirement can be calculated using the following formula:

Lysine maintenance requirement = 0.036 x bodyweight$^{0.075}$ (g/d)

For each gram of protein retained in the pig, 0.1 g of available lysine is required. Table 4.6 shows the increase in lysine requirement as bodyweight increases throughout the grower-finisher phase.

TABLE 4.6 **Lysine requirements for maintenance and protein gain in pigs from 30–100 kg liveweight (ACE Livestock Consulting Pty Ltd)**

Body weight (kg)	ADG (g/d)	Protein gain (g/d)	Digestible lysine requirement (g/d) for:				
			Mainte-nance	Protein gain	Available lysine	Total lysine*	Av Lys:DE
30–45	875	160	0.50	11.20	11.70	16.70	0.77
45–60	915	180	0.70	12.60	13.30	19.00	0.73
60–80	935	180	0.87	12.60	13.47	19.20	0.65
80–100	1000	190	1.05	13.30	14.35	20.50	0.60
Mean	936	179	0.81	12.50	13.31	19.01	0.68

* Assumes digestibility coefficient of 0.70

A large number of lysine titration trials funded by APL and the Pork Cooperative Research Centre (Pork CRC) have been conducted across Australia in both commercial and research centres to gain a solid understanding of the current lysine requirements of Australian pigs. In general, the lysine requirement of finisher pigs is greater than previously thought. Table 4.7 summarises the findings of the lysine titrations conducted in these APL and Pork CRC studies.

TABLE 4.7 Current recommended lysine levels to support near maximum performance (g standardised ileal digestible (SID) lysine/MJ DE) (ACE Livestock Consulting Pty Ltd)

	Sex			Metabolic modifiers	
Liveweight	**Entire males**	**Females**	**Immunocastrates**	***Paylean®***	**pST**
25–40 kg	0.76	0.74	0.76		
40–60 kg	0.70	0.67	0.70		
60–80 kg	0.64	0.60	0.64		
80–100 kg	0.60	0.56	0.52*	0.62	0.66

* Requirement for period three weeks after second vaccination to sale

NB: These requirements may need to be adjusted to suit farm specific differences like genetics, temperature, pen size, feed intake etc.

Securing more reliable and consistent supplies of protein and energy for pig diets

Imported soya bean meal is one of the optional raw materials used in Australian pig diets. As the product is imported, the pricing and availability is subject to fluctuations in the global market. Home grown alternatives including peas, lupins and canola meal can compete well with soya bean meal, however, the price of these commodities tends to be driven in part by the global soya bean meal price.

Identifying alternative raw materials which are in less demand by competing industries (i.e. the poultry, dairy and beef industries) is key to maintaining a viable pork industry. Pork industry research has resulted in the successful release of two new high and stable yielding, disease-resistant field peas with low anti-nutritive factors. In 2009 the *Maki* pea was released (Moore, 2009) followed by the 2011 release of *CRC Walana* field pea (Moore & Russell, 2013). These varieties were carefully selected to meet the requirements of pork producers.

Juncea or mustard meal (*Brassica juncea*) in the expeller-extracted form is another new alternative protein meal which has been identified as a viable alternative to canola meal for use in grower-finisher pig diets (Collins, 2011). The tolerance of pigs to juncea is determined by the glucosinolate concentrate in the meal. The upper tolerance level of glucosinolate for grower pigs was estimated to be 2.5 mmol/kg of finished feed. Glucosinolate concentration in juncea meal will vary depending on the growing conditions and processing method. Maximum inclusion rates in the diets of pigs should be determined once the glucosinolate concentrate of the juncea meal is known.

For Australian grain, the market pressure is driven by the global demand for grain. The global

demand and competition for grain is inevitably going to increase. Two new grain varieties which may be more attractive to pig producers have been identified. *Berkshire* triticale has been commercially available to grain growers since 2013. The variety was selected to produce high yielding, high energy triticale. Those grain growers who have already trialled the variety over a number of years appreciate its valuable agronomic traits and the flexible sowing dates. It has been identified as a viable replacement for wheat in some areas. *Shepherd* barley, with its resistance to leaf rust and reliable yields in northern NSW and southern Queensland, is another option for feed grain (Sturgess, 2011).

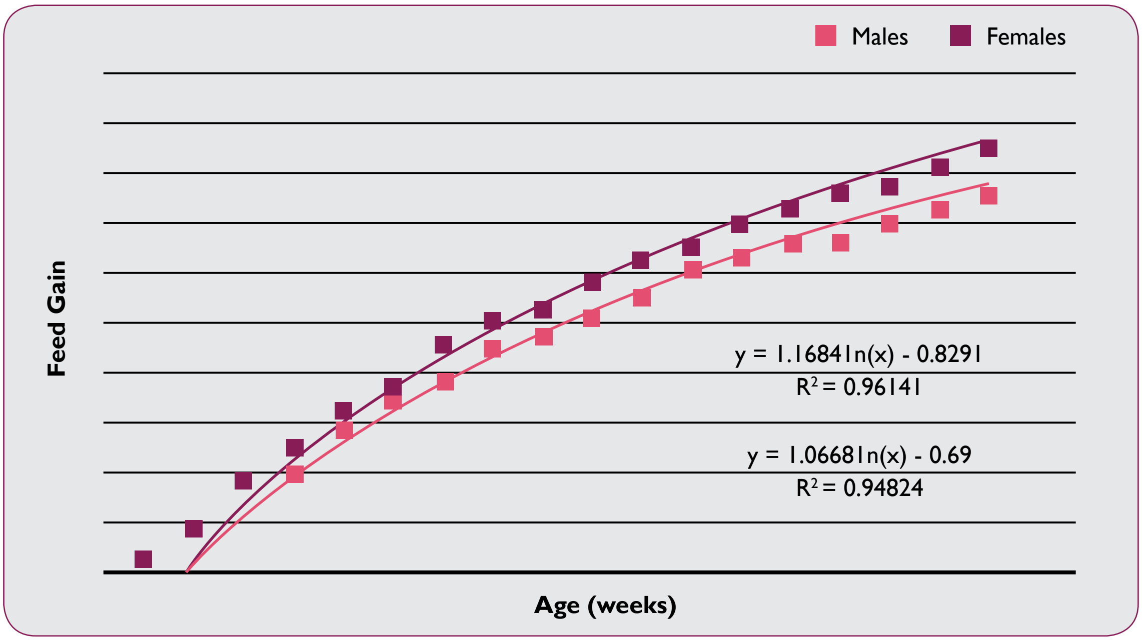
5.2 A Closer Look at Feed Conversion Efficiency

When monitoring performance and profitability of a pig operation it is important to keep the feed conversion ratio (FCR) in perspective. The overall objective is to achieve the best net margin per kilogram of pig meat produced. This may not necessarily be achieved with the best FCR. For example, cheap by-products can be economically advantageous to pig producers, but may cause a depression in feed conversion efficiency (FCE).

Feed conversion efficiency is a complex parameter. There is a high correlation between maximum FCE and profitability in most commercial systems. Feed conversion should be viewed as a significant performance indicator and worthy of considerable focus. Because of its complexity, improvements in FCR are likely to come from incremental advances in the many component factors (e.g. breed, health) rather than a single sweeping reform in any single component.

Feed conversion efficiency generally declines with age. Differences in the efficiency of entire males, females and castrates become evident in the late nursery stage. Figure 4.2 illustrates how the FCR (also known as 'feed:gain') of males and females diverge from weaning to slaughter.

FIGURE 4.2 Divergence in feed:gain of entire male and female pigs from weaning to slaughter (ACE Livestock Consulting Pty Ltd)



5.3 Split-sex Feeding

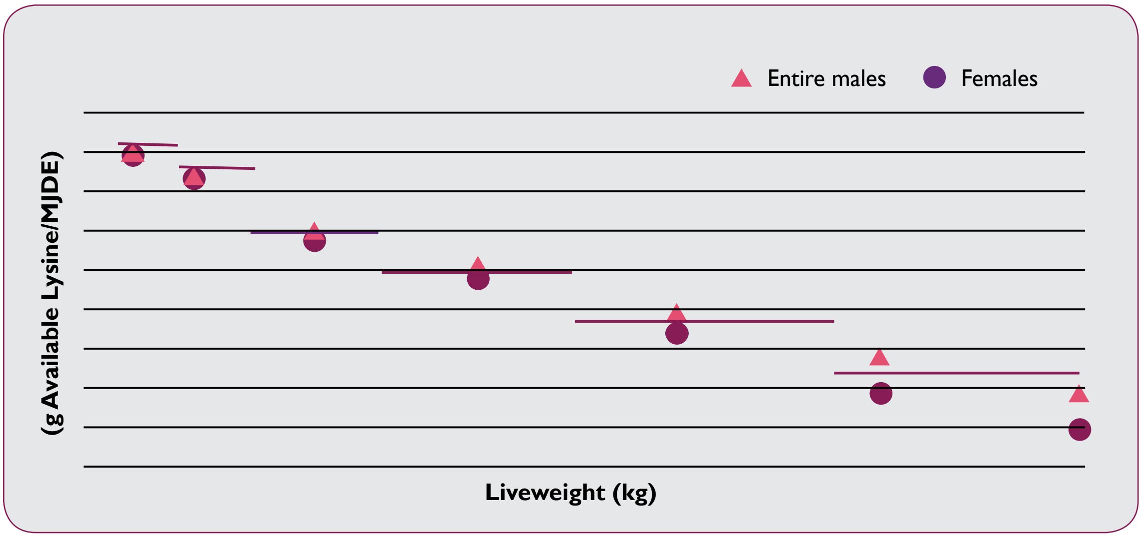
Male and female pigs differ when it comes to their potential for lean meat production. Females and castrates tend to deposit more fat than entire males in the finishing stages, so it is inappropriate to feed all three the same diet. Either the genetic potential of entire males will not be reached (if females are fed to achieve acceptable fat levels), or females will be fat at slaughter and penalties may apply.

Split-sex feeding is much more efficient when managed well. Entire male and female pigs are penned separately from roughly nine to ten weeks of age, and fed differently. Finisher entire male pigs need a higher specification diet than their female counterparts, which can eat, *ad libitum,* a lower energy diet to prevent depositing as much fat.

5.4 Phase Feeding

Phase feeding is one option commonly adopted by Australian pig producers. Phase feeding involves using a range of diets from 30–100 kg, each fed for a short period of time (two to six weeks) to try to closely meet the changing nutrient needs of the pigs (Figure 4.3).

FIGURE 4.3 Available lysine requirements relative to digestible energy in entire male and female pigs from weaning to 100 kg liveweight



It is best to alter the diet's specification regularly. Weekly or daily changes would be ideal, but are impractical. A minimum of three to four diets from 30–100 kg are required to economically facilitate efficient growth.

Developing sex-dependent phase feeding programs is another way to manage the differing nutrient requirements of males, females and castrates. Fewer diets can be used to achieve the same desired outcome. For example, female pigs may go onto the finisher diet several weeks prior to entire males.

5.5 Effects of Season

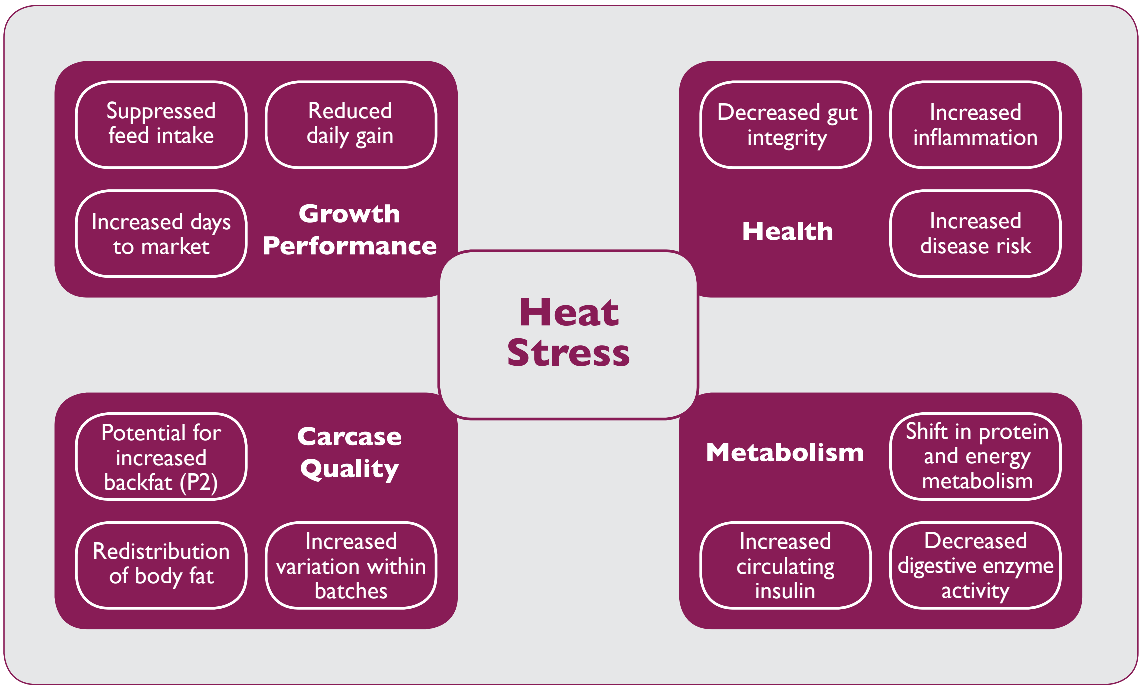
During summer, grower-finisher pigs may perform better if offered higher energy diets containing 1.5–3% added tallow/oil. The high fat content helps reduce the heat increment of digestion and avoids a depression in feed intake due to excessive heat load. If diet specifications remain unchanged as the weather cools down and the pig's appetite increases, you may be faced with a backfat issue in your pigs. In the cooler months, feed intake often increases as the maintenance requirement increases. A lower density diet may be useful if backfat thickness becomes an issue.

Consider having your diets reviewed in spring/early summer and again in autumn to minimise the impacts of season. Pigs have an evolutionary tendency to respond to decreasing day length and deposit additional fat prior to winter (largely driven by melatonin and its effect on growth hormone secretion). Strategies to manage rising backfat in April/May may need to be implemented if there is a history of such events.

5.6 Minimising the Effects of Heat Stress During Summer

Most pigs reared in Australia experience a period of heat stress during their life. The exact upper limit of the thermo-neutral zone (the temperature range they feel comfortable in) depends on the housing system employed. As a general guide, when temperatures exceed 25 °C for extended periods of time, grower-finisher pigs begin to experience heat stress. The most common sign of heat stress is a marked decline in feed intake (of up to 50%), however, the full impact of heat stress is extensive and affects a broad range of variables including pig performance, health, metabolism and carcase quality (Figure 4.4).

FIGURE 4.4 Impact of heat stress in grower-finisher pigs (adapted from Pearce, 2011)



Nutritional strategies to limit the impact of heat stress include:

- Formulating higher specification (denser) diets during summer to help maintain nutrient intake, whilst feed intake is declining
- Include adequate (i.e. minimum 2%) added fat to the diet to reduce the heat increment
- Formulate diets to an omega-6:omega-3 ratio of 5:1 or less to minimise inflammation and to regulate insulin, which is the hormone controlling the level of glucose in the blood
- Ensure the premix contains sufficient chromium (200–400 ppb) as chromium allows insulin to be used more efficiently in the body
- Add 1.25 kg/T of betaine or 3 kg of kelp to diets to assist with fluid balance within the body's cells
- Ensure feeder access is adequate so all animals can feed during the cooler parts of summer days
- Ensure adequate supply of cool water.

5.7 Using Metabolic Modifiers

Metabolic modifiers are products that can be used to improve the efficiency of growth, lean meat yield and backfat thickness of pigs. The following metabolic modifiers are currently available to the Australian pork industry and may be used by pork producers to improve growth efficiency and carcass quality.

Porcine somatotropin (pST)

Porcine somatotropin (pST) is a growth hormone produced in the pituitary gland of pigs under the control of the central nervous system. An identical product made by recombinant gene technology (sold as Reporcin®) can be used as a supplement via injection for four weeks prior to slaughter. Due to the labour intensive daily application (via injection), the most common program is a double dose three times per week.

Advantages

- Increases daily gain by approximately 15%.
- Decreases feed intake and feed conversion ratio.
- Decreases backfat.
- Increases lean meat yield.
- Effective in both high lean and average lean genetic lines.
- Effective in entire males, gilts and barrows (most profitable in gilts and barrows as it overcomes the sex difference).
- Excellent return on investment, if applied correctly.

Disadvantages

- Requires more expensive diets with higher protein, amino acid and calcium levels.
- Labour intensive (daily injection most effective, but trice weekly injections most common).
- Injecting is potentially dangerous for staff.
- Product is not widely accepted by some sectors of the pork market, though the final pork product is well regarded.

Ractopamine

Ractopamine (sold commercially as Paylean®) is a beta-agonist that can be added to the feed of pigs to improve feed conversion and to increase the proportion of lean to fat (without necessarily decreasing backfat thickness at the P2 site). The best response to ractopamine in improved genotypes is seen when comparatively high energy diets are fed *ad libitum*.

Advantages

- Increases daily gain by approximately 10%.
- Improves feed conversion by approximately 13%.
- Increases lean meat yield.
- Relatively easy application – in feed.
- Good return on investment.

Disadvantages

- Requires strategic application and careful marketing to maximise returns.
- Not accepted by some sectors of the pork market (though their concerns are not based on science or public health issues).

A large number of Australian studies in a range of commercial settings have been conducted to determine the best approach when using Paylean® in finisher pig diets. The range of expected performance improvements found across the Australian studies are outlined here:

- Consistently improved ADG between 5–10%
- Consistently improved FCR by 1.5–10%
- Improved slaughter weights (2.3–2.8 kg) or less days to market
- Improved carcase weights
- Potential improvements in feed intake observed in some studies (0–8%)
- Potential to reduce P2 backfat thickness slightly if sold at the same carcase weight
- Increased profit per pig ($3–$7).

To maximise the net returns on using Paylean® consider the following:

- If you experience depressed feed intakes in summer, consider increasing the Paylean® inclusion rate to account for the feed intake depression (e.g. the response to Paylean® will be depressed when feed intake is depressed)
- Aim for a maximum application period of 28 days (with the majority of pigs sold between days 7–21)
- Best responses to Paylean® are achieved using high energy diets (14.0–14.5 MJ DE/kg). Even with the additional diet cost, there is a net financial gain
- The spike in growth performance is generally achieved in the initial week of application but the benefits associated with improved carcase weights are achieved after three to four weeks of application
- Paylean® can be used in combination with pST to further enhance lean tissue growth.

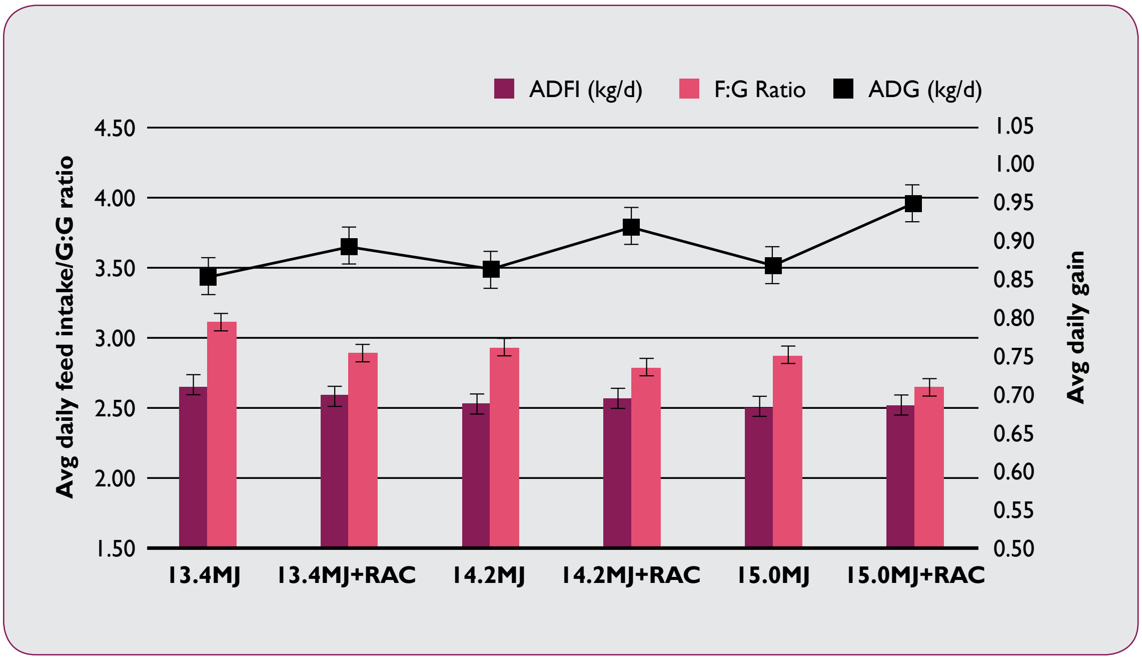
A study conducted by Edwards (2011) examined the response of 7.5 ppm Paylean® in the diets of finisher pigs fed for 28 days prior to slaughter, and found that dietary energy was a limiting factor in response to Paylean®. The treatments used in the study are shown in Table 4.8.

TABLE 4.8 Dietary treatments fed to finisher pigs for 28 days prior to slaughter (Edwards, 2011)

Energy Level	DE (MJ/kg)	Available lysing: DE (gm)	Paylean® (ppm)
Low	13.4	0.58	-
Low + Paylean®	13.4	0.58	7.5
Medium	14.2	0.58	-
Medium + Paylean®	14.2	0.58	7.5
High	15.0	0.58	-
High + Paylean®	15.0	0.58	7.5

Feed conversion efficiency improved with increasing energy density ($P < 0.05$) and the improvements were enhanced by the addition of Paylean® at 7.5 ppm to the diets ($P < 0.05$). The growth rate of pigs, regardless of energy density, increased with the addition of Paylean® (Figure 4.5). Even when the additional diet costs and the cost of Paylean® were considered, the most profitable treatment was the 15.0 MJ DE/kg plus Paylean® treatment.

FIGURE 4.5 Influence of dietary energy on the response of ractopamine on the growth performance of finisher pigs during the 28 days prior to slaughter (Edwards, 2011)



Ractopamine and pST can be used in combination to maximise performance in the late finishing stage. To examine the benefits of combining these metabolic modifiers, van Barneveld & Hewitt (2008) conducted a study with the following dietary treatments:

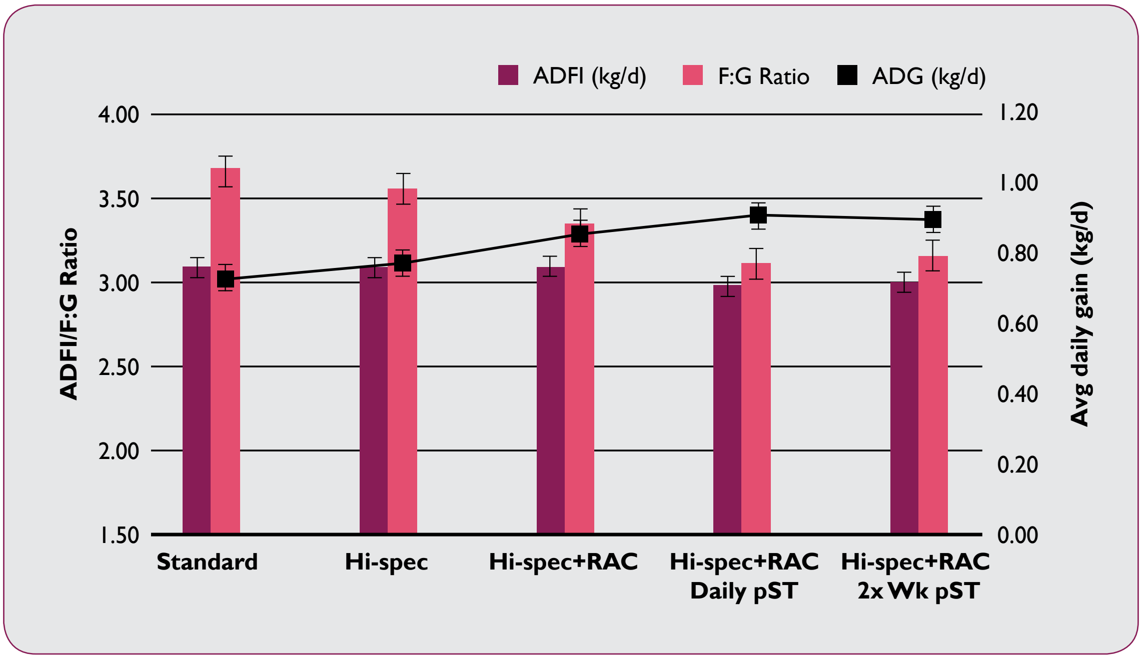
TABLE 4.9 Dietary treatments used by van Barneveld & Hewitt (2008) in finisher pigs

Treatment	Diet	Ractopamine	pST
Standard	Standard	0	-
Hi-Spec	Hi-spec	0	-
Hi-Spec+RAC	Hi-spec	5 ppm for 28 days	-
Hi-Spec+RAC+daily pST	Hi-spec	5 ppm for 28 days	5 mg daily
Hi-Spec+RAC+2x wk pST	Hi-spec	5 ppm for 28 days	20 mg twice weekly

Standard diet (13.4 MJ DE/kg; 0.55 g available lysine/MJ DE; threonine:lysine 0.67, methionine+cysteine:lysine 0.63)
Hi-Spec finisher (14.0 MJ DE/kg; 0.60 g available lysine/MJ DE; threonine:lysine 0.70; methionine+cysteine:lysine 0.67)

The addition of 5 ppm of ractopamine to the diets of finisher pigs for 28 days prior to slaughter improved the growth rate and feed efficiency or pigs ($P < 0.05$). Furthermore, combining ractopamine together with either daily or twice weekly injections of pST enhanced the improvements in feed conversion efficiency ($P < 0.05$) (Figure 4.6). Another study that looked at using pST only once per week with ractopamine found no net response to pST (Collins et al., 2011).

FIGURE 4.6 Influence of diet specification, ractopamine (RAC) and pST on growth performance (mean ± SED) of pigs during the 28 days prior to slaughter (van Barneveld & Hewitt, 2008)



Other dietary additives

Whilst not as remarkable in terms of improving lean meat yield, the following dietary additives can be used, preferably in combination, to effectively limit backfat thickness and enhance lean meat yield, without major concern from pork resellers or consumers:

- Chromium
- Pantothenic acid (Vitamin B5)
- Betaine
- Organic manganese.

For recommended inclusion rates please contact your nutritionist. Improved genotypes need comparatively high energy density diets, fed *ad libitum* to maximise lean meat growth in treated pigs to ensure the optimum response.

6 Providing the Best Environment

Design pig accommodation to get good performance while enabling management tasks to be carried out efficiently and safely. For growers and finishers, attention should be paid to:

- Climate control
- Health and welfare
- Feed and water access
- Observation and animal movement
- Feed distribution
- Manure removal
- Building materials
- Throughput planning.

6.1 Management

Pigs will only perform at their potential if good management minimises stress. It is the job of piggery staff to keep pigs comfortable and calm. Overstocking, poor housing and mixing unfamiliar pigs are stressful and leads to poor growth performance, as well as potential health challenges.

6.2 Mixing Pigs

It is ideal for pigs to remain in the company of those with which they were weaned, until sale. If this is not possible, take action to minimise the problems of mixing them and mix as few times as possible. Immediately when individual pigs from different pens are mixed, fighting will occur to determine pen hierarchy. Once these combats are settled, each animal will know its place within the social order of the group.

Anything which disrupts the social hierarchy can lower feed intake by 50% or more for at least a week. The individual's access to available nutrients, and setbacks caused by stress, varies the group's performance and therefore carcase quality. Growth variations within a pen are often thought to be differences in genotype or health; it is more likely to be caused by inadequate facilities and/or management.

Whether pigs at the bottom of the social order will suffer depends on the number in the group and the pen design. In groups of more than 30, pigs find it hard to remember their social position, but the attitude 'the smaller the group the better they do' must be measured against the cost of housing. A pen design which allows all pigs to feed, drink, exercise and rest will ease the stress of mixing. If feeding space is scarce, pigs of low social rank might feed when the others are finished, but it pays not to take this for granted. Improved management allows pigs to perform at their potential.

6.3 Ear and Tail Biting

The exact cause of ear and tail biting remains a mystery. However, in general, attacks of ear and tail biting are fewer when pigs have a good environment, nutrition and pen space. Remove tail bitten pigs at the first signs (when the skin is red and sore) and before the tail is chewed. Housed elsewhere and treated according to veterinary advice, the animal should heal within three or four days. If left in the pen for 24 hours or more, it may be mutilated, suffer from infection and abscesses, and not be fit to load.

Possible causes of tail biting can include:

- Overcrowding
- Boredom
- A poor environment, with temperature, humidity, air quality and noise problems
- Hunger and thirst
- Sudden diet changes
- Insufficient fibre or protein in the diet
- Insufficient minerals or vitamins
- Intestinal irritation.

For further information on tail biting, see *The Good Health Manual (1995).*

6.4 Moving Pigs

As with weaners, grower and finisher pigs should be moved as quietly as possible. Use stock-boards and make sure aisle width and gate placement make moving easy for both stock and handlers. Pigs prefer to move as a group and restricting them to a narrow passage increases their stress rate. Keep passageways clean so that pigs will not be tempted by spilled feed. They also like to see where they are going, so strategic use of lighting can be helpful when moving pigs between sheds and from sheds to transport.

6.5 Monitoring Performance

The effects of poor management can be subtle. Weigh a test pen of pigs upon entry, then the same pen one and four weeks later. This will help to identify possible set-backs and show whether facilities are adequate.

6.6 Identification

Pens should be clearly numbered. Have a record sheet handy for each pen, and record the date of entry, number of pigs, vaccination programs, drug withholding periods and deaths. Good lighting makes it easier to check pigs and read tags.

6.7 Ambient Temperature

Growing pigs become less sensitive to cold and more susceptible to heat as they grow from 20–120 kg. Large pigs lose relatively less heat than small pigs because they have less surface area relative to body mass. Increased sensitivity to temperature has resulted from the trend towards genetically leaner pigs.

Improvements in heating and cooling manages welfare, improves growth rates, feed efficiency, lowers the incidence of disease and deaths, and creates better working conditions for staff.

Ideal temperatures

Pig comfort depends on temperature, skin wetness, ventilation, stocking density, floor type, and whether there is bedding. Table 4.10 details recommended targets for temperature, air movement and humidity (to be used as a guide only). The pig's behaviour is the best guide to their comfort.

TABLE 4.10 Recommended targets for temperature, air movement and humidity

Parameter	Conditions	Target
Air temperature	30 to 60 kg LW	20–24 °C
	60 to 120 kg LW	15–22 °C
Air movement	If temperature is optimal	0.2 m/sec
	If temperature is elevated	0.5 m/sec
Humidity		60–80%

Floor type can have an influence on the temperature requirement of grower-finisher pigs (Table 4.11).

TABLE 4.11 Influence of flooring type on the temperature requirements (° C) of grower-finisher pigs (Premier Pig Program, 2009)

Liveweight	Straw	Concrete	Perforated metal	Slatted
30 kg	13–23	14–24	18–25	17–25
70+ kg	11–22	12–23	17–25	15–24

If pigs are too cold

When temperature drops too low, the pig will eat more to raise body heat. Although the growth rate may not be affected, feed conversion efficiency will suffer. Australian piggery buildings are often constructed to reduce heat in summer, while little attention is given to cooler conditions in winter.

If pigs are too hot

For each degree above the pigs' comfort zone, feed intake drops 1% for grower pigs and 2.5% for finishers (Whittington & Lemay, 2003), affecting both growth and feed conversion. In addition, larger pens are needed so pigs can lie away from others to cool off. Pigs make pens dirty in an attempt to create a wallow in which to keep cool.

For pigs to avoid their body temperature increasing as the environmental temperature increases, they must experience evaporative heat loss. As pigs cannot sweat, the main means of evaporative heat loss is via water vapour through respiration (panting) or from the skin (wallowing). Sprinkler systems are cheap and effective for heat reduction. For best results, wet pigs, let them dry, then re-wet them. Operate sprinklers when temperatures exceed 24 °C for growers and 22 °C for finishers and leave them on for five minutes, experimenting to find the best sequence. The system is working if pigs breathe normally (20–30 breaths per minute). Operate sprinklers during a warm night to encourage pigs to lie on the solid area when the houses cool down. Semi-slatted pens with rough floors will force pigs to lie where it is most comfortable (on the slatted area) and dirty the rest.

Fluctuating temperatures

Avoid large temperature variations between day and night. Fluctuations of more than 6 °C over a 24-hour period reduce growth rates and feed efficiency, and cause poor dunging habits. Variations can be reduced with correct insulation, control of ventilation rates, and automatic control systems.

Effect on carcase quality

Less fat is deposited at high temperatures and is more likely to be stored internally than as backfat. Less backfat may give more pigs higher carcase grades, but returns do not compensate for reduced growth caused by lower feed efficiency. Achieving minimal seasonal variations makes it possible to negotiate price with processors. The pig's condition at slaughter dates back to its birth, so there is no substitute for good management, sustained for the pig's lifetime.

Ventilation

Ventilation control is important to the pig's environment. Unsuitable or incorrectly used ventilation is a major setback in pig housing systems. Air movement disrupts the animal's surroundings and makes it feel cold. Each 0.1 m/sec more air movement is equivalent to a one degree loss in air temperature for a single finisher pig, while air movement of 0.3 m/sec does the same for groups. Ventilation reduces contaminants breathed in by pigs and staff, but a balance must be struck between introducing fresh air and maintaining the right temperature.

Humidity control

High humidity during hot weather can damage the health of pigs which rely on heat loss through respiration. Respiratory problems stem from low humidity, which dries out the skin and the respiratory tract, and makes the atmosphere dustier. High humidity aggravates diseases like Greasy Pig, Mange, Pneumonia and *Streptococcus suis*. Aim to maintain relative humidity at 60–80%. High relative humidity (e.g. 95%) is a greater problem at higher temperatures (e.g. >28 °C).

Air quality

Air quality makes its mark on health status, feed intake and growth rates. Quality is measured by the amount of gas in the air at pig level, the amount of air-borne dust, and the concentration of bacteria and other microbes. For more information on acceptable levels of gases refer to the section 'Dealing with gases' in *Chapter Three: The Weaner Pig, Section 6.2*.

Minimising dust

Most piggery dust is made up of feed particles, bedding materials, skin fragments and dried faeces. It is often mixed with harmful gases, spores and bacteria. Respirable dust (dust particles small enough to lodge deep in the lungs of animals and people) can cause permanent damage. This is an important occupational health and safety issue.

Dust levels depend on the type of feed, the feeding method, flooring, bedding, the ventilation rate, stocking density, population size and the method of manure disposal. It will help if fat or oils are added to feed during mixing, when pelleted diets are used instead of mash, and where liquid feeding systems are installed.

Special equipment for measuring dust in the air is available from occupational health and safety organisations, veterinarians, and some state Departments of Agriculture or Primary Industries. Most grower and finisher pigs in Australia are reared or housed in naturally ventilated sheds. This means that the producer has little influence over ventilation rates beyond keeping the width of sheds at 12 m or less, installing adequate ridge vents (width = 10% of shed width, and height of cap = 5% of shed width), and blinds or shutters.

Reduce stocking density (increase m^3/pig) and reduce the number of pigs per shed if sheds are naturally (rather than mechanically) ventilated.

Controlling the environment

The environment encompasses temperature, ventilation, humidity and air quality. Each has a direct impact on pig performance. A shed environment can be changed by using blinds, forced ventilation and evaporative cooling, the latter run automatically to achieve ideal conditions whether or not stock handlers are present. This prevents large fluctuations in temperature and humidity during a 24-hour period and enhances pig performance.

Contact commercial suppliers for more information on shed design and automated ventilation.

7 Stocking Density and Group Size

The Australian *Model Code of Practice for the Welfare of Animals (Pigs) 3rd Edition (2008)* recommends densities for housed pigs of various ages, identifies the areas where the welfare of the animals may be at risk, and outlines important aspects to be taken into account in ensuring the welfare of pigs. The space requirements set by the Code are the minimum space requirements for growing pigs housed indoors or in deep litter systems.

Indoor pig production has triggered large investments in buildings and made it essential to maximise returns. Overstocking may seem to maximise the return on investment by increasing the kg/m^2 but in reality overstocking compromises the welfare and health of the stock and the profitability of the enterprise.

The ideal stocking rate is generally considered to be between 12–20 pigs per pen, although as long as the facilities are adequate, pigs grow quite well in groups up to 1000. More space is needed in hot weather, and as pigs grow. Table 4.12 presents recommended space allowances for pigs housed in pens with a combination of one-third slats and two-thirds solid floor. Add 10% for pens with open drains.

TABLE 4.12 Minimum and recommended space allowances (m^2/pig) for grower-finisher pigs in conventional pens and deep litter housing

	Conventional sheds		Deep litter housing
Liveweight (kg)	**Minimum requirement***	**Recommended^**	**Minimum requirement*[1]**
30	0.29	0.46	0.38
35	0.32	0.51	0.42
40	0.36	0.56	0.47
45	0.38	0.60	0.49
50	0.41	0.65	0.53
55	0.44	0.69	0.57
60	0.47	0.73	0.61
70	0.52	0.81	0.68
80	0.57	0.89	0.74
90	0.61	0.96	0.79
100	0.66	1.03	0.86
110	0.70	1.10	0.91
120	0.74	1.16	0.96

Source * Australian *Model Code of Practice for the Welfare of Animals (Pigs) 3rd Edition (2008)*
Source ^ *Pigs RSPCA Approved Farming Scheme Standards August 2011*

[1]Higher space allowances may be necessary for optimal litter management

Overstocking of pigs impacts on welfare and affects pig growth rates. Remember that a small growth down-turn can considerably lower profit. For example, a 5% reduction in feed intake from weaning to sale results in a 10% decrease in growth rate and a 55% reduction in annual net revenue.

Fighting, cannibalism, tail biting, pen dirtying, inability to exercise and reduced profit are products of high stocking densities. It is vital to calculate the ideal stocking rate for pens, and ensure they are not exceeded.

While still meeting the Code, floor space requirements are:

- Less on slatted and partially slatted floors than on solid floors
- Greater where pigs are prone to respiratory problems, especially where ventilation and air movement are inadequate
- Less with more docile genotypes
- Less where feeding and watering spaces are adequate for every pig
- Less with a pen which is twice as long as it is wide
- Greater at high temperatures.

8 Housing Alternatives

Conventional grower-finisher housing costs, estimated at $400 per pig place, have in recent years increased in proportion to returns. All-in/all-out management practices will further add to this cost. The Australian pig industry must work towards reducing production costs to stay competitive on the world market.

Outdoor rearing systems for grower-finisher pigs may cost less but do not necessarily allow pigs to reach their potential. They require more management and should not been seen as an easy way out by those entering the industry with limited capital.

More grower-finisher pigs are now being housed in low-cost alternative systems, including eco-shelters as well as more extensive or free range rearing due to changing consumer preferences.

Eco-shelters

Common low-cost systems use tunnel house technology comprising tubular steel framing with a plastic cover, side barriers, and sawdust or straw bedding, commonly called eco-shelters. Eco-shelter housing building costs are estimated at $233 per pig place.

Advantages

- The system suits off-site production.
- Pigs can move freely in a relatively large area, while still being protected from a harsh climate.
- The system is cheap to build (approximately 60% of the cost of conventional sheds).
- The structure can relieve stocking pressures.
- The structure can be dismantled for other uses.
- Has a favourable image with some consumers.
- Does not involve the storage of liquid effluent.

Disadvantages

- A higher feed conversion ratio applies because more feed is wasted and more energy is used in exercise.
- In those without concrete floors, unacceptable levels of soil degradation occur in some areas, and during particular seasons (e.g. winter or wet season).
- Environmental control is insufficient to avoid high or low temperatures.
- Controlling temperature is difficult on hot days.
- Providing quality straw bedding can be expensive, especially during drought.
- Cost of cleaning shelters is greater and requires expensive equipment.
- Need to manage disposal, processing or on selling of spent bedding.
- Straw can be a vector for bacterial contaminates and mycotoxins.
- Housing pigs in large groups (150–200 per shed) can cause fighting and other problems.
- Environmental issues (e.g. the leaching of effluent) are harder to control.

- More dust creates more respiratory problems if ventilation levels are higher than in an intensive shed and if the shed is positioned to attract prevailing winds.
- Variations in sale weight occur as the system is usually all-in/all-out.
- Shelters can be less resistant to extreme weather damage.

APL funded research by Trezona-Murray (2008) showed that housing system impacts upon pig performance. In general, conventional sheds resulted in superior performance in the immediate week post-weaning and in finisher pigs from 12 weeks until slaughter, however, from one week post-weaning until 12 weeks of age, pigs performed best in deep litter eco-shelters.

Van Barneveld (2005) found that pigs housed in deep litter systems consume a diet that contained roughly 9% of bedding material. Pigs raised in deep litter system were generally fatter and less efficient than pigs housed in conventional sheds. Limiting the impact of bedding may be partially overcome by adjusting the nutrient density of the diets, especially in genotypes where appetite can be a limiting factor in growth performance of finisher pigs.

Utilising a combination of both conventional and deep litter housing systems from weaning to slaughter may allow producers to capitalise on the benefits the two systems offer.

9 Optimising Herd Health

A pig which is healthy when it reaches 30 kg liveweight has passed its most susceptible development period. However, grower and finisher pigs still need the best environmental, nutritional and health conditions to yield high quality meat, which is produced at least cost and sold for the best price.

Monitor the performance of the herd to detect diseases, particularly those not obvious. Feed conversion ratio, average daily gain and water intake are excellent health indicators, as clinical symptoms are not always present. Performance may drop because of many other factors. For instance, pneumonia may be triggered by a high stocking density, insufficient ventilation, and dust that carries organisms to and irritates the respiratory tract.

As with weaners, disease prevention in the growing and finishing herd is far better than a cure. The same methods apply, such as isolation and the controlled movement of people, animals and vehicles. As well as providing the best possible environment, the following general management practices will help:

- Adopt an all-in/all-out system, and clean all pens thoroughly between batches of pigs
- Check daily for clinical signs of disease in the growing and finishing herd
- Move pigs with clinical signs of disease to a hospital pen. Treat and record details (date, medication, pig identity, withholding period etc.)
- To avoid fighting and stress, keep groups or pens of pigs separate until market
- House age groups separately
- Avoid moving pigs too often, and mixing pigs to minimise fighting and stress
- Develop a vaccination and medication strategy with your veterinarian
- Observe withholding periods for all injectable drugs, in-feed and water medication.

The most prevalent diseases in the grower and finisher herd are likely to cause grower-finisher growth problems, scours and/or deaths. Deaths in the grower and finisher herd can be caused by infection (Erysipelas, Glässers Disease, *Pasturella* Pneumonia, Pleuropneumonia, Proliferative Enteritis, Swine Dysentery, Endocarditis, Oedema Disease, Salmonellosis and Porcine Circovirus Type 2), poor nutrition (Mulberry Heart Disease, twisted bowel, Hepatosis Dietetica, Mycotoxicosis and plant toxins) or other factors (Porcine Stress Syndrome, gastric ulcers or heat stress).

All deaths should be treated seriously, and a target death rate of less than 0.5% adopted.

Avoidance procedures are:

- Record and post-mortem all deaths, noting any warning signs, and watch for more deaths
- Pigs that lie away from others and are reluctant to move, eat or drink are likely to be sick. Note them for early detection of outbreaks, remove them to hospital pens and treat accordingly
- Examine all dead pigs externally and internally, and consult your veterinarian
- Laboratory test tissues from dead pigs to identify unknown causes
- Ask your pig specialist veterinarian to regularly check your pigs at slaughter
- Ensure that diets are providing adequate nutrients, especially sufficient Vitamin E and selenium.

10 Grower-Finisher Diseases

For specific information on grower-finisher health and disease, including causes, symptoms, diagnosis, treatment and control, refer to *The Good Health Manual (1995).*

The severity of respiratory diseases will be heightened by poor air quality (high levels of dust, ammonia and bacteria), temperature fluctuations of 6 °C or more, or by stocking more than 300 pigs in a shed. Respiratory disease complex can include Mycoplasma Pneumonia, Pleuropneumonia or a combination of the two.

10.1 Mycoplasma Pneumonia

Also known as Enzootic Pneumonia, a widespread chronic respiratory disease characterised by coughing, growth retardation and reduced feed efficiency.

Cause

Mycoplasma hyopneumoniae is responsible for the disease condition. Other organisms may be associated with the infection. Carrier pigs are the most common source of infection. The organism may persist for months in the lung of infected pigs. Excessive dust, irritating gases or concurrent infections result in more severe coughing.

Signs

The principal clinical sign is a chronic, persistent, non-productive cough. Pneumonia develops in some pigs with marked shortness of breath. Morbidity is high but mortality is low.

Diagnosis

History, clinical signs and post-mortem lesions are suggestive but laboratory tests are essential for confirmatory diagnosis.

Treatment

Antibiotics and chemotherapeutic agents have been used in feed or water, often with inconsistent results. Consult with your veterinarian for the best treatment option.

Prevention and control

There are several methods of controlling Mycoplasma Pneumonia, some of them being:

- Maintaining breeding stock negative for *M. hyopneumoniae*
- Keeping dusts level as low as possible
- Acclimatisation of gilts
- Biosecurity protocols
- All-in/all-out production and segregated rearing
- Appropriate vaccination program
- Early weaning may prevent transmission of the causal agents from dams to piglets
- Clean nursery and grower-finisher facilities in between batches with different disinfectants.

10.2 Pleuropneumonia

Also known as APP, named by the causal agent *Actinobacillus pleuropneumoniae*, Pleuropneumonia is a highly contagious disease, characterised by sudden onset, short clinical course, high morbidity and high mortality.

Cause

Actinobacillus pleuropneumoniae produces toxins and hemolysin in the lungs, causing damage in the lung tissues. Pigs that survive from the disease may remain as carriers.

Sign

Signs vary between acute and chronic forms of APP. The early signs include sudden onset, high temperature, apathy, anorexia and stiffness. A shallow non-productive cough is occasionally present. Marked shallow breathing with mouth breathing and perhaps, a foamy, bloody discharge from the mouth and nose may be observed in advanced conditions. Morbidity is high and mortality can reach 20–80%. Pigs may survive with chronic condition but the growth is very slow due to presence of pleural adhesions and abscesses in the recovered lungs.

Diagnosis

A tentative diagnosis can be made on the basis of history, clinical signs and post-mortem findings. Laboratory diagnosis is suggested for confirmatory diagnosis.

Treatment

Treating sick pigs with anti-inflammatory and anti-microbials may help to reduce the mortality but treating individual pigs with an injectable may not be practical in some situations.

Prevention and control

The following measures should be taken to control APP:

- APP free herds should be managed as closed herds
- New stock should be free of APP, and must be tested before introducing into the native herd
- All-in/all-out production system
- Age segregated rearing facilities with proper ventilation and standard stocking density
- Proper cleaning and disinfestation in between batches
- Vaccination program; autogenous vaccines work more efficiently
- Early weaning may help to prevent the transmission of causal agents from dams to piglets
- Depopulation can be done to eradicate APP from an endemic herd.

10.3 Proliferative Enteritis (PE or Ileitis)

Proliferative Enteritis (PE) is commonly referred to as Ileitis. Finisher pigs and young gilts in high health status herds are usually affected.

Cause

New information indicates that a bacterium *Lawsonia intracellularis* is the cause of Proliferative Enteritis. Little is known about the bacterium or about management factors leading to outbreaks.

Signs

Two forms of Proliferative Enteritis occur.

1. Death due to bleeding in the gut:
   - Occurring most in pigs 16 weeks and older.
   - Often affecting gilts after selection when rations are changed.
   - Occasional deaths increasing over several weeks.
   - Some pigs may develop blackish-tarry scours although scouring is not frequent.

2. Ill-thrift:
   - Generally seen in pigs from 6–16 weeks.
   - Reduced growth rates and appearance of ridge-backed pigs may be the first sign.
   - Scouring may appear as greyish-brown soft dung.
   - Mortality rates vary with the scour's severity.

Diagnosis

Proliferative Enteritis is indicated by sudden deaths in finishers or gilts selected for breeding, or poor growth rates in grower-finisher pigs. Post-mortem findings and laboratory tests can be used for confirmatory diagnosis. Regular slaughter checks provide an excellent way to troubleshoot for PE associated problems.

Treatment

Always consult with a veterinarian for appropriate treatment options.

Control

Give in-feed medication during the finisher phase, and for gilts, either continuously or by pulsing (two weeks on/three weeks off). Select a drug with a short withholding period to avoid residues in meat. To learn more about treatment and control consult your veterinarian.

10.4 Swine Dysentery

Swine Dysentery is a severe, infectious disease characterised by mucohemorrhagic diarrhoea, mostly occurring during the growing or finishing periods. Scours usually reduce growth rates rather than kill pigs.

Cause

The bacterium *Brachyspira hyodysenteriae* is the primary agent, but other organisms present in the gut may contribute to the signs. There are many other spirochetes living in the gut but not all of which cause disease.

Signs

Signs may vary from soft, green dung to a fluid (not watery), smelly, green to reddish-brown scour. Strands of mucus and pieces of the wall of the intestine may be present in the scour material.

Sometimes the dung is porridge-like and dribbles from the anus.

Growth rate is severely affected in both scouring and non-scouring animals. Poor growth rates may be the major sign of a Swine Dysentery problem. In severe cases the pigs lose weight, become weak and are dehydrated. Some may die.

Diagnosis

History, clinical signs and post-mortem lesions are the basis of tentative diagnosis. Laboratory tests are required for confirmatory diagnosis.

While considering a diagnosis of Swine Dysentery, one should be aware of recent work in describing a non-fatal diarrhoeal disease in pigs caused by *Brachyspira pilosicoli. B. innocens* may also be found in the large intestine.

Treatment

Isolate sick pigs and place them in a pen where their effluent will not contaminate other pens. Provide sick pigs with electrolytes in drinking water.

Destroy critically ill animals and bury or burn them. Market as many healthy pigs as possible to reduce stocking rates. This will also reduce the cost of medication.

Control and prevention

The following measures should be taken to control Swine Dysentery:

- Good hygiene combined with an appropriate medication strategy is very important
- Remove dung from pen floors regularly
- Stop effluent from the affected pen contaminating other pens
- Destroy rodents and clean pens during the medication period
- Always maintain a rodent control program on the farm
- Do not buy unknown pigs from a saleyard for breeding purposes. Obtain breeding animals from a herd you know and trust
- Swine Dysentery can be eradicated without de-populating the herd but becomes more difficult in herds with more than 200 sows. Develop an eradication program with your veterinarian
- Determine a method to maintain a quarantine barrier between clean pigs and those already in the system.

10.5 Salmonellosis

Cause

Salmonellosis is a disease caused by any of more than 2000 *Salmonella* serotypes. Only few serotypes cause disease in pigs. Pigs can be affected at any stage from nursery to grower-finisher.

Signs

Morbidity is usually low to moderate. Acute illness with marked depression and fever (up to 41.6 °C) is common and death occurs within 24–48 hours in a group of apparently thrifty pigs. Inappetence and weakness may also be observed. Nervous signs may occur in pigs; these animals may also suffer from pneumonia. Mortality may reach 100%. Diarrhoea is not common but nursing pigs may develop diarrhoea, and usually succumb to generalised septicaemia. Red to purple discolouration of skin of the extremities is developed due to septicaemia. Weaner or grower-finisher pigs show signs of a fever and have liquid faeces that may be yellow and contain shreds of necrotic debris.

Diagnosis

The history, clinical signs and typical post-mortem lesions might be adequate for tentative diagnosis. Laboratory diagnosis is recommended for confirmatory diagnosis. Salmonellosis has to be differentiated from other coliform Enteritis, Proliferative Enteritis, Trichuriasis (whipworm) and Swine Dysentery.

Treatment

Medication with antibiotics may reduce the mortality as well as severity of the disease. Antibiotics should be selected cautiously because many have lost efficacy due to bacterial resistance.

Control and prevention

Controlling Salmonellosis is important not only for pig production but also for human health. Pigs may serve as a source of *Salmonella* infection to humans via contaminated pork products, so efforts to reduce *Salmonella* in the food chain are a high priority for the industry. Good husbandry practices are essential. Standard biosecurity and hygiene protocols, and a vaccination program, should be in place. Sourcing stock from a single source is advisable. Stress due to transport, low or high temperature, overcrowding etc., should be minimised. Feed can be tested to reduce *Salmonella* contamination.

10.6 Porcine Circovirus Type 2 (PCV2)

Porcine Circovirus Type 2 is a viral disease which is common in most pig herds globally. PCV2 is an immunosuppressive disease which means an infected pig becomes immune-compromised and, as a result, is at a greater risk of developing other diseases.

Cause

PCV2 is caused by a very small DNA virus. Transmission is believed to occur via oral and nasal routes, and possibly as an aerosol.

Signs

The symptoms of PCV2 in pigs vary greatly from high levels of mortalities, poor growth and weight loss (progressing to the level of severe weakness between 5–14 weeks of age) to absolutely no symptoms whatsoever. Other symptoms include enlarged lymph nodes, skin rashes, difficulty breathing, jaundice, fever, stomach ulcers, diarrhoea or sudden death. Most pigs are infected with some level of PCV2, whilst not all exhibit clinical signs. In Australian, farms mortality and morbidity of the disease are usually undetected, however, subclinical conditions of the disease are evident by severe reductions in performance.

Diagnosis

As the clinical signs can be highly variable, the method of diagnosis needs to be discussed with your veterinarian and is likely to include herd examination, several autopsies, and tissue and blood sample collection for diagnosis of PCV2 and any associated diseases.

Treatment

Treatment is generally focused on the secondary disease which has been caused by the immune-suppression arising from PCV2. Treatment options should be discussed with your veterinarian on a case by case basis.

Control and prevention

Effective vaccination programs should be developed with your veterinarian. Maintaining high levels of immunity will help reduce the potential for clinical PCV2 to develop within a herd. Any steps taken to improve hygiene and reduce stress will help reduce the impact of PCV2 on a herd and include:

- Cleaning and disinfecting pens prior to use
- Lowering stocking densities
- Using solid partitions between pens, especially between pigs of different ages
- Allowing adequate space for feed and water
- Avoiding out-of-feed events at all times
- Managing air quality and temperature
- Minimising mixing events.

10.7 Mange

A parasitic skin disease caused by sarcoptic mange mite, characterised by marked itching and raised circular bumps on the skin.

Cause

The mite *Sarcoptes scabiei* causes most mange in pigs. It spreads by direct body contact. Mites from the dam may invade newly born piglets within a few hours of birth.

Signs

Frequent rubbing and scratching are the common signs. Signs of rubbing are more apparent under sunlight exposure. Other signs may include poor growth rate, decreased feed efficiency and low sow productivity. Morbidity is high but mortality is unusual.

Diagnosis

Clinical signs and skin lesions are suggestive to tentative diagnosis. Identification of mites in the skin scrapings or exudate is essential for confirmatory diagnosis.

Treatment

External use of parasiticides can be used after consultation with a veterinarian.

Prevention and control

A control program should focus on the breeding herd which if infected, inevitably transmit mites to the piglets. This program usually involves treatment of dams a few days prior to entering the farrowing shed. Control strategies may also include treating growing pigs at eight to ten weeks of age.

10.8 Other Diseases in Grower-Finishers

Roundworm

The larvae infest the liver and lung after being ingested as eggs from the dung of another pig. Lung damage can assist other agents to cause outbreaks of respiratory disease. Severe liver damage lowers growth rates, and the liver is condemned at slaughter.

Arthritis

In growing/finishing pigs, arthritis can stem from infected wounds caused by fighting, trauma, leg weakness or osteochondrosis, dirty pens, and diseases such as Erysipelas, Glässers Disease and Streptococcal infections. Common symptoms include lameness, swollen joints, reluctance to stand and diamond lesions or raised skin patches.

As well as performance monitoring, nutritional management and shed environmental management, take these steps to avoid diseases that can lower growth rates:

- Allow only healthy pigs to leave the weaner area
- Check that all pigs are getting up, eating and drinking daily
- Note unhealthy pigs and those with retarded growth
- Ask your veterinarian to regularly check your pigs at slaughter
- Move sick, lame or injured pigs to a hospital pen for treatment
- Practice age-segregated rearing as much as possible, i.e. keep growers and finishers away from younger pigs
- Sell slow growing pigs
- Treat pigs for mange
- Vaccinate according to your veterinarian's recommendations
- Monitor air quality, temperature and stocking rates in the grower-finisher sheds
- Monitor coughing to check for respiratory disease
- Clean pens/sheds/eco-shelters using detergent and water, and then disinfect (at recommended rates) and leave to dry before moving the next group of pigs in.

11 References

Collins, C.L. (2011) Evaluation of juncea meal for growing pigs. Pork CRC Project 1C-104. Available online at http://www.apri.com.au/1C-104_Final_Report_Juncea_110222.pdf.

Collins, C.L., Lealiifano, A. & Dunshea, F. (2011) Improving the response to Paylean® with the novel use of pST. Pork CRC Project 2H-104. Available online at http://www.apri.com.au/2H-104_Final_Report_110322.pdf.

Edwards, A.C. (2011) The effect of energy density on Paylean® responses in finisher pigs. Pork CRC Project 2H-111. Available online at http://www.apri.com.au/2H-111_Final_Report_110427.pdf.

Kim, J.C., Payne, H., Collins, C., Henman, D. & Mullan, B.P. (2012) Sulphur amino acid supplementation to improve herd feed conversion efficiency in commercial grower production system. Pork CRC Project 4B-109. Available online at http://porkcrc.com.au/wp-content/uploads/2013/02/4B-109-SAA-Final-Report.pdf.

Moore, K.L., Mullan, B.P., Campbell, R.G. & Kim, J.C. (2012) The response of entire male and female pigs from 20 to 100 kg liveweight to dietary available lysine. *Animal Production Science* Vol. 53. pp. 67-74.

Moore, S. (2009) Peas for a more reliable protein supply to the pork industry in the north. Pork CRC Project 1B-104. Available online at http://www.apri.com.au/1A-104_-_Peas_-_Final_Report_091204.pdf.

Moore, S. & Russell, A. (2013) Development of adapted field pea varieties for pork producing regions in northern and southern Australia. Pork CRC Project 4B-102. Available online at http://porkcrc.com.au/wp-content/uploads/2013/10/4B-102-Final-Report.pdf.

Pearce, S. (2011) The effects of heat stress and nutritional status on metabolism and intestinal integrity in growing pigs. *Graduate Theses and Dissertations*. Paper 12065. Available online at http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=3071&context=etd.

Premier Pig Program Technical Manual (2009) Alltech Inc., Kentucky, USA.

Sturgess, J. (2011) Enhancing supplies of high quality barley to meet pork industry demands in Queensland and northern New South Wales. Pork CRC Project 1A-106. Available online at http://www.apri.com.au/1A-106_Final_Research_Report_110922.pdf.

Trezona-Murray, M. (2008) Conventional and deep-litter production systems: The effects on fat deposition and distribution in growing female large white X landrace pigs. *PhD thesis*. Murdoch University. Available online at http://researchrepository.murdoch.edu.au/443/.

van Barneveld, R.J. & Hewitt, R. (2008) Efficiencies of ractopamine and pST on finisher pig performance. Pork CRC Project 2A-105 Experiment 3. Available online at http://www.porkcrc.com.au/2A-105_Final_Report_Exper_3_Summary_Sheet_0809.pdf.

van Barneveld (2005) Accurate assessment of diet intake and composition in various pig housing systems. Australian Pork Limited Project 1754. Contact APL for a copy of this report.

Whittington, L. & Lemay, S. (2003) Feed intake: Revisiting an old challenge. *Centred on swine*. Prairie Swine Centre Inc. Available online at http://www.prairieswine.com/centred-on-swine-volume-10/.

Chapter Five

Sale

1 Introduction

This chapter focuses on carcase and meat quality. Nutritional, transport and marketing aspects are discussed, including matching the product with market needs. It also covers recent research outcomes in the area of eating quality and tips on how to interpret slaughter data to best identify production phases which require attention.

2 Management to Maximise Meat Quality

Consumers in developed countries across the world are demanding a much higher standard of food quality due to higher incomes, more sophisticated tastes, and more competition. For many years, 'quality pork' simply meant lean pork, but the market now expects pork products to both look and taste good, and to have an attractive texture when processed or cooked.

Flavour, tenderness and juiciness are the three main qualities that influence a consumer's preference for pork. Research by D'Souza et al. (2012) showed that 30% of generic pork loin steaks was rated as unsatisfactory (1) or below average (2) for quality grade on a 1–5 scale, with (5) being premium. Channon et al. (2014) showed that the fail rate of pork loin steaks from Achilles hung, two-day aged loins was 26.4%. Recent outcomes from Pork CRC funded research has shown that the fail rate of loin steaks, across all pathway interventions imposed, ranged from 11% to 30% (Channon et al., 2016; Jose et al., 2013).

Management and nutritional strategies need to be adopted to minimise the occurrence of unsatisfactory pork experiences. This is increasingly important as the Australian industry faces continuing threats from the importation of pork. To ensure the long term viability of the Australian pork industry we need to aim to produce consistent quality pork to satisfy customers. Consumers expect both premium quality and value when purchasing meat and a considerable proportion of consumers are prepared to pay well for quality meat products.

3 Carcase Quality

The percentage of lean (muscle) and depth of backfat in relation to carcase weight determines carcase quality. Producers are currently paid on the basis of hot carcase weight and fat depth at the P2 site, which is located 65 mm from the midline of the carcase over the last thoracic rib. The grower-finisher period is the time to maximise both the quantity and quality of lean.

3.1 Genotype

Genotype determines the animal's potential to deposit lean relative to fat and is the main influence on carcase quality. Low backfat has a high level of heritability, so adopting a good breeding program can bring rapid improvements.

Do not reduce backfat depths to less than 8 mm at the P2 site (at 90 kg liveweight or greater) or fat and muscle tissue may separate badly during processing. Intramuscular fat content may also be very low.

3.2 Gender

The carcase quality of entire male pigs is better than that of castrates or females because entire males have higher lean:fat ratios. At the same liveweight, an entire male may have a P2 of 1–2 mm lower than its female counterpart. Entire males also have better feed conversion ratios and growth rates than females or castrates. However, meat quality must be considered when determining appropriate selling weights of pigs. Increased levels of boar taint in entire male pigs can have a detrimental effect on eating quality. The use of the immunocastration vaccine of entire male pigs can improve production efficiency compared to physical castration and as well as minimise boar taint risks.

3.3 Nutrition

It was once common to restrict pigs' feed for several weeks before sale to minimise carcase fat, but genetic improvements have made this unnecessary in most cases. When pigs are allowed to eat when they choose (i.e. are fed *ad libitum*), they are sold at a younger age due to improved growth performance and can produce tender meat with more marbling.

Modern lean genotypes respond well to high energy finisher diets, without negative effects on backfat. A study by Edwards (2011) showed that carcase weight and dressing percentage can also be improved in female finisher pigs offered high energy diets. During the finisher phase, fat-derived energy is utilised more efficiently than carbohydrate-derived energy. This was demonstrated by Philpotts et al. (2008) in finisher pigs (both entire males and females) where improved growth rates were observed in pigs fed diets containing 5% added fat compared with 1.3% added fat (Table 5.1).

It is considered that modern lean genotypes may not have intrinsic limits to protein deposition up to 120 kg liveweight, with protein deposition rates increasing with increasing energy intakes. Therefore, the use of high energy finisher diets can be financially advantageous depending on the cost pressures present in the commodity market.

TABLE 5.1 Backfat thickness in modern genotypes is unaffected by dietary added fat (Philpotts et al., 2008) and energy density (Edwards, 2011) of finisher diets

	Philpotts et al., (2008) Entire male and female		Edwards (2011) Females		
Digestible energy (MJ/kg)	13.8	14.0	13.4	14.2	15.0
Added fat/oil (%)	1.3	5.0	1.6	3.0	4.5
Feeding period (days)	42	42	28	28	28
Carcase wt (kg)	76.7	78.3	74.9	74.6	76.1
Backfat P2 (mm)	9.1	9.3	10.4	10.0	10.9
Dressing (%)	77.0	77.1	75.3	75.7	76.5

Restricted feeding of pigs during the pre-sale period is no longer recommended. Careful marketing and the use of the most cost effective finisher diets (depending on your genotype, raw material prices etc.) is preferred. Restricted feeding can also result in selling pigs at an older age, with the tendency to overstock and reduce feed conversion efficiency.

High fibre raw materials (e.g. oat hulls, lupin hulls, rice bran) may be used in finisher diets to lower feed costs. The use of high fibre finisher diets for a short period (e.g. three weeks) can reduce backfat thickness of pigs (Collins et al., 2009). This approach, however, can limit net returns due to decreased dressing percentages as feeding higher fibre diets generally results in an increased weight of the gastro-intestinal tract of the pig. The use of higher fibre raw materials needs to be assessed relative to net profits.

3.4 Porcine Stress Syndrome

Pigs with this syndrome, otherwise referred to as malignant hypothermia, are more susceptible to stress. It is caused by the recessive halothane gene, named due to the adverse effect that halothane anaesthetic can have on pigs carrying two recessive genes. Pigs may suddenly die when under stress, e.g. when being moved for transported to the abattoir or during lairage. Pigs can have two dominant genes (NN) or one dominant and one recessive gene (Nn) or two recessive genes (nn). Pigs with one dominant and one recessive gene are described as carriers and are less susceptible to stress than those carrying both recessive genes. A pig with two recessive genes (nn) is highly susceptible to stress. The recessive gene is more prevalent in lean, meaty pigs, particularly in the Landrace and Pietrain. Pigs which contain one (Nn) or both recessive genes (nn) are at risk of poor meat quality and the production of pale, soft and exudative pork. The presence of this gene is linked with increased muscle acidity, pale meat colour, poor water holding capacity and reduced tenderness.

Pigs with this gene have a better feed conversion ratio and a higher yield of lean meat, so selecting pigs for these two traits may increase the incidence of the halothane gene. Pigs can be tested for the gene and most breeding companies around the world have done this as part of efforts to remove these pigs from commercial herds. As a consequence, the halothane gene is less of an issue for meat quality than it once was.

3.5 Managing Backfat in Pigs

Managing backfat thickness is important to both maximise profits and optimise eating quality of pork. Whilst genetic selection for lean growth has reduced the prevalence of fat pigs, some payment schedules have become stricter on their tolerance (and payment penalties) for carcases outside of the desired matrix.

Factors which can contribute to undesirable changes in the backfat thickness of pigs include:

- Genotype
- Sex
- Slaughter weight/age
- Excessive feed intake
- Distorted growth patterns
- Diet specifications
- Diet separation
- Season
- Health
- Stress
- Stocking density
- Housing.

Seasonal effects on backfat thickness are often multifactorial. For example, producers may increase their matings in February/March to help offset production challenges associated with summer infertility. This may result in larger batches of pigs coming through the system. Increased stocking rates lead to increased stress, decreased growth rates and increased fat deposition (relative to lean). These challenges can then be exacerbated by the fact that these pigs are going through the finisher phase during summer (November/December) when feed intake may be suppressed.

Some of the challenges associated with the seasonal effects can be partially offset by utilising high density summer diets and lower density winter diets.

To ensure backfat does not become an issue in your herd, it is wise to:

- **Monitor pig performance and kill sheets regularly**. This will allow you to determine the best diet specifications to maximise returns based on your genetic potential.
- **Check stocking densities and access to feed and water**. When deciding on the appropriate stocking density, base it on the actual intended exit weight of the pigs.
- **Monitor feed quality and presentation**. Mixing procedures, raw material quality and appearance of finished feeds should be monitored regularly to ensure feed is of the best quality.

- **Create markets for slow growers.** Exploring alternative marketing opportunities for those pigs which are likely to cause problems is another way to enhance profits.
- **Optimise the timing of the second immunocastration vaccination.** Immunocastration is used to limit the risk of boar taint, reduce aggression and carcase damage of male pigs and to improve feed efficiency relative to surgically castrated males. Applying the second vaccination two weeks prior to slaughter is sufficient to minimise the risk of boar taint and minimise backfat (Lealiifano et al., 2011).

3.6 Manipulating Body Composition

The feed additives and animal products listed below can help redirect absorbed nutrients to allow more lean meat and/or less fat to be deposited. Refer to *Section 5.7 Using Metabolic Modifiers in Chapter Four: The Grower-Finisher Pig* for more detail on these products. Note that porcine somatotropin and beta-agonists are not considered acceptable by some pork retailers.

- **Betaine** can lower the number of very fat pigs and is often used in female finisher diets. Its effects on carcase quality should be monitored before and after use.
- ***Porcine somatotropin*** (pST or Reporcin®) is a pig growth hormone that significantly increases lean while reducing carcase fatness. It is typically injected every two days during the late finisher stage. Pigs must be fed a higher content of dietary amino acids relative to energy to deal with their need to deposit more protein.
- **Chromium** (yeast or picolinate) has potential for manipulating fat in finisher pigs, but variable results have been observed in research studies.
- ***Beta-agonists*** such as ractopamine (Paylean®) also improve growth rates and feed conversion and increase carcase lean. Pigs fed beta-agonists respond best to diets with higher energy and protein contents.
- **Organic manganese** is a more available form of manganese (compared to inorganic forms). Manganese is an essential nutrient for optimal lean protein deposition. Supplementing diets with organic manganese will ensure manganese is not a limiting factor in the performance of your pigs.
- **Pantothenic acid** (Vitamin B5) is a precursor for Acetyl CoA, a metabolic molecule involved in the balancing of carbohydrate and fat metabolism. Deficiencies of pantothenic acid can lead to altered lipid and carbohydrate metabolism. Higher levels than those commonly included in premixes to avoid deficiencies are required for positive carcase effects.
- **L-Carnitine** has the potential to improve lean to fat ratios through favouring lean protein deposition over fat deposition. It is believed that this is achieved by an improved ability of the pig to utilise fat for energy, and sparing amino acids for protein deposition.

These products have the potential to increase lean meat content of the animal but results should be monitored, as genotype, diet composition and other factors are involved. Producers must balance the benefits of using these products with the higher cost of diets and the attitudes of processors, retailers and consumers to feed additives.

4 Meat Quality

The sustainability of the pork industry is reliant on consumer purchasing habits and their consumption frequency. Consumers expect both premium quality and value when purchasing meat and a considerable proportion of consumers are prepared to pay a premium for quality meat products.

The drive to produce lean pork can have negative impacts on its flavour, tenderness and juiciness. The problem is further exacerbated by the average Australian consumer often overcooking pork.

The ability of producers to limit or avoid flavour taints, including boar taint, has a considerable influence on the industry's ability to export Australian pork into Asia, as Asian consumers are more sensitive to taint.

4.1 Boar Taint

Boar taint can be described as the unpleasant odour and/or flavour of cooked pork from entire male pigs, and is caused by high levels of both androstenone, a hormone produced by the testes, and skatole. Skatole and androstenone act synergistically to produce off tasting flavours in pork and contribute to boar taint – therefore boar taint is associated with entire male pigs.

Androstenone produces an intense perspiration or urine-like smell which many consumers find offensive. Androstenone accumulates in fat and its concentration increases sharply with increasing liveweight.

Skatole is produced when intestinal microbes break down the amino acid, tryptophan, in the hind gut. It can cause pork to have a faecal-like smell and a bitter taste. Skatole can also be absorbed through the skin due to faecal contamination of pens, particularly during hot weather. Skatole is a potential problem in both female and male pigs, including castrates. Skatole levels in the fat of entire male pigs increases in the last few weeks prior to slaughter as testicular steroids inhibit its breakdown by the liver. Levels of androstenone and skatole vary among animals. Both can be measured post-slaughter but the test is slow and expensive. In Australia, carcases are not classified on the basis of boar taint.

Poor correlations between carcase weights of entire male of 60–80 kg and androstenone and skatole concentrations in fat indicate that the use of carcase weight is not a reliable selection tool to minimise risks of boar taint (D'Souza et al., 2011). Boar taint was detected in 15–20% of light weight (64 kg ±5 kg) entire males.

Some options for reducing the risk of boar taint due to androstenone or skatole:

- **Use an immunocastration vaccine for all entire male pigs.** This involves two vaccinations administered to each animal, one during the grower phase (any time after eight weeks of age) and the other during the finisher phase (two to six weeks prior to slaughter).
- **Castrate male pigs.** Surgical castration is generally an unfavourable option for most producers because of their lower growth rate and increased fat deposition as well as welfare concerns. Some markets may prefer surgical castrates and are prepared to pay a premium. Immunocastration presents a more viable option for most producers (Table 5.2).

- **Do not sell entire males at liveweights more than 90 kg if not immunocastrated.** Although heavier pigs may be more profitable, and no penalties for meat quality exist in current market schedules, risks of boar taint are increased.
- **Avoid overstocking in the final two weeks before sale.** Design and maintain clean pens to keep pigs away from faeces, particularly in hot weather, as the issue of skatole is more prominent in summer.

Pay attention to meat quality when developing a breeding policy.

Research conduct by Lealiifano et al. (2011) showed that the timing of the second Improvac® vaccination can be delayed until up to two weeks prior to slaughter to minimise the increase in backfat commonly associated with immunocastration, whilst also reducing the risk of boar taint.

TABLE 5.2 Influence of the timing of the second Improvac® vaccination prior to slaughter on growth performance and carcase characteristics (Lealiifano et al., 2011)

	Control	2 wks	3 wks	4 wks	6 wks	P-Value
Start weight (kg)	58.2	58.9	58.1	58.2	58.9	0.971
Final weight (kg)	105.1	104.9	104.8	107.9	107.9	0.223
Voluntary feed intake (kg)	2.57^{a}	2.71^{ab}	2.76^{bc}	2.90^{cd}	2.99^{d}	0.001
FCR	2.32	2.30	2.50	2.54	2.45	0.091
Carcase wt (kg)	69.2^{ab}	68.3^{a}	67.9^{a}	71.0^{b}	71.2^{b}	0.027
Backfat P2 (mm)	11.7^{a}	11.3^{a}	12.8^{ab}	12.6^{ab}	13.7^{b}	0.054
Androstenone (ug/g)	0.91^{a}	0.11^{b}	0.11^{b}	0.10^{b}	0.13^{b}	0.001
Skatole (ug/g)	0.05	0.04	0.03	0.04	0.04	0.520
Testosterone (ng/g)	5.24^{c}	1.11^{a}	1.31^{ab}	1.57^{ab}	1.77^{b}	0.001

^{a,b,c} means within a row lacking a common superscript differ ($P < 0.05$)

Key conclusions from this study were:

- Delaying the second vaccination until two weeks prior to slaughter can help maintain feed intake and feed conversion efficiency similar to an entire male;
- Delaying the second vaccination until two to four weeks prior to slaughter can significantly reduce the risk of boar taint by lowering the levels of both androstenone and skatole in fat.

4.2 Contamination

With growing consumer awareness of food residue effects, producers must use management strategies to ensure that their product meets high health standards and is safe to eat. Only one well-publicised outbreak of food-poisoning is needed to result in a devastating impact on pork consumption. Make sure that no pigs are sold until the withholding period and export slaughter intervals for any veterinary medications that may have been used have expired.

4.3 Fat Quality

The firmness or softness of fat tissue is influenced by the fatty acid composition, principally the proportion of saturated and unsaturated fat acids present. Entire male pigs have softer fat than castrates and gilts because of a higher water and lower lipid content and increased levels of unsaturated fatty acids.

Whilst increasing the polyunsaturated: saturated fatty acid ratios in meat for human health reasons has attracted interest, this can reduce the shelf stability of the product. Changing the type and quantity of oil in the feed can alter the fatty acid composition in pig fat and muscle tissues. Off-flavours are most apparent in pigs fed unsaturated oils (e.g. canola oil), and there is more risk of rancid meat and off-flavours when large amounts of fish oil are used. Antioxidants (Vitamin E, selenium) can be utilised in feed to offset these risks.

When manipulating the fatty acid profile of pork fat, a four to six week period is required on the necessary diet to observe the profile changes. In some countries, pigs are finished on corn or acorns to produce niche market products which generally have increased intramuscular fat (marbling) and softer, less saturated fat. These attributes are desirable in the fresh pork market, but present challenges in the processed pork market.

5 Meat Production Objectives

The objective of rearing pigs is to optimise the amount of meat sold for the highest profit while safeguarding pig welfare and reducing negative environmental impacts.

Ways to achieve this:

- Management strategies that maximise meat quality
- Knowledge of the product the market requires
- Careful monitoring of markets and associated prices
- A negotiated contract
- Development of niche marketing opportunities.

5.1 The Product

It is vital to produce pork that consumers enjoy eating and are keen to buy again. Therefore, determine what makes a good product before you rear a pig to the point of slaughter and decide when to sell it.

Pork of high quality is:

- **Visually appealing:** with the correct ratio of lean to fat, pinky-red in colour, white fat and without excessive moisture or drip loss.
- **Suited to consumer needs:** with tenderness, juiciness and flavour which add up to a good eating experience.
- **Uniform:** so that processors, retailers and consumers are confident with what they are buying.
- **Uncontaminated:** by drug residues, parasites or heavy metals. Use quality assurance programs which involve key supply chain participants, including the producer, the transporter, the processor and the customer.
- **Priced competitively:** and supported by aggressive marketing.

Producers have a direct influence on all these, but are not directly rewarded. As previously stated, most Australian price schedules are based on carcase weight and depth of backfat rather than the qualities described here. Technological developments may see carcases assessed on these qualities in the future, so producers need to be aware of them to keep their customers and consumers satisfied.

5.2 Selecting for Sale and Sale Options

Selecting pigs for sale is important. Unless the 'how, where and when to sell' questions are addressed, the effort of rearing pigs can be wasted. Producers without a good marketing strategy should develop one or join a marketing group.

Selling by age

As mixing unfamiliar pigs is unwise, those weaned at a similar age usually stay in the same groupings through the weaner, grower and finisher phases, particularly in all-in/all-out rearing systems.

Advantages

- It is easier to sell all pigs from the same pen at the same age.
- If the opportunity exists to market out of a pen at multiple times, the removal of the heaviest pigs can improve the growth performance of the remaining pigs, reducing the risk of penalties.

Disadvantages

- A wide range in carcase weights and quality can occur.
- Pigs attract a lower average price because processors place high penalties on those carcases outside the preferred range of carcase weight and fatness.

Selling by weight

Price is largely based on the weight and fat content of the carcase, so the pig's stage of development at sale is very important.

Advantages

- Carcase weight and fat content are more uniform.
- Returns per pig will be higher because fewer carcases are penalised for being outside the buyer's specifications.

Disadvantages

- If autosorting equipment is not available, it will take time to weigh and measure backfat thickness of individual pigs for selection.
- Retained lighter pigs are mixed with other lightweights (making stocking rates drop for the period) unless pre-sale accommodation is built.

Selling pork versus bacon

Producers are often tempted to sell some of their pigs as porkers (at 40–55 kg liveweight) because of the higher price offered by processors. While more profit can be gained by rearing them to baconer weight (>55 kg liveweight), selling a proportion as porkers might be necessary if:

- Accommodation is not available to rear all pigs through to baconer weight.
- The herd has problems with pigs being overly fat, and selling lighter females saves price penalties later.
- Some pigs are 'tail-enders' and selling them as porkers is more attractive than retaining them for later sale as underweight baconers.
- Unhealthy pigs grow slowly, so these animals are best sold as porkers to keep infection levels down and provide healthy pigs with more space.

CASE STUDY: Marketing pigs for maximum profit

Tom, Jarad and Caleb Smith run a 2000 sow unit in central Victoria (Kia-Ora Piggery P/L). The success of their business has largely been driven by innovations and good management. They have chosen to invest time and labour in developing a robust marketing plan so they can maximise the profits from the >45,000 pigs they sell each year.

To help maximise profits and minimise risk, Kia-Ora markets their pigs through five buyers. Each buyer has their own preferred carcase specifications and associated penalty systems. For example, one buyer prefers castrated males heavier than 80 kg carcase weight, whilst the other penalises for castrate male carcases over 84 kg. So Kia-Ora splits their castrate pig loads between these two buyers to maximise profits and satisfy buyer requirements. Having multiple markets can also increase the chance of finding a more flexible buyer, which is important considering the dynamic nature of pig production. Larger buyers that have the facilities to bone out are generally more flexible.

Direct selling is hard work, involves added costs and extra risks, and requires very dedicated staff to make it work. Even with marketing flare, good financial skills and excellent PR skills, the right person will still face many challenges when direct marketing. Other buyers dumping cheap pork in the area you normally direct sell to is just one example of the many challenges associated with direct marketing. Logistics is also a major hurdle to work through, especially in country areas where lower numbers of pigs are consumed.

Kia-Ora also makes an effort to maintain dialogue with buyers about future target sales. For example at any one time they are discussing whether buyers will be interested in purchasing heavy castrates in six months' time. This dialogue allows Kia-Ora to best utilise their grower-finisher space based on predicted sales.

Kia-Ora only sells 30% of their pigs under contract at present. Tom believes contracts are a good option for producers when the contract factors in an allowance for the cost of production. This is particularly important to factor in if buyers are asking you to adopt alternative/compromised production systems.

Two to three weeks prior to market, all finisher pigs are weighed and penned according to liveweight. Those within a pen at weighing are all within 5 kg of one another. A sales computer program is used to alert staff as to when the pigs are ready to market. This weighing and penning allows them to:

- Sell vaccinated boars with Improvac® at the correct time (Kia-Ora is not prepared to compromise their quality by selling any more whole boars than absolutely necessary).
- Meet the exact weight requirements of the shop trade pigs (which are all gilts, mainly due to the difficulties in matching castrate vaccination timing with very specific weight requirements/demands).

CASE STUDY: Marketing pigs for maximum profit (Continued)

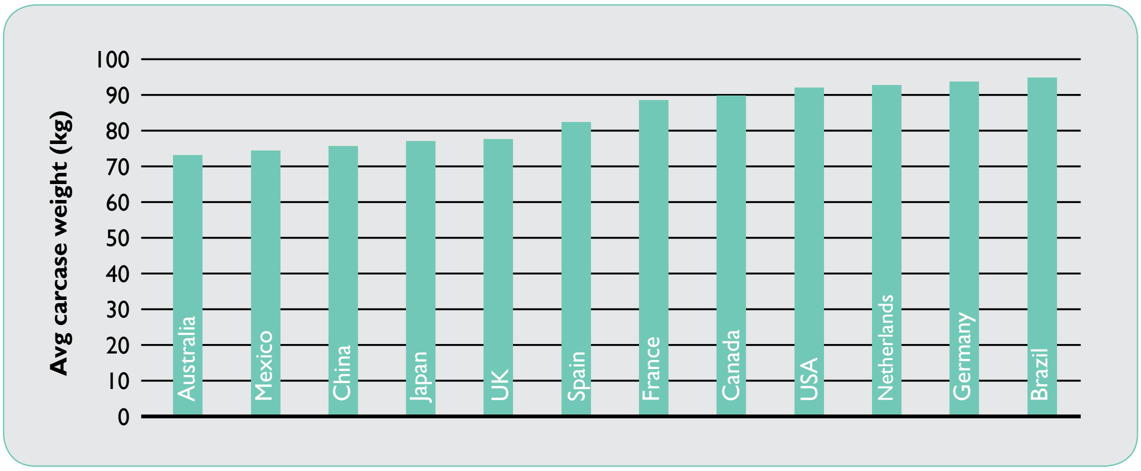
Regular visits to the abattoir in the past allowed Tom to establish a greater understanding of the abattoir process and build good relationships with both abattoir staff and butchers. Having a good relationship with the abattoirs is essential as you rely on them having the facilities and staff to sort and trim pigs for you at the scales to eliminate employing another person and costly sorting in the chillers.

Spending time to find the right buyer/s is important. Honest buyers who pay to agreed terms, with good consistent markets, offering good competitive prices should always be sought. Spend the time to get to know your buyer and their business, and encourage them to do the same with your business.

Selling heavy weight pigs

Pigs are sold at lighter liveweights in Australia compared with our international competitors (Figure 5.1). This adds to our production costs. Lower carcase weight is a major issue as costs, including levies and kill charges, are calculated on a per pig basis. In general, heavier carcase weights equate to a better return (as long as pigs are not overfat). Feeding a lower specification pre-sale diet to pigs heavier than 90 kg liveweight helps to manage feed costs.

FIGURE 5.1 Average carcase weight of pigs sold by country in 2012 (FAOSTAT, 2012)



There is no optimal liveweight at slaughter which will suit all producers; those considering sale of heavier pigs should keep the following in mind:

- Space to rear finisher pigs. Extra returns may soon pay for additional pre-sale housing.
- The fat to lean ratio of the genotype reared. Benefits of producing a heavier carcase may be lost due to price penalties for over fat pigs.
- Boar taint incidence, particularly with entire males, will increase with age and weight. Where immunocastration is accepted by customers, boar taint risks can be minimised.
- Check the processor's price schedule – there is retailer demand for a range of pork products from pigs of different weights.

6 The Selling System

Movements of pigs are typically between specialised production sites in vertically integrated farms (e.g. moving piglets from a breeder site to a grow out site) or from production sites to slaughter. Decreasing numbers of pigs are sold at saleyards. APL estimates that fewer than 1% of Australian pigs are moved or consigned through a saleyard.

6.1 Direct Consignment or by Contract

Direct sale at an agreed price is based on depth of backfat (P2) and carcase weight.

Advantages

- Lower market costs.
- Negotiated premiums based on weight and grade.
- Payment based on objective measurements.
- The producer is provided with carcase feedback (weight and fatness) and may also obtain parcial information on carcase quality and carcase condemnations.
- Individual contracts are possible.
- Reduced pre-slaughter handling due to direct consignment to abattoirs.

Disadvantages

- The market's unexpected highs cannot be exploited, although contract prices may be based on an agreed market indicator.
- Producers should:
  - Stipulate the day of payment as part of the contract.
  - Confirm backfat readings by using another kill site, request feedback from the processor or inspect carcases.
  - Regularly check weights and dressing percentage*.
  - Visit the abattoir often and establish communication with the processor.

  * Dressing percentage is calculated by measuring liveweight before sale ([dressed weight ÷ liveweight] x 100). It may be used, with price, to decide which processor to approach.

PorkScan: bringing home the bacon

PorkScan Pty Ltd has developed the PorkScan system which uses ultrasound to measure fat and muscle depth at the P2 site. At least 40% of Australia's annual pig production is assessed for fat depth using PorkScan. This non-invasive technology has allowed for more accurate, real time measurements of subcutaneous fat depth over the loin muscle. Images of each carcase scanned may also be retained by the processor.

A new system, using laser scanning techniques to predict lean and saleable meat yield of carcases and key primals on the slaughter floor, is in its final stages of development, with funding support from the Pork CRC and PorkScan Pty Ltd. Processors will be able to provide this information to producers and use this information to assist in grading carcases.

The PorkScan technologies are expected to be extremely beneficial to both processors and producers of pork as they allow for accurate and timely feedback on carcase quality.

6.2 Saleyard Auction

Live auctions, where less than 1% of the country's pigs are sold, promote competition and identify supply and demand.

Advantages

- Competitive environment.
- No price penalties apply, although buyers may choose to discount on the basis of previous purchases.

Disadvantages

- Price is based on subjective inspection of live animals which does not reveal carcase quality.
- Selling costs are 5–7% higher than with direct selling because of agent commissions, saleyard charges and extra transport.
- Moving pigs between the farm gate and the abattoir triggers bruising, weight loss, condemnations and stock losses.
- Fewer saleyards hold pig auctions nowadays.

7 Influences on Meat Quality

Customer satisfaction is an important outcome for the pork industry. Customer satisfaction is influenced by meat quality, eating experience and consistency. Channon et al. (2016) found that overall liking of pork is influenced by flavour, juiciness and tenderness, with flavour being three times more important than either juiciness or tenderness.

7.1 Fat

Like carcases, a major criterion of pig meat quality is its fat content. Fat is deposited as subcutaneous fat located under the skin, intermuscular fat which lies between main muscles, and intramuscular (or marbling) fat within the muscle. More subcutaneous fat can have a negative impact on consumer demand and although it can easily be trimmed off, it comes at a cost.

Marbling fat, combined with good cooking practices, contributes to tender, juicy and flavoursome meat. Marbling fat is a later maturing fat depot compared to subcutaneous fat deposits. Early maturing breeds deposit noticeable amounts of marbling fat earlier than later maturing breeds. Marbling fat declines at a similar rate to subcutaneous fat, so genetic selection for leaner carcases can affect both marbling fat and subcutaneous fat.

During the finisher phase, avoid feeding diets with high levels of unsaturated fatty acids (e.g. vegetable oils, corn), which will result in the deposition of softer fat. Also avoid feeding raw materials which may taint the fat of pigs and produce off flavours (e.g. fish oil, direct or via fish meal, and aromatic compounds, such as garlic).

7.2 Lean

Lean meat is comprised of protein (muscle and connective tissue), water and intramuscular fat. The structure of muscle proteins can be altered by rates of muscle temperature and acidity decline post-slaughter. Increases in the acidity of pork after slaughter causes muscles to lose their ability to bind water and increases drip loss; lowering its quality.

7.3 Post-slaughter Muscle Metabolism

After slaughter, the muscles are no longer supplied with oxygen. Muscle glycogen is broken down to produce lactic acid instead of supplying energy. Lactic acid lowers the muscle's pH and increases its acidity.

About 24 hours after a healthy, well-fed, rested pig has been slaughtered, with minimal stress, the pH of muscle declines from 7.2 in the live animal to between 5.5–5.8. An exhausted, or chronically stressed, pig with lower glycogen reserves will produce pork with a higher pH (greater than 6.0) due to lower lactic acid levels.

The extent and rate of acid production can have a large bearing on meat colour, texture, tenderness, juiciness, flavour, water-holding capacity and shelf-life. It may result in the production of pale, soft, exudative (PSE) pork or dark, firm and dry (DFD) meat. Although the incidence of PSE and DFD pork has decreased in Australia over the last 15 years, customer satisfaction rates of eating quality have remained stagnant during this period.

7.4 PSE Meat

This condition may occur if muscle glycogen levels are high at slaughter and breaks down rapidly immediately following slaughter to produce excessive lactic acid. Pork with a pH level of less than 5.5, drip loss of >5% and pale muscle colour can be classified as PSE (pale, soft and exudative). If muscle temperatures are high (typically >35 °C), the high acid levels will denature muscle proteins, making the meat pale and with a more open structure than normal (ultimate pH of 5.5–5.8) pork.

Denatured muscle proteins are less able to retain water, which is lost during chilling (5% compared with ~2.5% in normal meat). High muscle temperatures can occur in pigs stressed immediately before slaughter, and the rate of muscle pH decline can also be faster if the dressed carcase is not quickly chilled. The incidence of PSE varies between consignments, between abattoirs and the time of year. It is estimated that producers are responsible for 50% of PSE cases whilst processors are responsible for the remaining 50% of cases (Grandin, 1994).

PSE is more prevalent if:

- Pigs have the halothane gene, which makes them more stress-susceptible.
- They have been fed in the six hours before slaughter and have high levels of muscle glycogen.
- They are trucked to the abattoir in the heat.
- Resting periods in lairage prior to slaughter are less than two hours in duration.
- Animals are poorly handled immediately prior to stunning.

7.5 DFD Meat

Pigs with a low levels of muscle glycogen at slaughter will produce little muscle acid, resulting in dark, firm and dry (DFD) meat. In this case, the muscle proteins are swollen, rather than de-natured. Muscles retain more water than normal or PSE pork, but the meat looks dry. Shelf life of high pH pork can be reduced.

The condition is caused by chronic stress lasting more than 12 hours (e.g. during trucking) and being denied feed for 24 hours or more before slaughter. Poor handling practices on-farm can also cause prolonged stress.

7.6 Nutritional Strategies to Enhance Pork Quality

Australian pig industry funded research (D'Souza et al., 2000) showed that supplemental magnesium (Mg) offered via drinking water or fed to pigs for two days prior to slaughter improved meat colour, reduced drip loss and reduced the incidence of PSE. The recommended rate is 1.6 g of elemental Mg (coming from 20 g of Magnesium aspartate) per pig per day for two days prior to feed removal. Inorganic forms of magnesium (including $MgSO_4$) were also tested but were less effective when used at the same rate.

A number of feed additives may be used to enhance pork quality (Table 5.3). Contact your nutritionist to discuss the recommended use rates and application period of these additives.

TABLE 5.3 Feed additives that may positively influence meat quality

	Meat Quality Parameter						
Feed additive	Improve colour	Reduce drip loss	Reduce incidence of PSE	Reduce lipid oxidation	Increase intramus-cular fat/ marbling	Enhance flavour, juiciness, tender-ness	Reduce incidence of skatole induced boar taint
Organic Mg	X	X	X				
Organic Se	X	X		X		X	
Vitamin E	X	X	X	X			
CLA^					X	X	
Chromium					X	X	
Betaine		X					
Vitamin C	X			X			
Yucca		X					X
Vitamin D						X	
Organic Iron	X						

^ Conjugated Linoleic Acid

8 Pre-transport Management

Poor management just before transport can cause stock losses on the truck and poor meat quality at slaughter. Attention given to feeding and stress reduction is of prime importance.

8.1 Withholding Periods

There are serious consequences for the whole pork industry if pork and pork products containing chemical residues enter the domestic and export markets. Every producer must ensure that withholding periods and export slaughter intervals for antibiotics, chemicals and other veterinary medicines are strictly adhered to. Having a quality assurance program like APIQ✓® can ensure that there are quality management systems and recording systems in place to ensure withholding periods are adhered to. Contact Australian Pork Limited (APL) on 1800 789 099 for more information on APIQ✓®.

Check recommendations for each product used. For up to date information on withholding periods visit the Australian Pesticides and Veterinary Medicines Authority website at https://portal.apvma.gov.au/pubcris and search by brand name of the medication. Make sure you use the correct dose and keep clear records of treated pigs to identify them before sale.

8.2 Feeding

Feeding just before transport can increase the risk of death because digestion produces heat and can increase the incidence of PSE at slaughter. This practice can also increase carcase and offal contamination risks during dressing due to spillage from gastro-intestinal organs. Feed is not converted to meat for at least ten hours, so last-minute feeding does not increase carcase weight. If pigs have fasted for more than ten hours, carcase weight is lost. In some cases, providing pigs with drinking water that contains glucose and electrolytes can improve dressing percentage by retaining fluids.

8.3 Loading

Stress increases in direct proportion to the steepness of the loading ramp. Load pigs in the early morning and do not use dogs or electric prodders.

Pigs will baulk if suddenly exposed to strong light or other distractions, so yards should have solid walls and gates, if possible. Design laneways and ramps so they can move easily and the process will be faster. In hot weather, spray pigs after loading and discourage them from fighting.

The loading ramp design should:

- Be height-adjustable to accommodate a range of transport vehicles.
- Have a circular forcing pen to keep pigs moving into the race area.
- Have a double race ramp to encourage pigs to proceed.
- Include a walkway so the handler can move slow pigs along.

9 Transport

In the 2015/2016 financial year about 5 million pigs were slaughtered in Australia. Approximately 85% of Australian pigs are slaughtered in the seven export accredited abattoirs. Australian pigs can be transported several hundred kilometres to the abattoir and are not officially sold until they are killed. The producer's responsibilities do not end when pigs are loaded on the truck. The welfare of the pigs is the responsibility of the transport company (particularly the driver of the truck) during transit. Once unloaded, the welfare responsibilities lie with the abattoir management until slaughter. It is important that producers ensure both the transport company and abattoir are aware of their responsibilities.

Keep pigs in familiar groups during transport to calm them. Fighting accounts for two-thirds of pig deaths in transit. Other causes include high temperatures, feeding pigs just before slaughter and poor ventilation just behind the driver's cab, all of which can contribute to the development of PSE and DFD pork.

Trucking in the cooler hours on a hot day, regularly dousing with water, misting sprays, and covering pigs with shade cloth, particularly when delays in transporting or unloading occur, are requirements of the *Model Code of Practice for the Welfare of Animals (Land Transport of Pigs) (2003)* (available from CSIRO's website at www.publish.csiro.au/Books/download.cfm?ID=1502). When ambient temperatures exceed 25 °C, the loading density of pigs must be reduced by 10% (Table 5.4). In winter, pigs in transit need protection from cold winds.

Deaths are more common during long trips, so pay extra attention to stocking densities and the design of the transport vehicle. Adjust stocking densities to suit the weather (see Table 5.4) and do not overcrowd pigs, as they will have high body temperatures on arrival which is maintained for one hour in lairage and, perhaps, at slaughter. This can lead to pork quality issues.

Develop good communication with the transporter and the processor. Check the policy of your transport company who are obliged to comply with quality assurance schemes. Express concern on matters including stops during transit (which will restart fighting among unfamiliar pigs) and point out the need for air movement. If lairage facilities or handling techniques are inadequate, discuss it with those involved.

TABLE 5.4 Loading density guidelines for the transport of pigs based on light weight and ambient temperature

	2.5 m wide x 3 m long pen		2.5 m wide x 4 m long pen		Space allowance, m^2	
Liveweight (kg)	Min	Max	Min	Max	<25 °C	>25 °C
50	30	33	40	44	0.22	0.24
75	21	25	31	34	0.29	0.32
100	19	21	25	28	0.35	0.39
125	15	19	21	23	0.42	0.46
150	13	15	18	20	0.48	0.53
175	12	13	16	18	0.55	0.61
200	11	12	14	16	0.61	0.67

Source: *Model Code of Practice for the Welfare of Animals (Land Transport of Pigs) (2003)*

APL's 'Is it Fit for the Intended Journey' guide is a good source of information on pre-transport checks and decision-making required at time of loading. This guide is intended to support pork producers to comply with the Land Transport Standards (National Land Transport Act 2014).

10 Lairage and Slaughter

Placing animals into lairage pens upon arrival at the abattoir enables the abattoir to maintain a constant throughput of pigs. It also provides the animals with time to recover from transport to minimise pork quality issues. The requirements of lairage are:

- Shade and cool water.
- Water sprays in hot weather.
- No electric prods.
- No mixing of pigs from different groups.
- Pigs are rested for two to four hours before slaughter.

These requirements will contribute to a higher dressing percentage, fewer deaths and condemnations, and superior meat quality. Many abattoirs use carbon dioxide (CO_2) stunning systems, instead of electrical stunning, to improve carcase and meat quality.

11 Monitoring Feedback

Selling pigs by direct consignment gives valuable information on carcase quality. Most processors provide data on carcase weight, depth of backfat (according to the relevant price schedule), and any condemnations. Here are ways to analyse this data.

11.1 Profit Box and Carcase Weight Histogram

Make up a profit box and carcase weight histogram (Figure 5.2 and Figure 5.3) which will show at a glance whether most pigs are being sold at the most profitable weight and grade. To give the best return, pigs should occupy the top right corner of the premium box. Analyse by:

For a profit box:

- Creating a grid of your regular buyer's price matrix.
- Plotting dressed weights and depths of backfat for individual pigs.
- Plotting males and females on separate graphs, or with a different colour.

For a carcase weight histogram:

- Create weight ranges based on your price matrix.
- Weight ranges on either side of the premium range should be in 5 kg increments (as pigs grow at roughly 5 kg of carcase weight/week in the finisher phase).

The profit box and carcase weight histogram will give you an overview of your weekly slaughter. These graphs can be used to drive improvements in product and management. Things to check include:

- Aim for a minimum of 90% of pigs within the premium range.
- In carcases with thick backfat levels, are the pigs also too heavy? You may not have a backfat issue; you may just need to market pigs earlier.
- If backfat thickness is an issue, contact your nutritionist and adapt your feeding program from weaning.

FIGURE 5.2 **Example of a profit box highlighting males and females**

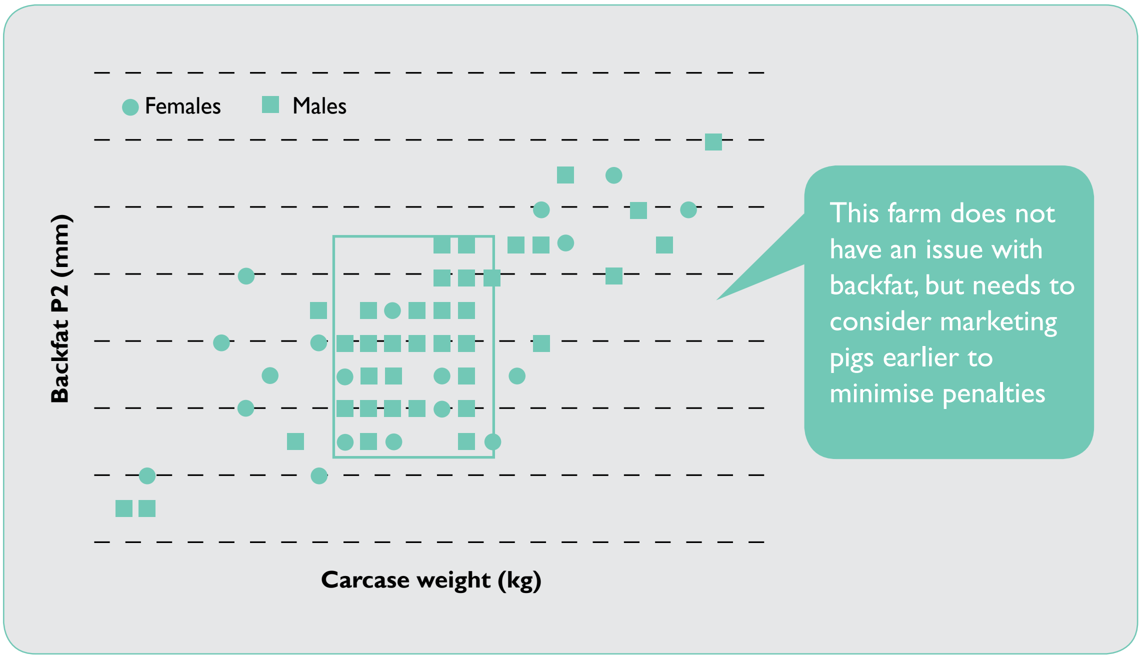
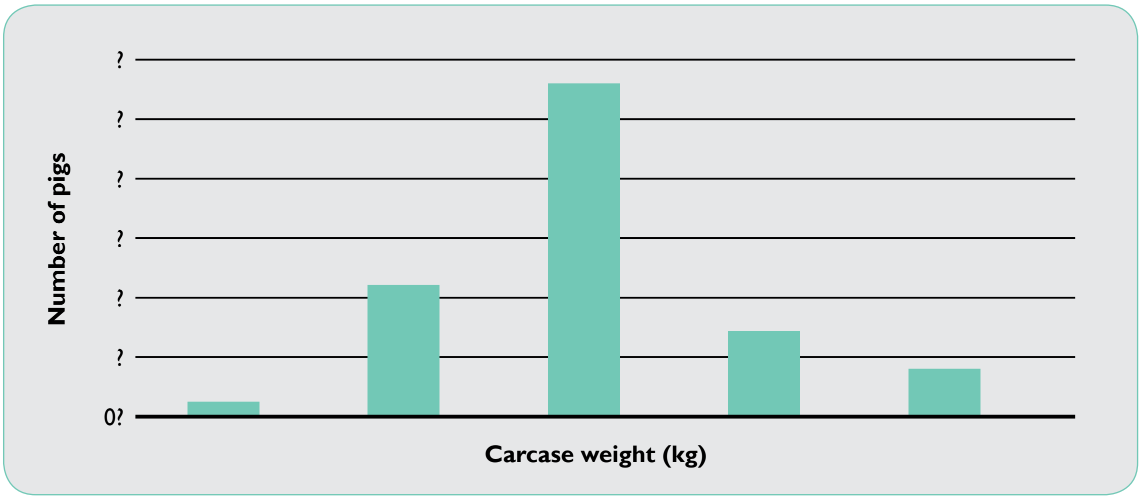


FIGURE 5.3 **Example of a carcase weight histogram with weight ranges in 5 kg increments**



11.2 Individual Feedback

It is useful to identify individual pigs by tattooing before sale and follow a consignment through the abattoir to gain direct feedback from the purchaser on important meat quality factors. Data on lean meat yield may become routine in future.

Of course, this information is of little benefit unless it is critically analysed and steps are taken to maximise return per kilogram of pig meat sold. Providing regular slaughter data to your nutritionist will help them refine your feeding program to maximise profit.

12 References

Channon, H.A., D' Souza, D.N., Hewitt, R.J.E., van Barneveld, R.J., McNaughton, K., Jarrett, R., Jose, C. & Dunshea, F.R. (2013a) Verification of eating quality pathways to produce consistently high quality pork. Pork CRC Project 3A-105. Final Report prepared for the Co-operative Research Centre for High Integrity Australian Pork.

Channon, H.A., D'Souza, D.N., McNaughton, K., Jarrett, R., Kiermeier, A. & Dunshea, F.R. (2013b) Determining the effect of ageing period, cut type, cooking method and internal temperature on sensory and technological quality of pork. Pork CRC Project 3A-106 1213. Final Report prepared for the Co-operative Research Centre for High Integrity Australian Pork.

Channon, H.A., D'Souza, D.N., & Dunshea, F.R. (2016) Developing a cuts based system to improve consumer acceptability of pork: Impact of gender ageing period, endpoint temperature and cooking method. *Meat Science* Vol. 121. pp. 216-227.

Channon, H.A., Taverner, M.R., D'Souza, D.N. & Warner, R.D. (2014) Aitchbone hanging and ageing period are additive factors influencing pork eating quality. *Meat Science* Vol. 96. pp. 581-590.

Collins, C.L., Tickle, K., Henman, D., Smits, R. & Philpotts, A. (2009) Maximising the benefit of high fat and high fibre diets during the finisher period. Pork CRC Project 2B-101. Available online at www.apri.com.au/2B-101_Finisher_fat_and_fibre_interactions_-_final_report.pdf.

D'Souza, D.N., Dunshea, F.R., Hewitt, R.J.E., Luxford, B.G., Meaney, D., Schwenke F., Smits R.J. & van Barneveld R.J. (2011) High boar taint risk in entire male carcases. Manipulating Pig Production XIII. R.J. van Barneveld. Adelaide, South Australia, Australasian Pig Science Association, Werribee, Australia. XIII: 259.

D'Souza, D.N., Warner, R.D., Leury, B.J. & Dunshea, F.R. (2000) The influence of magnesium supplementation type, and supplementation dose and duration, on pork quality and the incidence of PSE pork. *Australian Journal of Agricultural Research* Vol. 51. pp. 185-189.

D'Souza, D.N., Trezona Murray, M., Dunshea, F.R. & Mullan, B.P. (2012) Enhancing pork product quality and consistency: a pathway approach. *Proceedings of 58th International Congress of Meat Science and Technology*, Montreal, Canada, 12-17th August 2012, pp. PRODUCTP 83.

Edwards, A.C. (2011) The effect of dietary energy density on Paylean® responses in finishing pigs. Pork CRC Project 2H-111. Available online at www.apri.com.au/2H-111_Final_Report_110427.pdf.

Grandin, T. (1994) Methods to reduce PSE and bloodsplash. *Proceedings from the Allen D. Leman Swine Conference*. University of Minnesota. Vol. 2. pp. 206-209.

Jose, C.G., Trezona Murray, M., Mullan, B.P., McNaughton, K. & D'Souza, D.N. (2013) Determining the variability in eating quality of Australian fresh pork. Pork CRC Project 3B-101. Final Report prepared for the Co-operative Research Centre for High Integrity Australian Pork. Available online at http://porkcrc.com.au/wp-content/uploads/2014/05/3B-101-Final-Report.pdf.

Lealiifano, A., Pluske, J., Dunshea, F.R. & Mullan, B.P. (2009) Altering the timing of the immunocastration vaccine (Improvac®) to reduce its impact on attributes of pig performance. Pork CRC Project 2A-104. Available online at http://www.apri.com.au/2A-104_Expt_4_Improvac_Study-_Final_Report.pdf.

Lealiifano, A., Pluske, J., Nicholls, R.R., Dunshea, F.R., Campbell, R.G., Hennessey, D.P., Miller, D.W., Hansen, C.F. & Mullan, B.P. (2011) Reducing the length of time between slaughter and the secondary gonadotropin-releasing factor immunization improves growth performance and clears boar taint compounds in male finishing pigs. *Journal of Animal Science* Vol. 89. pp. 2782-2792.

Philpotts, A., Smith, C., Henman, D. & Collins, C. (2008) The effect of dietary fat level on growth rate and efficiency of finisher pigs. Pork CRC Project 2B-101. Available online at www.porkcrc.com.au/2B-101_Final_Report.pdf.

Chapter Six

Feed

1 Introduction

Feed is the single largest cost involved in producing pork. To maintain a viable and successful pig farm it is essential to ensure feed is used efficiently and effectively. There are a number of factors which need to be considered when managing feed. This chapter will cover factors including feed quality, home mixing, feed delivery and feed wastage.

2 Optimising Feed Quality

By using the best quality feed you will:

- Reduce feed costs
- Maintain consistent, reliable pig production
- Maximise feeding efficiency
- Benefit from advances in pig nutrition research
- Reduce the risk and impacts of health challenges.

Pig producers can choose between mixing feed on-farm or buying manufactured feeds from commercial mills. The cost of commercially milled feed not only includes raw materials and physical manufacturing charges, but feed formulation, manufacturing equipment, storing raw materials, quality control procedures, and being responsible for supply. Mixing diets on-farm is not an option unless you are prepared to manage all these factors yourself.

The following information will allow you to manage nutrition for maximum feed quality. It will help you decide whether on-farm mixing is your most cost-effective option, have control procedures in place to ensure that the quality of diets mixed on-farm is high, and to check the cost of manufactured diets.

Before you start, compare the costs, benefits and disadvantages of mixing diets on-farm to buying feed from a commercial mill.

2.1 Mixing Costs

There is no simple answer to the perennial question, whether pig producers should buy their feed from a commercial mill, or mix on-farm. When determining this, many producers focus on cost, but the true cost of on-farm mixing is seldom considered.

A decision to mix at home requires a commitment to run a feed mill as a stand-alone business designed to support pig production.

The true cost of home mixing can be arrived at using the following equation:

$$\textbf{Home mixing costs} = \frac{(a/b) + c + d + e + f + g + h + i}{j - k}$$

a = Total capital costs of mixing equipment, feed sheds and storage facilities including installation
b = Write-off time in years for capital equipment
c = Annual interest on the plant
d = Annual repair costs
e = Labour cost of mixing per year

f = Fuel and power costs
g = Interest on paying in advance for raw materials
h = Buying, finding and negotiating the purchase of raw materials
i = Raw material analysis costs
j = Tonnes of feed mixed per year
k = Milling losses (dust, moisture) and wastage.

When the true cost is known, you may discover that the difference between home mixing and buying commercial diets is not great. If you 'save' by mixing on-farm without having raw materials and mixed diets analysed for nutrient content and quality, you could be losing far more because your pigs are not performing as they should.

2.2 Pros and Cons of Buying Commercial Feed

If a commercial mill is nearby, transport costs can be saved so using manufactured feed seems sensible, particularly when a farm can get competitive bids from several nearby mills and buy in bulk.

The best deals can be achieved when a close liaison is established with the mill's technical staff. They then understand the production constraints of your farm, including genetics, feed change points, housing facilities, health status and market requirements.

Commercial feed mills can make specifically tailored diets, but their willingness to do so will depend on the size of your enterprise. Most mills offer standard diets for pigs, based on their experience with a range of herds, however, modern pig production systems, regardless of size, need diets to be fine-tuned for the genotype and production system.

Commercially produced feed gives the producer little control over the actual composition of the diets. Pig producers understand the importance of diet quality and its influence on cost and pig performance.

Those who mix diets on-farm may improve feed quality if they buy from a commercial mill, where quality control is inbuilt. Some mills spend up to $7.50/T on checking the quality of feed ingredients and mixed feed.

Feed form can have an impact on pig performance and profitability. Some feed mills are limited to producing feed in mash form (rather than pellets). Feed mills may also have restrictions on what raw materials they will stock (e.g. restricted animal material, Paylean®), especially when the mill is servicing both ruminant and monogastric industries. These restrictions may compromise pig performance.

2.3 Pros and Cons of Mixing On-farm

Apart from cost, there are other reasons why you may prefer to mix diets on-farm:

- You have full control over the composition of your diets
- You can grow your own grains
- Home-mixing is more flexible and convenient if feed additives are used
- Greater flexibility to trial/change feed additives.

On-farm mixing seems to make sense for producers who grow their own grain, or have access to good supplies of local grain, and have the labour. Distance from a local feed mill is also a consideration, but the more a producer undertakes home mixing, the greater are the risks. Home mixing often stops because of labour shortages or the fact that buying from commercial mills saves time. As the size of a piggery grows, producers are in a better position to negotiate prices with feed manufacturers. More milling equipment is required as farms which home mix expand in pig numbers, adding to capital costs when funds may be best used elsewhere.

If you do decide to home mix, it is important to carefully select the right person to operate the feed mill. Attention to detail, accuracy and appreciation of precision and consistency are all important attributes a feed mill operator should have. Similarly, standard operating procedures need to be in place so that others can operate the mill if necessary.

2.4 Pellets versus Mash

For producers who do choose to buy in prepared feed and have the option of choosing between pelleted feed or mash, it is important to consider the options based on the feed delivery system used. More time (almost double) is required for pigs to consume mash feed versus pelletised feed, particularly when delivered through a dry feed system. As a result, producers may need to consider feed space to ensure pigs are not competing excessively for feed. The effects of feed type are much less pronounced if feed is delivered through a wet/dry feeder (MacDonald & Gonyou, 2000).

Sopade et al. (2013) showed that weaners and growers offered pelletised sorghum or barley based diets performed better than pigs offered the same diet in mash form (Figure 6.1 and Figure 6.2). If the grain components of these diets were reground to remove large particles, the effect of feed type (pellet versus mash) became insignificant.

FIGURE 6.1 Feed conversion ratio of weaner pigs offered barely based or sorghum based diets ground once or reground presented as a mash or pellet (Sopade et al., 2013)

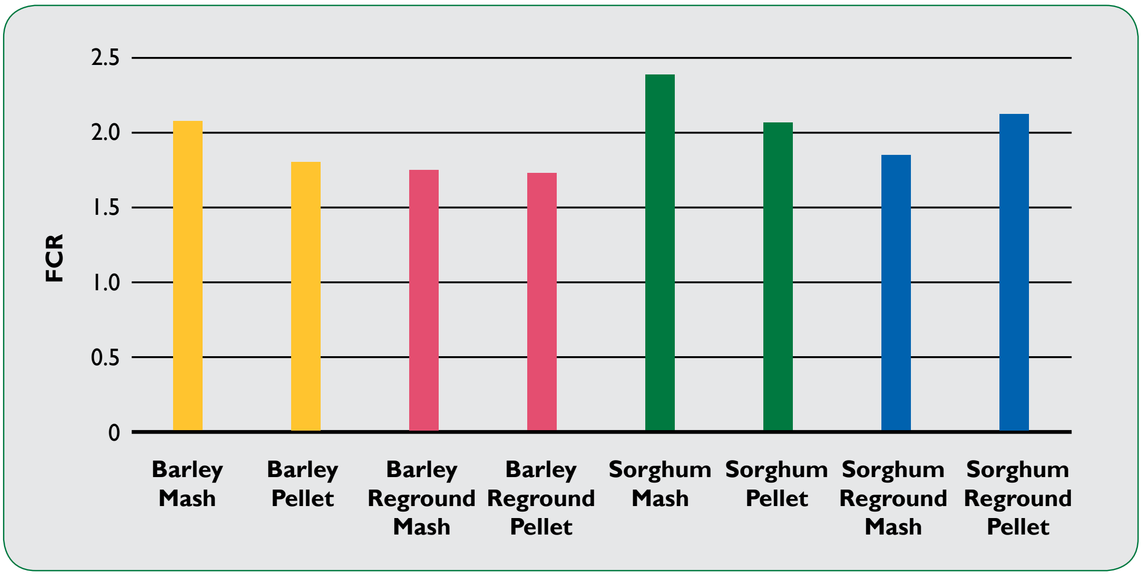
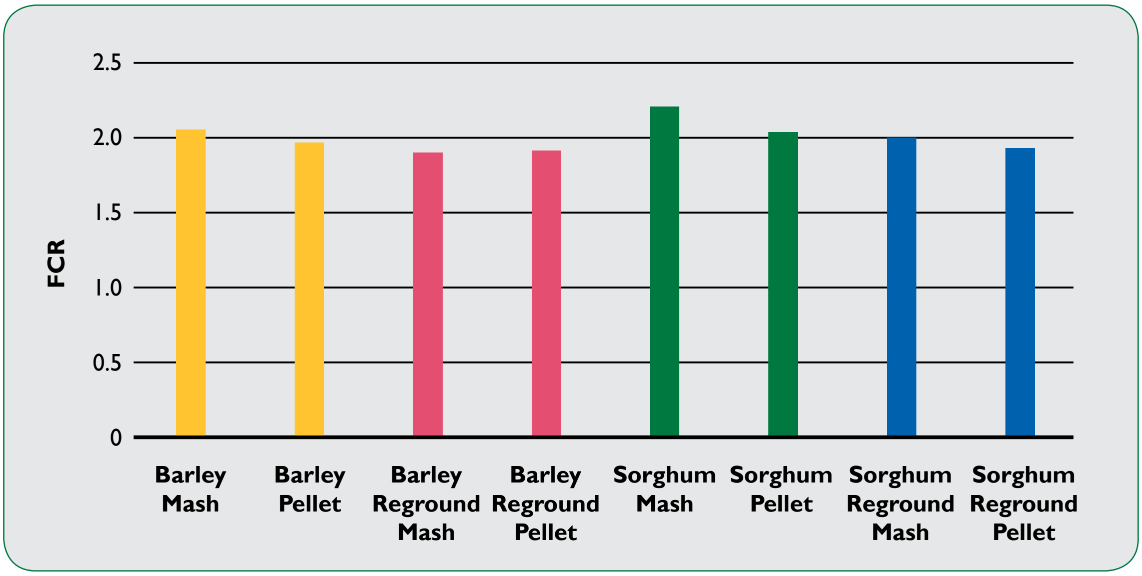


FIGURE 6.2 Feed conversion ratio of grower pigs offered barely based or sorghum based diets ground once or reground presented as a mash or pellet (Sopade et al., 2013)



Keeping a close eye on particle size and particle size distribution is more important in mash feeds which are not exposed to heat treatment as in the pelleting process Research by Sopade (2010) found that digestion and FCR of pigs fed mash feeds based on sorghum and barley were improved by 11% and 8%, respectively, when no larger particles (>1 mm) were present. They also reported that heat treatment to enhance feed efficiency was not advantageous if the grind size was sufficient.

2.5 FeedSafe

All stockfeed mills in Australia have been invited to meet a minimum standard based on the principles of the *Australian Code of Good Manufacturing Practice* for the manufacture of feed. This standard is known as FeedSafe and all participating feed mills can be found on the Stock Feed Manufacturers' Council of Australia website at www.sfmca.com.au/accredited_feed_suppliers.

Under the Code, audits are used by the Stock Feed Manufacturers' Council of Australia to meet minimum standards in the following areas:

- Buildings and equipment
- Staff training
- Approval of ingredient supplies and quality
- Feed formulation
- Manufacturing processes
- Finished feed testing
- Handling customer feedback
- Chemical and feed additive use.

When buying from a commercial mill, the PigPass national vendor declaration requires feed to be purchased from feed mills with an approved quality assurance program. Producers are responsible for obtaining a declaration or proof of quality assurance certification from their feed supplier.

2.6 Monitor Commercial Feeds

Although mills use quality control procedures, this does not guarantee the feeds are perfect. Producers should make their miller aware that the feed is under constant scrutiny and use a form of quality control themselves. Ensure all feed samples are kept for six months or until all pigs offered that feed have been sold.

Collect a sample of each batch delivered, label it with the diet name and delivery date, and store it in a sealed container in a cool, dry, dark place. Analysis has already been paid for in the purchase price, so there is little point in having the sample re-analysed unless pig performance is a problem.

Hardness and durability – the pellet's ability to withstand the rigours of handling either pneumatically or mechanically – are measures of pellet quality.

Pellet hardness is the amount of direct pressure needed to break a pellet. If purchasing pelletised feed, make a note of the level of fines and ensure they are kept to a minimum. Pellet durability is measured as the volume of fines produced following tumbling or pneumatic conveying in set conditions. Ensure the manufactured feed is delivered in dry conditions or, if it is raining, make sure the feed is dry as it enters the silo.

3 Achieving the Best Quality Home-mix

A home mixing system must be considered a separate enterprise to the pig unit. If you are not prepared to undertake *all* of the following, order feed from your local manufacturer.

Although many options are possible with home mixing systems, the basic procedures are the same:

- Have a suitable place to mix feed
- Have adequate storage for raw materials
- Choose the highest quality, most cost effective ingredients
- Review diet formulations regularly
- Add all ingredients by weight
- Use the right person and equipment for the job
- Use special management procedures for feed additives
- Design a standard mixing procedure to maximise feed quality
- Routinely monitor the quality of raw materials and mixed feeds
- Keep detailed records.

3.1 A Suitable Place to Mix Feed

You should be able to mix feed in any weather, using a stationary mixer or a mix-all attached to a tractor. Persistent rain should not interfere with the supply of feed.

Clean the area regularly to prevent dust, dirt, wasted feed and ingredients accumulating on the mixing shed's floor, surrounding grounds, machinery, ceilings, roof, wall cavities, ledges and rafters. Dispose of waste efficiently.

Keep the area free of rodents, birds, insects and domestic pets using an effective, documented pest control program and/or improving building design. Have sufficient ventilation to remove dust and odours.

Building a new feed milling area requires compliance with environmental and occupational health and safety standards available from local councils.

CASE STUDY: Get your grain tested and use the results

A 500-sow farm did not inform their nutritionist when they switched from old season to new season wheat, barley and lupins. The reduction in protein content was marked and the result was a significant decline in weaning weight of pigs over a four month period which impacted on growth performance through to slaughter. The farm had the grain tested but had forgotten to pass on the test results to the nutritionist and inform them of the grain change.

3.2 Adequate Storage for Raw Materials

For bulk feed

Label and number all silos and feed bins for easy identification. Inspect them regularly for structural problems and retained feed or ingredients. Implement an inspection and cleaning schedule for each silo/feed bin including any milled grain bins. The schedule should also include inspection for holes, rust spots, lid security and insect contamination. Look carefully for wet spots, mould and insects. Fix a problem as soon as you see it.

Bins containing mouldy feed or ingredients should be emptied, the contents discarded and the container thoroughly cleaned and allowed to dry before refilling. Remember to also clean the area surrounding and directly below feed bins, silos and mixing equipment.

Record pesticides used in a feed bin or silo, and mark the container to prevent cross-contamination and residues. Grains intended for storage for longer than six months must be chemically protected against insects. Ensure bins are air-tight for effective fumigation.

Grains in bulk storage will better resist weevil infestation if moved regularly, e.g. removed for use, or by drawing contents from the bottom and returning them to the top. Bins should be painted white or zinc-coated to keep the contents cool. Where possible, off grade grains (i.e. frosted) and small broken seeds should be consumed quickly as the effective shelf life on these products is shorter.

For bagged ingredients

Bagged materials require enough storage space for each product to have clear separation from others. Have an easy to clean area, keep it clean, dry and store away from direct sunlight. Rotate bagged materials so that first in are first used. Store torn bags separately for quick use or return them to the manufacturer. Label all bags for easy identification and seal open bags to protect the contents from rodents and insects.

WARNING: Mouldy Feed Facts

Mycotoxins are naturally occurring toxic substances produced by various moulds. There are hundreds of known mycotoxins. The main mycotoxins that cause problems for pigs include; alfatoxin, zearalenone, deoxynivalenol (also known as vomitoxin or DON), T-2 toxin, fumonisins, ochratoxin and ergot.

Conditions that can favour mycotoxin production of farm plants and feed mills are:

- Broken or split grains
- Warm humid storing
- Above standard moisture products – grains, meals
- Poor mill and silo hygiene.

Steps to prevent mycotoxin occurrence during storage include:

- Ensure storage facilities are dry and present minimal temperature fluctuation
- Where possible, aerate grains to maintain ideal and uniform temperature levels
- Clean milling equipment and silos regularly
- Minimise levels of insects and fungi in storage facilities.

Mycotoxins can have very serious reproductive, growth and health effects and no pig class is exempt from their effects. Pigs are the most susceptible livestock to mycotoxin contamination, with breeders and young pigs being the most sensitive groups. It is common for multiple mycotoxins to be present within a single raw material or finished feed. Unfortunately, mycotoxins often behave synergistically with the effects being exacerbated. The impact of mycotoxins can have long term effects including reduced vaccine response, reduced fertility and organ damage.

Grain and finished feeds samples can be tested for the main mycotoxins. In years or seasons when the risk of mycotoxin contamination is high, it can be useful to consider the use of mycotoxin binders. Discuss with your nutritionist which product is best for you.

Common symptoms of mycotoxicosis in weaners through to finishers include:

- Reduced feed intake
- Suppressed growth rates
- Decreased feed conversion efficiency
- Immunosuppression
- Increased incidence of disease
- Poor vaccine response
- Vomiting
- Rectal/vaginal prolapses
- Sudden death
- Pale/weak pigs
- Bloody faeces
- Higher incidence of liver/kidney disease
- Splay legs
- Dermal lesions
- Diarrhoea
- Pulmonary oedema
- High incidence of cancer.

3.3 Choose the Best Ingredients

The vast choice of ingredients available in Australia, their quality range, and other factors (e.g. relative price, milling factors, storage and availability) make the job of selecting ingredients for pig diets difficult. The best is seldom the cheapest and the cheapest. The cheapest is seldom worth using. It is wise to have raw materials analysed for nutrient content prior to purchase to establish their value and to maximise their use.

Each MJ of digestible energy is worth roughly $30 and each percent of protein is worth about $5.

In general, any feed ingredient has nutritive value and can be included in a balanced diet if it is not toxic or harmful to a pig. However, some nutrient sources cannot be fed to pigs under any circumstances. These products are outlined in Part 4, Division 1, Section 41 of the *Livestock Disease Control Act 1994*, which reads as follows:

Swill feeding of pigs

1. *A person must not-*
   a. *store any material originating from a mammal or that has been in direct contact with material originating from a mammal at premises at which pigs are kept;*
   b. *collect any material originating from a mammal or that has been in direct contact with material originating from a mammal for use for feeding to any pig;*
   c. *feed or allow access to, any material originating from a mammal or that has been in direct contact with material originating from a mammal, to any pig; or*
   d. *supply to another person material that originates from a mammal or that has been in direct contact with material originating from a mammal that the person supplying the material knows is for use for feeding to any pig.*

Penalty: 120 penalty units.

2. *Subsection (1) does not apply to any material which is-*
   a. *the flesh, bones, blood or offal of mammals slaughtered at an abattoir or a knackery licensed under the Meat Industry Act 1993 which is fed to pigs at that abattoir or knackery with the approval of the Secretary;*
   b. *any material containing flesh, bones, blood or offal of mammal carcases which has been treated by a process approved in writing by the Secretary;*
   c. *the carcase of a mammal which has been slaughtered at premises for the purpose of feeding it to pigs at the same premises if the premises have been approved in writing by the Secretary;*
   d. *milk;*
   e. *a milk product or milk by-product from a dairy manufacturing business licensed under the Dairy Act 2000.*

The fines for infringing this act are severe, so make sure you comply. It is highly likely that the addition of any raw animal products to your pig feeds will create dietary imbalances, as well as earning you a fine if it is illegal. Swill feeding is illegal because meat and mammalian material can contain viruses. Diseases like Foot-and-Mouth Disease, Classical and African Swine Fever and Transmissible Gastroenteritis can be carried and transmitted by feeding swill to pigs. Check with your veterinarian, nutritionist, Australian Pork Limited (APL) or Department of Agriculture and Water Resources officer if you are unsure. For more information on swill feeding visit APL's website at http://australianpork.com.au/wp-content/uploads/2013/09/FACT-SHEET-Swill-feeding-its-illegal_2013.pdf.

3.4 Have the Raw Ingredients Analysed

Collect as much information as possible about the nutrient content of ingredients before you purchase them. Analyse grains and protein meals for moisture, digestible energy and crude protein content. Moisture content can influence how the grain will store and it can be used to adjust analysis values. Protein will raise inclusion levels, and the value of the grain.

These values can be used as a guide to amino acid and other nutrient levels without further testing, however, accurately testing of digestible energy as well as the total protein and availability of essential amino acids can now be determined rapidly for minimal cost. Large quantities of a single ingredient make it worth having additional chemical analysis. These test results will allow your nutritionist to make the most efficient use of your raw materials.

Bagged, as well as bulk, raw materials should be regularly chemically tested for nutrient composition especially if purchased from a different supplier. Where possible, it is best to have a short list of approved suppliers to help reduce the variability in product quality. A digestible energy and amino acid availability test are strongly recommended, especially (but not exclusively) when sub-standard grains or protein sources are under consideration.

3.5 AusScan: Getting the Most Out of Our Grain

AusScan Online is the result of a partnership between AusScan, an Australian-based NIR feed ingredients project, and Aunir a leading independent developer and supplier of NIR spectroscopy calibrations based in the United Kingdom.

AusScan Online is a website hosting the AusScan NIR calibrations for cereals and proteins. Producers and nutritionists have available two unique calibrations:

- **In vivo energy values for cereals** (wheat, barley, triticale and sorghum) fed to livestock. The NIR calibrations have been developed for Pig Digestible Energy (DE); Poultry Apparent Metabolisable Energy (AME) and Ruminant Metabolisable Energy (ME) values.
- **Reactive lysine values** in soybean and canola meal to assess the level of "heat damage" of the protein and amino acids.

Quality of grains fed to livestock are likely to vary as prime quality grains are directed away from animal production. Feed grade classified grains can have small grains size, weather damage, light bushel weight and high screenings and usually attract a lower purchase price. The DE of grains vary greatly primarily due to growing conditions and environmental factors such as soil type, irrigation and drought. The AusScan calibrations includes frost damaged, partially germinated and drought affected grains as well as more normal well-grown and irrigated grains which results in robust calibrations.

The current calibration predicts pig faecal DE with an accuracy of +/- 0.26 MJ/Kg. The economic value of 1 MJ/kg of digestible energy is worth $25–$30 per tonne of grain, depending on the base cost of the grain. Table 1 shows the variation within and between pig faecal DE value of grains from samples used in the AusScan calibration. For example wheat (12.7–14.5 MJ/kg) and barley (10.8–13.9 MJ/g) show a wide range in pig faecal DE and opting to use average values could result in considerable economic implications. Testing cereal grains for DE allows the nutritionist to formulate with greater precision and optimise the value of the feed inputs.

Pork CRC research showed that imported soybean meals had a 27% cross-shipment variation and a 13% within-shipment variation in reactive lysine content, and demonstrated that total lysine content should not be used for accurate prediction of reactive lysine content. This research has led to the recent development of NIR calibrations for rapid prediction of reactive lysine content in soybean and canola meals. A precise value of reactive lysine markedly enhances the accuracy of diet formulations and addition rates of synthetic lysine. The reactive lysine values also assess the levels of heat damage in the product enabling decisions to accept or reject loads. Early results from the AusScan database for percentage of reactive lysine to total lysine levels ranged from 69–100% in soybean meal and 75–94% in canola meal indicating a wide range in reactive lysine levels in these protein meals and the need to account for this in diet formulations.

Nutritionists can formulate with far greater cost effectiveness using the AusScan calibrations. Valuing grains and plant based protein meals to a known nutrient density helps to optimise the value of the feed ingredients.

TABLE 6.1 Range of Pig Faecal DE (MJ/kg) for all grains used in the calibrations

Grain	Average Faecal DE (MJ/kg)	Range
Wheat	13.8	12.7–14.5
Barley	12.9	10.8–13.9
Sorghum	14.4	13.4–15.0
Triticale	13.5	12.8–14.5
Maize	14.0	13.1–14.8

Information from an 'AusScan Analysis' for pigs:

Available energy is expressed in different units for each animal species:

- Pigs digestible energy (DE) = energy in the diet minus energy in faeces
- Cattle and sheep metabolisable energy (ME) = energy in the diet minus energy in faeces, urine and methane
- Poultry apparent metabolisable energy (AME) = energy in the diet minus energy in faeces and uric acid excreted into the cloaca with the faeces.

For **cereal grain** samples, each NIR scan using the AusScan calibrations will produce the following test results:

- In Vivo Energy for cereal grains (wheat; barley; triticale and sorghum):
  - Ileal DE content (MJ/kg as is)
  - Faecal DE content (MJ/kg as is)
- Proximates (calibrations are from the Aunir Ingot Laboratory calibrations* – Results are on an "as is" basis)
  - Moisture %
  - Fat (ether extract) %

* NOTE: Aunir Ingot Laboratory calibrations are built using one of the largest global animal feed and feed ingredient databases which incorporates:
- 20 years + of seasonal, varietal and regional variation.
- 350,000 + samples.
- 4 million + referenced data points.

  - Fat (acid hydrolysis) %
  - Protein %
  - Crude fibre %
  - Ash %
  - Starch %
  - Total sugars %
  - NDF %
  - ADF %

For **Soybean and Canola meal** samples, each NIR scan using the AusScan calibrations will produce the following test results:

- Reactive Lysine for protein meals Soybean and Canola
  - Total Lysine (g/kg, as is)
  - Reactive Lysine (g/kg, as is)
  - Total and SID amino acids (g/kg, as is) - only available for soybean meal.
- Proximates (from Aunir Ingot Laboratory calibrations - Results are on an "as is" basis)
  - Moisture %
  - Crude protein %
  - Crude fat %
  - Crude fibre %

TABLE 6.2 Commercial Laboratories offering the latest AusScan Calibrations

Laboratory	Postal Address	Phone	Contact Email
Symbio Laboratories	PO Box 4312, Eight Mile Plains, Queensland 4113 Australia	07 3340 5702	admin@symbioalliance.com.au
Lienert Australia	8 Roseworthy Road, Roseworthy 5371 SA Australia	08 8524 8150	admin@lienerts.com.au
Feed Central	10775 Warrego Hwy, Charlton QLD 4350	07 4630 4899	info@feedcentral.com.au
Feed Central	38 New Dookie Road Shepparton Vic 3630	03 5823 0000	info@feedcentral.com.au
Feedworks	ACE Laboratories, 12 Gildea Lane Bendigo East Vic 3550	03 5429 2411	www.feedworks.com.au
NSW Department of Primary Industry*	Wagga Wagga Agriculture Institute, PMB Wagga Wagga NSW 2650	02 6938 1999	denise.pleming@dpi.nsw.gov.au

* Will prepare sample, scan the sample and email the scanned file to the customer to upload to AusScan Online. This requires the customer to have an account with AusScan.

For more information about AusScan contact:

Charles Rikard-Bell
Manager, Commercialisation and Research Impact, Pork CRC:
E: c.rikardbell@porkcrc.com.au M: +61(0) 439 513 723

Will Greenwood
Commercial Manager, Aunir
E: william.greenwood@aunir.com P: +44 (0) 1327 810686

www.ausscanonline.com

3.6 Know the Protein Value of Your Raw Materials

The Precise Nutrition Evaluation (PNE) by Adisseo is another service available that complements the AusScan service. This service can provide you and your nutritionist with local data on individual raw materials which confirms not only the total protein and amino acid content, but more importantly the availability of the (standard ileal digestible) amino acids. This service is currently provided through BEC Feed Solutions Pty Ltd. Only 250 g of a raw material is required. For further information, contact BEC Feed Solutions Pty Ltd on 1300 884 593 or www.becfeedsolutions.com.au.

3.7 Avoid Contamination

Producers should never buy feed grains which contain significant quantities of weed seeds or are infested with moulds, simply because they are cheaper.

Poor harvest and storage conditions can cause growth of moulds on feed grains. High moisture levels encourage moulds, so grains with a moisture content higher than 12.5% should not be stored for use in feeds. The moulds which develop on feed grains, often invisible, can produce chemical compounds called mycotoxins. It is difficult and costly to analyse the presence or absence of these.

Toxic weed seeds contaminate feed grains and will vary depending on where the grain grows. Some are very unpalatable and pigs reject them. As little as 0.5% of jute or wild vetch and 0.1% of thornapple, for example, will lower feed intakes.

The quantity of weed seeds needed to poison pigs depends on the weed species. Only 0.004% (two seeds/kg) of rattle pod will poison pigs, while 0.25% (200 seeds/kg) of Sesbania pea are considered safe. The most devastating weed seeds are about the same size as the grain they contaminate, and cannot be screened out. Very small toxic weed seeds, such as heliotrope, are hard to detect. Some weed seeds such as wild radish or wild oats are relatively harmless but if unsure of the content check with the Department of Agriculture in your state or simply reject the raw material.

Some highly valuable protein sources contain anti-nutritional elements which, if not monitored, will slow growth, especially legumes such as faba beans, chick peas and field peas. Some oilseed meals also need watching.

3.8 Ingredient Supply and Quality

It is important to choose ingredients that are consistent in supply (all year) and quality (the least amount of nutrient variation). Inspect the physical quality of the ingredients. At all costs, avoid moulds, have grains tested by a registered seed laboratory for weed seed contamination, and keep a check on grain density. Never accept over-processed protein meals (with a burnt colour and odour) as pig performance will be impaired.

Here's what to look for when assessing physical quality of feed ingredients:

- Colour – typical, bright, uniform
- Odour – clean, characteristic
- Moisture – free flowing, non-sticking, no wet spots
- Texture – reasonable particle size
- Uniformity – consistent in colour and overall appearance
- Appearance – free of dirt, mould, foreign materials, and bird/rodent/insect contamination.

When selecting ingredients do not think simply 'will my pigs eat this?' Instead, endeavour to find the best ingredients and be aware of their nutrient composition, so that risk is avoided and performance and profit are maximised. The saying 'you are what you eat' is particularly relevant to pigs.

Samples of all raw materials collected should be bagged, clearly labelled and stored in a cool, dark, and dry location for at least six months. Every new raw material should be treated with the care outlined above.

Grain Trade Australia has produced a series of commodity standards containing vital information on the standards to observe when buying grain for use in pig diets. These standards can be accessed on Grain Trade Australia's website at www.graintrade.org.au/commodity_standards.

3.9 Change Diet Formulations Regularly

A formulation must be changed whenever a new ingredient, or new batch of the same ingredient, is introduced. There are no exceptions. The diet specification can stay the same if pigs are growing well, but diet *re-formulation* is necessary to ensure specifications are maintained for the lowest possible cost. Table 6.3 shows how the main ingredient composition in a grower diet change as wheat protein changes from 11% to 14% (all other things being equal). It also shows how the reliance on protein meals (in this case peas) and tallow decrease as the protein content of grain increases.

TABLE 6.3 Change in major raw material balance in a 14.2 MJ DE and 0.68 g standard ileal digestible lysine:DE grower diet as the protein content of wheat increases from 11% to 14%

% ingredient	Wheat 11%	Wheat 12%	Wheat 13%	Wheat 14%
Wheat	66.0	70.2	76.5	76.8
Peas	14.4	10.2	3.24	3.04
Canola	13.0	13.0	13.0	13.0
Soya	0.35	-	-	-
Meat meal	2.95	2.97	2.99	3.00
Blood meal	-	0.54	1.35	1.20
Tallow	1.0	0.90	0.77	0.80
Minor ingredients^	2.3	2.19	2.15	2.16

^ Includes vitamin and mineral premix, amino acids, salt, etc.

To ensure you have optimum performance and best use of your raw materials it pays to have your diets re-formulated when raw materials change. Different ingredients should never be directly substituted without totally re-formulating the diet. Have a written master formula, with mixing instructions, formulated by a qualified nutritionist and kept on file with a record of diets in use.

Feed millers should be fully conversant with computer diet formulation print outs and the formula should clearly identify the feed to be mixed. Again, no alterations should be made without completely re-formulating the diet. The batch weight should not exceed the highest weight the feed mill equipment can mix.

Over-specifying diets can also slow production. Pigs cannot store unnecessary protein and it is metabolically costly to excrete excess protein. Over specified diets waste valuable protein and energy.

3.10 Add All Ingredients by Weight

It is vitally important to weigh ingredients rather than add them by volume. Different ingredients have different bulk densities, as shown in Table 6.4. Even within grains, bulk density can be affected by factors including moisture, variety, quality (which can be affected by environmental and processing conditions), seed shape (± awns) and contamination of raw materials.

TABLE 6.4 Bulk density (kg/L) of raw materials commonly used in pig feeds (Tapco Inc., n.d.)

Feed ingredient	Bulk density (kg/hectolitre)
Barley	61–69
Canola	64–77
Lupins	72–78
Oats	43–50
Peas	61–77
Sorghum	68–72
Soya	75–77
Triticale	60–80
Wheat	72–83
Whey powder	50–55

Two sets of scales are needed to weigh minor ingredients before they are added to the mixer. One is used to weigh micro-ingredients (up to 2 kg), such as vitamins, minerals and synthetic amino acids, that are too expensive to waste. A large set of kitchen scales or a hanging pocket scale (up to 10 kg) are ideal for other feed additives.

To weigh large amounts of ingredients, such as cereals or protein meals, a number of options are available, including:

- Load bars for the entire mixer. This is the best option because it is accurate and efficient, but it is the most expensive option.
- A weighing hopper introduced between the auger and hammer or roller mill. This is usually inexpensive, flexible and accurate, but more time is spent on transferring ingredients to the mixer.
- Tipping buckets calibrated for each grain is the cheapest option and are easy to incorporate into existing systems, however, tipping buckets requires regular calibration and can be inaccurate.

3.11 The Right Equipment – The Right Person

Decide the best type of mill for the predominant grains to be used and the type of pigs being fed. Observe the manufacturer's recommendations for capacity, method and time of operation for all equipment.

Roller mills

These consist of two rollers which rotate towards each other. The grain is crimped, kibbled, crushed or cracked depending on the roller gap width and the fluting configuration of the adjustable rollers. Milling is more efficient if the rollers are grooved or fluted. Roller speed and the number and shape of the flutings dictate the fineness of the grain.

Advantages

- The coarser texture of rolled wheat, sorghum or maize can help reduce gastric disorders like stomach ulcers.
- Roller mills have a high output for low power, e.g. a 25 cam, 7.5 kW mill will crush two tonnes of wheat an hour and crimp four tonnes an hour.
- Feed mixtures with rolled grain do not bridge readily in storage silos or self-feeders.
- Processing produces little dust or heat.
- Construction is simple and robust, with sealed bearings. Maintenance is low.
- Roller mills are safe to use when all moving parts are housed behind guards, and the operator turns off the rollers before cleaning out a blockage.

Disadvantages

- Roller mills are not suitable for roughage, such as hay or wet material.
- They can only process one kind of grain at a time.

Hammer mills

These consist of many free-swinging strips of metal, which act as hammers, attached to a heavy duty drive shaft which turns at about 300 rpm. The grain is split by the whirling hammers and hurled against a heavy sheet of steel called a cracker plate. Screens with holes available in various sizes control how long the grain is kept in contact with the hammers.

Advantages

- High output.
- Simple, robust and easily maintained.
- A wide range of grains can be handled simultaneously.

Disadvantages

- Hammer mills have a high power requirement.
- The dust caused by this type of milling can affect feed quality.
- The variation in particle size is increased.
- Little adjustment other than screen size.

Disc mills

The grinding action is achieved on a disc mill by the action of two plates or discs. Feed ingredients are ground between the two discs and various grind size can be achieved by regulating the gap between the discs. The base plate remains stationary whilst the second disc rotates.

Different animal species and/or classes of the same species have an ideal particle size; the disc mill has the capability of being able to have pre-set grinding options to suit the various combinations of target animals. For instance, wheat can be finely ground for young weaner pigs but have a coarser structure for the more robust finisher or breeder animals. The distance between the discs can be easily set manually, or alternatively, an automatic option is possible through a setting in the plant's control panel.

Advantages

- Low power output.
- Small footprint.
- Consistent particle size.
- Hinged milling chamber for rapid cleaning.
- Low noise.
- Minimum dust generation.
- Automatic particle size adjustment for different animal groups.

Disadvantages

- High replacement costs for discs.
- High fat based products can lead to blockages.

Weighing equipment must be regularly maintained and checked for accuracy. All equipment should be subjected to a regular maintenance program. Frequent lubrication is vital, together with checking parts subject to excessive wear. Records of breakdowns and repairs should be kept so service dates can be adjusted. Test feed mixers for efficiency at least twice a year.

Mixing equipment

A range of mixers can be used to prepare mixed feeds for pigs:

Tumble mixers or concrete mixers are useful for blending premixes, or very small batches of feed (10 kg).

Vertical mixers consist of a tank 3–5 m high and 1.2 m in diameter, with a large vertical auger in the centre. Ingredients are placed in a chute at or near the bottom. The auger lifts the feed up the inner auger to a spreader at the top from which it falls back to the bottom.

Horizontal mixers comprise a horizontal tank or covered trough with revolving beaters, paddles or ribbons. These are very effective for mixing coarse roughage (up to 50% of the diet) with grains and additives. Power requirement for horizontal mixers is higher than for vertical mixers, but mixing is faster and more efficient.

Mix-alls (mobile mixers and mills) consist of a hammer or roller mill mounted on a common chassis with a vertical or horizontal mixer, plus a discharge auger. The whole unit can be powered by a 30 kW tractor. The mix-all is very convenient if there is distance between bulk grain storage sites on-farm.

Do not use machines and equipment that cannot be cleaned or flushed out, as different feed formulations should be mixed without fear of cross-contamination. Clean all equipment thoroughly after it is used for medications.

All milling equipment should have adequate dust extraction capacity. Magnets and sieves should be used to extract foreign material from the mixer.

Operators should be fully conversant with the use of all equipment and its routine maintenance. They must wear suitable protective clothing, especially noise protection and dust masks. A first aid kit should be kept handy in the feed mill.

When mixing is being completed by more than one operator, ensure that records are kept to show who was responsible for each batch.

3.12 Management Procedures for Feed Additives

Store all antibiotics, prescribed drugs and premixes in a cool, dark and dry location. Prescribed drugs and antibiotics should be kept under lock and key and access restricted to nominated staff. A regular (at least weekly) stocktake of these products should be conducted to confirm stock on hand and to ensure quantities matches usage for the audit period. A record of all medications and chemical treatments should be kept and is required by APIQ✓® (visit the APIQ✓® website www.apiq.com.au for more information).

If mixed feed requires specific instructions about feeding and/or withholding periods, notify piggery staff and identify the animals concerned. Implement a flushing and a mixing sequencing protocol to help reduce the incidence of unwanted carry-over material contaminating subsequent batches. Staff must be made aware of current legislation standards on product withholding period and any export slaughter interval (ESI) requirements. Incinerate or dispose of empty bags responsibly that contained medications.

When using a stock medicine or veterinary preparation, make sure it is a registered product and a current veterinary prescription is available for the prescribed medications. Pay special attention to mixing instructions and incompatibility statements. Also check the concentration of the active ingredient is the same on the script and on the package. If unsure on the correct inclusion rate, producers should consult their nutritionist and/or veterinarian before mixing the diets.

3.13 Design a Standard Mixing Procedure

Label all raw materials and keep a checklist to record additions to the mix. Use this to ensure that the right materials have been added and as a way to monitor raw material use for inventory control.

Add raw materials in a sequence so that they are evenly distributed. Start with half of the grain, then add all premixed materials, protein concentrates and tallow before mixing in the remaining grain.

Combine premixes or other feed additives with a carrier (e.g. 10 kg of a protein concentrate or milled grain) to help their distribution. Do not over-fill or under-fill the mixer, as uneven mixing could impair feed quality.

Mixing must be timed from when the last ingredient has been added – many producers unwisely stop at this point. Mixing times depend on the type of mixer used, so check the manufacturer's instructions to determine the time needed to achieve the best result.

Collect samples of mixed feed that is still in the mixer and compare them with samples collected at pig level. This will show whether the feed separates during delivery and will highlight any changes in nutrient composition.

Adding tallow to diets

Tallow should not be added last, but in gradual, spaced quantities to ensure it is well mixed.

The feed mixing improvement program FEEDCHEQUE (van Barneveld, 2001) revealed that many mixing operations added tallow too late and processed it too fast. This has a number of consequences including:

- Poor distribution of tallow causing mix inconsistencies which lowered pig performance
- The need for regular cleaning to remove tallow build-up around the top of the mixer
- Tallow lost, lowering expected dietary digestible energy (DE) levels, and causing dust.

The FEEDCHEQUE program revealed that when tallow was added last via the premix chute, based on the theory that it would 'flush out' any premix residues in the chute or cross-auger. However, this leaves a large amount of 'sticky' tallow residue which traps premix, antibiotics and protein concentrates so that antibiotic residues can be passed from one mix to the next. Other diet components can contaminate subsequent mixes.

There are simple ways to improve the way tallow or oil are mixed. Tallow should be added two thirds of the way through mixing, when the bulk of the cereals or grain legumes are already there. Add it slowly (4–6 kg/minute) to ensure even distribution, avoid lumps forming, and avoid build-up which affects the composition of the finished diet.

The premix chute should not be used for tallow. Crude fat measurements in diets where tallow is added in this way may be as much as 2% lower than expected, and large build-ups in mixers may occur.

Some mix-alls come with a tallow delivery port which enters the cross-auger. This slows down the process, but tallow can clog unless another material is travelling through the cross-auger at the same time. With this system, premixes and protein concentrates are the carriers and tallow may restrict their distribution.

Adding tallow from the top of the mixer has excellent results, but this is extremely unsafe.

Never carry buckets of hot tallow up a ladder and empty them into the top.

Setting up a pump system is one alternative. It can drip tallow into the top of the mixer via

a header tank. Even more effective is a pump system that sprays tallow into the mix, but the pressure needed to deliver the hot tallow may burst the hose and severely injure the operator.

Another method is using a plate made to the same specifications as the inspection plate on a New Holland 253 mix-all. Similar inspection plates can be found on most GEHL mixers and some electric vertical mixers. This enables gradual, constant tallow delivery any time during mixing. The plate has an inlet port protruding slightly into the mixer to prevent feed being forced out. The positioning and angle of the inlet port must allow a free flow and stop the central auger catching on the inlet. A hose is connected to the inlet port and attached to a tallow bucket mounted on the mixer's side.

Just before adding tallow, a rod of the same length as the inlet port should be pushed through it to ensure there are no blockages. As another safety precaution, a tap can be placed near the plate end of the inlet hose, allowing the hose to be removed even when there is tallow in the bucket.

People who have to deal with a build-up of tallow around the top of their mixers will find that this technique results in feed constantly moving past the inlet port, with any build-up diminishing quickly without the need for manual cleaning.

If mixing medicated feeds, manually clean the mixer before changing the way you add tallow. This prevents cross-contamination between diets.

How to build a tallow addition port

Remove the inspection plate from the base of the mixer on your mix-all. Use this as a template for the tallow port. Cut a piece of 1.5 mm or 2 mm galvanised plate to the same size as the inspection plate. Cut a length of 20 mm galvanised pipe 150 mm long, and cut a hole in the galvanised plate for the pipe and insert it, keeping the bottom edge flush with the plate.

Place the pipe at a 60° angle to the plate. Use silicone as a gasket around the galvanised plate. To run the tallow to the port, use a Premo Flex® multi-purpose, high pressure hose of 25 mm and 250 psi attached to a 20 L metal bucket mounted on the side of the mixer. **Make sure the auger in the mixer does not hit the protruding pipe before mixing, as there is little clearance.**

3.14 Monitor Mixed Feed Quality

Collect one sample per week of each diet (e.g. grower, creep, dry sow) or one sample per 100 tonnes of feed produced, whichever is greater. To collect a sample, take 10–15 grab samples from either bulk supply or from individual bags then combine these grab samples in a bucket and mix well before collecting your feed sample for analysis (250–500 g).

Composite samples should be divided into two, with one kept in a cool, dark, dry place for at least six months, and the other sent to a laboratory for chemical analysis. Review finished feed analysis with your nutritionist and amend diet formulations if you need to or correct feed mixing and delivery practices.

Uniformity is important to the quality of mixed feed, which should be a dry mixture with a uniform dispersion of highly concentrated micro-ingredients. A perfect mixture is one where every sample taken has identical nutrient content, however, this is impossible to achieve in practice because of:

Particle size: This depends on the ingredients being used and the form in which the diet is being fed. When ingredients have very different particle sizes, the particles usually separate. Sieving grain or finished feed samples through a Bygholm or Sopade sieve can give you an idea of the particle size, range and distribution. The hand held sieving device has been developed by Peter Sopade at the University of Queensland and further information is available from APL and the Pork CRC. This information can be used to adjust your mill settings.

Particle numbers: There are more particles present as particle size is reduced. Using fine ingredients will help to achieve uniformity.

Particle shape: This interferes with the flow and the mixture has a tendency to pack down.

Density: Ingredients with distinctly different particle densities tend to separate during mixing and handling.

Electrostatic charge: Particles which develop a charge through friction, etc., can attract or repel other particles and make distribution harder.

Dustiness: Dust particles indicate that micro-ingredients have been lost in the air and dust collection systems, where they can be a health and safety hazard. To reduce the dustiness of feed, contact your nutritionist to amend the diet composition.

Hygroscopicity: If feed ingredients take in moisture, clumping and caking occurs along with reduction in particles. Milk powders and betaine are examples of hydroscopic materials.

Flow: The mixture will be more uniform if ingredients flow freely.

Uniformity of the mix can be checked using particle sieves, coloured iron filings and chemical analysis. Take care with the order in which ingredients are added.

Manual feed sieve to help producers improve feed quality and digestibility

Australian pig industry research conducted by Sopade (2010) developed a manual sieve to assist feed millers and farms to monitor the particle size distribution of their feed. This easy-to-use tool can allow feed producers to adjust their mill settings to enhance feed quality and digestibility. Whilst the concept is similar to the Bygholm sieve which contains four grind size compartments, the Sopade sieve contains seven grind sieve compartments.

How to use the Sopade sieve:

1. Remove the lid.
2. Place the wooden block in front of the largest screen.
3. Fill up the first compartment with your feed sample.
4. Remove the wooden block and replace the lid.
5. Shake the sieve for three to five minutes or until passage of feed stops.
6. Gently tap the sieve to flatten out the feed within each compartment.
7. Read and record the height of the material in each section.
8. Determine the total height of all compartments combined.
9. Calculate the percentage of feed in each compartment using the following equation:

Height of feed x 100 / total height of combined feed = % of feed

The desired outcome is to have the majority of the feed in the range of 600–800 microns. The particle range will depend on the major grains used and the milling method (roller mills and disc mills allow more control of particle size). Lower particle sizes can enhance feed conversion efficiency, however, the risk of gastric ulcers is increased. Aim for a finer grind for weaners (600–700 microns) and a coarser grind for finishers and sows (800–1000 microns).

3.15 Keep Detailed Records

Keeping good records is an important task for running any successful business including a pig enterprise. Keeping good records can provide you with up to date information which allows you to manage your business efficiently, identify strengths and weaknesses, and also monitor changes and improvements being made. Keeping good records is also required for auditing purposes for APIQ✓®.

- Carry out a weekly stock take of raw materials and reconcile stock on hand against how much you think has been used. This helps to double-check that the right materials have been mixed in the right proportions.
- Keep a record of the origin, delivery date, lot number, price, purchase specifications and quantity of each raw material. Also record when any diet formulations have been changed.
- Feed manufacture and distribution records should be kept, including the miller's name, date of manufacture, storage, and the animals to which the diet is fed.
- Record when medications were added, and which pigs had them.
- Note diet formulation changes.
- Record any errors in feed mixing, and which animals received this feed.
- Maintain a log of samples submitted for analysis, and the results.
- Feed milling procedures should be clearly recorded and regularly checked.

4 Feed Delivery and Waste Management

4.1 Aim for Little Waste and High Performance

The Australian pig industry currently uses an estimated 1.7 m tonnes of feed each year. If every piggery wasted just 5% of all feed mixed or purchased, 85,000 tonnes, worth about $43m, would be wasted. This is enough feed to maintain a 13,000 sow operation. The true wastage is likely higher with estimated feed wastage being closer to 10% on some farms.

Monitoring and minimising feed wastage is an important step to optimising piggery profitability. It is worth repairing or replacing old feeders to reduce feed wastage. From 30–100 kg liveweight, the average pig is expected to consume 170 kg of feed. If feed wastage can be reduced from 10% (17.0 kg) to 5% (8.5 kg) the expected saving would be $3.40 per pig, or $21,250 per year for a 250 sow operation.

Wastage can be avoided if feeders are designed with mechanical restrictions, like sliding metal plates to restrict feed flow. A high lip at the front, and dividers in multi-spaced feeders, can prevent pigs from rummaging and wasting.

The best feed efficiency is achieved when modern genotypes are offered nutritionally balanced feed *ad libitum*, supplied through single space wet/dry feeders.

Vermin control is another important factor to consider in feed wastage. An adult rat consumes roughly 15 g/day. This equates to 5.5 kg per year. This means 220 rats consume the same amount of feed as a sow in a year. Maintaining an effective vermin eradication program is important, not only for disease control but also for maximising feed use. Cleaning up spilt feed and minimising feed wastage are important for rodent control also.

4.2 Feeding Systems

When choosing the best feeding system to suit your piggery operations there are a number of things to consider:

- What are the main ingredients available?
- Is there a stable supply of by-products available that may provide economic advantages?
- How will the diets be offered – wet or dry, as mash or pellets?
- How long with diets or raw materials be stored before use?
- Is the preferred feeding system flexible?

Dry feeding

Most Australian pigs are fed dry meal or pellets, with free access to water. Dry feed is easy to store and handle and its contents and consistency can be controlled. Most producers who mix feed on-farm offer mash, which is cheaper to produce but more prone to wastage.

Pellets reduce dust and feed wastage as well as improve growth rates and feed conversion. Ideally, they do not break up during auger delivery and they prevent pigs from selecting specific ingredients and discarding the rest.

Dry feeding systems for growers and finishers include floor feeding, troughs, self-feeders, tunnel feeders, single space wet and dry feeders and single space dry feeders. Regardless of the feeder system used, it is important to adjust the feeder space allowance and/or stocking density in response to temperature or health challenges.

Adequate feeder space allowance will never compensate for overcrowding and vice versa. Broken or insufficient feeders should be replaced. It doesn't take long to recover the cost.

Floor feeding

Floor feeding is very wasteful and, even if restricted, can increase carcase quality variations because some will eat more at the expense of others. As a consequence it is generally not a recommended practice for grower finisher pigs.

Trough feeding

This traditional system, designed to allow all pigs to feed simultaneously, is uncommon in modern piggeries without a liquid feeding system. Recommended feeder space allowances for pigs are outlined in Table 6.5. As a rule of thumb, trough space for one pig should be 10% wider than the shoulder width of the pig. Head and shoulder barriers limit aggression and feed wastage, and baffles across the trough will stop pigs lying in it. Pen shape and reduced stocking rates influence how well the trough works.

TABLE 6.5 Feeder space allowances for pigs fed *ad libitum* using trough, multi-space self-feeders or tunnel feeders (based on data published by Carr, 1998)

Liveweight (kg)	Feeder space allowance (mm)
5	75
10	33
15	38
20	40
30	46
40	52
50	56
60	60
70	64
80	67
90	70
100	73

Multispace self-feeders

Self-feeders use less space than troughs because pigs do not feed simultaneously. Four pigs to a place is recommended for simple, barrier-free feeders. More can be accommodated if head barriers are fitted to protect and isolate feeding pigs. The hopper size determines how many times the feeders need refilling. Ideally the hopper should hold a minimum of 12 hours' worth of feed or be connected to an automated refilling device to avoid out of feed events.

Tunnel feeders

These are effective *ad libitum* feeders with head protection for the pig. They have no moving parts, work well double-sided, and can be used as pen divisions. The maximum number of pigs which can be fed on each side of one tunnel feeder can be calculated from Table 6.5.

Single space wet and dry feeders

Used in most modern piggeries, these feeders are designed to allow the pig to drink while consuming its feed. Wastage is minimised and the feeders improve daily feed intake because the diet is more palatable and there is less aggression. The feeding rate is often more than double with a wet and dry feeder, so the number of visits per pig to the feeder per day is less, hence the stocking rate can be higher compared to a dry feeder system. One wet and dry feeder can provide for 10–15 pigs, and extra drinkers are needed in each pen. To minimise carcase fat, diet adjustments may be needed to compensate for higher intakes. Flow rates greater than 0.5 litres/minute trigger feed spillage and pen fouling.

Single space dry feeders

These have all the benefits of the above and are cheaper than multispace self-feeders, however, single space dry feeders do not have a water supply and the maximum stocking rate should be 10 pigs per feeder.

Which is best for you?

Piggeries use many variations of the dry feeders described here, so it is difficult to define which is best. Consider the following when assessing the feeders for your operation:

- Up to 95% of aggressive behaviour occurs at feeding time. To avoid wastage and spoilage, select feeders designed to allow pigs non-competitive access and enough time to eat
- The less maintenance needed the better. To avoid corrosion, make the base from concrete, strong stainless steel or plastic. Cheaper material can be used for the hopper. Flow rate adjustment devices should be easy to access and able to be changed without tools. An anti-bridging device should be included.

When evaluating feeders in production units, observe:

- The pig's posture while eating
- The position of pig's head in the feeder
- The pig's body position in relation to the feeder
- Feed distribution inside the trough and outside the feeder
- The behaviour of pigs eating and waiting to eat.

Liquid feeding

Liquid feeding is usually an automatic or semi-automatic system that accurately combines the desired mix of meal and liquid and deposits it into a trough. These systems can deliver set amounts of feed to individual pens.

Advantages

- Improved feed conversion ratios (10% better than mash feeding).
- Feed intake more stable in hot weather.
- Ability to utilise cost effective by-products (e.g. dairy by-products).
- Dust and feed wastage is reduced.
- A separate drinking system, while desirable, is not essential for grower and finisher pigs.
- Liquid feeding systems are very flexible and enable phase feeding.

A further advantage of liquid feeding is that the nutrients are soaked, so they are more freely available. Phytases, which occur naturally in some grains and seeds, are activated. This helps to increase the absorption of phosphorus by the pig.

It is vital that a liquid feeding system is well managed so that pigs eat all the feed. Otherwise, water soluble components may be wasted and dietary imbalances result.

Disadvantages

- Liquid feeding systems initially are expensive.
- To prevent fouling, pen design and trough placement are crucial.
- Pipe blockages can occur if the meal is coarse or the ratio of water to meal is incorrect.
- Uneaten food sours quickly, fouling pens.
- Liquid feeding is not recommended for pigs under 20 kg liveweight.
- It is hard to control the exact specifications of each pig's diet.
- Liquid by-products are often highly variable in composition.
- Risks with boar taint can be increased in systems where pen fouling is common.

Diet formulation using liquid feed ingredients is somewhat more complicated than formulating diets based on dry raw materials. Extracting the full value from a liquid feeding system requires your nutritionist to have a sound understanding of the feeding system and the by-products being used.

4.3 Finished Feed Testing

Another way to ensure that your feed is used as efficiently as possible is to have the finished feeds tested for crude protein, fat and moisture composition. You then need to compare the computed values shown on your diet print outs (for diet examples see *Chapter Eight: Monitoring Performance*) with the values reported by the lab. Some variation may occur due to the variable nature of raw materials.

There is no need for concern if the values differ by a few percentage points or less. For example, if crude protein on the diet formulation sheet equals 20% but the analysed values equal 18%, there is no cause for immediate alarm. Greater variation may mean that the diet does not match the formulation. Have the results checked or the laboratory test repeated.

It may be necessary to diagnose factors affecting feed quality. Table 6.6 summarises the action to be taken when comparing analysed values with formulated values. The table is based on the calculated ratio of analysed results relative to formulated results. For example, if you have your weaner feed tested and the analysed crude protein level is 21.1% and the formulated crude protein level on your computer printout is 22%, then the ratio of the two is = 21.1/22.0 = 0.96 (hence there is no need for concern).

TABLE 6.6 Diet quality ratio of analysed finished feed values to formulated feed values

<table>
<tr><th>0.7</th><th>0.8</th><th>0.9</th><th>1</th><th>1.1</th><th>1.2</th><th>1.3</th></tr>
<tr><td colspan="3">Lower than predicted</td><td></td><td colspan="3">Higher than predicted</td></tr>
<tr><td colspan="2">Poor performance</td><td>Marginal</td><td>Perfect</td><td>Marginal</td><td colspan="2">Wasting money</td></tr>
<tr><td colspan="2">Diagnose problem</td><td colspan="3">Continue to monitor finished feeds</td><td colspan="2">Diagnose problem</td></tr>
</table>

5 References

Carr, J. (1998) Garth pig stockmanship standards. 5M Enterprises.

MacDonald, K.A.M. & Gonyou, H.W. (2000) Effect of feed presentation on the feeding behaviour of grower/finisher pigs. *Prairie Swine Centre Annual Report.* 25-26. Available online at www.prairieswine.com/effect-of-feed-presentation-on-the-feeding-behaviour-of-growerfinisher-pigs.

Sopade, P. (2010) Processing methods for improving the utilisation of cereal grains by pigs: Development of a rapid in-vitro starch digestion technique for animal feed. Pork CRC Project 1B-102. Available online at http://porkcrc.com.au/1B-102-Rapid_in-vitro_starch_digestion_Summary.pdf.

Sopade. P. (2016) Optimising particle size distribution for grains and protein sources. Pork CRC Project 4B-112. Visit www.porkcrc.com.au for the Summary Report.

Tapco Inc. (n.d.) Bulk material density table. Available online at www.tapcoinc.com/content/product_data/Tapco_Catalog_09_p88-94.pdf.

van Barneveld, R.J. (2001) FEEDCHEQUE: Assessment guide and Introduction and preliminary assessment. Australian Pork Limited.

Chapter Seven

Water

1 Introduction

Water is often considered the forgotten nutrient, yet it is the single most important nutrient of life. Without water, no metabolic or physiological processes within the body can occur. As well as body temperature control, water is necessary for the movement of nutrients to the cells, removal of waste products from these cells, mineral or acid/base balance, protection of the nervous system, and lubrication of joints. Water accounts for between 50–80% of bodyweight depending on the age and fat content of the pig.

Water consumption is closely linked to feed intake during any given phase of production. However, water consumption in proportion to feed intake decreases with the pig's age and increases in hot weather. If pigs cannot drink enough, they eat less. The chapter covers the basic information about the importance of water, water use and water quality.

2 Water Intake

As a general rule pigs consume two to three times more water than feed. Expected water intakes for grower-finisher pigs are shown in Table 7.1. This rate of water intake can increase in hot weather. To avoid feed intake depression during summer, it is important to ensure you have sufficient clean, cool water available for your pigs.

TABLE 7.1 Expected levels of daily water intake in pigs from weaning to slaughter (ACE Livestock Consulting Pty Ltd)

Liveweight (kg)	Ave feed intake (kg/d)	Min water intake (L/day)	Max water intake (L/d)
20	0.9	1.8	2.7
40	1.7	3.4	5.1
60	2.1	4.2	6.3
80	2.6	5.2	7.8
100	2.8	5.6	8.4

Newly weaned pigs are particularly sensitive to water intake. Providing piglets with access to water nipples in the farrowing crate can help eliminate the challenge of learning to drink from a water nipple in the immediate post-weaning period. Additional bowls of water on the nursery floor in the immediate post-weaning period can also be useful to limit the risk of dehydration in the vulnerable pig.

2.1 Drinker Allocation and Positioning

One drinker (nipple, bite or bowl) is enough for 10–15 pigs under normal conditions, and two should be placed in each pen in case of blockage in one of the drinkers and to avoid aggression over one drinker. Place them at least 60 cm apart and install 'bite-type' nipple drinkers at a 45–90° angle from vertical. Drinker heights need to be adjusted to suit the weight of the pigs. Guidelines for nipple drinker height are shown in Table 7.2. Heights should be set for the smallest pig in the pen. For water troughs, a length of 300 mm per 20 finishers is recommended.

TABLE 7.2 Guidelines for the use of nipple drinkers (Gonyou, 1996)

Weight of pigs (kg)	Height from floor to nipple at 90° angle (cm)	Height from floor to nipple pointing downwards at 45° angle (mm)
5–10	26–32	31–38
10–30	32–46	38–55
30–50	46–55	55–65
50–100	55–69	65–82
100+	69–73	82–87

2.2 Flow Rate

Flow rate should be checked at least monthly by timing how long it takes to fill a 5 L or 10 L bucket. Recommended flow rates for nipple drinkers are outlined in Table 7.3.

TABLE 7.3 Recommended flow rates for water delivered via nipple drinkers (Muirhead & Alexander, 1997)

Class of pig	Liveweight range (kg)	Flow rate L/min
Weaner	7–25	1.0
Grower	25–50	1.4
Finisher	50–110	1.7

2.3 Temperature

Make sure the water is cool. Water is often carried from a supply tank via black poly pipe, and is too hot for pigs to drink. Bury or insulate external supply lines to pig sheds to keep water cool and insulate header tanks well.

3 Water Quality

It's important to know what the quality of the drinking water being offered to the pigs is. When considering the importance of water quality, you need to focus on a range of impacts, including:

- The impact of water quality directly on the pig
- The impact of the water quality on the delivery system (scale or precipitates can restrict flow and block drinkers)
- The impact of water quality in the delivery of nutrients/medications via the water system (low pH water can cause some medications to precipitate out).

Pigs can tolerate water quality below the standard recommended for safe drinking, however, quality should still be reasonable. It is recommended that you have your water sources tested four times per year. This will help establish background information and also provide information on the seasonal effects. Laboratories that provide a water testing service are listed in Table 7.4. Water quality recommendations for pig drinking water are outlined in Table 7.5.

TABLE 7.4 List of laboratories conducting water testing

Laboratory	Address	Phone	Email
SGS Food and Agriculture Laboratory	PO Box 549, Toowoomba QLD 4350	07 4633 0599	www.au.sgs.com
Toowoomba Regional Water	PO Box 3021, Toowoomba Village Fair QLD 4350	07 4688 6270	labservices@toowoombaRC.qld.gov.au
ALS Group	Gate 6 Sharon Street, La Trobe University, Bendigo Vic 3550	03 5441 0700	https://www.alsglobal.com/locations/asia-pacific/pacific/australia/victoria/bendigo-environmental
NSW DPI Diagnostic and Analytical Services	Sample Submissions, Industry & Investment NSW, Wollongbar Primary Industry Institute, Bruxner Highway, Wollongbar NSW 2477	02 6626 1103	wollongbar.csu@industry.nsw.gov.au
Aquascope	15 Viewgrand Drive, Berwick Vic 3806	03 8794 7077	solutions@aquascope.com.au
Australian Water Quality Centre	PO Box 1751, Adelaide SA 5001	1300 653 366	awqu@sawater.com.au
ACE Laboratory Services	Gildea Lane, Bendigo East Vic 3550	03 5443 9665	acelab@vic.chariot.net.au
The Chem Centre	PO Box 1250, Bentley WA 6983	08 9422 9800	enquiries@chemcentre.wa.gov.au
Silliker Microtech Pty Ltd	181 Claisebrook Road, Perth WA 6000	08 9227 6499	sales@silliker.com.au

TABLE 7.5 **Chemical and microbiological water quality guidelines for pigs (adapted from van Heughten (n.d.) and Patience (2011))**

Parameter	Recommended for pigs	Risk level for pigs
pH	6.5–8.5	<6.5 or >8.5
Conductivity (ECs/m)	<3125	>4690
Total dissolved solids (ppm)	<1000	>3000**
Total Hardness (ppm)	60–200	<60 or >200
Ammonia (ppm)	<1	>2
Nitrate (ppm)	<100	>100
Nitrite (ppm)	<10	>10
Chloride (ppm)	<250	>1000
Salt (mg/L)	<400	>2000
Iron (ppm)	<0.3	>0.5
Manganese (ppm)	<0.05	>0.1
Sulphate (ppm)	<250	>500
Fluoride (ppm)	<2–3	
Sodium (ppm)	<150	
Magnesium (ppm)	<400	
Potassium (ppm)	<3	
Calcium (ppm)	<1000	
Zinc (ppm)	<40	
Copper (ppm)	<0.01	
Selenium	<0.05	
Phosphorous	<7.8	
E. coli (CFU/ml)	0	
Total CFU (CFU/ml)	<10,000 (@ 22 °C)	

** Levels up to 5000 ppm are potentially still acceptable as long as the predominant anion in the water is not sulphate. Osmotic diarrhoea may occur when excessive sulphates are present

4 Interpreting Your Water Quality Test Results

Table 7.6 shows an example of a water test result for pig drinking water.

1. Firstly you need to look at the conductivity (EC) or the total dissolved solids (TDS). TDS is a measure of all materials (including salts) that are dissolved in the water. EC is a measure of the water's ability to carry electrical current. These two values are related and can be used as an indicator of one another, but conductivity is simpler to measure. An estimate of TDS can be determined using the following formula:
   - Conductivity * 0.64 = Total dissolved solids
2. If the TDS or EC is higher than the recommended value, you then need to look at whether the solids are high due to excessive salt. This is estimated by the salt from chloride value or by dividing the chloride value by 0.60. If this level is below the recommended level stated in Table 7.5. then the majority of the TDS is likely coming from carbonates which are not known to be of major concern to pigs. If the salt level exceeds the recommendation you may need to reduce the level of added salt in the pigs' diets.
3. To ensure there is no risk of toxic poisoning check that fluoride and nitrite levels are within the recommended limits.
4. If the hardness score is above the recommended level, there is a risk that accumulation of scale can occur, which in turn can affect the water delivery, water treatment and heating equipment in the piggery. Flushing lines regularly with acidifiers can help reduce the build-up of scale and bio-film.
5. High levels of iron (Fe) in the water can promote the growth of potentially harmful bacteria. If test results reveal high iron levels together with high bacterial contamination (high total CFU count), consider the use of in-water acidifiers to limit the transfer of pathogenic bacteria from water to pigs.
6. If using surface waters like dams and rivers, monitor levels of bacteria including *Escherichia coli* to ascertain they do not exceed 1000 colony-forming units (CFU)/100 ml. The presence of *E. coli*, *Salmonella* and *Campylobacter* can indicate faecal contamination.

TABLE 7.6 Example of a water analysis test result for pig drinking water

Analysis	Result*	Unit of measure	Method	Detection limit
Electrical Conductivity	3223	uS/cm	WAT001/WAT003	
pH	8.34	pH units	WAT001/WAT003	
Total dissolved ions	2060	mg/L	WAT022-006	0.100
Bicarbonate alkalinity	1526.3	mg $CaCO_3$/L	WAT005-1	1.0
Total alkalinity	1558	mg $CaCO_3$/L	WAT005-1	1
Saturation index	0		SAT001	
Chloride	228	mg/L	ANL001	1
Fluoride	4	mg/L	ANL001	1
Nitrate	<1	mg/L	ANL001	1
Nitrite	<1	mg/L	ANL001	1
Sulphate	<1	mg/L	ANL001	1
Salt from chloride	376	mg/L	ANL001	1
Aluminium	0.87	mg/L	MIN001	0.10
Boron	0.92	mg/L	MIN001	0.010
Calcium	1	mg/L	MIN001	1
Copper	<0.1	mg/L	MIN001	0.10
Iron	0.38	mg/L	MIN001	0.10
Magnesium	<1	mg/L	MIN001	1
Manganese	<0.01	mg/L	MIN001	0.010
Molybdenum	<0.05	mg/L	MIN001	0.050
Phosphorus	<1	mg/L	MIN001	1
Potassium	4	mg/L	MIN001	1
Sodium	980	mg/L	MIN001	1.0
Sulphur	<1	mg/L	MIN001	1.0
Zinc	<0.01	mg/L	MIN001	0.010

*Water analyses are on an 'as received' basis, all other results are on a dry matter basis

5 References

Gonyou, H.W. (1996) Water use and drinker management. Prairie Swine Centre 1996 Annual Reports. Saskatoon, Saskatchewan, Canada. Available online at www.prairieswine.com/pdf/1311.pdf.

Muirhead, M.R. & Alexander, T.J.L. (1997) Managing pig health and the treatment of disease: A reference for the farmer. (J. Carr Ed) 5M Enterprises Ltd. Sheffield, United Kingdom.

Patience, J.F. (2011) Water quality issues in pork production. *Proceedings of the Allan D. Leman - Conference*. pp. 157-164.

van Heughten, E. (n.d.) Guidelines for water quality in pigs. *Animal Science facts: Extension swine husbandry ANS00-811s*. North Carolina State University. Available online at www.ncsu.edu/project/swine_extension/publications factsheets/811s.pdf.

Chapter Eight

Monitoring Performance

1 Introduction

This chapter describes ways to collect data on growth rates, feed conversion and mortality rates, and how to use this information to assess your current performance. It can be compared with simulation models before setting your own production and cost targets. Step by step instructions are given on measuring feed intake, growth rate, feed conversion, P2, mortality rates, age at sale, minimising stress, sale liveweight and dressing percentage.

2 Why Monitor Performance?

It takes effort to monitor a herd's performance, but producers who don't will miss out on basic information about their herd's growth rates and feeding efficiency.

Making monitoring part of a daily management routine means that performance levels can be checked at any time so that objectives can be met, targets set, and any problems recognised and rectified quickly. With the rapid advances being made in technology, real time pig monitoring is now a reality for some producers and a real possibility for others.

The tight profit margins associated with modern pig production makes it vital to sustain efficiency for long term viability. Those who do not routinely monitor performance are unlikely to remain competitive and viable for long.

During the weaning to sale phase the *minimum* information needed to assess herd growth and nutritional performance is:

- Hot carcase weight (kg)
- P2 at sale (mm)
- Age at sale (days)
- Mortality rate from weaning to sale (%)
- Feed usage from weaning to slaughter (kg of feed/kg of pork produced).

Additional information on other parameters such as those listed here can help improve your assessment of herd performance:

- Sale liveweight (kg)
- Growth rate from birth to slaughter or weaning to slaughter (g/day)
- Dressing percentage (difference between liveweight and hot carcase weight, expressed as a percentage).

Choose the performance monitoring system that works best for you, given the availability of your staff, time and equipment. The job gets easier as data collection becomes routine.

Use the collected information to maximise profits and respond immediately to production downturns. The average performance data is important but monitoring variation is also essential for maximising profits.

3 Individual Pig Identification

In order to record data on individuals or groups of pigs, it is necessary to use one or multiple forms of identification.

3.1 Ear Tattoos

Before pigs are three weeks old (the younger the better), use tattoo pliers, numbers (blocks of needles) and tattoo ink to mark their ears with individual numbers.

Advantage

- Identification is reliable and permanent.

Disadvantages

- The procedure is slow.
- Pigs must be caught before the number can be read.
- Poor tattooing (blunt needles, not enough ink or plier pressure) makes numbers hard to read.
- Ear damage can make identification impossible.

3.2 Ear Tags

Ideal for short term identification. Tags specially designed for pigs cause little discomfort.

Advantages

- Quick and easy to apply.
- Available in a variety of colours.
- Can be pre-numbered.
- Suitable for pigs of any age.

Disadvantages

- Tags can be lost through fighting or scratching.
- Tags are difficult to read if pigs are dirty.
- Larger tags may be needed as the pig grows.

Electronic ear tags are also an option. They are widely used in the industry in breeder herds for electronic sow feeding systems as they allow activation of individual pigs' rations. Electronic tags also overcome the problem of dirty tags as they can be read using a hand-held wand, and can also give quick feedback to the stockperson as to whether the sow has eaten her ration or not.

3.3 Ear Notching

Ear notching is a quick and easy identification method if a suitable notching pattern is chosen. Piglets are notched with specially designed pliers at age one to two days. The procedure must be carried out by a skilled and competent stockperson, and the instruments must be well maintained, cleaned and disinfected thoroughly prior to use, though this procedure is discouraged under the *Model Code of Practice for the Welfare of Animals (Pigs) 3rd Edition (2008)*.

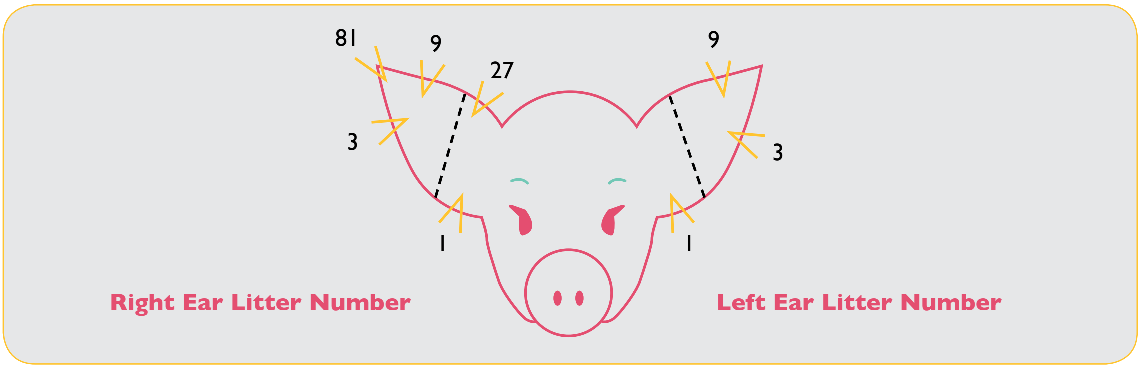
Advantages

- Identification is permanent.
- Numbers can be read from a distance.
- The piglets appear to feel little discomfort.

Disadvantages

- Numbers can be hard to read if the ear is damaged.
- Care is needed to achieve accurate identification.
- It is necessary to learn what each notch represents.

FIGURE 8.1 Example of an ear-notching system for pigs *(Source: Certified Pedigreed Swine)*



3.4 Micro-chip Implants

Implantable microchips are cylindrical devices that are implanted in the subcutaneous tissues using a hypodermic needle. These devices contain four components: a capacitor, antenna, connecting wire and a covering. When activated, the microchip transmits a unique, pre-programed identification number.

Advantages

- Identification is permanent.
- The piglets appear to feel little discomfort.

Disadvantages

- Micro-chips are costly and not easily retrievable.
- Mild inflammation can occur at the insertion site.
- Can pose a potential food safety issue with regard to foreign bodies in carcases at slaughter.

4 Weighing Pigs

Weighing pigs throughout the weaning to slaughter period allows producers to assess the performance of their pigs. Weighing the same batch of pigs at multiple time points (i.e. at weaning, change of diet and/or change of shed) and tabulating the weights by the pigs' average age can allow producers to determine phases where the pigs might require additional attention.

A range of mechanical or electronic scales should be available for weighing all from the smallest individual piglet to large groups of finisher pigs. Check the scales regularly to ensure accuracy, which should be within 0.1 kg for pigs weighing up to 10 kg, and 1 kg for heavier animals. Use weights if available, or buckets of water (1 L weighs 1 kg), as test weights to calibrate. Bags of feed give inaccurate results. Test the range of weights the pigs are usually weighed at. Do not assume that the scales can accurately weigh 10 kg if pigs are usually weighed at 80 kg and vice versa.

The movement of pigs makes it difficult to obtain an accurate reading from clock face scales. Electronic scales, programed to provide an average weight after a set time period, give accurate readings unaffected by movement.

It is far more efficient to establish a weighing area than to move the scales – even portable types – from pen to pen.

4.1 Using the Crate

Some scales come complete with a crate, while others need one fitted. In any case:

- Ensure that the gate is easy to operate and the pig cannot open it from inside
- Use a stable crate so the pig is willing to step in and keep still
- Make individual crates narrow enough to prevent the pig from turning
- Avoid injuries to operators by giving them easy access to a crate used to test backfat or estimate the eye muscle area.

4.2 Mechanical Scales

Single portable crates with a clock face scale are still used for weighing individual pigs of up to 150 kg. Clock face scales are more robust than electronic, but need to be kept clean and dry to remain accurate.

Mechanical scales designed for pigs are hard to find, but scales can be purchased and a crate built to suit. Larger platform scales are available for weighing groups of pigs and smaller clock face scales are often used for individual piglets or weaners.

4.3 Electronic Scales

Scales with electronic load cells and digital indicators are readily available. Designed specifically for livestock, they can be equipped with an individual crate or used for group weighing platforms.

Electronic scales must be well maintained to keep them working accurately. Remove and store the digital indicator when the scale is not in use. Crate or load cells should also be stored in a clean, dry, dust-free environment. Use conduit over wiring to guard it from rats and mice.

5 Comparing Nutrition and Performance

Unless you know what your pigs are eating and how well they are converting their feed to lean meat, it is impossible to improve your nutrition program. Collecting real time data on a regular basis should be a routine management procedure. This information can be used to identify the production phase that may require improvement. Options for gathering information to determine how efficiently your pigs are utilising their feed and performing are outlined here.

5.1 Liveweight versus Age

Identify pigs with their birth week using one of the identification methods outlined earlier, then:

- Weigh at least 50 males and 50 female pigs individually at set time points (e.g. four, eight and 14 weeks of age). To avoid biases, it is best to select a number of pens and weigh all the pigs within a given pen
- Record the age and liveweight of all sold pigs or estimate sale liveweights from abattoir kill sheets
- Record the herd data in a table like the example shown in Table 8.1. Plot the weight versus age data onto the graph shown in Figure 8.2. See how you compare.

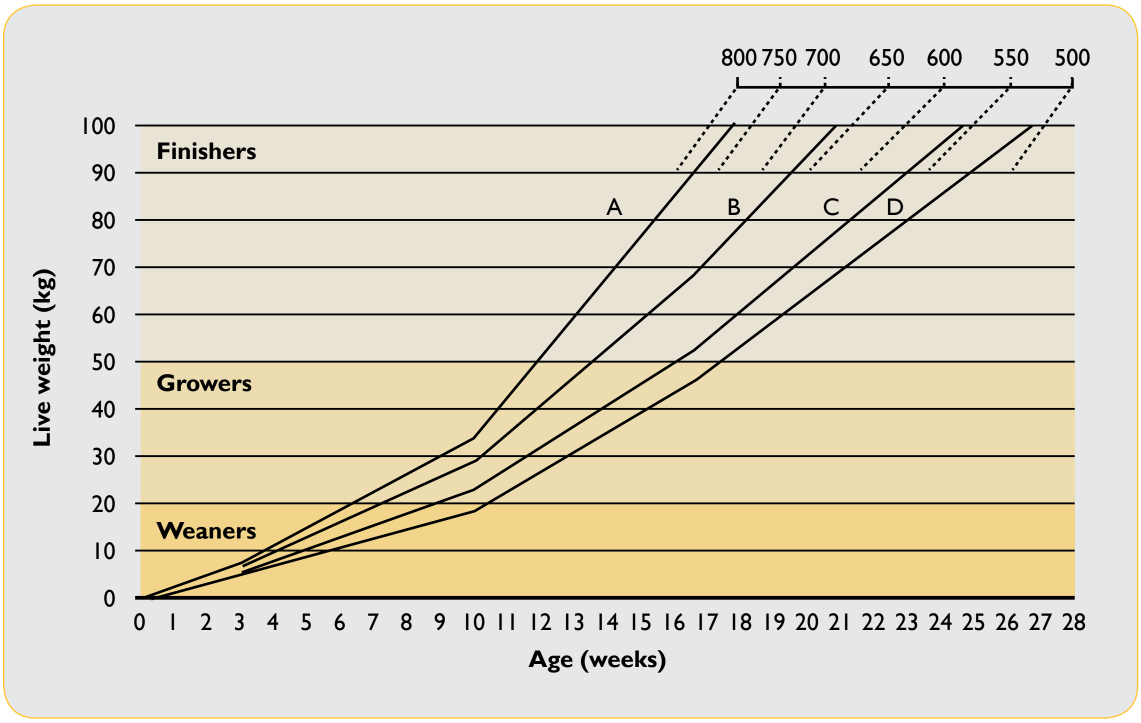
TABLE 8.1 Example of data collection for liveweight versus age

Pig	Sex	Age	Weight	Age	Weight	Age	Weight	Age	Weight
1	F	4	8	8	22	14	60	18	93
2	M	4	7	8	20	14	58	19	91
3	F	4	6	8	17	14	53	20	87
4	F	4	8	8	23	14	61	18	95
100	M	4	9	8	25	14	64	17	92

Blank templates like Table 8.1 can be found in Appendix C.

CHAPTER 8 MONITORING PERFORMANCE

FIGURE 8.2 Herd weight versus age (van Barneveld et al., 1998)



Acceptable nutrition performance levels:

The growth curves shown in Figure 8.2 represents the following:

A+	=	exceptional animals
A-B	=	highly improved superior genotypes
B-C	=	sound commercial performance range
C-D	=	marginal commercial performance range
D-	=	unsatisfactory performance.

If your growth curve on Figure 8.2 places your pigs in class B-C, you have a reasonable genotype which you can build upon.

If your growth curve falls below C-D, nutrition may not be the only issue that needs attention.

5.2 Liveweight versus Feed Use

The pigs weighed to calculate liveweight by age can also be used to calculate liveweight by feed used. To make true assessments of feed efficiency you need the data to be as accurate as possible. Use the following procedure and don't take shortcuts:

- Select five pens of pigs at given age points (e.g. four, eight and 14 weeks of age)
- Weigh and record the average liveweight of the pigs in these pens
- Record the number of pigs in each pen

- Fill all feeders until they are full and level. Do not pack down the feed. NB. No need to weigh the feed you are adding to fill the feeder
- Record all feed added to the feeder over the next four days
- At the end of four days, weigh and record the quantity of feed required to bring the feeders back to their original full level. NB. You need to begin and end the experiment at the same time of day
- Record the data in a table like the example in Table 8.2
- Calculate the feed used per pig per day for each pen using the following equation:

$$\text{Feed used per pig per day} = \frac{\text{Total feed added to the feeders (kg)}}{\text{Number of pigs x 4 days}}$$

TABLE 8.2 Example collection sheet for feed intake data

Pen	1	2	3
Diet name	Starter	Starter	Starter
Ave age (weeks)	4	4	4
Ave Liveweight (kg)	8	7	9
No. of pigs in pen	15	16	15
Sex of pigs	M	F	M
Day 1 feed added (kg)	0	0	2
Day 2 feed added (kg)	4	3	4
Day 3 feed added (kg)	6	7	6
Day 4 feed added (kg)	2	3	5
Feed added to fill feeder at the end of day 4 (kg)	3	2	2
Total feed used (kg)	15	15	19
Feed use/pig/day (kg)	0.250	0.234	0.317

Blank templates like Table 8.2 can be found in Appendix C.

5.3 Digestible Energy versus Liveweight

When comparing between farms or even between seasons, it is more accurate to compare liveweight against digestible energy intake rather than gross feed intake, as energy densities of diets can vary substantially. The conversion between feed intake and digestible energy intake can be done using the Table 8.3 and the information calculated previously. You will need a print out of your diets. All formulation programs generate a slightly different print out. Two examples of formulation print outs are shown in this chapter. Contact your nutritionist if you need help interpreting your diet printouts.

TABLE 8.3 Example data collection sheet for calculating digestible energy intake per pig per day at a specific liveweight or age

Diet name	When fed (age or liveweight)	Available lysine (g/MJ DE)	Digestible energy (MJ/kg)	Feed usage/pig/day (kg)	DE Intake/day (MJ)
Starter	8–10 kg	0.90	15.1	0.267	4.03

Feed usage can be obtained from Table 8.2.

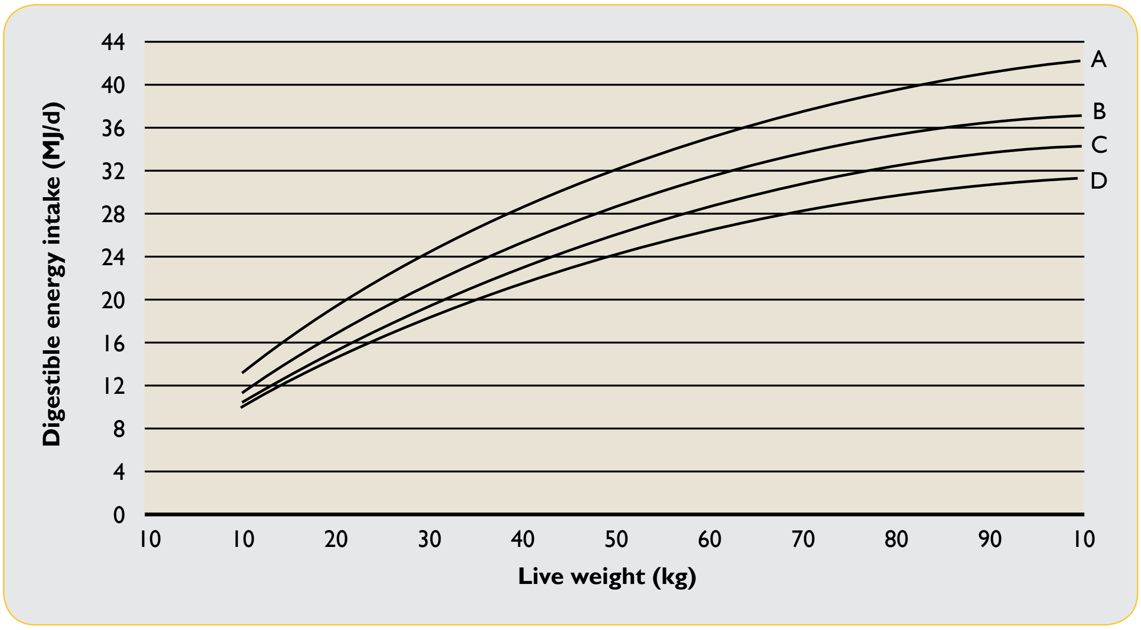
Blank templates like Table 8.3 can be found in Appendix C.

Once you have completed Table 8.3 you can now plot daily digestible energy intake against liveweights, as shown in Figure 8.3.

Referring back to the 'acceptable nutrition performance levels' guide, if your growth rates are in class B-C (taken from Figure 8.2) and they match your estimated energy intake levels (taken from Figure 8.3), you should use routine nutritional management practices to maintain current performance.

If your growth rates are in class B-C or above and your daily energy intake is in C-D or below, you have calculated incorrectly, as it is impossible to produce pigs for less than the plotted daily energy intake at each performance level. Check feed intake and growth measurements. If all calculations appear correct, repeat the data collection exercise.

FIGURE 8.3 Energy intake required to achieve growth rates shown in Figure 8.2 and final backfat of 12 mm (van Barneveld et al., 1998)



If growth rates are in class B-C or above and daily energy intake is in A-B or above you are feeding inefficiently. To remain viable and increase profits, identify the cause(s) of the inefficiencies (Table 8.4).

TABLE 8.4 Interpreting nutrition versus performance data

Growth rate	Daily energy intake				
	A+	A-B	B-C	C-D	D-
A+	Perfect	**Check feed intake and growth rate measurements**			
A-B		Very good			
B-C			Respectable		
C-D		**Diagnose the problem**			
D-					

CASE STUDY: Different ways of expressing amino acids in pig diets

In the past nutritionists have used total amino acid values for raw materials when formulating pig diets. As science has evolved and we continue to gather a greater understanding of digestive physiology, nutritionists are now more likely to formulate to available or standard ileal digestible amino acid values. For a producer, the terms ‘available’ and ‘standard ileal digestible’ can be considered interchangeable.

Not all of the amino acids within a raw material are necessarily available to the pig. Factors including fibre (content and type), processing methods, and anti-nutritional factors can limit the availability of amino acids to the pig. For example, the amino acids in synthetic amino acids products, e.g. Lysine-HCl, are almost completely available (>99%), whilst the amino acids in canola meal range in availability from 75–87% and from 35–74% in lucerne.

Interpreting formulation printout from Format

1

Formula basic data

Code :	6666	Name	: **JO BLOGGS PIG GROWER 1**		
Sell price:	0.0	Batch [Kg]:	1000.0	Group code:	
Cost :	345.683	Created	: 13/01/14	Version :	
Margin :	-345.683	Updated	: 13/01/14	FM origin :	
Tonnes :	60.0	User name	: MEGAN	VM key :	

Diet name

External reference:
Script file name :

Raw material	%	[Kg]	Tonnes	Cost	Diet cost
6 WHEAT 13%	54.54	545.4	32.724	245.0	133.623
14 BARLEY 10 %	10.0	100.0	6.0	212.0	21.2
120 PEAS	15.0	150.0	9.0	340.0	51.0
318 SOYABEANMEAL-48%	2.0	20.0	1.2	695.0	13.9
322 CANOLAMEAL-37%-ROL	10.0	100.0	6.0	425.0	42.5
400 MEATMEAL	3.1	31.0	1.86	720.0	22.32
420 BLOODMEAL	0.5	5.0	0.3	1200.0	6.0
520 TALLOW-MIXER	2.8	28.0	1.68	750.0	21.0
550 SALT	0.2	2.0	0.12	260.0	0.52
560 LIMESTONE	1.0	10.0	0.6	300.0	3.0
600 LYSINE-HCL	0.39	3.9	0.234	2200.0	8.58
605 D,L-METHIONINE	0.1	1.0	0.06	4700.0	4.7
610 THREONINE	0.14	1.4	0.084	2250.0	3.15
620 TRYPTOPHAN	0.02	0.2	0.012	20500.0	4.1
977 ROVABIO EXCEL-ENZ PMX	0.03	0.3	0.018	5300.0	1.59
1179 PHYZYME XP.5000-POWDER	0.01	0.1	0.006	13200.0	1.32
6916 FEEDOX	0.02	0.2	0.012	2600.0	0.52
9502 ELITE PIG GROWER PMX	0.15	1.5	0.09	4440.0	6.66
	100.0	1000.0	60.0		345.683

Analysis

[VOLUME]	Percent	100.0	SODIUM	%	0.122844	SID M+C/LY RATIO	0.627587
DEPIGS	**MJ/KG**	**14.5092**	ACID BIN	MEQ/KG	659.782	SID THR:LY RATIO	0.656855
NET ENERG	MJ/KG	9.9556	CHOLINE	MG/KG	1480.646	SID ISO:LY RATIO	0.551766
PROTEIN	**Percent**	**18.73866**	PHYTATE	%	0.252942	SID TRY:LY RATIO	0.18344
FAT	Percent	5.0758	SALT	%	0.34179	SID ARG:LY RATIO	0.981481
FIBRE	Percent	3.9595	TOTAL L	%	15.0	SID HIS:LY RATIO	0.37994
ASH	Percent	4.56625	SID LYS	%	1.018464	SID LEU:LY RATIO	1.072304
LYSINE	**%**	**1.145277**	W3	%	0.152236	SID VAL:LY RATIO	0.712457
CALCIUM	%	0.91617	W6	%	0.99393	**SID LYS:DE RATIO**	**0.070194**
TOTAL P	%	0.51252	W6:W3		6.528876		
AVAILABL	%	0.40274	SID MET/LY RATIO		0.384893		

Digestible Energy (DE)
Crude Protein (CP)
Total Lysine (T.Lys)

Standard Ileal digestible lysine: DEratio

Interpreting formulation printout from Concept 5

Example Diet Print Concept.txt

CFC — TRIAL FORMULA — Date: 01/13/2014

Plant: 2 ACE

Product: 6666 JO BLOGGS PIG FINISHER — Version: 3

Ingr Code	Ingredient Name	Kgs	Pct	Owning /Tonne	Total Cost
4	WHEAT 11%	500.300	50.030	270.00	135.08
14	BARLEY 10 %	250.000	25.000	235.00	58.75
120	PEAS	60.000	6.000	336.00	20.16
322	CANOLAMEAL-37%-ROL	130.000	13.000	344.00	44.72
400	MEATMEAL	20.000	2.000	720.00	14.40
520	TALLOW-MIXER	18.000	1.800	1,030.00	18.54
550	SALT	2.000	0.200	260.00	0.52
560	LIMESTONE	11.000	1.100	300.00	3.30
600	LYSINE-HCL	4.000	0.400	2,300.00	9.20
605	D,L-METHIONINE	1.000	0.100	4,750.00	4.75
610	THREONINE	1.500	0.150	2,500.00	3.75
620	TRYPTOPHAN	0.100	0.010	35,000.00	3.50
977	ROVABIO EXCEL-ENZ.PMX	0.300	0.030	5,300.00	1.59
1179	PHYZYME XP.5000-POWDER	0.100	0.010	13,200.00	1.32
6916	FEEDOX	0.200	0.020	2,600.00	0.52
9502	ELITE PIG GROWER PREMIX	1.500	0.150	4,440.00	6.66
	Formula Totals:	1,000.00		326.76	326.76

Nutrient Composition: (Class 1)

Nutr	Nutrient Name	Amount	Units
2	DRY MATTER	90.221	Percent
3	D.E.PIGS	14.016	MJ/KG
5	NET ENERGY PIGS	9.686	MJ/KG
14	PROTEIN	15.741	Percent
15	FAT	4.065	Percent
16	FIBRE	4.298	Percent
17	ASH	4.387	Percent
22	LYSINE	1.021	%
23	METHIONINE	0.362	%
24	METH + CYSTINE	0.730	%
25	THREONINE	0.715	%
26	ISOLEUCINE	0.572	%
27	TRYPTOPHAN	0.189	%
49	CALCIUM	0.854	%
50	TOTAL PHOSPHORUS	0.470	%
51	AVAILABLE PHOS.	0.351	%
52	SODIUM	0.113	%
58	ACID BINDING CAPACIT	615.82	MEQ/KG
81	CHOLINE	1,646.07	MG/KG
84	AVAIL.LYSINE	0.869	%
114	PHYTATE P	0.273	%
116	SALT	0.322	%
117	TOTAL LEGUMES	6.000	%
118	BULK DENSITY	64.512	KG/HL

Nutrient Ratios

Nutr	Nutrient Name	Units	Per	Nutr	Nutrient Name	Units	Ratio Amount
23	METHIONINE	%	1.000	22	LYSINE	%	0.355
24	METH + CYSTINE	%	1.000	22	LYSINE	%	0.715
25	THREONINE	%	1.000	22	LYSINE	%	0.701
26	ISOLEUCINE	%	1.000	22	LYSINE	%	0.560
27	TRYPTOPHAN	%	1.000	22	LYSINE	%	0.185
84	AVAIL.LYSINE	%	1.000	3	D.E.PIGS	MJ/KG	0.062

Page 1

6 Calculating Sale Liveweight

Options given in this section present viable alternatives for the collection of performance data, whatever the management system.

Estimation provides basic data only. Use it as a starting point and adopt another option soon.

Group weighing provides reliable data to indicate general piggery performance.

Individual weighing gives highly accurate data which reveals even slight variations in performance.

6.1 Estimation

A rough estimate of sale liveweight can be obtained from abattoir kill sheets. Multiply the average dressed weight of the carcase by the conversion factor (see Table 8.5 for carcasses weighing less than 60 kg and Table 8.6 for carcases heavier than 60 kg) to get the standard carcase weight. Divide the standard carcase weight by the dressing percentage to determine the liveweight at sale. The dressing percentage can vary depending on abattoir dressing procedures, but assumes a standard dressing percentage of 75%. Note that for pigs processed in Western Australia, the conversion factor is 68%.

EXAMPLE: Calculation of sale liveweight

Average dressed weight	= 65 kg
Dressing procedure	= head ON; flare fat OUT; fore-trotters OFF; hind trotters ON
Conversion factor (from Table 8.6)	= 1.023
Calculated average sale liveweight	= (65*1.023)/0.75 = 88.7 kg

TABLE 8.5 AUS-MEAT standard carcase conversion factor grid for pig carcases (HSCW) ≤60 kg

Head	Flare fat	Fore trotters	Hind trotters	Maximum scale wt (kg)	Conversion factor
On	In	On	On	60.0	1.000
On	Out	On	On	59.0	1.012
On	In	Off	On	59.5	1.011
On	In	On	Off	59.5	1.011
On	Out	Off	On	58.5	1.023
On	Out	On	Off	58.5	1.023
On	In	Off	Off	59.0	1.022
On	Out	Off	Off	58.0	1.035
Off	On	On	On	56.0	1.078
Off	Out	On	On	55.0	1.092
Off	In	Off	On	55.5	1.091
Off	In	On	Off	55.5	1.091
Off	Out	Off	On	54.5	1.105
Off	Out	On	Off	54.5	1.105
Off	In	Off	Off	55.0	1.104
Off	Out	Off	Off	54.0	1.120
Skull out	In	On	On	57.0	1.057
Skull out	Out	On	On	56.5	1.071
Skull out	In	Off	On	56.5	1.070
Skull out	In	On	Off	56.5	1.070
Skull out	Out	Off	On	56.0	1.083
Skull out	Out	On	Off	56.0	1.083
Skull out	In	Off	Off	56.0	1.082
Skull out	Out	Off	Off	55.0	1.096

Source: www.ausmeat.com.au/media/44218/piglang_08_lr.pdf

TABLE 8.6 AUS-MEAT standard carcase conversion factor grid for pig carcases (HSCW) ≥60 kg

Head	Flare fat	Fore trotters	Hind trotters	Maximum scale wt (kg)	Conversion factor
On	In	On	On	60.0	1.000
On	Out	On	On	59.0	1.012
On	In	Off	On	59.5	1.011
On	In	On	Off	59.5	1.011
On	Out	Off	On	58.5	1.023
On	Out	On	Off	58.5	1.023
On	In	Off	Off	59.0	1.022
On	Out	Off	Off	58.0	1.035
Off	On	On	On	56.0	1.078
Off	Out	On	On	55.0	1.092
Off	In	Off	On	55.5	1.091
Off	In	On	Off	55.5	1.091
Off	Out	Off	On	54.5	1.105
Off	Out	On	Off	54.5	1.105
Off	In	Off	Off	55.0	1.104
Off	Out	Off	Off	54.0	1.120
Skull out	In	On	On	57.0	1.057
Skull out	Out	On	On	56.5	1.071
Skull out	In	Off	On	56.5	1.070
Skull out	In	On	Off	56.5	1.070
Skull out	Out	Off	On	56.0	1.083
Skull out	Out	On	Off	56.0	1.083
Skull out	In	Off	Off	56.0	1.082
Skull out	Out	Off	Off	55.0	1.096

Source: www.ausmeat.com.au/media/44218/piglang_08_lr.pdf

6.2 Group Weighing

Group weighing gives a better indication of sale liveweight than estimation. It can be achieved by either:

- Weighing a previously tared, loaded truck at a public weighbridge as the pigs are transported to market and dividing the weight by the number of pigs
- Weighing groups of pigs immediately before transport and dividing by the number of individuals weighed.

6.3 Individual Weighing

Weighing each pig as it is loaded for transport provides accurate records and enables variations to be monitored. Larger variations mean a lower average price of meat per kilogram.

7 Measuring Feed Conversion

Feed conversion ratio (FCR) measures the efficiency of conversion of feed into pig meat. FCR values in the typical grower herd from wean to finish range from 2.07–2.72 on a liveweight basis (Pork CRC Benchmarking 2012-2013).

Herd FCR can be used to measure feed efficiency in the entire production system, however, as the growing herd eats most, feed use should be separately monitored for weaners, growers and finishers.

Options for measuring FCR cannot show how much feed is wasted. Feed wastage has an important influence on FCR estimates. It pays to record excessive feed wastage (e.g. if a feeder is emptied in a pen) and include this in FCR calculations. To improve accuracy, assume a minimum wastage level of 5% or 10%, and subtract this from the total used.

The options here involve monitoring performance on a liveweight basis, so FCR is measured accordingly. Gut fill of pigs (influenced by diet) can affect FCR, so interpret calculations carefully.

7.1 Obtaining an Estimate

The following steps over a set period (e.g. 12 weeks) can provide a FCR estimate from weaning to sale:

1. If the pigs' average weaning weight is not known, weigh at least 100 pigs to gain an accurate figure.
2. Determine sale liveweight by weighing pigs just before slaughter or by dividing the average dressed weight (recorded on abattoir kill sheets) by the dressing percentage.
3. Estimate the quantity of weaner, grower and finisher feed used over the period. First estimate the feed on hand, then record the quantity mixed or purchased within the time span. Use the data input sheet (Table 8.7) to record this information.
4. Also record the number of finisher pigs slaughtered (refer to abattoir kill sheets). Omit, at this stage, other deaths during the weaning to sale period. The FCR value will indicate the amount of feed used per pig sold.

TABLE 8.7 Data input sheet for feed use – an example

Diet	On hand at start	+ Purchased or mixed	- Remaining at end	= Used
Weaner	1	51	2	50
Grower	1	80	1	80
Finisher	2	97	3	96
Total	4	228	6	226

A template of Table 8.7 can be found in Appendix C.

Now you have enough data to calculate the liveweight FCR from weaning to sale. The following calculations are required:

(A) Change in pig weight (kg)
= average sale liveweight (kg) minus average weaning weight (kg)

(B) Pig meat produced from weaning to sale (kg)
= change in pig weight (kg) multiplied by number of pigs sold over recording period

(C) Liveweight FCR from weaning to sale
= total feed used over recording period (kg) divided by pig meat produced from weaning to sale (kg)

7.2 An Accurate Figure

An accurate liveweight FCR can be gained for any growth phase by measuring pigs' feed intake and weight gain. Follow these steps for all pigs weaned over a two week period, or for at least 100 pigs, whichever is higher, and make sure to have even numbers of male and female pigs.

Measure feed intake

1. Record the number of pigs in each pen.
2. Fill all feeders to the top and level without packing feed down tightly.
3. Weigh and record all feed added to these feeders over the growth phase (e.g. weaner pens to grower pens).
4. At the end of the test period, weigh and record the amount of feed needed to top up the feeders.
5. Calculate the feed used per pig per day for each pen of pigs by using the following equation:

$$\text{(A)}\quad \text{Feed consumed per pig (kg)} = \frac{\text{total feed added to the feeders (kg)}}{\text{number of pigs in the pen}}$$

Measure weight gain

1. Weigh all pigs in each pen.
2. Record the number of pigs in each pen.
3. Calculate the average weight of each pig by using the following equation:

$$\text{Average pig weight (kg)} = \frac{\text{total weight of pigs in the pen (kg)}}{\text{number of pigs in the pen}}$$

4. At the end of the test period, re-weigh all pigs in each pen and record the number in each. Use the above calculation to determine the average weight of each pig.

5. Calculate the average weight gain (AWG) of a pig in each pen with the following equation:

$$\text{(B)} \quad \text{AWG (kg)} = \text{average pig weight at end (kg)} - \text{average pig weight at beginning (kg)}$$

Calculate FCR

1. Calculate the liveweight FCR for each growth period using the following equation. Ensure the units for feed used and pig weight produced are the same (e.g. kg of feed used and kg of pig meat produced).

$$\text{Liveweight FCR} = \frac{\text{total feed consumed per pig (kg)} \quad \text{(A)}}{\text{total weight gain per pig (kg)} \quad \text{(B)}}$$

8 Calculating Age at Sale

There are a few methods for determining the age of pigs at sale. The most common are tattooing the ear of each pig during its birth week, or using ear notching. Every pig's birth week is recorded at sale and subtracted from the sale week, giving an average age at slaughter.

9 Calculating Growth Rates

9.1 An Estimation

The easiest (but least accurate) way of estimating growth rates is to divide the average sale liveweight by the age of the pigs (in days). This gives an average growth rate (g/day) for the pigs' entire lives.

$$\text{Growth rate (g/day)} = \frac{\text{sale liveweight (kg)}}{\text{age (days) x 1000}}$$

When comparing, ensure growth rates apply to the same growth period (e.g. from birth to sale or from weaning to sale).

9.2 An Accurate Calculation

The best way to monitor growth rates is to weigh every pig at the end of every growth phase, i.e. at weaning, at transfer to grower pens, at transfer to finisher pens, and at sale. Some producers find it more practical to routinely weigh groups of pigs at the end of each growth phase, but this method fails to show variations in individual animals.

The accurate procedure outlined here is best used every three months so that seasonal effects can be noted. Growth rate figures gained are invaluable for fine-tuning nutritional programs.

The following data is collected for all pigs weaned over two weeks (or a minimum of 100 pigs, whichever is greater). It is continued until the pigs are slaughtered.

At birth

- Tattoo or notch an ear of each pig with the week of birth (1–52).

At weaning

- If individual pigs cannot be identified, ear tag and number all those weaned over the two weeks of measurement.
- Record each pig's number and sex.
- Calculate and record (with ear tattoo) each pig's age at weaning.
- Weigh each pig as it is weaned.

Weaners to grower pens/growers to finisher pens

- As each pig is transferred, weigh it, then calculate and record its age.

At sale

- Weigh each individual pig immediately before transport.
- Calculate and record the age of each pig at sale.
- Calculate the growth rate (GR) of each pig for each period using the following:

$$\text{GR (g/day)} = \frac{\text{weight at end of period 2 minus (kg) weight at end of period 1} \times 1000}{\text{age at end of period 2 minus age at end of period 1 (days)}}$$

This method determines the growth rate for each phase so an accurate growth curve is produced for the pig's entire life. Sex differences in growth rate can also be determined.

EXAMPLE: Calculating weaner growth rates

Weaning weight	= 8 kg
Weaning age	= 28 days
Weight at transfer	= 27 kg
Age at transfer	= 63 days
Growth rate (g/day)	= (27 kg – 8 kg) / (63 days – 28 days) * 1000 = (19/35) * 1000 = 543 g/day

10 P2 and Eye Muscle Measurement

10.1 Measuring P2

Backfat measured at the P2 point indicates fat and lean in the carcase. P2 is also used as a basis for payment and as fat pigs are undesirable, they attract a lower price.

P2 is measured at the last thoracic rib, 59 mm across from the backbone (Figure 8.4). Two or three layers of fat lie underneath the skin.

Most abattoirs will provide information on fat measurements at slaughter, with some of the major abattoirs using PorkScan for determining P2 (Figure 8.5). P2 can be measured on live animals using ultrasound technology. Ultrasound instruments use a probe held on the animal while high frequency sound waves penetrate the tissue, without pain or damage. An echo indicates a change in tissue type.

FIGURE 8.4 Carcase cross section showing P2 measurement point (Source: AUS-MEAT Limited)

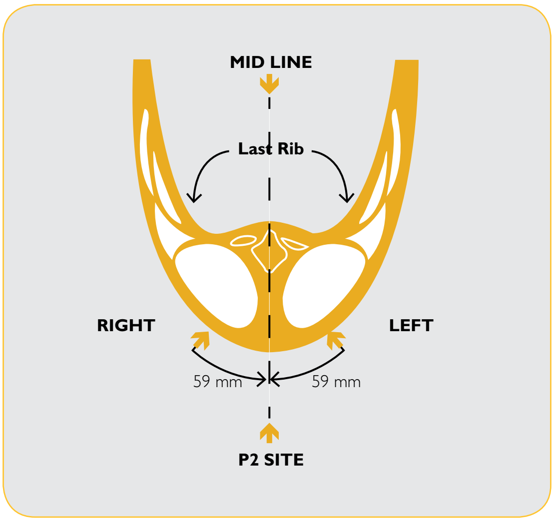
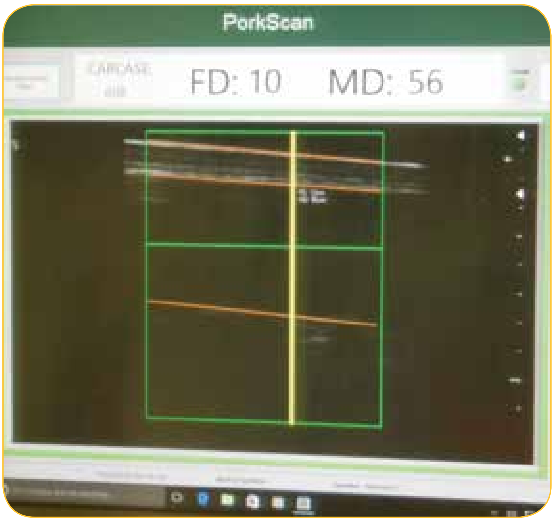


FIGURE 8.5 PorkScan image showing P2 fat depth measurement



Modern real-time ultrasound machines can be used for both pregnancy testing sows and gilts and P2 measurements in sows and grower-finishers, all using the same sector probe. This kind of ultrasound machine can be purchased for around $5,500 + GST. Whilst most producers mainly use their machine for pregnancy testing sows, it can be useful to use it as a means of verifying the backfat measurements included in your kill sheet data. You can also consider using it to fat score gilts prior to first mating or for sows before and after lactation.

To measure P2, hold the probe at right angles to the muscle, using mineral oil to make contact between the probe and the skin. The probe must be held correctly, with good contact on the skin otherwise the measurement may not be accurate. For best results, also measure fat at the P1 position (45 mm from the backbone) and P3 (80 mm from the backbone), and take an average. If P1 and P2 vary by more than 2 mm, re-check them.

When properly used, the instrument displays detailed information and a skilled user can tell which echoes are fat readings, which are interference and whether a third layer of fat exists, however, displays can be hard to interpret until the technique is mastered.

Measure pigs at 50 kg liveweight or more to achieve the best results. At lower weights the animal is too small and has not enough backfat for an accurate reading.

Selection pressure for P2 has resulted in pigs of modern genotypes depositing fat elsewhere on the carcase, making P2 less reliable as a fat indicator. More sophisticated methods including use of ultrasound arrays, image analysis and laser scanning can give a better indication of the carcase's lean meat content than P2 alone.

For more information on how to interpret your P2 measurements refer to *Chapter Five: Sale*. Contact commercial suppliers for more information on ultrasound options and pricing.

10.2 Eye Muscle Estimate

The size of pigs' eye muscles can be estimated with a special ultrasound instrument similar to those used by the medical profession to monitor foetus growth in humans, or detect cancerous lumps. The technique is also used with beef cattle to estimate marbling and fat over the rump before export.

Measure the height and width of the eye muscle or run the probe around the area to calculate a 'lean meat yield' estimate. These measurements can be incorporated into programs like PigBLUP as an aid in selecting breeding stock. These machines are traditionally purchased by breeding companies or large units who have a research and development unit.

Sophisticated equipment needed for eye muscle measurement cost about $23,500 + GST. Some consultants can provide a service for an hourly fee.

If you do decide to purchase your own ultrasound machine, important things to consider include:

- Are there service technicians available within Australia to repair/replace machines/parts?
- Negotiate with the supply company so that if your machine is sent away for repairs you can be provided with a loan machine in the meantime
- Machines should last for more than seven years and can be used for multiple purposes, so invest appropriately
- When getting a quote for a new machine, ensure that the quote includes the necessary add-ons (e.g. carry case, spare battery etc.).

11 Calculating Mortality Rates

11.1 Mortality from Weaning to Sale

Record the number of pigs weaned and the number sold. Use the following equation to calculate mortality percentages for this growth phase:

$$\text{Weaning to sale mortality (\%)} = \frac{\text{number of pigs weaned} - \text{number of pigs sold}}{\text{number of pigs weaned}} \times 100$$

11.2 Mortality Rates for Each Growth Stage

Collect detailed records of deaths, and their causes, for separate growth phases (weaners, growers and finishers). The mortality rate at each stage can be clearly identified and the group first affected revealed, so that disease prevention programs can begin promptly.

Examine every pig unless the cause of death is obvious (see post-mortem details in *The Good Health Manual, 1995*). Information about respiratory diseases, round worm infection and other health problems can be gained from scours, dehydration and death of a weaner. Use the data collection sheet in Table 8.8.

Having collected detailed information, calculate mortality rates for each growth phase using the following equation:

$$\text{Mortality rate (\%)} = \frac{\text{number of dead pigs over growth phase}}{\text{number of pigs in growth phase}} \times 100$$

EXAMPLE: CALCULATING WEANER MORTALITY RATES

Number of growers = 101

Number of weaners = 107

Mortality rate (%) = ((107-101) / 107) * 100
= 5.6% for weaner phase

11.3 The Importance of Post-mortem Examination

Conducting post-mortems is a useful way to get feedback from your pigs on their current health challenges. Training staff on how to conduct successful post-mortems is very important; your veterinarian will be able to assist with this training and it is important to consult with your veterinarian regarding the best procedure for post-mortems and sample collection. Most post-mortems should be conducted as soon as possible after the pig has died. Conduct as many post mortems as possible and take photos of the abnormal areas for your veterinarian. Make sure you include sufficient background information and collect and store samples according to your veterinarian's guidelines to enhance the likelihood of successful diagnosis.

TABLE 8.8 **Post-mortem sheet**

Dead pig information record

Date pig found dead ....

Identification and age of pig (i.e. litter number, birth date, birth week)..........

Location of pig (i.e. shed and pen number, position in pen)..........

Weight of pig (approx.)..........

Body condition (thin, fat, bloated, normal)..........

Previous health problems (i.e. clinical signs observed)..........

Period of illness (i.e. date pig first noted as sick or off feed)..........

Medication history..........

(a) Treatments (injections and dosing)

medicine name..........

amount/volume..........

date..........

(b) In-feed and water medication

medicine name..........

amount in water/feed..........

date..........

Health of pen mates (i.e. deaths and sick pigs in same pen)..........

Health of same age group (i.e. deaths and sick pigs in similar age group, current mortality rate for batch)

....

Estimated time dead (i.e. time of death or time found dead, time of post-mortem) ....

Vaccination status (vaccinations)

type..........

date..........

Reproduction status (sows or gilts)

date weaned..........

date mated..........

farrowed..........

12 Calculating Dressing Percentage

If dressing percentage on individual pigs is necessary, staff must go to the abattoir and identify each animal by correlating the pig number with its dressed weight.

There are a number of options to avoid this inconvenience. The following will give an accurate mean dressing percentage for your herd:

1. Group weigh all pigs before transport to record the liveweight sold
2. Collect the total dressed weight from the abattoir kill sheets after each slaughter
3. Before calculating dressing percentage, make the following adjustments to liveweight if a pig dies during transport, or before slaughter:

$$\text{Adjusted liveweight sold} = \text{liveweight sold} - \frac{\text{liveweight sold x no. of dead pigs}}{\text{total no. of pigs}}$$

Dressing percentage can then be calculated using the following equation:

$$\text{Dressing percentage (\%)} = \frac{\text{dressed weight sold}}{\text{adjusted liveweight sold}} \times 100$$

13 How Do You Compare?

When you know your current performance, compare it with your competitor (anyone selling pork into the same market as you). It can be a big or small piggery, your nearest neighbour, or producers overseas. Consider joining a benchmarking group to compare your herd's performance with others.

Those who do not compare their performance with industry benchmarks risk focusing on secondary issues while overlooking important priorities which affect profitability. For instance, if a herd's feed conversion ratio is near the best in Australia, but the weaner mortality rate is 10%, there is little point in buying new feeders when weaner management needs attention first.

First, compare performance with that of other producers then resolve to make improvements in one or more key production areas. Some who fail this basic objective may not remain viable. This guide outlines suggested production targets. These are only to be used as a guide. You should discuss suggested requirements for your operation with your nutritionist.

Pig producers are good at recording information, but often do not use the data obtained. Here's your opportunity!

Comparing your performance with your competition highlights which management changes should get priority once production costs and potential profit have been calculated. This should apply when judging the value of change in any production phase. Computer simulation models (e.g. Auspig) can be used, or help can be sought from a consultant or pig industry adviser who may also spot issues taken for granted (like feed spillage), as well as answer 'what if?' questions.

The accuracy of the simulation models are only as good as the original data used. If there are concerns about the data, consider evaluating your current recording systems (and commitment).

Remember the overall objective – 'to maximise profit from every kilogram of pig meat sold using methods which are efficient, humane and sustainable'.

14 References

van Barneveld, R.J., Edwards, A.C., Mullan, B.P. & Slade, J. (1998) Producers guide to pig nutrition – Volume 2. *The Pig Research and Development Corporation.* (J. Fergusson Ed) Union Offset Cp. Pty Ltd, Canberra.

Chapter Nine

Designing a Nutrition Program

1 Introduction

This chapter identifies the components of a diet, how the pig uses the nutrients and how to feed different diets to pigs of different age groups and sexes. Your nutrition program should be designed in conjunction with your nutritionist. By using the information you have gathered whilst monitoring your pigs' performance you can now fine tune your nutrition program to maximise profitability.

Although the basic principles of nutrition apply to all pig producers, nutrition programs need adjusting to suit individual operations and their physical production constraints.

Between weaning and sale, nutritional needs of pigs change constantly. They depend on liveweight, the amount of nutrients needed for maintenance or growth, the pig's genotype, the ratio of fat to lean, the sex of the pig and its physiological state.

It is impractical to try to match changes in pig needs by changing the diet, for example, on a daily basis. The number of diets used depends on the size of the piggery and its production flow. Smaller piggeries find it hard to justify more than a simple three-diet program for weaners, growers and finishers.

As stock numbers grow, it becomes feasible to introduce a wider range of diets. Three-stage weaner, two-stage grower, finisher and pre-sale pigs are fed accordingly. It is also possible to feed grower and finisher diets to each sex.

The flexibility of all-in/all-out, single age, single sex batch production enables phase or blend feeding, as long as each stage has its own feed delivery system. This provides a series of integrated diets which can come from one silo of a set composition, or gradually varying the proportions of two basic feeds so the diet meets the pigs' requirements.

2 Collecting Background Information for Your Nutritionist

Professional nutritionists need background information (about growth characteristics and production systems) to determine cost effective diets, and to manipulate the growth and final carcase quality of your pigs.

Much of this has already been obtained by gaining accurate figures on how well your pigs are eating (see *Chapter Eight: Monitoring Performance*). Armed with details of growth rate, feed intakes and acceptable carcase quality, the nutritionist can get to work.

Knowledge of production systems, the pig flow, diet change points, and available facilities (pen size, stocking density, pen numbers, silos etc.) will enable the nutritionist to construct a series of diets which closely match requirements. Complete the following form to give to your nutritionist.

1	**Herd size (number of sows):**			
2	**Genetic background:**			
	Source of stock:			
	Breeding program used:			
3	**Health status (minimal disease, pathogen free etc.):**			
	Routine vaccinations used:			
4	**Average weaning age:**			
	Weaning system (batch farrowed, continuous):			
	Frequency of weaning:			
5	**Production stages:**			
	Growth stage	**Age out (weeks)**	**Weight out (kg)**	**Diet name**
	Weaner 1			
	Weaner 2			
	Weaner 3			
	Grower 1			
	Grower 2			
	Finisher 1			
	Finisher 2			
	Pre-sale			

6	**Stocking rates:**			
	Growth stage	**Pigs/pen**	**m^2/pig**	**Housing type (e.g. conventional/ eco-shelter)**
	Weaner 1			
	Weaner 2			
	Weaner 3			
	Grower 1			
	Grower 2			
	Finisher 1			
	Finisher 2			
	Pre-sale			

7	**Feeder type and delivery method:**		
	Growth stage	**Feeder type**	**Method of delivery**
	Weaner 1		
	Weaner 2		
	Weaner 3		
	Grower 1		
	Grower 2		
	Finisher 1		
	Finisher 2		
	Pre-sale		

8	**Actual liveweight data:**
	Transfer data recorded *Chapter Eight: Monitoring Performance*

9	**Final carcase values:**		
	Carcase value	**Example**	**Measurements**
	Average slaughter age (wks)	*21*	
	Ave carcase weight (kg)	*98*	
	Ave P2 Backfat (mm)	*11*	
	Backfat range (mm)	*7 to 19*	
	Backfat variance (%)	*18%*	
	Gradings		
	1. less than 7 mm	*9%*	
	2. 8-12 mm	*66%*	
	3. 13-14 mm	*15%*	
	4. 15 mm or more	*10%*	
	How are you pigs sold (e.g. under contract, at live market etc.)?		
	At what liveweight/backfat do you get penalised?		

10	**Estimated feed used:**		
	Growth stage	**Diet name**	**(kg/pig/day)**
	Weaner 1		
	Weaner 2		
	Weaner 3		
	Grower 1		
	Grower 2		
	Finisher 1		
	Finisher 2		
	Pre-sale		

11	**Water:**	
	Source:	
	Quality:	
	Parameter	**Measurements**
	Conductivity (Ecs)	
	Total dissolved solids (ppm)	
	Chloride (ppm)	
	Total hardness (ppm)	
	Iron (Fe, ppm)	
	Total colony forming units (CFU/ml)	

12	**Shedding type:**
	Age:
	Insulation:
	Environmental control:
	Outside construction:
13	**Feed:**
	Source (home mixer or buy in feed):
	For home mixer:
	Mixer type and size
	For feed buyer:
	Mill where feed is manufactured
	Constraints on delivered feed (truck size, RAM free mill, etc.)
14	**Commodity**

		Protein (%)*	$/T	Tonnes available	Comments
Grains	Wheat				
	Barley				
	Sorghum				
	Triticale				
	Oats				
	Maize				
	Other				
Legumes	Peas				
	Lupins				Albus or sweet
	Faba beans				
	Chickpea				
	Other				
Vegetable protein	Soya bean meal				
	Full fat soya				
	Canola meal				Solvent or expeller
	Other				
Animal proteins	Meat meal				
	Blood meal				
	Fish meal				Source
	SDPP				

14	Commodity (Continued)					
	Fats/oils	Tallow				
		Vegetable oil				
		Fish oil				
		Poultry tallow				
	Sundries	Groats				
		Biscuit meal				Chocolate or plain
		Extruded wheat				
		Skim milk powder				
		Whey powder				
		Chocolate milk				
		Yeast protein				
		Limestone				
		DCP				
		Salt				
		Lysine				HCl or sulphate
		Methionine				DL or MHA
		Threonine				
		Tryptophan				
		Other				
	Additives	Weaner premix				
		Grower premix				
		Breeder premix				
		Acids				
		Enzymes				
		Betaine				
		Choline chloride				Strength?
		Medications				
		Zinc oxide				Source
		Mycotoxin binder				Brand

* Explanatory notes

Protein

Precise formulation is possible if accurate protein values are available for all major materials. If several parcels of one material has variable protein content, nominate them separately or blend to derive a consistent protein level.

Cost

This should be the all-up delivered price (including carriage and storage). For home grown materials, cost is the net sale price of the material if they were to be sold on the open market.

Tonnes

To ensure that the diets use the right proportions (assuming stocks are available), nominate the tonnes of each grain in stock or stipulate the proportion of others to be sourced.

Comment

The column should be used to point out any peculiarities which will interest the nutritionist. For example:

- Barley is weather damaged, 52 kg/Hl, contains 5% peas and some smut
- Maximum three grains at a time can be used
- Detail the origin/source of meat meal, fish meal etc.

The more information provided, the lower the risk of a misunderstanding between the nutritionist and the producer, and the better the diets will be.

To design a good nutrition program, you need to know the nutrients provided by the feed and how the pigs digest them. Cater for the fact that pigs' nutritional needs change over time.

3 Feed Composition

No single ingredient will supply the pig with all the nutrients it needs to produce lean meat, so we need to prepare a diet containing a range of ingredients.

A nutrient is a substance supplied by the diet to meet the pig's needs. It performs a specific function in the body. If it is absent or in short supply, productivity and health will suffer and some pigs may die.

Ingredients supply nutrients. A balanced diet is a mixture of ingredients that supply the nutrients in the right proportions. Although the pig has no specific need as such for ingredients, some are more palatable or digestible than others.

The potential value of a food to supply a particular nutrient can be shown by chemical analysis, however, there's a need to account for losses during digestion, absorption and metabolism.

For this reason, the best way to define the nutritive value of a feed ingredient is to determine the 'availability' of specific nutrients to the animal. How much of each nutrient is in a form suitable for pig health and growth? Is the nutrient combined with other compounds which will interfere with its use (e.g. phytate, glucosinolates)? The difficulties of getting an exact measure of nutrients often force us to apply a best estimate.

The following are present in feed ingredients in varying proportions:

Carbohydrates – Provide the body with energy and can be converted into body fat.

Fats – Provide energy in a more concentrated form than carbohydrates and can be converted into body fat.

Proteins – Provide amino acids for growth and repair.

Minerals – Used in growth and repair and to help regulate body processes.

Vitamins – Help to regulate body processes. Most vitamins must be provided in the diet.

Water – Like the oxygen in air, water is also essential for life and is classed as a pro-nutrient.

3.1 Carbohydrates

Carbohydrates are compounds of carbon, hydrogen and oxygen, and their chemical structures are based largely on glucose units, linked together in various lengths and ways. Classifying carbohydrates depends on the number of units they contain.

Monosaccharides (one sugar) – Glucose is the most common monosaccharide. Most carbohydrates are broken down to glucose during digestion, then absorbed and used for energy.

Disaccharides (two sugars) – Sucrose (glucose + fructose) or common sugar is the main disaccharide and a source of energy. Another source is the disaccharide lactose (glucose + galactose), which is found only in milk.

Oligosaccharides – These consist of two to ten monosaccharide units joined together. High levels can be found in legumes like lupins, soybeans and peas. Some functional oligosaccharides (e.g. mannan oligosaccharides, xylo oligosaccharide, fructo oligosaccharide) can have specific health benefits for pigs.

They are not digested in the small intestine as no enzymes are present to break down the long sugar chains. As a result, they provide a substrate for fermentation in the large intestine. Beneficial oligosaccharides provide substrates to preferable gut bacteria, whilst unfavourable oligosaccharides may provide substrates for harmful bacteria which may cause increased production of harmful gases and change the consistency of digesta, restricting the ability of enzymes to digest other nutrients in feed.

Polysaccharides – Of most importance are cellulose and starch, both comprising chains of glucose. Cellulose gives plants rigidity and form, while starch is a reserve food supply, appearing mainly in seeds. Cereals like wheat and barley contain high starch levels and are the dominant energy source in Australian pig diets. Starch is far more soluble than cellulose and more easily digested.

Most fibre in feeds is made up of non-starch polysaccharides (NSP), with cellulose the main one. NSP are not susceptible to pancreatic enzymes, and the small intestine's low supply of micro-organisms means that NSP passes on to the hind gut to be broken down. The end products of this microbial degradation, lactic acid and volatile fatty acids, are easily absorbed and can be used by the pig for energy, however, the process is accompanied by energy losses of 33–50%.

The presence of NSP can also increase the viscosity of digesta, slowing its movement and the process of digestion. The impact of NSP's in feed can be significantly reduced through the use of NSP degrading enzymes (e.g. betaglucanases, xylanases, cellulases).

3.2 Fats

Tallow and vegetable oils are the most common fats added to pig diets. Poultry tallow and fish oil are also used. Most other ingredients also contain fat in some form.

Like carbohydrates, fats are compounds of carbon, hydrogen and oxygen, but have less oxygen. Fats are a more concentrated source of energy than carbohydrates, and store most of the animal's energy reserves.

Food fats consist mainly of triglycerides, combinations of three fatty acids with a unit of glycerol. The difference between one fat and another is the different fatty acid each contains.

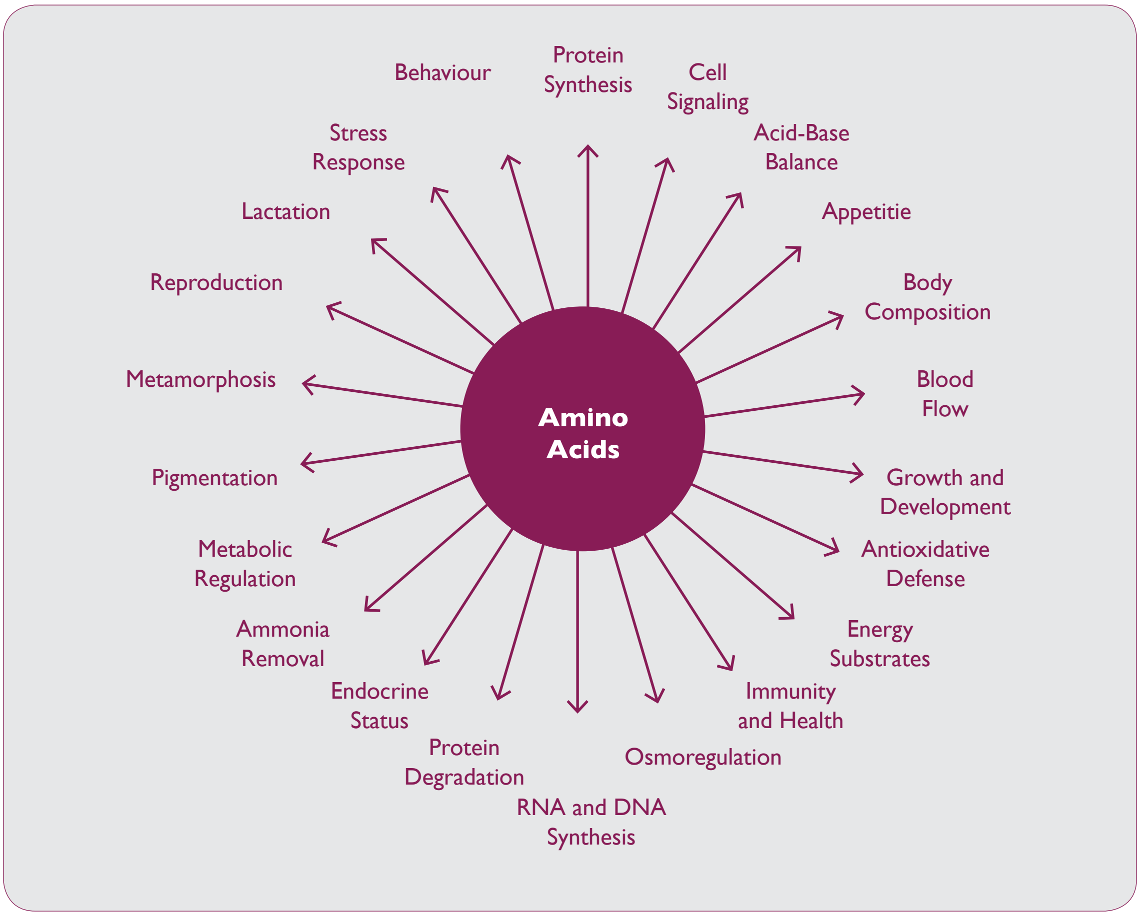
In future, pig producers and nutritionists will need to be familiar with the role of fatty acids in pig diets. Some polyunsaturated fatty acids, e.g. n-3 and n-6 types, are essential for pig growth. Pig diets should be formulated around an n-6:n-3 ratio to ensure a beneficial oxidative balance is maintained.

From a consumers' point of view, it is important to limit pigs' consumption of saturated fatty acids and trans-fatty acids. Fat from these pigs will contain a higher proportion of the saturated fats associated with cardio-vascular disease. Consuming the correct ratio of mono-unsaturated/polyunsaturated fatty acids is also important, however, soft carcase fat can be an issue for many processors.

3.3 Proteins and Amino Acids

All proteins are compounds of carbon, hydrogen, oxygen and nitrogen. Proteins are an essential part of cells, where they regulate life processes and provide structures. Protein as amino acids is needed for the body's growth and repair (Figure 9.1).

FIGURE 9.1 Roles of amino acids in whole body homeostasis (adapted from Wu, 2010)



Proteins consist of chains of amino acid units, and the way particular amino acids are linked gives each protein its characteristic properties. More than 200 different amino acids have been identified, with only 22 used by the pig to make proteins. Some can be synthesised in the pig, and are known as *non-essential* in the diet. Others are *essential*, in that they cannot be synthesised and must be provided in the diet (Table 9.1). There are a few amino acids which are considered *conditionally essential* for the newly weaned pig, as their ability to synthesise sufficient amounts of these amino acids is impaired during the post-weaning growth check.

TABLE 9.1 Nutritional classification of amino acids

Essential	Non-essential
Arginine	Alanine
Histidine	Asparagine
Isoleucine	Aspartic acid
Leucine	Cystine
Lysine	Glutamic acid**
Methionine	Glutamine**
Phenylalanine	Glycine
Threonine	Proline
Tryptophan	Serine
Valine	Tyrosine

** Can be *conditionally essential* in newly weaned pigs

3.4 Minerals and Vitamins

In modern pig production, vitamins and mineral requirements are met by adding commercially manufactured premixes. The contribution of vitamins and minerals from raw materials is often disregarded due to extreme variability. General ranges of vitamin and mineral levels used in commercial pig premixes from weaning to slaughter are shown in Table 9.2. You will notice that the range provided is broad. Recommendations from vitamin and mineral manufacturers are often higher than those used commercially. For more detailed advice, discuss your premix requirements with your nutritionist. There may be specific instances where the vitamin or mineral premix requirement changes, for example, higher levels of chromium, manganese and Vitamin B5 can be useful for limiting backfat and increasing carcase lean in grower-finisher pigs where backfat thickness is an issue. Some vitamins like choline are not included in premixes due to their ability to antagonise other vitamins, so it is typically added as a raw material at the diet level. Magnesium is not traditionally added to Australia premixes due to the abundance of magnesium in our common raw materials.

TABLE 9.2 Guide to vitamin and mineral levels used and recommended in weaner, grower and finisher premixes (ACE Livestock Consulting Pty Ltd)

			Units	Weaners	Growers	Finishers
				Quantity per kg of finished feed		
Vitamins						
	A		MIU	10–20	7–10	5–8
	D3		MIU	1.8–2.5	1.5–2.5	1.0–2.0
	E*		g	40–150	40–100	40–100
	K	Menadione	mg	2–6	1–4	1–4
	B1	Thiamin	mg	1.5–5.0	1.0–3.0	1.0–2.0
	B2	Riboflavin	mg	5–15	4–10	4–10
	B3	Niacin	mg	25–55	15–40	15–40
	B6	Pyridoxine	mg	3–8	1.5–4.5	1.5–3.5
	B9	Folate	mg	0.75–2.5	0–1.5	0–1.0
	B12	Cobalamin	mg	0.02–0.06	0.01–0.05	0.01–0.05
	B5	Pantothenic acid	mg	15–45	25–65	25–65
	H	Biotin	mg	0.1–0.4	0.1–0.3	0.1–0.2
	C	Ascorbic acid	mg	0–200	0	0
Minerals						
	Copper		mg	10–20	20–100	20–100
	Iron		mg	100–150	60–100	60–100
	Zinc		mg	100–140	100–120	80–120
	Manganese		mg	50	40–50	40–50
	Cobalt		mg	0.3–1.0	0.2–0.5	0.2–0.5
	Iodine		mg	0.5–2.0	0.8–1.0	0.8–1.0
	Selenium		mg	0.25–0.35	0.25–0.30	0.25–0.30
	Chromium		mg	0.2–0.4	0.2–0.4	0.2–0.4
	Boron		mg	0	0–15	0–15

* Natural Vitamin E is considered to be two to three times as strong as synthetic Vitamin E, so be careful when comparing premixes, e.g. natural Vitamin E at 40 g is equal to synthetic Vitamin E at 80 g

Using organic sources of minerals is increasingly more common in pig diets (predominately sows and piglets). Organic minerals are more bio-available to the pig so lower inclusion rates can be used. If you wish to use only organic minerals please contact your nutritionist to discuss the replacement levels required.

4 Understanding Digestion

To prepare diets to match the pig's needs we must understand the basics of how pigs digest protein, carbohydrates and fats, and how protein and energy are used.

The pig's digestive tract is a continuous tube extending from its mouth to the anus. Its function is to ingest, move, digest and absorb food, and eliminate solid waste. The mouth, pharynx, oesophagus, stomach, small intestine, caecum and large intestine are parts of the digestive tract. The food moves along the tract by contractions of the circular muscle in the intestinal wall. It is transported along the tract and mixed with digestive juices. The digested nutrients are brought into contact with the mucous membrane of the intestine for absorption.

4.1 Physical Digestion in Pigs

Physical digestion in the mouth

Digestion in the mouth is mainly through chewing, which helps to break up large particles of food and mix it with saliva, which acts as a lubricant. Saliva in pigs is about 99% water.

Physical digestion in the stomach

The stomach is a simple compartment in which food is stored and digestion begins. In the adult pig, it can hold about eight litres. The inner surface of the stomach contains a variety of cells which secrete gastric juice.

Glands are stimulated to secrete gastric juice by the presence of food in the stomach and the hormone gastrin. Gastric juice consists mainly of water, but also contains hydrochloric acid, pepsinogens and inorganic salts. These begin the process of digestion.

Physical digestion in the small intestine

The small intestine, the main absorption site, comprises the duodenum, the jejunum and the ileum, and contains a series of finger-like projections called villi, which increase the surface area and aid absorption of nutrients.

When partly digested food leaves the stomach and enters the small intestine it is mixed with secretions from the duodenum, liver and pancreas. The duodenal glands produce an alkaline secretion which acts as a lubricant and protects the duodenal wall from hydrochloric acid, which has come from the stomach.

Bile secreted from the liver passes to the duodenum through the bile duct. It contains sodium and potassium salts of bile acids, bile pigments, cholesterol and mucin and is stored in the gall bladder until required. Bile salts play an important part in fat digestion.

Pancreatic juice is secreted by the pancreas, a gland that lies in the duodenal loop and opens into the duodenum through the pancreatic duct, and is a source of endogenous enzymes.

Physical digestion in the large intestine

The small intestine absorbs most of the digested nutrients. By the time food has reached the entrance to the large intestine, most hydrolysed nutrients have been dealt with.

With normal diets, a small amount of material always resists the action of enzymes in the alimentary canal. The large intestine glands are mainly mucus glands which do not produce enzymes, so digestion in the large intestine results from microbial activity, or enzymes in the food carried down from the upper part of the digestive tract.

In the large intestine, especially the caecum, there is much activity from microbes which metabolise residues. Faeces passed through the anus from the large intestine consist of water, undigested food residues, digestive secretions, epithelial cells from the tract, inorganic salts, bacteria and the products of microbic decomposition.

4.2 Chemical Digestion in Pigs

The chemistry of digestion is simple for the three major food types (carbohydrates, fats and protein) as the same basic process occurs. The only difference is the enzymes needed to act on all three.

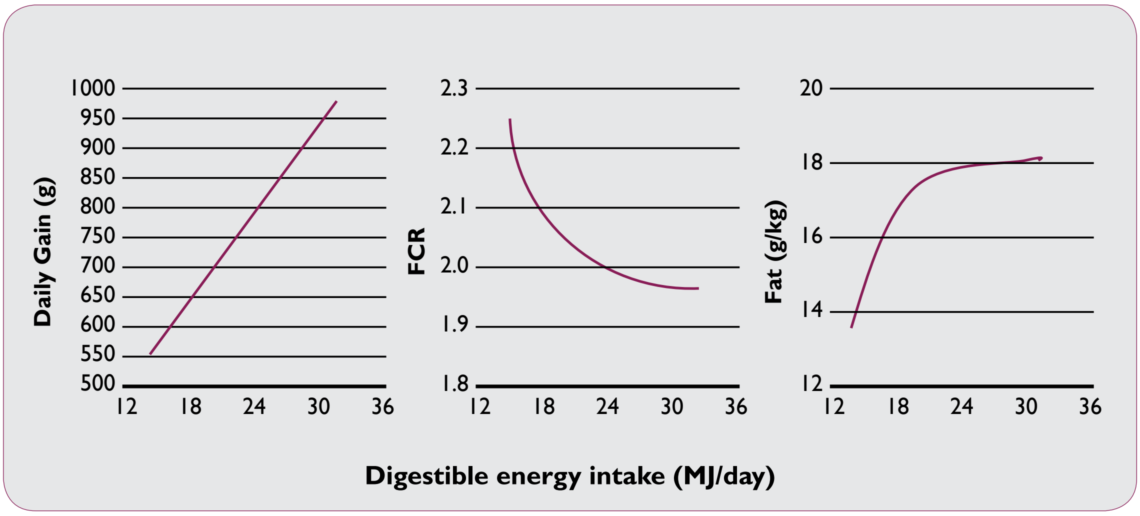
5 Nutritional Requirements

5.1 Energy

If producers know the relationship between energy intake and lean muscle growth for pigs of different age or sizes, they can predict how energy intake affects growth and composition and use this information profitably.

The capacity for growing pigs to deposit lean meat is greater than their ability to consume energy. This means that they can be offered *ad libitum* access to high energy diets without excessive fat or a drop in feed conversion efficiency (Figure 9.2). The more energy a pig consumes, the faster it will grow assuming the diet is adequately supplied with balanced protein.

FIGURE 9.2 Schematic relationships between digestible energy intake and growth rate, feed conversion ratio (FCR), and bodyfat deposition of modern genotype 30–60 kg pigs (based on schematic graphs by Campbell, 1987)



Gut capacity limits the amount of feed a growing pig can eat, so voluntary energy intake of a pig weighing under 60 kg depends on the diet's energy concentration.

Females have less potential for muscle growth than males. Between 30–60 kg, when fed normal energy levels (e.g. 28.0 MJ DE/day), there is little difference between the sexes in growth rate and fat deposition, however, at higher DE intakes (30+ MJ/kg) female pigs deposit more fat and have a higher feed conversion ratio.

Finisher pigs

In the finisher pig, energy intake may exceed the requirement for maximum lean protein deposition, and the pig may begin to lay down proportionally more fat (relative to lean). This tends to be a greater problem in females and castrates rather than entire males.

Under commercial conditions, the appetite of genetically advanced pigs is often limited due to the impact of environmental and social factors (e.g. stocking density, social behaviours) reducing the amount of time spent eating. Hence, modern pigs are mostly lean and fat pigs are a rare occurrence. Research conducted by King et al. (2004) found that in modern Australian pigs there is no limit to protein deposition rates from 80–120 kg liveweight, when high feed intake is maintained (Table 9.3).

TABLE 9.3 Performance and protein deposition rate of boars and gilts from 80 to 120 kg liveweight when housed in individual pens continues to promote unrestricted appetite (King et al., 2004)

	Energy intake*	ADG	FCR	Protein deposition^
	MJ DE/d	g/d	F:G	g/d
Boars	47.7	1376	2.41	247
Gilts	40.9	1040	2.76	182

* Pigs had *ad libitum* access to a 14.4 MJ/kg DE diet

^ Empty body protein deposition rate of pigs

Energy intake for the highest rate of protein deposition depends on the finisher's sex and genotype, housing and management. The data in Table 9.3 shows the potential growth of Australian pigs, however, typical energy intake in commercial finishers housed in group pens are estimated to average 35–36 MJ DE/day which is a limiting constraint to maximising protein deposition.

It is hard to generalise about the best energy intake for finishing pigs. When deciding the appropriate nutritional program it is important to factor in the appetite capacity of your genotype as well as taking into account the impacts of various housing systems. Pigs with lower appetites will require diets with higher nutrient densities.

The difference between males and females means that feeding different diets to each will maximise lean meat sold and reduce feeding costs.

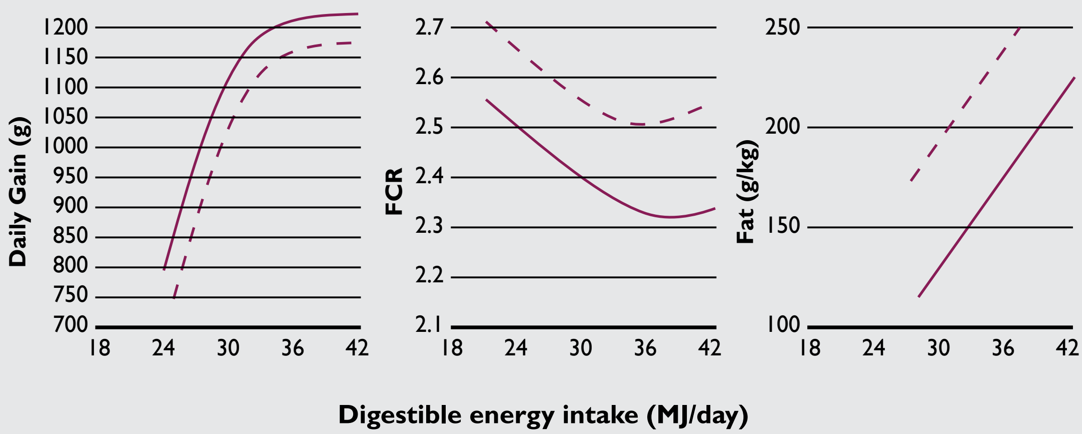
In pigs with a lower potential for lean growth, growth rates plateau or slow as the maximum lean protein deposition has been reached (Figure 9.3) with additional energy being converted to fat. At the same time, feed conversion begins to deteriorate and backfat continues to increase.

Regardless of genotype, females deposit protein slower, have a higher feed conversion ratio than males and will be fatter at all feeding levels. Females also need less energy for basic body functions, which adds to the difference in carcase fat between the sexes.

Genetic gains over the last few decades have seen a reduction in the difference between males and females. This change is mainly related to the greater improvement in the lean muscle potential of females relative to males. Differences in backfat thickness between males and females have decreased from around 1.5 mm to 0.5 mm over this time.

Depending on the genotype and pigs' environment, split-sex feeding with either separate diets or with different diet change-over points, can still be the most efficient feeding strategy for finishing pigs above 60 kg.

FIGURE 9.3 Schematic relationship between energy intake, growth rate, feed conversion ratio (FCR) and body fat composition of modern genotype male (solid line) and female pigs (dashed line) from 60–100 kg (based on schematic graphs by Campbell, 1987)



5.2 Protein and Amino Acid

Pigs do not have a requirement for protein as such, but they need an appropriate level and balance of individual amino acids, ten of which are essential for growers and finishers. It is difficult to consider how much of each is required when formulating diets, so an 'ideal protein' estimate is used.

This is based on the view that, as dietary amino acids are used for lean muscle growth, their balance in lean muscle reflects the balance in which they are needed in the diet. If we know the ideal balance the diet needs, we can concentrate on how much of the first limiting one is needed, then express the quantity of all others relative to this.

The estimate of ideal protein changes as the pig grows. It will vary depending on the ratio of maintenance to growth, because the amino acids used for each of these processes is slightly different. Table 9.4 outlines the ideal pattern of amino acids for pigs of six different weight groups.

Because lysine, present in most cereal-based pig diets, will be the first limiting amino acid, the requirements for other amino acids are expressed as a proportion of available or standard ileal digestible lysine. Pigs' need for lysine depends on liveweight, energy intake, sex, genotype, health and environmental conditions.

TABLE 9.4 Ideal amino acid balance for growing pigs expressed as standard ileal digestible requirements (Evonik, 2009)

	0–20 kg	20–40 kg	40–60 kg	60–80 kg	80–100 kg	100–120 kg
Lysine	100	100	100	100	100	100
Methionine	33	34	34	35	36	35
M+C[1]	60	62	62	63	65	65
Threonine	63–70^^	65	65	67	71	69
Tryptophan	22	20	20	20	19	18
Arginine	42	40	40	36	32	32
Isoleucine	55	55	55	55	55	55
Leucine	100	100	100	100	100	100
Valine	68	68	68	68	68	68
Histidine	32	32	32	32	32	32
P+T[2]	95	95	95	95	95	94

[1] Methionine + cysteine

[2] Phenylalanine + tyrosine

^^ Threonine requirements change depending on the weaning transition. Elevating threonine during the post-weaning growth check can help maintain and repair gastrointestinal function.

An adequate intake of protein and essential amino acids is needed for maintaining existing tissues and new growth. Deficiency of any amino acid will limit muscle growth, slow weight gain and increase carcase fatness. Conversely, supplying too many amino acids is wasteful and can slow growth, particularly in the later stages of development.

Maximum available (or SID) lysine to digestible energy ratios vary from 0.70–0.85 g/MJ DE for the 30–60 kg range, and are affected by energy intake and sex. Males and females have similar requirements when their feed is restricted, but males need a higher lysine:DE ratio than females when fed *ad libitum*.

Because the pig's relative capacity for muscle growth declines as it grows, so does its need for dietary protein and essential amino acids relative to energy. During the finisher stage, entire males have more capacity for muscle growth than females.

For finisher pigs, maximum lysine:DE ratios range from 0.52–0.68 g lysine/MJ DE. Current lysine requirements for Australian grower-finisher pigs are explained in greater detail in the *Chapter Four: The Grower-Finisher Pig*.

5.3 Protein and Energy

Stated requirements for protein or energy apply to one performance level only. Protein for lean muscle growth and intake of protein and energy go through two phases.

The first is protein dependent. Lean muscle grows with protein intake, unaffected by any change in energy intake. The second, energy dependant phase deposits protein only when energy is raised.

Because of the connection between dietary energy and lean meat deposition, it is useful to express dietary amino acid requirements in relation to the amount of dietary energy, or e.g. g available lysine/MJ DE.

6 Specifying Diets

To set diet specifications for a group of animals, we need to account for the variation between individual animals. A specification calculated at the mean of the population satisfies the needs of only half the population, however, raising the specification to meet the needs of the very best animals is expensive and wasteful.

The most cost-effective compromise is to raise the target by one standard deviation above the mean, which will meet the needs of 85% of the herd. The greater the herd variance, the more inaccurate this judgement becomes.

6.1 Example Nutrition Programs for Small versus Large Piggeries

Small piggeries of lower genetic merit (<100 sows)

Weaning at four weeks (8.0 kg = average weaning weight).

Continuous flow production, three separate sections (nursery, grower and finisher).

TABLE 9.5 Example of a simple feeding program

Creep*	Commercial pellet from 3–6 weeks
Weaner	7–10 weeks
Grower	11–15 weeks
Finisher	16 weeks to slaughter

* Creep feed should be offered for at least one week prior to weaning

Creep

It is not easy to mix a high quality creep feed on-farm. The best option is to purchase a good quality creep pellet or crumble from a professional feed mill or supply company. This also makes it easier to ensure all ingredients are fresh since commercial feed mills have a high turnover of ingredients such as milk powders. This pellet/crumble should be used both in the farrowing house and for two weeks post-weaning. This diet needs to cater for the digestive capacity of the four week weaner so choose an appropriate quality product. Depending on the range offered by the feed additive company, they may have multiple products which allow you to phase feed your piglets. As a general rule, the normal specification would be 15.0+ MJ DE/kg and a minimum of 0.85 g available (or SID) lysine/MJ DE. Milk powder, cooked cereals, fish meal and acidifiers should all be included.

Ensure the diet has a low acid-binding capacity, supplemented with organic acids. Feed intake is a major limit to growth in this phase, so digestibility and palatability are important.

Weaner

Now the pigs have transitioned through the post-weaning growth check, it is time to capitalise on their impressive feed conversion capacity. There is not a great need for milk products to be included in this diet. Diets should still contain a broad range of high quality and palatable raw materials, at low inclusion rates. Normal specifications are 14.5–15.0 MJ DE/kg and 0.80 g available lysine/MJ DE.

Grower

This is the phase of rapid lean gain, so the diet needs high energy (14.0–14.5 MJ DE/kg) and about 16 g of available lysine/day to support a protein deposition rate of 140 g/day. At a feed intake of about 1.7–1.8 kg or 24 MJ DE/day, this means the available lysine/DE ratio for growers should be 0.68 g/MJ DE.

Finisher

For finishers, energy consumption should be kept within about 32–36 MJ DE/day from a feed intake level about 2.4–2.7 kg/day and an energy density of 13.2–14.0 MJ DE/kg. If protein is deposited at 160–180 g/day, the available lysine/DE ratio would be 0.55–0.60 g/MJ.

Larger piggeries of higher genetic merit (>250 sows)

These use:

- Superior genotypes
- Specialised nurseries
- Multi-site production
- Probably practise all-in/all-out, single age, single sex groups
- Weaning at 28 days.

TABLE 9.6 Example of a complex feeding program from weaning to slaughter

Creep	Commercial pellet from 3–5 weeks	
Weaner 1	6–7 weeks	
Weaner 2	7–10 weeks	
	Males	**Females**
Grower 1	10–12 weeks	10–12 weeks
Grower 2	13–15 weeks	13–14 weeks
Finisher	16–19 weeks	15–18 weeks
Pre-sale	20–21 weeks	19–22 weeks

* Creep feed should be offered for at least one week prior to weaning

Creep

Design this diet with the immature 21–28 day weaner in mind. The diet must be highly digestible, palatable and contain sufficient amounts of milk products with a base of cooked cereal. Amino acid density should be high (0.9–1.0 g av. lysine/MJ DE) and so should energy (15.0 + MJ DE/kg). The initial diet should be used both in the farrowing house and in the first week to ten days post-weaning. This diet should be carefully designed to minimise the growth check and support a smooth weaning transition.

Weaner 1

Now the piglet has transitioned through the weaning process, we need to begin managing the weaner for efficient lean growth, keeping in mind that the digestive and immune systems are still maturing. This diet will contain similar raw materials to the creep diet but the inclusion rate of milk powders, cooked cereals, plasma proteins, fish meal etc., can be reduced. The diet specifications will be similar to the creep diet (0.85–0.90 g av. lysine/MJ DE and 14.8+ MJ DE/kg).

Weaner 2

Typically this diet is fed to pigs from 15–30 kg of liveweight. Milk powders are no longer required and more economical feed ingredients can be introduced at low levels. The focus with this diet is to capitalise on efficient lean growth. The diet specifications should be around (0.78–0.85 g av. lysine/MJ DE and 14.5–15.0 MJ DE/kg).

Growers through to pre-sale

In this example, female pigs are offered a different nutritional program by varying the ages (weights) at which the various diets are changed, rather than providing sex-specific diets. This practical approach means that fewer diets are needed, but it will work only if facilities and production logistics allow.

TABLE 9.7 Suggested achievable commercial performance and protein deposition rates in finisher pigs (ACE Livestock Consulting Pty Ltd)

	DE intake*	Growth rate	Protein deposition	Feed intake (kg/day) for different diet densities (DE)		
	MJ/d	g/day	g/day	14.0 MJ	13.6 MJ	13.2 MJ
Entire males	35	1100	215	2.50	2.57	2.65
Females	33.5	1000	195	2.40	2.45	2.55

* Assumes 10% feed wastage

6.2 Example Nutrition Programs for Entire Males and Female

Examples of dietary specifications for male and female diets are listed in Table 9.8. Expected feed intakes, growth rates and feed efficiency values for each phase through to sale are in Table 9.9 for entire males and Table 9.10 for females. These are based on energy costs of maintenance and growth, where growth has achieved a final P2 backfat of 9 mm in males and 10 mm in females at the final weights indicated.

There is no allowance for feed wastage, so it may be necessary to add up to 10% to the feed usage values to get practical feed efficiency. The final result across both sexes would be 700 g/day with a herd feed conversion efficiency (dead weight) of about 3.33.

Changes in diet specifications and feed can be reviewed with the help of production feedback. The feed intake achieved in each phase is particularly interesting, as it depends on feeding methods, environmental factors and management. It may be necessary to adjust dietary specifications for each phase to control the daily nutrient intake.

TABLE 9.8 Examples of dietary specifications (ACE Livestock Consulting Pty Ltd)

			Ratios of av. AA to av. Lysine^					Comment
	DE (MJ/kg)	Av. lys. /DE (g/MJ)	Meth.	Meth/ cys.	Threo.	Iso.	Tryp.	
Creep	15.5	0.95	0.33	0.60	0.67	0.57	0.22	
Weaner 1	15.2	0.85	0.33	0.60	0.65	0.55	0.21	
Weaner 2	14.8	0.78	0.34	0.62	0.65	0.55	0.20	
Porker*	14.5	0.72	0.34	0.62	0.65	0.55	0.20	Optional
Grower 1	14.2	0.69	0.34	0.63	0.65	0.55	0.19	For males
Grower 2	13.8	0.65	0.35	0.65	0.67	0.55	0.19	For females
Finisher 1	14.0	0.60	0.35	0.65	0.70	0.55	0.18	For males
Finisher 2	13.5	0.56	0.36	0.66	0.70	0.55	0.18	For females
Pre-sale*	13.2	0.52	0.36	0.66	0.69	0.55	0.18	Optional

*These diets may be used for specific batches of pigs to help them catch up or to help manage pig flow

^ For the full set of amino acid ratios refer to Table 9.4

TABLE 9.9 **Projected feed intakes, growth rates and feed conversion efficiencies of entire males fed diets based on specifications contained in Table 9.8**

Feeding phase	Age (w)	Weight (kg)	Gain (g/d)	FI (kg/d)	FCR	Feed usage/pig (kg)					
						C	W1	W2	P	G1	F1
Creep	3–5*	6.0–10.5	360	0.40	1.10	3.3*					
Wean 1	6–7	10.5–16.5	430	0.59	1.37		8.3				
Wean 2	8–10	16.5–32.0	740	1.25	1.69			26.3			
Pork	11–12	32.0–44.5	890	1.73	1.94				24.2		
Grow 1	13–16	44.5–70.7	935	2.00	2.14					56	
Fin 1	17–21	70.7–106.0	1010	2.43	2.41						85
Total											203.1

* Creep feed offered in the farrowing house for one week (500 g/pig) and pigs weaned at 8 kg at 28 days

Total feed used to produce one male pig including breeder feed @ 55 kg (fed to its mother during gestation and lactation) = 258.1 kg.

106 kg liveweight

79.5 kg dressed weight

Herd FCR = 3.25

Average growth rates

Wean to sale = 824 g/d

Birth to sale = 711 g/d

Feed usage breakdown	
Creep	1.3%
Weaner 1	3.2%
Weaner 2	10.2%
Porker	9.4%
Grower 1	21.7%
Finisher 1	32.9%
Breeder	21.3%

TABLE 9.10 Projected feed intakes, growth rates and feed conversion efficiencies of females fed diets based on specifications contained in Table 9.8

Feeding phase	Age (w)	Weight (kg)	Gain (g/d)	FI (kg/d)	FCR	Feed usage/pig (kg)					
						C	W1	W2	G2	F2	P/S
Creep	3–5*	6–10.5	360	0.40	1.10	3.3*					
Wean 1	6–7	10.5–16.5	430	0.59	1.37		8.3				
Wean 2	8–10	16.5–31.5	714	1.26	1.77			27.7			
Grow 2	11–13	31.5–49.6	862	1.79	2.08				37.6		
Fin 2	14–17	49.6–75.1	911	2.15	2.36					60.2	
P/sale	18–21	75.1–102.1	964	2.50	2.59						70
Total											207.1

* Creep feed offered in the farrowing house for one week (500 g/pig) and pigs weaned at 8 kg at 28 days

Total feed used to produce one male pig including breeder feed @ 55 kg (fed to its mother during gestation and lactation) = 262.1 kg.

102.1 kg liveweight

77.6 kg dressed weight

Herd FCR = 3.38

Average growth rates

Wean to sale = 791 g/d

Birth to sale = 684 g/d

Feed usage breakdown	
Creep	1.3%
Weaner 1	3.2%
Weaner 2	10.6%
Grower 2	14.3%
Finisher 2	23.0%
Pre-sale	26.7%
Breeder	21.0%

7 References

Campbell, R.G. (1987) Response of the growing pig to energy intake. In 'Feeding standards for Australian Livestock: Pigs'. Standing Committee of Agriculture. CSIRO. pp. 5-18.

Evonik (2009) Standard ileal digestible amino acids in pigs. Available online at http://feed-additives.evonik.com/product/feed-additives/Documents/120427-nr-swine-EN.pdf.

King, R.H., Campbell, R.G., Smits, R.J., Morley, W.C., Ronnfeldt, K., Butler, K.L. & Dunshea, F.R. (2004) The influence of dietary energy intake on growth performance and tissue deposition in pigs between 80 & 120 kg liveweight. *Australian Journal of Agricultural Research* Vol. 55. pp. 1271-1281.

Wu, G. (2010) Functional amino acids in growth reproduction and health. *Advances in Nutrition* Vol. 1. pp. 31-37.

Chapter Ten

Conducting On-farm Nutrition Trials

1 Introduction

On-farm trials enable a change in a production system to be evaluated before it is widely applied. Trials are conducted to assess new diets or ingredients. It is not easy to conduct a perfect trial in a commercial setting, but there are some ideas listed here to help you get the most out of the trials you do decide to conduct.

When done well, just one on-farm trial will give results in which you can have complete confidence, and which ultimately will improve production efficiency and profit. Before deciding/agreeing to do a trial, consider how likely the trial is to have a successful outcome. Discuss the trial with piggery staff and get them enthused and interested – it will help ensure the trial is a success.

This chapter pinpoints why producers might consider a farm trial and then describes how to conduct a trial so that the results are meaningful and can be interpreted. It provides trial design examples and some warnings about interpreting results from other sources.

2 Why Conduct a Trial?

Trials should allow you to assess what the effects of changes in the nutrient specifications or ingredients of the diet will have on growth performance, and whether they are profitable. Most people conduct trials because they are seeking to improve on their current performance. Most trial outcomes generally result in improved profit either through, improved performance or reduced production costs.

The modern producer has a choice of many available feeds, with variable benefits. On-farm nutrition trials give information of a product's value to, and likely impact on, a production system. Trials can also be useful ways of monitoring pig performance and aid in engaging staff further in their job.

3 Setting up a Trial

3.1 State Your Aims

Before any experiment is conducted, it is important that achievable goals are identified. The more complex a trial, the more likely it is to fail. Keep aims simple but specific, and write them down before you start.

Some examples might be:

- If I increase my digestible energy level in my finisher diet over summer from 13.2–14.0 MJ DE/kg, I can improve my finisher feed conversion efficiency without increasing the market penalties (e.g. backfat thickness, heavy or light carcases)
- If I include an acidifier in my weaner diet at 4 kg/T for the first two weeks post-weaning, I can reduce mortality, the number of fall back pigs present at ten weeks of age and therefore reduce the variation within a batch.

3.2 Define Your Treatments

Every trial must have at least one 'control' treatment and one or more 'test' treatments. In many cases, your existing diet and feeding level can be used as the control, however, in some cases it is necessary to have a 'negative control' too. For example, if you are currently using an additive for growth promotion and you want to test an alternative you need to have a minimum of three treatments:

1. Negative control without any additives
2. Control with current additive
3. Treatment with new additive being assessed.

NB. The base diet for all three treatments should be the same.

The reason you need a negative control is to confirm that the current additive is in fact promoting growth in your pigs. If you do not include a negative control (no additive included) and the positive control (with your current additive) and the treatment group (with the new additive) come out the same, all you will know is that the current additive and the new additive gave similar performance. You will not know whether you are extracting any value from either product. Note that if you have a negative control, you may incur production losses if the current additive is already quite effective.

3.3 Select a Suitable Area

When comparing two nutrition treatments, other factors must not interfere with the results. Use exactly the same sized pens, with the same sized fittings for all treatments and space them evenly within the same shed.

3.4 Select Enough Pigs

The more pigs used, the more accurate the result. The experimental unit in your trial is the smallest unit of measure. For example, if you are measuring feed intake the unit is the feeder, or pen of pigs (not the individual pigs). So you need to select the appropriate number of experimental units. Variation is a natural part of any biological system, but it does cause some headaches when conducting trials. Variation is greatest in younger pigs (weaners) so more experimental units are required, e.g. ten pens of weaners might be required per treatment, whereas for grower-finishers six pens per treatment is likely to be enough.

If you don't have enough pens at one time, consider running the trial over a number of replicates. You need to ensure though that each treatment is equally represented during each replicate. For example, if you are running a weaner trial with two treatments (control versus treatment A) and require 20 pens, but your shed only had 12 pens, then you should run two replicates of ten pens, with five pens of each treatments in each replicate.

3.5 Use Pigs of the Same Sex and Weight

Group pigs according to sex and weight within a 3–5 kg weight range. Make the average weight in one pen as close as possible to that in other pens and be prepared to weigh and re-group. Avoid any bias (e.g. pigs from the same litter should not share a trial pen). Sorting by sex is most important for grower-finisher trials. If you don't sort by sex, then make sure each pen contains equal numbers of males and females.

When pigs have been penned, randomly choose one pen for each treatment and identify pigs with numbered ear tags which have a different colour for each treatment.

Allow about a week for pigs to adjust to their new environment and, during this time, feed all the same diet *ad libitum*.

3.6 Collect Measurements

Most use growth rate, feed intake and feed conversion ratio measurements when conducting an on-farm nutrition trial. In nutrition trials with finisher pigs, carcass measurements may also help in assessing the effects of the nutritional treatments. A detailed outline of how to collect and calculate this data can be found in *Chapter Eight: Monitoring Performance*.

3.7 Collate the Results

To derive value from an on-farm nutrition trial, plot and compare results. Using a graph is the best way, as reading it will reveal treatment differences and assist decision making. Simple statistics may be applied to the results to determine if there are any significant differences between the treatments.

With careful planning and adherence to these guidelines, trials can be conducted with little disruption to production systems. With practice, producers will find wider applications for on-farm trials, each enhancing the unit's efficiency.

3.8 Case Study

Here is a case study to illustrate the process of conducting an on-farm trial.

A feed additive manufacturer has sent you information about a new enzyme, claiming it will increase growth rates and feed conversion efficiency. Because of the cost, you correctly decide to conduct an on-farm trial to test whether the enzyme is effective and justifies its price. You follow the guidelines outlined previously.

List objectives

You wish to assess the effect of enzyme inclusion in weaner diets on growth rates and feed conversion efficiency. These simple, clear objective will make it easy to get results.

Treatments

Treatment 1 – control:

You use your standard weaner diet as the control. To ensure the diet does not change during the process, bag off enough to feed the weaner pigs on trial from 8–15 kg.

Treatment 2 – test:

Your test diet (standard weaner diet + enzyme) will contain the enzyme you wish to evaluate. As this is your first on-farm trial, you add the enzyme to your standard weaner diet at the manufacturer's recommended rate.

Treatment 3 – optional:

For this kind of trial an optional third treatment could be considered. You may ask your nutritionist to reformulate your weaner diet(s) with lower amino acid and energy specifications (to see if you can save money without a drop in performance when the enzyme is added).

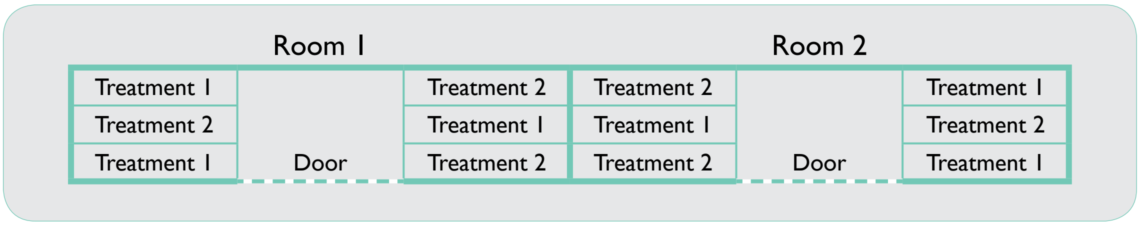
Selecting the pens

You have an all-in/all-out weaner shed with six pens in each room. Because you are working with weaners you will need 12 matching pens per treatment with an ideal stocking density of, say, 12 pigs per pen. You decide to run the experiment over four weeks, using two weaner rooms.

Each room will have three pens on Treatment 1 and three on Treatment 2. If pigs in one room were all fed Treatment 1 and the others Treatment 2, growth differences might be caused by differences between the rooms, not the diet or treatment.

All pens are the same size, have the same stocking density, the same number of drinkers and the same feeders. You randomly allocate each treatment in the rooms as follows:

FIGURE 10.1 Example of how to assign treatments within and across rooms



Selecting the pigs

Because you are using 12 pens with 12 pigs in each, you select 144 pigs from each week's farrowings. As this trial will run for four weeks, all pigs are weighed and sexed at weaning and, based on this, allocated to one of the six pens. Avoid same litter groupings. The weight of all 12 pigs in a pen should range within 3 kg, excluding light or heavy pigs. Separate males and females and distribute same-litter pigs as widely as possible.

TABLE 10.1 Example of treatments, replicates and total number of weaners required

Replicate	Control		Treatment		Total
	Males	Females	Males	Females	
1	36	36	36	36	144
2	36	36	36	36	144
3	36	36	36	36	144
4	36	36	36	36	144
Total	144	144	144	144	576

You then ear tag the pigs, choosing a blue tag for those on Treatment 1 and red for pigs on Treatment 2. You label the pens in each room clearly with the treatment group (control or enzyme).

The procedure is repeated each week and, when it ends, six pens of males and six of females have received each treatment as follows:

FIGURE 10.2 Example of how to assign sex and weight evenly between treatments and across rooms

Room 1			Room 2		
Treatment 1 Male (5–7 kg)		Treatment 2 Male (5–7 kg)	Treatment 2 Female (7–9 kg)		Treatment 1 Female (7–9 kg)
Treatment 2 Female (5–7 kg)		Treatment 1 Female (5–7 kg)	Treatment 1 Male (8–10 kg)		Treatment 2 Male (8–10 kg)
Treatment 1 Male (7–9 kg)	Door	Treatment 2 Male (7–9 kg)	Treatment 2 Female (8–10 kg)	Door	Treatment 1 Female (8–10 kg)

Liveweight and feed intake data

You collect this to calculate growth rate and feed conversion ratios.

To measure liveweight, it is okay to weigh each pig in a pen individually or the whole pen at one time. Because your pigs are not individually identified, you will use an average liveweight per pen. Do this at least fortnightly, preferably weekly, or when you change feeds (if you have multiple diets from 8–15 kg).

To measure feed intake level you use the following procedure, while being aware there are no short-cuts:

- Record the number of pigs in each pen
- Fill all feeders in the pens until they are level and full (no need to record how much feed is added)
- Weigh and record all feed added to the feeders over the set period
- Weigh and record the quantity of feed needed to exactly refill the feeders at the end of the experiment
- Calculate the feed used per pig per day for each pen, using the following equation:

$$\text{Feed used per pig per day (kg)} = \frac{\text{Total feed added to the feeders (kg)}}{\text{Number of pig days}}$$

NB: Pig days = number of days on trial multiplied by the number of pigs in a pen. For example, if the trial period is seven days and there are ten pigs in a pen, and one pig dies on day four, then the pig days = (3 days * 10) + (4 days * 9) = 66 days.

Calculate growth rates and feed conversion ratios

You calculate the growth rate of each pig for the trial as follows:

$$\text{Growth rate (g/day)} = \frac{\text{Average end pen weight (kg) x 1000} - \text{Average start pen weight (kg) x 1000}}{\text{Number of days on trial}}$$

You calculate liveweight FCR of each pig for the trial as follows:

$$\text{Feed used per pig (kg)} = \frac{\text{Feed added to feeders (kg)}}{\text{Number of pigs in the pen}}$$

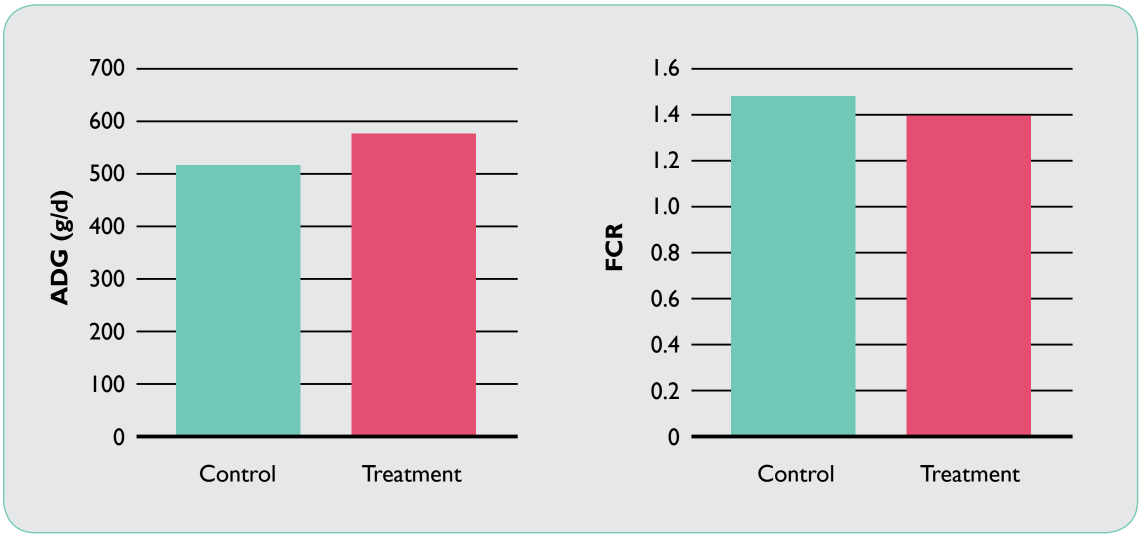
$$\text{Liveweight FCR} = \frac{\text{Feed used per pig (kg)}}{\text{Average end weight - average start weight (kg)}}$$

NB: When calculating FCR, ensure the units for feed used and weight of pig produced are the same, e.g. kg of feed used and kg of pig meat produced. See *Chapter Eight: Monitoring Performance*.

Collate the results

At the end of the trial, you compare the results using a bar graph like in Figure 10.3. To confirm differences between the treatments you need a statistical test. Ask your nutritionist to help you.

FIGURE 10.3 Example of bar graphs illustrating growth performance (ADG and FCR) for trial pigs



Make a management decision

Examine performance improvements (or otherwise). Calculate the cost-effectiveness of using the additive commercially. If the treatment proves its worth, act quickly to lift your profit margin. If the results are unexpected, don't repeat the trial hoping for another answer. Consider alternative ways to conduct the trial, as you may gain a response under slightly different conditions. After all, a trial is only a small window through which to view a larger picture.

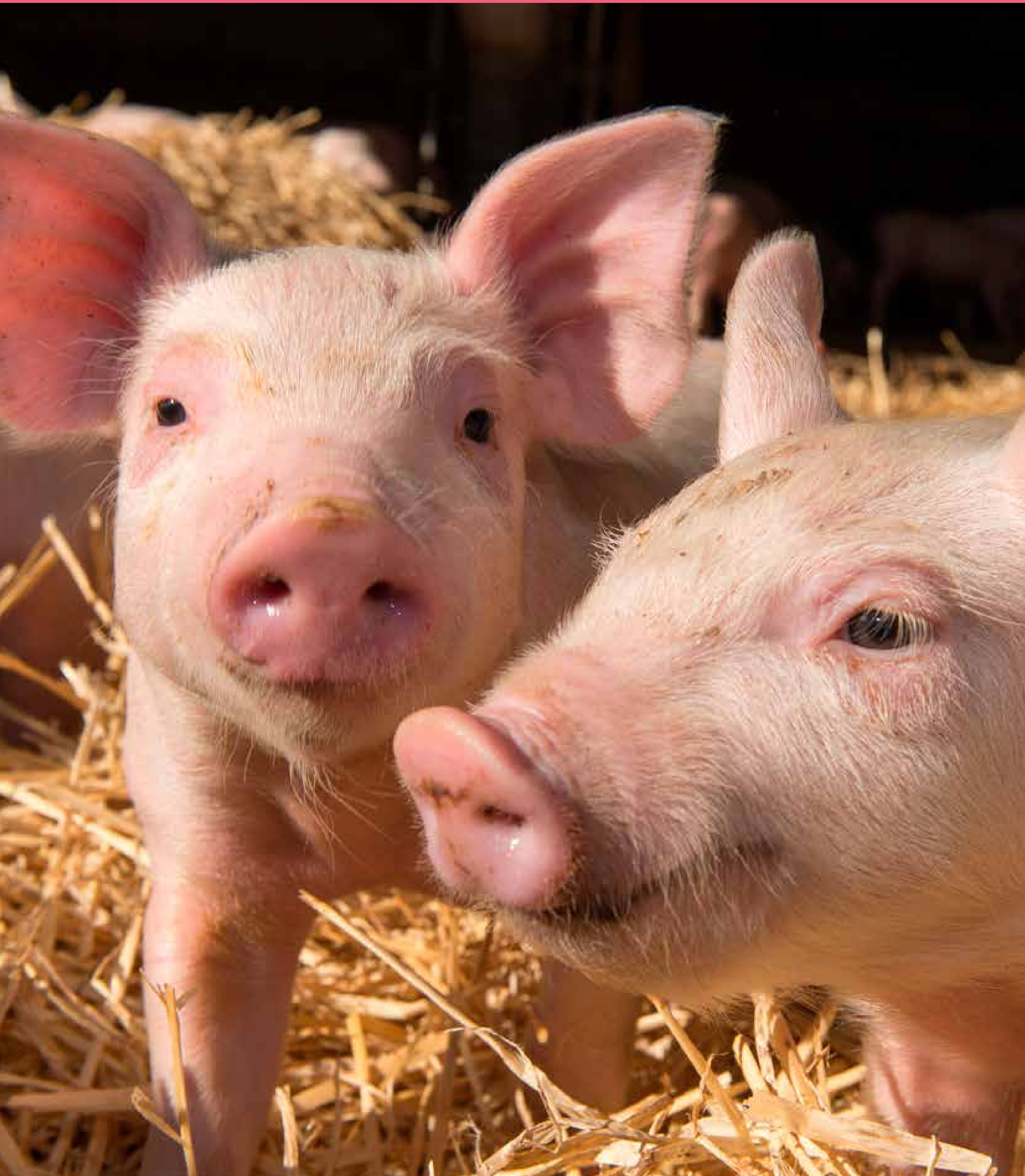
NB: If the trial is being conducted in weaners, it is normally best to monitor performance until slaughter as the ultimate unit of measure is the kilograms of saleable pork. Ideally the benefits need to be maintained or increased once the experiment has ended.

4 Interpreting Results from Other Sources

The pig industry's progress depends on producers' rapid access to clear scientific information which they can put into practice and which works. The presentation of some information makes it hard to interpret actual benefits or pitfalls, but the following guide will help producers avoid traps:

- Do not accept data showing a *trend* to improve performance or a *trend* for a treatment to be cost-effective. Make sure information has been statistically analysed, and consider action only when *significant differences* between treatments can been shown *statistically (P <0.05)*. Ensure that the sample size (number of animals) used was appropriate for the outcome they were testing. Trends often indicate that the sample size was too small.
- Make sure that the performance of the pigs on the control treatment is satisfactory. Be wary of results that indicate an improvement with a particular treatment if the performance of pigs on the control treatment is suboptimal.
- Beware of data which claims a cost-saving technology will not *significantly* alter herd performance. Testing for a significant difference, and not finding it, does not prove things are the same. Careless testing can produce no-difference comparisons.
- Demonstrating a new technique on-farm does *not* prove its value, although someone who has bought one is keen to show it works. Scientists tend to enthuse about practical demonstrations that prove practical theory, but the novel technique or product may *not* work for you later. Scientific ideas must be scientifically *proved* before they are demonstrated in practice, to avoid misleading potential customers.
- When applying scientific data which has statistical backing, make sure you do so under the *exact* conditions of the experiment. For instance, a trial conducted in a different farming system, in different weather, with different kinds of animals, qualities and inputs, is unlikely to have the same result for you. A new treatment must be tested under a range of conditions before it can be hailed as a true advance.
- Use caution when interpreting research data from computer simulation models, which are useful as decision making tools, but are not designed to give scientific results. Output depends on inputs, so recommendations should first be given a small scale trial, on-farm. It is also unwise to take on the results of a simulation which has used data from another farm.
- Be wary of data presented as a percentage increase, as a trivial increase in performance levels can appear very large when expressed that way. For example, if A=5 and B=6 there is 20% improvement, while if A=50 and B=51 it's 2%. In each case the absolute benefit is one unit!
- Ensure that the manufacturer/ distributor can give you a clear and easy to understand explanation of how, when and where the product works. This should help ensure that the product has been developed with sufficient scientific backing.
- If you are not confident about reviewing the information/data provided to you by the manufacturer/distributor insist that they contact your nutritionist.
- If you are interested in a product but not yet 100% convinced, ask to speak to another producer privately who is using the product.

Appendices



Appendix A Nutrition Glossary

Absorption: The process of absorbing nutrients from the digestive tract into the blood or lymph system.

Acid-base balance: Body fluids are maintained just on the alkaline side of neutrality (pH 7.3-7.5) by buffers in the blood and tissues. Buffers include proteins, sodium phosphate, potassium phosphate and bicarbonate.

Acid-detergent fibre (ADF): A refinement of crude fibre analysis. It contains the crude lignin and cellulose fractions of plant material, as well as silica.

Acidifiers: Feed additives or supplements used in pig diets to; lower the pH of the gut, offsetting acid-binding effects of some ingredients or to lower the pH of the urine (in the case of benzoic or phosphoric acid). Acidifiers also alter the gut environment to limit the presence and survival of harmful bacteria (e.g. *E. coli*) and promote the growth of beneficial bacteria (e.g. lactic acid bacteria).

Additive: Any material deliberately added to the diet to preserve it, improve its taste, increase its digestibility or serve as a medicine or supplement.

Ad libitum: Feed offered continuously, without restriction.

Aflatoxin: A mycotoxin produced on grains by a mould. Concentrations as low as 20 parts per million can damage a pig's liver.

Alanine: A non-essential (dispensable) amino acid.

All-in/all-out: A production system which keeps groups of pigs together and isolated from others for their lifetime. The system can make feed use more efficient.

Alkaloids: Naturally occurring organic bases, some of which are anti-nutritional and reduce feed intake, other are beneficial and can have anti-inflammatory benefits.

Amino acids: Components of dietary protein, which creates lean muscle. Ten different amino acids must be supplied in the feed and 12 more are produced from digested protein. The four amino acids often lacking in cereal based diets are lysine, methionine, threonine and tryptophan.

Amino acid availability: The amount of amino acids the pigs can actually use. Availability can vary with ingredients and processing. Available amino acid content is a more meaningful measurement than total amino acid content.

Amino acid balance: A measure of protein quality. A high quality protein supplies the essential amino acids in proportions the animal needs. Because amino acid requirements change with age, every age, every growth phase has a different ideal balance of amino acids.

Amino acid (first-limiting): The essential (indispensable) amino acid present in the least amount to suit dietary needs. In most pig diets this is lysine.

Amino acids (synthetic): The amino acids lysine, methionine, threonine, tryptophan, iso-leucine, arginine, valine and glutamine/ glutamic acid can be produced artificially and added to diets as supplements.

Amylases: Enzymes which hydrolyse starch and glycogen to maltose and ultimately glucose.

Anaemia: A nutrition-related disease caused by a shortage of red blood cells because of iron deficiency or a lack of vitamins involved in the formation of red blood cells.

Animal protein: Any protein in feed derived from animal by-products, (e.g. dry rendered meat, fish, whey, milk, blood, feathers, plasma, and poultry by-products).

Anthelmintic: Feed additives which kill worms or prevent their growth.

Antibiotics: Substances produced by living organisms which inhibit the growth of other organisms. Used to control bacterial infections, and added to the diet in small amounts to improve growth.

Anti-nutritional factor (ANF): Any component within feed (natural or synthetic) which limits nutrient absorption and lowers pig performance. ANFs can be toxic, preventing absorption of nutrients and causing disease or death.

Anti-oxidant: A substance which prevents fats from going rancid. Many fats, particularly vegetable oils, contain natural anti-oxidants which keep them fresh short term.

Arachidonic acid: Straight chain fatty acid containing 20 carbon atoms and four double bonds. Found only in animal fats.

Arginine: Indispensable amino acid in the pig.

Ascorbic acid: Commonly known as Vitamin C.

Ash: Residue left after all organic matter has been burned off in a muffle furnace.

Aspartic acid: A dispensable amino acid.

Bacteria: Single cell micro-organisms which can have a symbiotic (beneficial) or parasitic (non-mutual) relationship with pigs. Elevated levels of harmful bacteria are responsible for food spoilage and disease. They can be used for oxidation and fermentation. Some bacteria, known as pathogens, produce toxins which cause disease.

Barley: Grain of *Hordeum vulgare*, important as food for humans and animals, and used in brewing.

Basal metabolic rate (BMR): Energy is being used at the basal rate (basal metabolism) when the body is at complete rest, free from draughts, at a moderate room temperature and 12–14 hours after a meal. This energy is needed to maintain the heartbeat, respiration, body temperature and muscle tension.

Batch-drying: Involves the cooking of whole blood in a jacketed cylindrical cooker indirectly heated by steam at high pressure.

Beta carotene: A red/ yellow pigment in plants, converted to retinol in the body. A rich, natural source of Vitamin A.

Betaine: Trimethylglycine. Occurs in sugarbeet, beetroot and cottonseed. Used as a feed additive to reduce backfat in finisher pigs or to reduce the osmotic stress in sows during heat stress and in piglets during the immediate post-weaning period.

Bile: Liquid produced in the liver and stored in the gall bladder. It consists of bile salts, bile pigments, and cholesterol. Bile salts help to digest fats.

Bio-availability: The percentage of any nutrient actually used by the animal. To be valuable, nutrients must be digestible, absorbable and able to reach the site of the body where they are needed. Different feeds vary in nutrient bio-availability.

Biological value: A single numerical value (0–100) ascribed to a protein as an estimate of the relationship between its essential digestible amino acid content and the corresponding requirements of the pig, e.g. fish meal has a BV of 77 while the BV of cereal protein is only 50 due to its low lysine content.

Biotin: A water-soluble B vitamin (also known as Vitamin H) used in metabolism. Biotin is produced in the intestine by bacteria and is commonly supplemented in the pig premix. When added to sow rations, it may improve litter size and weight and aids return to oestrus. It is mainly used to prevent hoof lesions in pigs, lameness and laminitis.

Blood meal: A protein source made by air-drying, ring-drying, batch cooking, spray-drying or boiling blood from slaughter.

Blood plasma (spray-dried): A protein source derived from plasma component of blood (porcine, bovine or ovine) which has been spray-dried at high temperatures for short periods of time. A highly digestible protein source which also contains beneficial bioactive factors (e.g. immunoglobulins) which can be used in piglet diets to promote feed intake and immunity. Spray-dried blood plasma is relatively expensive.

Brewer's grains: The by-products of beer production. Uncommonly used as a feed ingredient in pigs. Used dried, wet or as condensed liquid soluble, more commonly in ruminant feeds.

Bran: The outer layers of cereal grain, most of which are removed when the grain is processed. Bran can be used as a raw material in sow feeds to increase crude fibre levels.

Buffers: Substances which resist change in acidity or alkalinity.

Caecum: First part of the large intestine, separated from the small intestine by the ileocolic sphincter.

Calcium: An essential macro-element and the most abundant mineral in the body. Ninety nine per cent occurs in bones and teeth in the form of calcium phosphates, with the remainder having a role in tissue development, energy metabolism and muscle operation.

Calcium carbonate: Ground limestone, a common source of dietary calcium.

Calorimeter: Instrument for measuring oxidisable energy present in a substance by burning it in oxygen and measuring the heat released.

Canola meal: A protein source obtained after the oil has been cold-pressed, expeller or solvent extracted from full fat canola seed.

Carbohydrates: Substances composed of carbon, hydrogen and oxygen. They provide the body with energy and can be converted into body fat.

Carboxypeptidase: Enzyme of the pancreatic juice.

Carotene: Red or yellow pigment in plants, converted into retinol in the body.

Casein: The main protein of milk.

Cellulose: Forms the supporting cell structure in plants. It is not digested by pigs, but is useful in providing bulk for intestinal functioning.

Cereals: Any grain or edible fruit of the grass family which can be used as food, including wheat, barley, triticale, oats, maize, millet, rye, sorghum and rice.

Chelated minerals: Minerals combined with amino acids or peptides to improve their bio-availability to the animal's system.

Chloride (Cl): Together with sodium, chloride forms salt which helps the water balance of the body.

Cholesterol: Principal sterol present in tissues of higher animals and found in all body tissues, especially the brain and spinal cord. Not essential in the diet, as it is synthesised in the body.

Choline: Usually classed as a vitamin, it is an essential dietary factor involved in fat metabolism and other metabolic functions.

Citric acid: Tricarboxylic acid, widely distributed in plant and animal tissues. Used as flavouring.

Cobalt: An essential mineral involved in synthesis and metabolism of Vitamin B12. It is needed for maintenance, blood cell production and growth.

Colostrum: The first milk produced by the sow after birth. High in immunological components (like antibodies), fat and other nutritional factors.

Concentrate: Protein, vitamins and minerals intended to be mixed with grain on-farm to form a complete ration. Generally included at considerable levels 5–40%.

Conditionally essential nutrients: Nutrients which are manufactured by the pig under normal circumstances, but may be required as supplements during critical periods (i.e. during the post-weaning growth check). Examples of conditionally essential nutrients for newly weaned pigs include nucleotides and glutamic acid.

Copper: An essential mineral mainly used to produce red blood cells. Deficiency causes anaemia, low immunity to disease and poor weight gain.

Copper sulphate: A common source of copper which has antibacterial properties.

Cost: Feed is about 65+% of the total cost of raising pigs, with 76% of feed dollars spent in the grower-finisher phases.

Creep feed: Highly palatable, easily digestible feeds offered to piglets while suckling, and for the first week post-weaning.

Crude fibre: Chemical measurement of the cellulose, hemi-cellulose and lignin in plant material. An unreliable measurement of limited use in pig nutrition.

Crude protein: Estimation of the organic protein content of a feed ingredient based on the distilled nitrogen level multiplied by a constant (6.25).

Crumbles: Pelleted feed intentionally broken into granules.

Custom premix: Premix formulated to a customer's specifications.

Dextrose: Another name for glucose. A simple monosaccharide found in plants which can be directly absorbed into the blood stream during digestion.

Dicalcium phosphate: The predominant phosphorus and calcium source in European and North American pig rations.

Dietary fibre: Combination of soluble and insoluble fibre constituents including hemicellulose, cellulose and lignin.

Dietary protein: Provides animals with amino acids which build proteins for lean meat, foetal tissues and milk.

Digestibility: The proportion of a feed removed from the digestive tract of an animal and not recovered in the faeces. Amino acid digestibility is usually based on recovery at the end of the small intestine (terminal ileum), as any amino acids released from protein beyond this point will not be used to synthesise protein in the pig.

Digestible energy (MJ/kg): The difference between the energy in the feed and energy in the faeces. This represents the proportion of energy removed from the pig's digestive tract.

Digestion: Process by which feed components are physically and chemically broken down in the digestive tract into simple components ready for absorption.

Disaccharides: Sugars consisting of two monosaccharides linked together.

Dispensable: Nutrients made in the body and not needed in the diet.

Deoxynivalenol (DON): A mycotoxin produced by *Fusarium* species (particularly *Fusarium culmorum)* DON mainly affects corn, oats, wheat, barley and triticale. Symptoms of DON contamination include feed refusal, vomiting, immunosuppression and kidney failure.

Dressing percentage: The weight of the hot, eviscerated carcase expressed as a percentage of liveweight shortly before slaughter.

Duodenum: First part of the small intestine, between the stomach and the jejunum.

Dust: Breathing in high levels of feed-dust in enclosed buildings may harm both pigs and humans. Adding small amounts of supplemental fat or molasses can help reduce dust.

Electrolytes: Salts and sugars which can be used to reduce the effects of dehydration.

Empty bodyweight: The animal's liveweight before slaughter less the weight of the digestive tract contents.

Emulsifier: Any feed additive used to hold fat in suspension.

Energy: Total chemical energy in a food is *gross energy*. After an allowance made for losses in the faeces, the remainder is *digestible energy*. After allowance is made for loss in urine, the remainder is *metabolisable energy*. Finally, after allowing for heat increment (loss of energy through digestion of food and metabolism of nutrients), the remainder is *net energy*.

Enzyme: Special proteins which accelerate the rate of a specific chemical reaction without being affected themselves. They enable complex changes to occur in the body. Enzymes can be produced by the body and supplemented in feed.

Essential (amino acids): Refers to nutrients the animal cannot produce in sufficient quantities to satisfy demand, so they must be supplied in the diet.

Extrusion processing: Heat, pressure and/or steam applied to an ingredient or diet. The process increases the product's bulkiness.

Fats: Substances insoluble in water but soluble in organic solvents such as ether, chloroform and benzene. They provide energy in a more concentrated form than carbohydrates, and can be converted into body fat. An essential storage tissue which will buffer against variations in nutrient supply and insulate the pig. Fats improve texture and palatability of feed.

Fat-soluble vitamins: Vitamins A, D, E and K occur in food in solution in the fats. They are stored in the body to a greater extent than water-soluble vitamins.

Fatty acids: Organic acids consisting of carbon chains with a carboxyl group at one end. Linoleic, linolenic and arachidonic acids are essential fatty acids which pigs cannot create from their feeds. They are necessary to build prostaglandins and cellular structure.

Feed conversion ratio (FCR): Calculated by dividing the amount of feed used by the amount of bodyweight gained over a set time period.

Feed efficiency: An important measure of overall efficiency in pig production. It accounts for the cost of feed, the major cost of raising pigs and growth rate (kg feed/kg gain).

Feed wastage: The amount of feed which is not consumed by the pig. Feed wastage can negatively impact on piggery profitability if not minimised and managed.

Feeders: The device used to hold feed for pigs. Costly feed waste can often be avoided by good feeder design and maintenance.

Fish meal: A protein source made from surplus fish, waste from filleting and fish unfit for human consumption. It is dried in vacuum, by steam or hot air, and powdered.

Flavours, synthetic: Mainly mixtures of esters.

Folic acid: A vitamin otherwise referred to as folate.

Formic acid: A short chain organic acid commonly used in pig diets to reduce pH and control gram negative bacteria including *E. coli* and *Salmonella*.

Full-fat soybeans: The roasted or extruded whole soybean. A useful source of fat and protein for pigs.

Fumaric acid: A short chain organic acid commonly used in pig diets to reduce pH and control gram negative bacteria including *E. coli* and *Salmonella* species.

Gain per day: Rate of gain should be calculated based on weight in and weight out.

Gastro-intestinal tract: The entire digestive tract from the mouth to the anus.

Glucose: A monosaccharide or simple sugar. An important energy supply.

Glutamic acid: Generally a non-essential amino acid. A conditionally essential amino acid in young pigs.

Gluten: The protein complex in wheat, barley, triticale and to a lesser extent, rye. It is not present in oats, rice or maize.

Glycine: A non-essential amino acid.

Glycogen: Storage form of carbohydrate in the animal's liver and muscles.

Gossypol: Yellow toxic pigment found in some varieties of cottonseed.

Groats: Oats from which the husk has been entirely removed when crushed.

Haemoglobin: The red colouring matter of the red blood cell, composed of the protein *globin*, combined with an iron-containing pigment *haem*.

Hammer mill: Mill in which material is powdered by impact from a set of hammers in a continuous process.

Hemicelluloses: Complex carbohydrates found, with cellulose and lignin, in plant cell walls.

Hormones: Chemical agents produced in the body, also known as endocrines. They act as chemical messengers which stimulate other tissues.

Indispensable (essential): Nutrients which cannot be made in the body in sufficient amounts for health, and must be present in food.

Intake: Fast gain requires good feed intake. Reduced feed intake accounts for an estimated 75% of any slow-down in daily gain. Intake is affected by temperature, space, health, feed quality, ration density, water quality and quantity, feeder design, genetics and animal behaviour.

Intestine, small: The section lying between the stomach and the large intestine, comprising duodenum, jejunum and ileum. The site of most food digestion and absorption of its products.

In vitro: Literally 'in glass'. Used to indicate an observation made experimentally in a test-tube rather than from natural living conditions, *in vivo*.

In vivo: In the living state, as distinct from *in vitro* – in the test-tube.

Iodine (I): One of the essential minerals. Important for thyroid function. Marine products such as salt and algae are rich sources of iodine.

Iron (Fe): An essential mineral and a component of haemoglobin, the red pigment in blood. Plays a major role in the transport of oxygen in the body. Prolonged deficiency leads to anaemia.

Isoleucine: An essential amino acid.

Joule: The metric measure of energy.

Kjeldahl determination: A widely used method of determining total nitrogen in a substance by digesting with sulphuric acid and a catalyst in a Kjeldahl (long necked) flask. The nitrogen is converted into ammonia, which is measured.

Lactic acid: The acid formed in muscle from glycogen immediately after death.

Lactose: Milk sugar.

Lean gain: Fast-growing, feed-efficient pigs that yield a very lean carcase require diets formulated to provide enough protein, energy and lysine to maximise lean-tissue growth.

Lectins: Toxic substances found in many legumes.

Legume: Seeds of the leguminosae, including peas, beans and pulses.

Leucine: An essential amino acid.

Lignin: Associated with carbohydrates of the cell wall of plants, lignin is a heavy, aromatic compound.

Lipase: Enzyme which hydrolyses fat to glycerol and fatty acid.

Lipids: A group of substances including fats, oils, waxes, complex compounds such as phosphatides and cerebrosides, sterol esters and terpenes. They are insoluble in water and soluble in ether.

Lower critical temperature (LCT): The environmental temperature at which pigs start eating more to stay warm.

Lysine: The most common essential amino acid. Deficient in cereals, it can be supplied in a synthetic form, or via protein meals.

Macro-mineral: Includes calcium, phosphorus, potassium, sodium, chloride, magnesium, iron and zinc.

Magnesium (Mg): A dietary essential, involved in the use and metabolism of ATP. Most magnesium is in the bones, but it is also needed for the function of some enzymes.

Maintenance: At the maintenance level of feeding, the animal's requirements are only just met, so net gain or loss of nutrients is zero.

Manganese (Mn): An essential mineral for bone development and tissue metabolism. Manganese deficiency can cause lameness and reproductive problems.

Meat meal: Protein source obtained from the by-products of slaughter, such as lungs, spleen, kidneys, brain, liver, blood, fatty tissue, stomach and intestines. Meat meal also offers a good source of calcium.

Medium chain fatty acids: Fatty acids containing 8–12 carbons which are directly absorbed via the portal blood and rapid utilised by key organs. They are an excellent energy source for pigs experiencing periods of malnutrition (during the post-weaning growth check). Medium chain fatty acids have broad spectrum antibacterial properties and are effective against both gram negative and gram positive bacteria.

Metabolic modifier: Additives which are used to promote lean gain over fat deposition. Examples are beta-agonists, betaine, chromium picolinate and porcine somatotropin.

Metabolism: The process of chemical change in living cells, i.e. growth of new tissue, breakdown of old tissue, and energy production.

Methionine: An essential amino acid containing sulphur. Methionine is available on a commercial scale and is added to feed. The common synthetic forms are DL-Methionine and MHA methionine.

Micro-ingredient: An ingredient required in only very small amounts, e.g. less than 0.01% of the total diet.

Micro-mineral: Also referred to as trace elements. Mineral salts, they include copper, selenium, zinc, iron, iodine, manganese, chromium and cobalt, and are needed in small amounts.

Micro-organisms: Include bacteria, moulds and yeasts.

Mill mix: The hulls, bran, broken grain and other by-products of grains.

Minerals: Pigs are more likely than any other animal to suffer mineral deficiencies because they are fed a high grain diet, their anatomy places more demand on their bones, they grow fast, and may not have contact with soil.

Molybdenum (Mo): Mineral essential for the function of enzymes.

Mono dicalcium phosphate: A common source of calcium and phosphorus.

Monosaccharides: Simple sugars.

Moulds: Fungi which can cause rapid food spoilage and produce mycotoxins.

Mycotoxins: Compounds produced by moulds which, when consumed by animals and humans, cause toxicity. Not all moulds produce mycotoxins.

Neutral-detergent fibre (NDF): The residue left after extraction of a foodstuff with boiling neutral solutions. It refers mainly to lignin, cellulose and hemicellulose, and is a measure of plant cell wall material.

Niacin: A water soluble B vitamin needed for carbohydrate, fat and protein metabolism, and cell growth.

Nicotinic acid: A B-complex vitamin.

Nitrogen balance: The difference between the dietary intake of nitrogen (as protein) and its excretion (as urea and other waste products).

Non-starch polysaccharides (NSP): Known collectively as dietary fibre.

Nutrient: Essential dietary factors such as vitamins, minerals, amino acids and fats. Sources of energy are not termed nutrients.

Oats: Grain from the species *Avena*.

Offal (animal): Includes all parts cut away when the carcase is dressed, including liver, kidneys, brain, spleen, pancreas, thymus, tripe and tongue.

Offal (cereal): Is bran and germ discarded when white flour is milled.

Oilseed: Seeds grown as a source of oil, e.g. sunflower, sesame, soya, juncea etc.

Palatability: Taste, feed texture and smell influence acceptability. Young pigs are most susceptible to unpalatable feed.

Palm kernel oil: Oil extracted from the kernel of the nut of *Elaeis guineensis*.

Palm oil: Oil extracted from the outer pulp beneath the outer skin of the nut from the oil palm, *Elaeis guineensis*.

Pancreas: An organ in the abdomen which secretes the hormones, insulin, enzymes and antibacterial substances collectively known as pancreatic juice.

Pancreatic juice: Digestive juice produced by the pancreas and secreted into the duodenum.

Pantothenic acid: A vitamin essential for the metabolism of fats and carbohydrates. Higher levels may be required in grower-finisher pigs where backfat issues are occurring.

Pelleting: Increases digestible energy in a ration by 10–15%, and reduces feed wastage.

Pepsin: Enzyme contained in the gastric juice.

Peristalsis: Method of movement along the intestine.

pH: Used to denote the acidity or alkalinity of a substance. Pure water is pH 7 (neutral); below 7 is acid, above is alkaline.

Phase feeding: Starting pigs on a relatively high-protein diet and then phasing the protein/ amino acid levels down to meet what the pig needs as it gets older. Producers who phase feed generally use three to five diets from 30-100 kg.

Phenylalanine: An essential amino acid.

Phosphorus: An essential macro-element for bone growth, tissue development, energy metabolism and muscle operation.

Phytase: Phosphatase enzyme responsible for breaking down phytic acid to increase phosphorous and calcium availability in feed.

Porcine somatotropin (PST): A naturally occurring growth hormone which can increase daily gain and feed efficiency, and reduce fatness.

Potassium: Complements the action of sodium in functioning of cells.

Probiotics: Organisms which help stimulate proliferation of desirable organisms rather than killing pathogenic bacteria, as antibiotics do.

Proline: A non-essential amino acid.

Propionic acid: A short chain organic acid (acidifier) commonly used to preserve feed against the growth of mould and some gram negative bacteria.

Protein: Combination of amino acids essential in the diet and contain nitrogen. Can be converted into carbohydrates and used to provide small amounts of energy. High protein diets can be used to control backfat through reduced energy retention.

Protein deposition: Protein laid down (generally as muscle) by the animal.

Protein-energy ratio: Protein content of a food or diet expressed as a ratio between energy from protein and total energy.

Proximate analysis: Chemical analysis of feed ingredients for crude protein, ether extract, (i.e. crude fat), crude fibre, acid-detergent fibre, neutral-detergent fibre, ash, and dry matter.

Pyridoxine: Vitamin B6.

Records: Important to track measures of nutritional efficiency, feed intake etc. Records are necessary to make meaningful adjustments.

Rendering: The process of liberating fat from fat cells which constitute adipose tissue.

Riboflavin: Vitamin B2.

Ring-dried blood meal: Process which coagulates blood by steam heating. Coagulum is centrifuged and dried with hot gas in a ring drier.

Roller mill: Pairs of horizontal cylindrical rollers, separated by a small gap and revolving at different speeds. Materials are ground and crushed in one operation.

Saponins: Group of substances occurring in plants which, when in contact with water, produce a soapy lather.

Screenings: Waste left over after grains are cleaned. Includes light and broken grains, weed seeds, hulls, chaff, sand and dirt.

Selenium: A vital mineral for enzyme processes and an important component of the antioxidant glutathione peroxidase. Deficiency can cause poor reproduction, lactation failure, low immunity to disease and death.

Serine: A non-essential amino acid.

Skim milk: Milk from which most of the fat has been removed, but all the protein and lactose remains.

Sodium: Forms salt, together with chloride. Salt maintains the water balance of the body and sodium is also essential for muscle and nerve activity.

Sorghum: *Sorghum vulgare*. A cereal which thrives in the subtropical regions in eastern Australia.

Soya: A bean (*Glycine max*) important as a source of oil and protein. When raw, it contains a trypsin inhibitor which can be destroyed by heat.

Split-sex feeding: Entire males of all breeds respond to higher protein levels relative to energy than gilts of the same genetics. Penning pigs by sex and feeding different diets can cut feed costs.

Starch: Polysaccharides composed of large numbers of glucose units linked together. Forms an important source of energy for the pig.

Stocking density: The number pigs within a given space. Crowding pigs slows growth and reduces feed efficiency.

Tannins: Polyphenolic substance which has an astringent taste. Some tannins are believed to have health benefits.

Thiamine: Vitamin B1. Required to release energy from carbohydrates.

Threonine: An essential amino acid. The gastrointestinal tract has a high requirement for threonine, especially during stressful events, disease and malnutrition.

Toxins: Harmful substances produced by plants, animals or microorganisms. Acts like an antigen in the body, causing an immune response and may cause death.

Toxic: A substance which is present at such a level it becomes poisonous. Many vitamins and minerals become toxic when used at high levels.

Trace elements: Mineral salts needed in small amounts, e.g. iodine, copper, manganese, magnesium, iron, and zinc.

Trypsin: Enzyme of pancreatic juice which attacks parts of the protein molecule not attacked by pepsin. Trypsin is important for protein digestion.

Tryptophan: An essential amino acid involved in appetite regulation and immune response. Requirement is elevated in pigs experiencing disease challenge.

Tyrosine: A non-essential amino acid.

Ulcers: An open sore caused by a break in the skin or mucous membrane. Feed which has been ground too fine, or extended periods of time off feed, are the major causes of ulcers in pigs.

Valine: An essential amino acid. Valine can be in limiting supply in vegetarian pig diets. Synthetic valine is a popular feed additive in the European Union.

Vitamins: Help to regulate body processes. With the exception of Vitamin D, they cannot be made in the body and must be supplied in the feed. Described as either fat-soluble (Vitamin A, D, E or K) or water-soluble (thiamine, riboflavin, niacin, pantothenic acid, Vitamin B6, Vitamin B12, biotin, choline and Vitamin C).

Vitamin A: Includes both retinol and carotene. Essential to growth, skin and sight.

Vitamin B complex: A group of eight B vitamins. These vitamins occur together in cereal germ, liver and yeast.

Vitamin B1: Thiamine – needed to release energy from carbohydrates.

Vitamin B2: Riboflavin – essential for carbohydrate oxidation.

Vitamin B6: Important in energy metabolism.

Vitamin B12: Involved in amino acid and enzyme system functions.

Vitamin C: Ascorbic acid – essential for growth.

Vitamin D: Needed for calcium and phosphorus use in bone development. Formed in the skin under the action of ultra violet light.

Vitamin E: An important antioxidant which aids immune system development and fertility.

Vitamin K: Necessary for blood clotting.

Volumetric mixing: Reliability of mixing based on volume is affected by foodstuff density. Weight-based mixing is more reliable.

Wet feeding: Adding water to feed either in the trough or beforehand. It tends to increase consumption and reduces dust.

Whey: Residue from the manufacture of cheese, during which most of the fat and protein have been removed.

Zinc: An essential mineral which helps maintain tissue integrity (a healthy gut) and immunity.

Zearalenone: An estrogenic mycotoxin produced by *Fusarium* species found in feed ingredients which can cause reproductive failure, weak piglets, poor litter size, and abortions. Zearalenone can be found in wheat, barley, corn, sorghum and rye. Cool moist weather during cereal production and storage is conducive of zearalenone presence.

Appendix B Troubleshooting

This is a user-friendly guide to help producers find answers to major problems. Refer to the relevant section of the guide for further information.

A large variation in performance during the year

- Set targets and tolerance levels.
- Improve the environment.
- Change diet composition to match the season.
- Are weaning weights low at certain times of the year?
- Has there been an outbreak of disease with some batches?
- Check performance of batches of pigs on a regular basis.
- Have many pigs been changed to new diets at the wrong liveweight?
- Does stock handling need improvement?

A higher proportion of fat pigs at slaughter

- Has the age of pigs at slaughter been increased?
- Reduce the nitrogen content of finisher diets for female pigs.
- Have the pigs suffered a setback during the weaner/grower phase?
- Is the diet correctly formulated?
- Have diets been properly mixed?
- Check your current buyer schedule with those from other processors.
- Improve genotype through better selection techniques and/or purchase new stock.
- Is there a temperature/seasonal effect?
- Consider the use of metabolic modifiers during the finisher phase.
- Use your ultrasound machine to double check backfat thickness just prior to slaughter.

Dirty pens

- Check the environment.
- Are the pigs overstocked?
- Is there a good supply of cool water?
- Is feed wastage high?
- Improve stock handling.

High incidence of tail biting

- Minimise stress.
- Is the diet correctly formulated?
- Don't mix unfamiliar pigs.
- Don't overstock.
- Improve stock handling.
- Check the environment.
- Is there adequate feeder access?
- Review diets to ensure minimal gastrointestinal irritation.

Pigs have low appetite

- Has a new supply of grain been used in the diet?
- Are ingredients contaminated?
- Check the water supply.
- Are the pigs too hot or too cold?
- Check the pigs' health. Is there a problem with respiratory disease? Consult your veterinarian.
- Check the environment (particularly the number of pigs/airspace and air quality).
- Are the pigs overstocked?

Post-weaning diarrhoea

- Feed a highly digestible diet before and after weaning.
- Minimise stress at weaning.
- Provide a good environment at weaning.
- Clean pens thoroughly and keep empty for as long as possible in between batches.
- Make sure pigs have clean feed and good quality water.
- Check the medication and vaccination program for your sows and weaners.
- Consider using spray-dried porcine plasma.
- Consider using low protein creep feeds temporarily.

High level of condemnations at slaughter

- Have vaccinations been properly given?
- Check health program.
- Check handling of stock during loading, transport and in lairage.
- Improve stock handling.
- Check withholding periods.

Poor meat quality

- Reduce the level of the stress gene via a breeding program.
- Minimise stress during the pre-slaughter period.
- Discuss the problem with the processor.
- Review diet additive levels.

High dust levels in pig sheds

- Increase the oil/molasses content of the diet.
- Increase airspace per pig.
- Add water to feed mix.
- Clean pens more often.
- Does the feed delivery system need fixing?
- Improve stock handling.
- Monitor to see how bad it really is.

Poor growth rates

- Check the adequacy of diets.
- Check health status.
- Is food intake of pigs limited?
- Reduce stocking rate.
- Increase airspace.
- Improve genotype.

High FCR

- Check energy and amino acid level of diets.
- Check for high feed wastage in either feed delivery or direct from feeders.
- Check temperatures in grower-finisher sheds.
- Consider changing from mash to pelleted feeds.
- Check health status.
- Check the durability of feed pellets.

High mortality rates

- Arrange for a visit from a veterinarian.
- Check the vaccination and medication program.
- Revise the hygiene and cleaning program.
- Reduce stress levels.
- Improve stock handling.
- Formulate diets for positive immune development.

Appendix C Templates

TEMPLATE 1: **Collection of liveweight versus age**

Pig	Sex	Age	Weight	Age	Weight	Age	Weight	Age	Weight
1	F	4 wk	8 kg	8 wk	22 kg	14 wk	60 kg	18 wk	93 kg

TEMPLATE 2: Collection of feed intake data

Pen	1	2	3	4	5
Diet name	Starter				
Ave age (weeks)	4				
Ave Liveweight (kg)	8				
No. of pigs in pen	15				
Sex of pigs	M				
Day 1 feed added (kg)	0				
Day 2 feed added (kg)	4				
Day 3 feed added (kg)	6				
Day 4 feed added (kg)	2				
Feed added to fill feeder at end of day 4 (kg)	3				
Total Feed used (kg)	15				
Feed use/pig/day (kg)	0.250				

TEMPLATE 3: Calculating digestible energy intake per pig per day at a specific liveweight or age

Diet name	When fed (age or liveweight)	Available lysine (g/MJ DE)	Digestible energy (MJ/kg)	Feed usage/pig/day (kg)	DE Intake/day (MJ)
Starter	8-10 kg	0.90	15.1	0.267	4.03

TEMPLATE 4: Calculating feed use

Diet name	On hand at start (T)	+ Purchased or mixed (T)	- Remaining at end (T)	= Used (T)
Weaner	1	51	2	50
Total				

AUSTRALIAN PORK LIMITED
ABN 83 092 783 278

Level 2, 2 Brisbane Avenue, Barton ACT 2600
PO Box 4746 Kingston ACT 2604 Australia

P: 02 6285 2200   F: 02 6285 2288
E: apl@australianpork.com.au

www.australianpork.com.au