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Protein in pig feeds – How much do they need ?

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Protein is needed in pig feeds only because it supplies amino acids (AA). Of the total amino acids in the diet, only the digestible amino acids are biologically available to the animal.

Effect of excess protein in feeds

There are three reasons why we might limit crude protein (CP) level in pig feeds:

1. Price – protein feeds usually cost more per tonne than cereals
2. Pig performance (FCE) will be better on low protein diets provided AA requirements are met
3. Organic Nitrogen (ON) excretion is determined by CP in diet. Excess protein means more ON excreted and possibly more land to utilize this nitrogen.

While the pig needs the ten essential amino acids in the diet, in the correct proportions, we normally concern ourselves with five AA which are in relatively short supply in the common feed ingredients. These are lysine, methionine, methionine plus cystine, threonine and tryptophan. If the levels of all five in the diet are adequate and the total amount of digestible protein is adequate then the levels of other essential AA will usually be sufficient.

A protein that contains the perfect balance of the individual essential AA combined with adequate amounts of non-essential AA is referred to as "ideal protein". The ideal blend is expressed relative to the lysine requirement as shown in Table 1 for the most limiting amino acids in barley-wheat-soyabean meal diets.

Ingredients vary widely in the amount of the principal (or most valuable in pig diets) in their protein. The protein feeds most useful in pig feeds are those high in lysine, methionine and threonine. E.g. lysine varies from about 8% of the protein in whey to 2.2% of the protein in sorghum. Pig feeds should have about 6 to 7% lysine in the protein. Methionine content of fish meals can be about 3% of the protein while peas, beans and lupins are under 1%. Whey protein is high in threonine (6 to 7% of protein) while wheat is low (about 2.75% of the protein). This means that as we include "non-traditional" ingredients in pig feeds, we must do so with care and consider the content of several amino acids.

Digestibility of amino acids varies between ingredients and between amino acids within a single ingredient (Table 2). While we used mainly cereal based diets this was not a problem but with current high cereal prices there will be pressure to use a wider range of ingredients and especially to use cereal by-products. We will now need to compare diets and express the needs of the pig on the content of digestible amino acids.

Table 1. Estimates of main amino acids in ideal protein for growing pigs (percentage relative to lysine at 100%)

	Range of values, %	*Recommendation, %*
Methionine	25 – 30	30
Methionine + Cystine	50 – 63	60
Threonine	60 – 75	65
Tryptophan	15 – 19	18

Table 2. Digestibility of lysine, methionine and threonine in selected ingredients

	Lysine	*Methionine*	Threonine
Barley	75	84	75
Wheat	81	89	83
Soyabean meal	92	93	89
Maize gluten	66	84	70
Lysine HCl	100	-	-

A shortage of the amino acid which is most limiting relative to the requirement will limit pig performance as shown in Table 3. This could result if synthetic lysine is supplemented without adjustment of the other amino acids. On very low protein diets supplemented with lysine, threonine and methionine, tryptophan deficiency might be the reason. Synthetic lysine can be poorly utilized if included at a high level and the pigs are fed only once daily or in liquid feed where fermentation occurs.

Table 3. Effect of deficiency of first limiting AA

5% deficiency means	***Weaners 7 to 30kg***	***Finishers 30 to 100kg***
Daily gain, g	-14	-15
Poorer FCE	0.04	0.05
Lean meat, %	-	-0.3

Too much of any one amino acid may depress pig performance too as shown by Karen O'Connell at the 2004 Teagasc pig conference where high levels of lysine resulted in reduced growth rate and poorer FCE.

Table 4 shows two finisher diets one high protein and one low protein, formulated to contain a minimum of 11g/kg, lysine, 3.3g/kg methionine, 6.6g/kg methionine plus cystine, 7.2g/kg threonine and 2.0 g/kg tryptophan. Both have the same levels of the critical amino acids.

Since both diets are considered equally capable of meeting the needs of the pig, they should both support at least equal growth rate. However, there is less excess N to be excreted from the low protein diet and therefore FCE will be better.

There is abundant other evidence that low protein diets support better FCE, intake and growth rate provided the AA needs of the pig are met (e.g. Table 5 from UCD). As a rule of thumb each 1% extra protein requires 1% of the feed energy for conversion to urea in the body and excretion. On that basis the low protein diet in Table 3 will support 5% better FCE making it worth 5% more per tonne or €11 at present prices but the low protein diet will be dearer.

Using low protein diets in all stages of production, it would be possible to reduce the ON excretion from each sow to below 70kg as illustrated in Table 6.

Table 4. Effect of amino acid supplementation on diet crude protein

	High protein	Low protein
Barley-Wheat (50:50), kg/t	653	794
Soya Hi Pro, kg/t	320	173
Minerals and vitamins, kg/t	17	17
Fat, kg/t	10	1
Lysine hydrochloride, kg/t	0	4
DL_Methionine, kg/t	0	0.9
L-Threonine, kg/t	0	1.3
Analysis, g/kg*		
Crude protein	220 (188)	169 (142)
Lysine	11.8 (10.0)	11.1 (9.7)
Methionine	3.3 (2.9)	3.5 (3.1)
Methionine + Cystine	7.2 (6.1)	6.7 (5.7)
Threonine	8.2 (7.0)	7.2 (6.3)
Tryptophan	2.9 (2.4)	2.1 (1.7)

** Values in brackets are digestible protein and amino acids*

Table 5. Effect of protein level on finisher pig performance

	CP = 21%	CP = 15%
Daily feed, g	2,110	2,220
Daily gain, g	859	945
FCE	2.47	2.38

Source: Carpenter, O'Mara and O'Doherty, 2005.

Table 6. N excretion from four feeding regimes of high and low crude protein diets

	High	Medium	Low	Very low
Crude protein in diets, %				
Dry sow	18	17	13	13
Lactating sow	18	17	16	16
Starter/Link	24	22	22	22
Weaner	22	21	20	19
Finisher 1	20	18	18	17
Finisher 2	20	18	16	16
Finisher 3	20	18	16	14
N in manure, kg/sow/year	93	82	71	66

Protein and ON excretion

The amount of nitrogen in the manure is the difference between the input (amount of feed and its crude protein content) and the output in pig meat. We assume that the loss of N to the atmosphere as NH_3 and N_2 is a constant percentage of that excreted.

A larger number of pigs sold, heavier slaughter weight and poorer FCE will all inflate the ON output per sow. Based on analysis of diets from feed mills DAFF in 2006 increased their estimate of ON excretion from 75kg/sow per year to 87kg. This resulted in a 12% increase in the amount of land required. This makes compliance with the SI 378 of 2006 more difficult. Protein levels in feeds in 2007 are marginally lower than in 2006 but could be reduced substantially.

Low protein diets will also result in:

- less ammonia in the atmosphere
- less odour from the manure
- less water consumed leading to a lower volume of manure

Recommendations

Table 7 shows our current recommendations for energy and amino acid content of feeds for different categories of pigs. Adjustments are needed as dietary energy changes.

Conclusions

Lower protein levels in pig feeds are desirable from the point of view of pig performance and compliance with legislation. Therefore, feed manufacturers need to reassess protein levels in feeds. Having the correct balance of digestible amino acids is critical.

Table 7. Amino acid recommendations for pigs, g/kg

	Starter	Link	Weaner	Finisher 1	Finisher 2	Pregnant sow	Lactating sow
DE, MJ/kg							
Total crude protein and amino acids, g/kg							
Crude protein	210	200	185	165	145	120	160
Lysine	15	14	13	11	10	7	10
Methionine	4.5	4.5	3.9	3.6	3.3	2.3	3.6
Methionine + Cystine	9	9.0	7.8	7.2	6.6	4.2	6.5
Threonine	10	9.8	8.5	7.8	7.2	4.6	7.0
Tryptophan	3.0	3.0	2.6	2.4	2.2	1.4	2.0
Ileal digestible protein and amino acids							
Crude protein	160	150	145	130	120	100	120
Lysine	12.8	11.9	10.2	9.4	8.5	5.0	8.0
Methionine	3.8	3.6	3.1	2.8	2.6	1.6	2.0
Methionine + Cystine	7.7	7.1	6.1	5.6	5.1	3.3	5.0
Threonine	8.3	7.7	6.6	6.1	5.5	3.6	5.8
Tryptophan	2.6	2.4	2.0	1.9	1.7	1.0	1.5

Caring for Sick and Injured Pigs

Ciarán Carroll, Teagasc, Moorepark

Introduction

EU Welfare Regulations are based on five freedoms (hunger and thirst; discomfort; pain, injury or disease; express most normal behaviour; fear and distress), all of which relate to the sick and injured pig.

Caring for sick and injured pigs is taken for granted on most pig units, but how well do we actually do it? What is your routine for identifying and treating sick or injured pigs? Do you have an up-to-date Herd Health and Welfare Programme in operation on your unit? Are your staff aware of it and more importantly do they implement it? How adequate are your recovery pens?

Identification and Diagnosis

The stockperson should always be looking out for signs of ill-health. These include loss of appetite, separation from group, listlessness, swellings, lameness or injury, panting, coughing or sneezing, scouring or constipation.

- Pigs must be inspected at least once daily
- Each pig must be seen
- Sick pigs or pigs that appear ill must be treated without delay
- Injured pigs must get immediate treatment
- Identify the pig by spray/marker
- Carefully examine the pig and it's environment
- What do you think is wrong with it? Seek veterinary advice if necessary
- Know when veterinary intervention is needed and treat according to advice
- Should the pig be left in the pen? This should only happen if the pig is able to move around freely and have an uninhibited access to the feed and water.

Treatment

- What drug has been recommended by the vet?
- What method of drug administration should be used?
- What is the required dose level?
- How often should the pig be treated?
- Record the treatment in the Animal Remedies book
- Assess the response daily

Recovery Pens

Your health and welfare programme should specify a procedure for isolating and caring for sick or injured pigs. There should be an appropriate number of recovery pens available for each category of pig on the unit. Pigs with infectious disease problems should be kept in separate recovery pens from injured pigs. Recovery pens should be easily reached so that the pigs can be checked regularly. The recovery pen should:

- Be easily accessible for regular checks
- Be warm and draught-free
- Be well lit
- Provide for continuous easy access to fresh water and feed
- Be easy to wash and disinfect (this should be done regularly)
- Provide a solid lying area
- Use bedding materials, e.g. straw
- One person on the unit should have responsibility for all sick pigs
- There should be a maximum of six pigs per pen with a floor area of up to $1m^2$ per pig (up to 100kg) and $3m^2$ per sow.

Casualty Pigs and Euthanasia

The Pig Veterinary Society booklet on "The Casualty Pig" provides detailed guidelines on treating sick and injured pigs. Where pigs will not or do not respond to treatment they should be euthanized humanely, without delay. Generally, a pig should be euthanized if it has failed to respond to treatment within 24 to 48 hours.

Euthanasia is defined as a humane death occurring without pain or distress. Despite best efforts every unit will have pigs that will become ill or injured in such a way that euthanasia may need to be considered. It should be carried out by a vet or by a stockperson using an approved method. The stockperson must be trained and competent in any such method used on farm. When making decisions the producer must consider pig welfare, economics and public health. In general, an animal should be culled when it is no longer profitable or euthanized when it is inhumane to allow it to continue living.

Producers can be reluctant to euthanize pigs for economic reasons. The difficulty is defining when the pig becomes uneconomic and whether to treat or euthanize it. The decision is often heavily weighted by the perceived ability of the pig to return a profit. Another significant factor in their reluctance to euthanize is the unpleasantness of the job. Most people do not like euthanizing animals, even if they are in pain and often go to great lengths to avoid it. Survey results in North Carolina indicate that having a clear protocol for when to euthanize pigs will help reduce some of the job stress felt by unit staff. Therefore, it is critical that a standard euthanasia protocol is written into your Herd Health & Welfare programme.

Euthanasia Considerations

The following should be considered when choosing the best methods to use:

1. Human Safety: must not put producers/staff at unnecessary risk
2. Pig Welfare: should minimise any pain or distress on the pig
3. Practicality/technical skills required: easily learned and repeatable
4. Cost: must be economical to ensure it is used when needed
5. Aesthetics: should not be objectionable to the person administering the procedure
6. Limitations: some only suitable for certain sizes of pigs or certain locations

Methods of Euthanasia

The method used should result in rapid unconsciousness followed by cardiac or respiratory arrest and ultimate loss of brain function. It should minimise stress and anxiety experienced by the pig prior to unconsciousness.

- Blunt Trauma to head: a sharp firm blow to top of head with a heavy blunt instrument – suitable for young pigs up to three weeks of age. However, this is probably the most objectionable method from an staff/administrator point of view. Alternatives should be considered (see Carbon Dioxide section below).

- Gunshot: may only stun adult animals therefore neck (carotid) or armpit (brachial) artery must be severed once the pig is stunned. A gun license is required as is training in firearm use and safety. The use of a shotgun will reduce the risk of ricochet. Because of safety issues this method of euthanasia is generally not recommended.

- Penetrating Captive Bolt: as for gunshot. Requires pithing or bleeding of neck/armpit artery. It is a much safer method than gunshot.

- Electrocution: a two step procedure is recommended. First the pig must be rendered unconscious. If electrical stunning is used, electrodes must be placed on opposite sides of the head so that current travels through the brain. Secondly, the current should be redirected through the heart of the unconscious pig to induce cardiac fibrillation. This will result in cerebral anoxia and death.

- Anaesthetic Overdose: must be administered by vet only.

- Carbon Dioxide: causes rapid onset of anaesthesia with subsequent death due to respiratory arrest. It is very safe for personnel and relatively inexpensive. In North Carolina they have a simple system for small pigs using a rubbish bin with inlet and outlet valves installed in the lid and a plastic bag liner can be used. After checking for complete euthanasia, the bag containing the pigs can be removed. This system, though not presently in operation in Ireland, should be seriously considered as a safe and effective method of euthanizing young pigs.

Personal Safety

Personal safety is paramount with all methods of euthanasia. Provide adequate training and ensure that staff are competent in the chosen methods for your farm. Carry out "refresher" training with them in consultation with your vet. If in doubt about the methods/procedures use a vet or licensed slaughter person.

Summary

Develop and implement a Herd Health and Welfare Programme for your unit. Train staff and ensure they are competent at identifying and treating sick and injured pigs. Having standard protocols in place will ensure that they are swift in making decisions on what is best for the pig and for the unit. Provide an adequate number of suitable recovery pens. Euthanasia should be used as a management tool to alleviate the suffering of individual pigs and to protect the health of all pigs on the unit.

References used

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Marketing Pigs to Maximise Profit

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Producers and processors involved in the pig industry share the common goal of improving carcase quality. To achieve this, producers need timely access to accurate carcase information. This enables them to identify where improvements can be made and quantify the effects that changes on the farm have on carcase quality.

Current situation

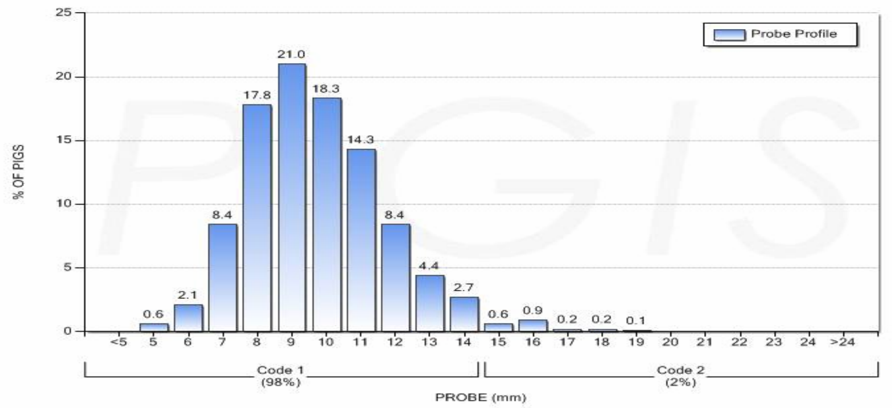
In Northern Ireland, as elsewhere, producers currently receive individual carcase details for their pigs including weight, P_2 fat measurement and condemnations from the processing plant. A basic summary showing averages for these measurements is also provided. This information while useful is limited, with no easy way to compare either changes in carcase quality over time, or individual producers against the "best" producers. This limitation has been overcome by the development of the Pig Grading Information System (PiGIS), which was recently launched in Northern Ireland. This is a tailor-made computer programme that assists both producers and processors in Northern Ireland to assess and benchmark carcase quality, allowing improvements to be quantified.

A key feature of PiGIS is that kill data relating to weight, grade and condemnations are directly uploaded from all pig processing plants in Northern Ireland to a central benchmarking database. This information can be accessed by registered producers in Northern Ireland via the internet at ***www.ruralni.gov.uk/pigis***. Each producer has an individual identity and password which allows secure access to their data only, from their home computer on a "real time" basis. The programme has been developed to be easy to use, totally flexible and provide analysis which is self explanatory.

PiGIS reports

Through PiGIS, producers can assess the quality of carcases supplied over any given time period, providing total flexibility. Figure 1 shows a typical PiGIS report. In this case the range in probe measurements for 1256 pig carcases supplied by one producer over a specified time period is illustrated.

Figure 1 Grading profile



Summary Information

Number Of Pigs:	1256
Rank:	-
Code 1	98.0%
Code 2	2.0%
Average Probe:	9.7 mm
Probe Variability:	1.89
Condemned[1]:	1.0%

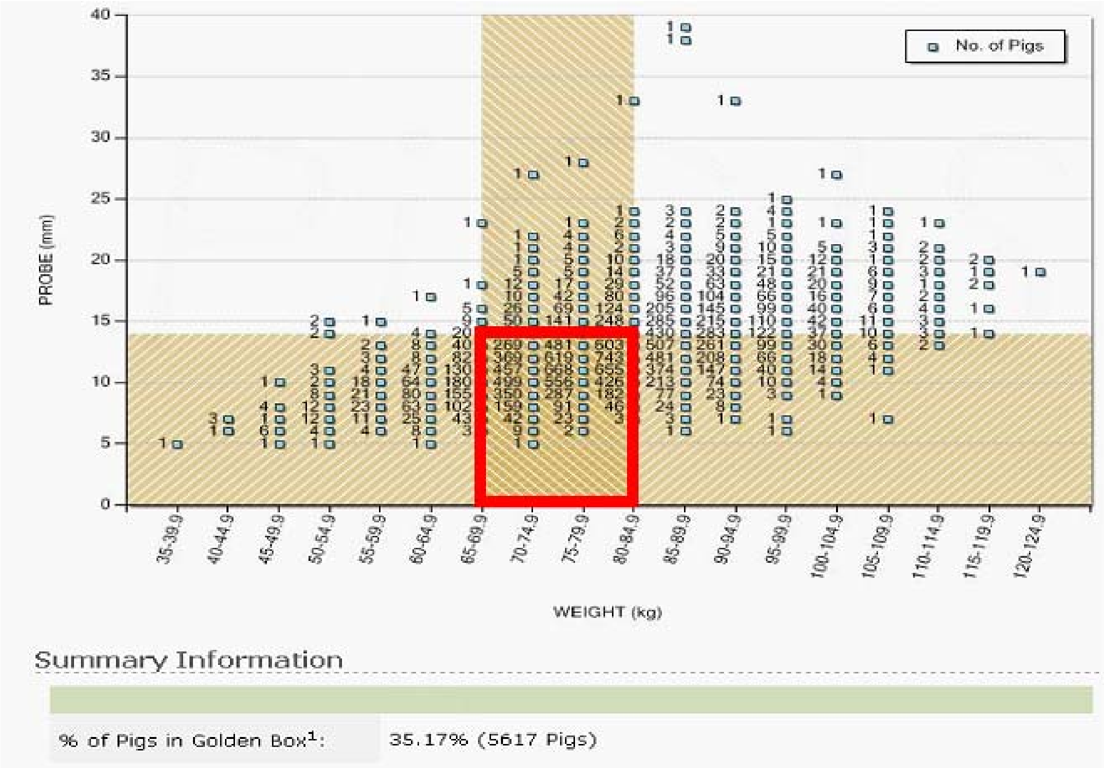
The percentage of pigs in each probe category is shown as a bar-graph. More detailed information is provided in the accompanying summary table including average probe measurement, variation in probe and the percentage of pigs in each grade. Similar information can also be obtained for carcase weight.

The result of on-farm changes which influence grading, weight and thus financial returns can also be identified using PiGIS. For example, the effect of changes in genetics, nutrition and slaughter weight can be easily and quickly quantified using the programme to compare carcases from one time period against another. From this, the optimum slaughter weight to reduce penalties can be identified.

The "Golden Box"

The "Golden Box" facility quantifies the number of carcases within more stringent specifications. In Northern Ireland, contracts currently provide bonus payments for pigs within "tighter" weight and grade ranges. Through PiGIS, producers can quantify the proportion of carcases that receive these payments. A typical report is shown in Figure 2, where 35% of pigs are in the Golden Box range from 65kg to 80kg with probe measurements of 14 mm or less. The benefits of farm changes can be determined by the effect on the proportion of Golden Box pigs.

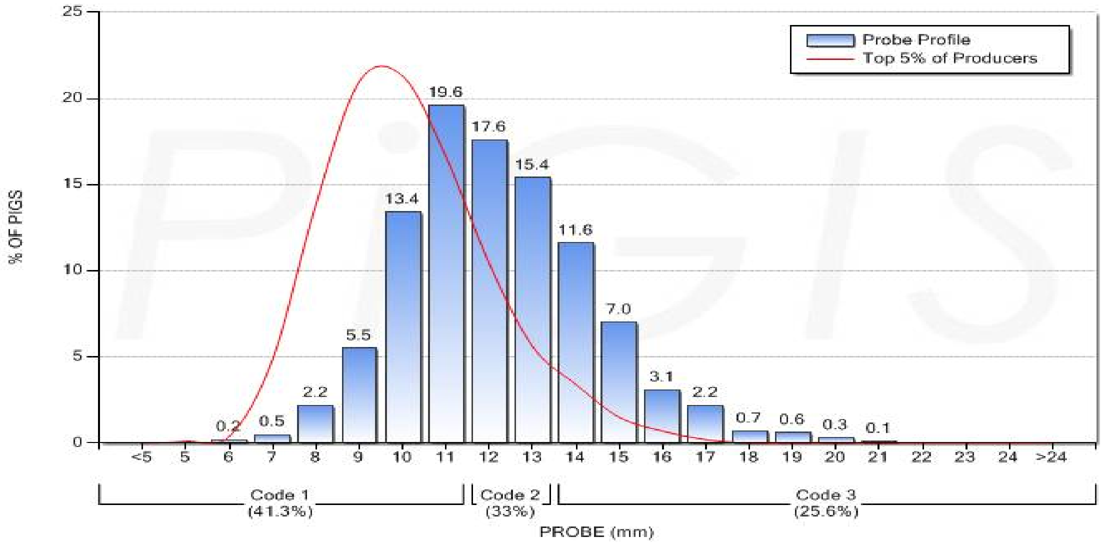
Figure 2 Percentage of pigs in the Golden Box limits



Compare with the "rest or the best"

Using the powerful benchmarking facility within PiGIS producers for the first time, can compare or benchmark the quality of their carcases with "the rest or the best" in the industry over any time period. With this facility producers can compare the weight, grade or proportion of "Golden Box" pigs with any proportion of the industry. For example, the percentage of pigs in each grade supplied over any time period chosen can be compared with the industry as a whole or the top 5%, 10%, 20% etc. A typical benchmarking report is shown in Figure 3.

Figure 3 Producers grading compared with the top 5% of the industry



Summary Information

	Demo Farmer	Top 5%
Number Of Pigs:	2375	3456
Rank:	26%-50%	-
Code 1	41.3%	78.2%
Code 2	33.0%	16.0%
Code 3	25.6%	5.8%
Average Probe:	12.2 mm	10.2 mm
Probe Variability:	2.19	1.74
% Pigs Condemned[1]:	0.5%	0.3%

In this example the grading profile for the individual producer is shown as a bar graph, with the top 5% of producers, shown as a curve. More detailed information on average values, variation and percentage of pigs in each grade is easy to extract from the summary table. By using either weight or grade, producers can immediately identify how their pig carcase quality compares with the best in the industry and where necessary, take appropriate action to address any problems.

Similarly marketing groups can use PiGIS to compare the quality of individual member's pigs with all pigs marketed by the group. Alternatively the quality of the group's pigs can be compared with the whole industry.

Processor activity

A "local" version of the programme (i.e. not connected to the internet) is available for processors to assess and benchmark the carcase quality of pigs slaughtered in their plant. The processor can rank producers either by carcase weight, grade or level of condemnations. The

PiGIS program can thus assist processors to match pigs supplied by a particular producer to customer requirements, thus allowing them to target carcases for specific market outlets.

Additionally, PiGIS enables processors to work with and assist producers identify problems in their supply of pigs, highlighting areas for improvement. This allows the industry to collectively work together for mutual benefit and strengthen the pig meat supply chain.

Industry analysis

The programme also allows the assessment of population parameters for the national supply. Changes in carcase weight or grade can easily be assessed for large numbers of pigs over any time period. This information can be relayed to producers, allowing them to take corrective action and to be more pro-active in subsequent years.

The Northern Ireland pig industry is confident that with PiGIS, both producers and processors have a tool to help them improve the quality of Northern Ireland pig carcases and thus the performance of the pig sector in the market place.

To view a demo of the PiGIS software, visit ***www.afbini.gov.uk/pigis***.

Feeding the Pig from Weaning to 25kg Liveweight

Gerard McCutcheon, Oak Park

Prior to weaning piglets are suckled by the sow approximately every hour throughout the day and night. The frequent suckling of small amounts of highly digestible milk ensures that the small gut is not overloaded with indigestible material. At weaning, pigs must move from frequent and regular liquid food to solid food. They must also adapt to changes in the pattern of food intake. The ability of the pig to adapt to these changes is directly dependent on its size and age at weaning.

The weaned pig requires a more mature digestive system than a suckling pig to digest the less digestible post weaning diets. The time it takes the pig to have its digestive system adapt to solid feed is one of the limitations affecting post weaning performance. The key to good post weaning performance is a highly digestible diet. Diet digestibility is a function of the selection of dietary ingredients appropriate to the digestive competence of the pig. These digestible ingredients can be expensive. The provision of a good water supply to these newly weaned pigs is also crucial. Lack of water or poor availability of water leads quickly to dehydration.

In Ireland, we have a higher feed cost per kg of pigmeat produced than our European counterparts. This is partly due to our island status and the requirement that a portion of feed ingredients be transported into the country. The combination of diets that are used on Irish pig units is also a factor in this higher feed price. In this paper I wish to concentrate on the diets fed to first stage weaner pigs and to identify where savings can be made.

It is important to grow the pig fast, but at the same time it is important to get value for money. Lawlor and Kavanagh (1995) emphasised that the sooner one can move a pig on to a lower density diet the lower the cost of feeding the pig. For this reason target usage levels for starter and link feed should be set for weaned pigs. A feed budget sets down how much of the different diets should be fed per pig.

Table 1 below shows the usage of three diets in the weaner section on Irish farms over the past four years.

Table 1: Weaner Diets and Feed Performance on Irish Farms

Year	**2003**	**2004**	**2005**	**2006**
Average Weaning Age (Days)	28	28	28	29
Average Weaning Weight (kg)	6.9	6.7	6.6	6.9
Average Weight at Sale/Transfer (kg)	36.1	35.4	36.5	34.8
Starter Diet per Weaner (kg)	3.4	4.6	4.3	3.7
Link Feed per Weaner (kg)	6.9	7.2	7.0	7.1
Weaner Feed per Weaner (kg)	41.0	40.6	42.6	39.1
Total Feed per Weaner (kg)	51.3	52.4	53.9	49.9
Daily Feed Intake (g)	774	774	801	743
Average Daily Gain (g)	434	434	444	422
Feed Conversion	1.79	1.82	1.82	1.81

Ref: Pigsys 2006

What is a reasonable target usage of starter diet (16 MJ DE per kg;1.6% lysine)? In practice, for pigs weaned at 28 days a reasonable intake of 200 gram/day fed for 10 days after weaning would amount to 2.0kg of starter diet per pig. If we make an allowance for 200g/pig (2kg/litter) to be fed in the farrowing rooms it would bring the total starter diet to 2.2 kg/pig.

The Pigsys figures show that farmers are using more starter diet than this target figure. The 3.7 kg fed in 2006 is 1.5 kg in excess of this target. If this were replaced with weaner ration the saving is 1.5 kg by 89 cent/kg less 1.7 kg by 29 cent/kg = 84 cent/pig. This calculation has assumed that the feed conversion on weaner diet will be poorer because the energy content (14.4MJ DE per kg) is lower .

A reasonable target of link feed usage is 5kg / pig weaned at 28 days. This is below the 7.1 kg figure recorded in 2006. Achieving the target would save 2.1 kg of link at 56 cent/kg versus a cost of 2.2 x 29 cent = 53 cent / pig. *Note:* The above calculations are based upon commercial feed prices at the end of August, 2007 (time of writing).

The research shows that feeding lower levels of starter and link diets did not affect subsequent performance for pigs weaned at reasonable weaning weights. Table 2 shows work from

Moorepark comparing a low usage of starter (1.5kg/pig) and link diet (3kg/pig) with a higher usage (ie 3kg starter diet and 6kg of link).

Table 2: Response to quantity of starter/link

	Low (1.5, 3)	*High (3,6)*
Wean Wt (kg)	7.1	7.1
Day 1-26		
ADG (g)	378	389
Intake (g)	477	465
FCE	1.27	1.20
Weight Day 54	37.6	38.0
		(Lynch, 1994)

When analysing performance it is important to look at the figures from weaning to transfer/sale. Looking at figures over a shorter period may not give a true picture. Over emphasis can often be placed on maximising performance by feeding high levels of expensive starter and link diets. Pigs fed only moderate levels of these diets have the ability to exhibit compensatory growth after the starter phase and reach 30kg in the same length of time but at a reduced cost (Kavanagh, 1994).

Feed Budgeting

The only way to control feed usage is to measure the usage of each diet. In practice the best method is to count the bags of starter diet that is required for each weeks weaning and only feed that amount to that group of pigs. This may mean that the larger pigs go onto the link diet sooner than the smaller pigs in the group. This is where the stockman has a clear role to play.

If you are purchasing the link diet in bags you should count out the bags required for the group of pigs and this will help reduce the risk of over-feeding this more digestible but expensive diet. Where link feed is being purchased in bulk there is a temptation to keep pigs on this diet until they are transferred to the second stage weaner house. This needs to be monitored closely. Again the stockman has to decide when the pigs are suitable for weaner diet and get them eating it as soon as possible.

Table 3: Cost per kilogram liveweight gain on starter diet

Name	**Feed Cost per Kg C**	**FCE**	**Start Age Days of age ?**	*Cost/kg Gain*
Starter	89	1	21 days+	89 cent
Link	56	1.3	35 days+	73cent
Weaner	29	1.8	49 days+	52 cent

Management Tips to optimise weaner feed costs

1. Base decisions on a cost/kg liveweight gain basis ultimately cost per kg dead
2. Change pigs to less expensive diets as soon as possible
3. Keep feed fresh and palatable to maximise intakes
4. Adjust feed hoppers to minimise feed wastage
5. Replace or repair old feeders that are wasting feed

Summary

In order to improve costs, current figures for feed use and efficiencies must be prepared for your unit. New targets should be set and a plan agreed with all staff involved on how to achieve these target figures. Costs may be reduced by supplying the animal according to its requirements. Over or under supply of nutrients can present hidden costs. The aim is to minimise feed cost per pig.

Feeding the growing pig from 25 to 45kg

Peadar Lawlor

Summary

Ireland and the UK, unlike other pig producing countries target the transfer pigs from weaner to finisher diets when they weigh in excess of 32kg. On some Irish units, pigs may not be switched from weaner to finisher diets until they reach 45kg LW. Other countries cease feeding the equivalent of our weaner diet when pigs reach 20 to 25kg. At a time when feed prices are escalating, producers must ensure that expensive feeds are used wisely and not wasted.

What are we currently feeding to pigs between 25 and 45kg?

According to PIGSYS Report (2006) weaner pigs are being transferred to finisher accommodation at c.35kg. As this figure is just an average weight, some producers are transferring pigs earlier than this but many producers are not transferring pigs to finisher accommodation until they are more than 40kg live-weight. These pigs are being fed a weaner diet, typically containing 14.3 MJ DE/kg and 13.1 g/kg lysine. A standard finisher diet contains 13.7 MJ DE/kg and 11.1 g/kg lysine.

What are the actual nutrient requirements of pigs from 25 to 45kg?

The correct concentration of nutrients in a formulated diet can only be determined after first determining the pig's daily requirement for nutrients and the pig's daily feed intake. Daily feed intake is influenced by sex, genotype, diet energy density, stocking density, environment, disease and the diet ingredients used. Table 1 is derived from BSAS (2003) and O'Connell (2005). It demonstrates that a standard weaner diet is over specified for pigs of this weight but that a standard finisher diet is insufficient to meet the requirements of pigs in this weight range.

Producers that transfer weaner pigs to finisher accommodation late should consider using a diet containing 14.15 MJ DE/Kg and 12.5 g/kg total lysine (Table 1) once pigs have reached c. 25kg (5 weeks post-weaning). Producers that transfer pigs to finisher accommodation earlier should consider using this diet (Table 1) as a first stage finisher diet until pigs reach c.45kg (9 weeks post-weaning).

If a single diet was then to be fed from 45kg to slaughter at 100kg then such a diet should contain 13.2 MJ DE/kg and 10.5 g/kg lysine (Table 2). Such a diet is specified lower than finisher diets currently fed on Irish pig units and this would also result in further savings in feed costs.

Table 1. Expected feed intake, DE and total lysine requirement (20 and 45 kg).

Pig weight Kg	Feed intake kg/day	Digestible energy MJ DE/day	Digestible energy MJ DE/kg	Total lysine g/day	Total lysine g/kg diet
20	1.01[1]	14.9[1]	14.7[1]	11.6[1]	11.5[1]
45	1.90[1]	25.9[1]	13.6[1]	17.7[1]	9.6[1]
Mean	**1.46**[1]	**20.4**[1]	**14.15**[1]	14.7[1] **18.2**[2]	10.6[1] **12.5**[2]

[1] BSAS (2003), [2] O'Connell (2005).

Table 2. Expected feed intake, DE and total lysine requirement (45 and 105 kg).

Pig weight Kg	Feed intake g/day	Digestible energy MJ DE/day	Digestible energy MJ DE/kg	Total lysine g/day	Total lysine g/kg diet
45	1.90[1]	25.9[1]	13.61[1]	17.71[1]	9.61[1]
105	2.76[1]	35.6[1]	12.81[1]	20.21[1]	7.31[1]
Mean	**2.33**[1]	**30.8**[1]	**13.21**[1]	18.91[1]	8.51[1] **10.5**[2]

[1] BSAS (2003), [2] O'Connell (2005) – pigs fed diets containing 13.8 MJ DE/kg performed optimally at 10.9g/kg lysine but because pigs will eat to meet there energy requirements 10.5g/kg lysine should be sufficient here when the diet contains 13.2 MJ DE/kg.

Table 3. Balance of essential amino acids relative to lysine (=1.00) [1].

	Growing pigs
Lysine	1.00
Methionine	0.30
Methionine + cystine	0.59
Threonine	0.65
Tryptophan	0.19
Isoleucine	0.58
Leucine	1.00
Histidine	0.34
Phenylalanine	0.57
Phenylalanine + tyrosine	1.00
Valine	0.70

[1] BSAS (2003)

What are the savings in feed cost associated with changing pigs to a first stage finisher diet between 25 and 45 kg?

1. Reduced Notional Manufacturing Margin

In a report commissioned by the pigs and pigmeat committee of the IFA, Lynch *et al.* (2002) found that the notional manufacturing margin (NMM) charged by feed compounders was much higher for weaner (€72.15/tonne) compared to finisher diets (€20.15 – 25.28/tonne). All diets were formulated using barley, wheat, soyabean meal, minerals and vitamins. The NMM is the difference between the sale value of the diet and the ingredient cost associated with producing the diet. At a good FCE of 2.00 between 25 and 45kg, 40 kg/pig of feed is required. The lowest difference between the NMM of weaner and finisher feed is €46.87/tonne (or 4.7 c/kg feed) and this translates into a 9.4 c/kg LW gain (€1.88/pig) higher feed cost associated with feeding weaner instead of finisher diet.

Some of the higher NMM may be because of the extra transport costs associated delivering load fractions of weaner diet.

2. Reduced Ingredient and Nutrient Costs

For illustration purposes, a typical weaner diet (14.3 MJ DE/kg and 13.0 g/kg) lysine was formulated using (a) barley, wheat, soyabean, minerals and vitamins (Weaner diet a - €281/t ingredient cost) or (b) barley, wheat, soyabean, 10% full fat soya, 5% fishmeal, minerals and vitamins (Weaner diet b - €337/t ingredient cost) (Table 4).

Fishmeal and full fat soya are definitely not necessary in diets for pigs of 25kg.. Table 4 shows that adding these ingredients to the diet can increase the diet cost by €56/t with little additional benefit to pig performance. On a 500 sow unit this would be an annual cost of c.€62000.

Our proposed substitute diet for the period from 25 to 45kg (14.15 MJ DE/kg and 12.5 g/kg lysine) was formulated containing (c) barley, wheat, soyabean, minerals and vitamins (1st stage finisher diet c - €279/t ingredient cost). Ingredients were costed in the formulation at prices prevailing on September 11th 2007. Feeding a 1st stage finisher diet in the period from 25 to 45kg reduces the ingredient cost of the diet by €2/tonne compared to weaner diet a. However when the nominal marketing margin is included, the saving in price between the diets may be as high as €49/tonne.

What are the savings in feed cost associated with changing pigs to a second stage finisher diet between 45 and 100 kg?

For illustration purposes, (a) a typical finisher diet (Finisher diet a; 13.7 MJ DE/kg and 11.1g/kg lysine) and (b) our proposed second stage finisher diet (Finisher diet b; 13.2 MJ DE/kg and 10.5 g/kg lysine) was formulated using (a) barley, wheat, soyabean, minerals and vitamins (Table 4). Ingredients were costed in the formulation at prices prevailing on September 11th 2007. The saving associated with changing to a lower specified finisher diet from 45 to 100kg was calculated at €0.86/pig.

Table 4. Comparison of ingredient composition and cost of diet.

Stage	**25 to 45 kg**			**45 to 100 kg**	
Item	**Weaner a**	**Weaner b**	**1st St finisher c**	**Finisher a**	**Finisher b**
Chemical Composition					
DE (MJ/kg)	**14.3**	**14.3**	**14.15**	**13.7**	**13.2**
Lysine (g/kg)	**13.1**	**13.1**	**12.5**	**11.1**	**10.5**
Ingredients[1]					
Barley (kg)	20.0	29.1	20.0	35.1	71.4
Wheat (kg)	45.7	39.0	49.0	38.2	-
Soya (kg)	29.5	13.9	26.6	23.7	24.8
Soya Oil (kg)	2.7	1.0	2.2	1.0	1.0
Full Fat soya (kg)	-	10.0	-	-	-
Fishmeal (kg)	-	5.0	-	-	-
Amino acids (kg)	0.4	0.3	0.5	0.3	0.1
Min + vits (kg)	1.7	1.7	1.7	1.7	2.7
Costs					
Ingredient cost (€/t)	**281.30**	**337.11**	**279.24**	**266.86**	**254.58**
NMM (€)	72.15	72.15	25.28	25.28	25.28
Commercial price (€/t)	**353.45**	**409.26**	**304.52**	**292.14**	**279.86**
Feed cost (€/pig)	**14.14**	**16.37**	**12.18**	**44.19**	**43.33**
Feed cost (€/kg LW)	**0.71**	**0.82**	**0.61**	**0.80**	**0.77**

[1] Ingredient prices on September 11th 2007: barley, €245; wheat, €265; soya, €255; full fat soya, €410; fishmeal, €1300.

Summary

Considerable savings in feed costs (minimum €1.96/pig) can be made by changing pigs from a weaner diet to a first stage finisher diet at 25 kg LW. This saving is mainly associated with the reduced nominal marketing margin associated with finisher diets relative to a weaner diet. Fish meal and full fat soya are expensive dietary ingredients and should never be fed in the period from 25 to 45kg. Inclusion of such ingredients even at low levels can add €56 to the cost of a finished tonne of feed. Further though smaller savings can be made by feeding a second stage finisher diet in place of a standard finisher diet between 45 and 100kg.

At current ingredient prices, cumulative savings in feed cost per pig of €2.82/pig could be made where a first stage finisher diet was fed in place of a simple weaner diet from 25 to 45kg and where a second stage finisher diet was substituted for a standard finisher diet from 45 to 100kg. If the weaner diet substituted, contained expensive ingredients like fishmeal and full fat soya then the savings could be as high as €5.05/pig.

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Maximizing Feed Intake in Growing Pigs

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1. INTRODUCTION

Much has been said and written about feed intake in the pig. It is therefore surprising that it remains a topic of much interest to pork producers, as we appear to be continually challenged to reach a maximum, or at least an optimum, level of feed intake on a consistent basis. However, the focus on feed intake is not surprising in that it is the ultimate driver of growth. It would be difficult to envision a farm achieving financial success without maximizing – or at least optimizing – feed intake. As an example, Dr. de Lange at the University of Guelph, using a pig growth simulation model, calculated that income per pig place is reduced by $9.50 per pig sold if feed intake is 11% less than expected. Such calculations will vary among farms, but the general conclusion is clear; feed intake drives growth rate, growth rate drives barn throughput and barn throughput drives profits.

There are situations where feed intake may not maximized. One is carcass grading systems that demand feed intake restriction in order to achieve carcass fat content targets; another is the adoption of extensive as opposed to intensive production systems, with an attendant reduction in capital costs. Because I was asked to speak on maximizing feed intake, I assume these circumstances do not apply to this audience.

When comparing performance among farms, differences in feed intake are surprisingly large. As one example, a small survey conducted in the Canadian province of Alberta in the early 1990's revealed that feed intake varied by 35% among farms. Based on data I have seen from individual farms over the past 20 years, this degree of variation in intake is not exaggerated.

2. FEED BUDGETS

Feed budgets are estimates of the quantity of each diet that will be fed to a pig. Feeding programs are typically designed by determining the quantity of feed that will be consumed by a pig during each phase of its growth cycle. Implementation of the feeding program is then achieved by delivering a specific amount of each diet to a group (pen, room or barn) of pigs based on the quantity of feed per pig and the number of pigs being feed. Table 1 illustrates an example feed budget for a 600-sow farrow-to-finish herd weaning at 3 weeks of age and marketing pigs at 117 kg live weight.

Studying feed budgets can be an extremely useful exercise. In our experience, comparing the "theoretical" feed budget – or the one upon which the diets were formulated – against the actual feed budget – or the amount of each diet actually consumed by the herd – can be the difference between making a profit or losing money. Errors in the implementation of feed budgets can therefore reduce net income or impair pig performance or both (Table 2). It is not uncommon to see deviations between theoretical and actual feed budgets accounting for differences in feed cost per pig sold in the range of 10% or more.

More than 60% of the pig's total feed intake will be consumed after it reaches 60 kg. Therefore, diets in the last phase of the feeding program must be carefully formulated to avoid additional and unnecessary cost while at the same time ensuring adequate nutrient intake to optimize net income.

3. FEEDING PROGRAM OBJECTIVES

As strange a statement as it may seem, the objective of the feeding program on a given farm should be clearly defined and communicated to all personnel involved. In my experience as a consultant, it is not uncommon to find three different people working ostensibly for the same farm to define three different targets for the feeding program. For example, the farm owner generally wants to see net income maximized. The nutritionist may have a higher emphasis on one or more performance indicators, such as feed conversion, because that is how he is being compared to his/her competitors. Finally, the barn manager may be concerned about a specific productivity target, such as grading, since this may be a key component of his production bonus. Clearly, in this situation, someone is bound to be disappointed with the feeding program. Therefore, the objective of the feeding program should be discussed with all people involved, and a clear objective(s) defined – and agreed upon. This can be a critical step in ensuring the success of our feeding program.

4. MANAGEMENT STRATEGIES TO INCREASE FEED INTAKE

The first step to maximizing feed intake is to measure it! The U.S. National Research Council, in their publication, Nutrient Requirements of Swine, provide an equation that estimates the daily energy intake in the pig based on body size:

$DE_{INTAKE} = 13{,}162 \times (1 - e^{-0.0176BW})$

where BW is body weight of the pig and "e" is a constant = 2.7183. Dry matter of the feed is assumed to be 90%.

In our experience, the daily feed intake on most commercial herds falls within the range of 85% to 95% of the amount predicted by this equation. We rarely see feed intake above 105% or below 70%. This equation is helpful because it can be used as a benchmark. If feed intake is below 95%, improvement is definitely possible and if feed intake is below 85%, improvement is desirable. If feed intake is below 80% of what the NRC predicts, then the problem is likely to be very serious.

Ideally, develop a feed intake curve for your farm that defines the feed intake of pigs at different stages of growth. It is not unusual on commercial farms to identify feed intake problems at specific stages in production, or even within a stage of production. For example, a feed delivery system that is acceptable for smaller pigs may become problematic as they grow and their requirements increase. Consequently, it is extremely valuable to be able to identify where shortfalls in feed intake are occurring, as it allows more specific and effective management strategies to be implemented. Use of liquid feeding systems should make this step relatively easy.

Use the list of factors in the following sections to determine where improvement is most likely to be achieved. Focus first on 1) the most likely candidates, given the history of the herd, and 2) the factors that are most likely to have the greatest impact. In my experience, feed delivery, building ventilation and herd health are the most likely candidates – or the ones with the biggest payback - on most farms. However, herd health is also the one that is the most difficult to change.

Reassess feed intake as per item #1 and #2 above, to evaluate the response to management changes.

Continue to monitor feed intake as a key and critical indicator of barn management success. Seasonal changes will become apparent and may also be corrected.

5. MAXIMIZING FEED INTAKE: The Social and Physical Environment

The pig's physical and social environment are clearly major determinants of feed intake. Modern confinement housing systems place the onus of responsibility with respect to the pig's comfort clearly on the shoulders of pork producers, since the pig has little opportunity to self-select a more favourable environment. The use of straw, or outdoor housing, provides the pig with more latitude in this regard (shade versus sun, wet versus dry, draughty versus calm, etc).

5.1. Barn temperature

I assume this is not much of a problem in Ireland, given the climate, but keeping barn temperatures too high will obviously lower feed intake. For every ºC above the pig's thermal comfort zone, feed intake will drop 40 grams per day. Bigger pigs will be affected more by heat stress than smaller pigs.

During periods of hot weather, feed intake can be enhanced by feeding diets with reduce fibre and protein content and by using sprinklers. If evenings are cool, lowering the ventilation set point by 8ºC will also increase overall feed intake.

It is generally recommended that pigs enter the growout barn at 22 to 23ºC and that this temperature be lowered by about 1.5ºC every week until the temperature reaches 15ºC at about 55 kg bodyweight. When the ambient temperature rises above these levels, a number of actions can be taken to increase feed intake:

feed a diet with reduced crude protein and fibre content

use sprinkler systems to provide direct cooling of pigs and to wet the floor, thereby increasing heat loss from the pig's body

move pigs during the cooler part of the day

5.2. Social Interaction

5.2.1. Space Allocation

Floor space allowance is best expressed as a function of $BW^{0.667}$; maximum feed intake occurs when floor space allowance for growing pigs is set at 0.039 m^2 $BW^{0.667}$. However, the economic optimum lies somewhat below this standard. Legislated or marketplace defined standards will also influence floor space allowance.

5.2.2. Regrouping

In order to maintain efficient use of barn space, regrouping of animals may be required from time to time. Regrouping may occur when pigs are weaned or move from the nursery to the growout barn; it may also occur when pigs approach market weight and some pigs within a pen or room reach market weight while other pen or room-mates remain behind. Mixing or re-grouping of animals as they approach market weight will decrease feed intake by at least 5% to 10%.

Re-grouping pigs should not be undertaken simply to improve uniformity within a pen. Regrouping will not improve performance, and in fact will increase days to market due to the disruption which occurs during mixing. The less pigs are mixed, the better off they are in terms of overall performance. Mixing may only make economic sense when it significantly improves building utilization.

5.2.3. Group Size

The number of pigs housed within a pen will affect barn design as well as construction cost. Hence, there is growing interest in the expansion of group size to 500 animals or even more. We have known for a long time that pigs housed in very small groups (eg. 5 pigs per pen) will eat more than pigs in conventional pens housing 20 to 25 pigs. Based on the most recent research, it appears that if all other factors are equal, large group sizes (100+ per pen) will reduce feed intake by no more than 3% to 5%, as compared to 20 to 25 pigs per pen.

6. MAXIMIZING FEED INTAKE: Pig Factors

While the pig's physical and social environment are clearly major determinants of feed intake, there are also factors intrinsic to the pig that are also important.

6.1. Genetics

The baseline feed intake for a pig will be defined by its genotype. This will dictate targets for feed intake, as genotypes do differ. However, genotypes with the greatest feed intake may not be the ones with the fastest growth rate, or the greatest lean gain (Table 3).

6.2. Barn entry weight

It is an undeniable fact that bigger pigs eat more feed. Therefore, anything that can be done to increase the size of pigs entering growout will increase feed intake. For this reason, to solve feed intake problems on some farms, we often begin our investigations in the nursery.

6.3. Health status

Health status is one of the key factors that explain the large differences in feed intake among farms. In response to pathogens, the immune system is activated to synthesize the components of its defence mechanisms, such as cytokines. An increase in cytokine production decreases feed intake. Thus, reducing the burden of pathogens to which pigs are exposed will increase feed intake.

Controlled studies have shown that poor health status can reduce feed intake by 5% to 15%, or more (>30%) in severe cases. Even moderate health problems can reduce feed intake by 5%.

7. MAXIMIZING FEED INTAKE: Diet Factors

7.1. Diet energy concentration

Feed intake is very much under the control of the nutritionist. It would be very easy for a nutritionist to increase feed intake in a herd simply by modifying the energy profile of the diet; pigs will increase their intake of a low energy diet in order to maintain constant – or at least try to maintain constant – feed intake (Table 4). In this study, feed intake increased as diet DE content decreased, but since growth rate did not change, feed efficiency went in the opposite direction. This experiment represents an excellent example of how outcomes must be based on economic factors rather than simply pig performance; if this pork producer had selected his feeding program based on feed efficiency – a common target - he would have lost money.

7.2. Ingredient quality

Recent research has shown that feed intake varies among individual barley or wheat samples. For example, feed intake varied by 21% among 4 barley samples and by 17% among 4 wheat samples (Table 5). Unfortunately, it is not yet possible to easily identify those wheat or barley samples that will maximize feed intake or growth rate, but the level of fibre may be involved.

7.3. Nutrient balance

The balance of amino acids, as well as the balance of energy in relation to amino acids will affect feed intake. Excess minerals, especially calcium, may also reduce intake. Indeed, many nutrient imbalances will impair feed intake.

7.4. Antinutritional Factors

Many common ingredients contain anti-nutritional factors (ANF) that can lower feed intake. Soybean meal must be heated to destroy undesirable enzymes in the seed. Canola meal and field peas also contain ANF; however, if included in the diet at recommended levels, the impact on feed intake will be negligible.

CONCLUSIONS

Feed intake is an important driver of success. Because feed intake is closely linked with growth rate and feed efficiency, it is sometimes difficult to determine if the cause of problems on a particular farm are due to primary factors reducing feed intake or secondary factors that are more related to growth rate. Environmental, social and nutritional factors all play a role, as well as the character and health status of the pig. This can make solving feed intake problems a real challenge, because typically, shortfalls are the result of more than one single deficiency in the production system. Nonetheless, because improved feed intake is usually associated with increased net income, there is a strong motivation to maximize – or optimize – feed intake on a given farm.

Table 1. An example feed budget for pigs from weaning to market

Diet Name	**Diet #**	**Pig wt., kg**	**Pig Age, d**	**A.D.G., g**	**A.D.F., g**	**Feed:Gain**	**Feed/pig, kg**
Starter 1	201	6.2 to 6.6	19 to 23	115	125	1.1	0.5
Starter 2	202	6.6 to 8	23 to 29	300	330	1.1	2.0
Starter 3	203	8 to 14	29 to 42	475	620	1.3	8
Starter 4	204	14 to 22	42 to 55	600	870	1.5	11
Starter 5	205	22 to 35	55 to 72	765	1,224	1.6	21
Grower 1	301	35 to 50	72 to 88	865	1,900	2.2	31
Grower 2	302	50 to 65	88 to 104	920	2,300	2.5	38
Finisher 1	401	65 to 80	104 to 120	930	2,600	2.8	46
Finisher 2	402	80 to 95	120 to 136	930	2,850	3.1	46
Finisher 3	403	95 to 105	136 to 147	880	3,000	3.4	38
Finisher 4	404	105 to Mkt	147 to 159	830	3,000	3.6	32

NB. Feed budgets should be tailored to the circumstances of a specific farm. The above feed budget is provided for illustration only, and should not be adopted without consultation with a nutritionist.

Table. 2. Impact of correcting error in feed budget implementation on nursery pig performance

	Prior to Correction	**Following Correction**	**Feed Budget/Targets**
No. turns	12	2	
No. pigs	2,673	540	
Phase 1 diet, kg	0.4	2.0	2.0
Phase 2 diet, kg	15.4	18.8	17
Phase 3 diet, kg	23.7	22.3	24
Entry age, days	19.2	19.2	19
Exit age, days	71.2	72.2	72
Entry weight, kg	6.0	6.2	6.5
Exit weight, kg	30.5	34.2	35

Source: Patience (unpublished data)

NB. Correction of the feed budget increased the feed cost per pig by CAD 2.87 (€2.02) but increased nursery exist weight increased farm net income by CAD 1.85 (€1.30).

Table 3. Genotype effects on feed intake and growth, including relative ranking ().

Genotype	Feed Intake	Daily Gain	Lean Gain
	- kg/d -	- g/d -	- g/d -
1	3.145 (2)	916 (5)	329 (5)
2	3.019 (5)	924 (4)	361 (3)
3	3.055 (3)	1,010 (2)	390 (2)
4	3.238 (1)	1,001 (3)	332 (4)
5	3.028 (4)	1,017 (1)	393 (1)

Source: Gu et al., 1991

Table 4. Effects of feeding diets formulated to contain 3.20 (13.4mj), 3.35 (14.0mj) or 3.50 (14.7mj) Mcal DE/kg on the performance of growing/finishing pigs on a commercial barn

	Digestible energy (Determined Mcal/kg: mj/kg)				
Item	**3.12 (13.1)**	**3.30 (13.8)**	**3.43 (14.4)**	**SEM**	**P**
No. pigs	240	240	240		
Body weight, kg					
Initial	37.4	36.6	36.5	0.87	0.02
Final	118.61	117.97	118.98	0.29	0.05
Average daily gain, kg/d	0.99	0.98	1.00	0.02	0.31
Average daily feed intake, kg/d	2.94	2.85	2.77	0.04	0.01
Feed efficiency, gain/feed	0.34	0.34	0.36	0.01	0.002
Tail-enders[a]	48	45	37	------	------
Days to market (average)[b]	79.9	80.7	79.0	------	------

Source: Patience et al., 2007

[a] Number of pigs not reaching market weight during the allotted experimental period.

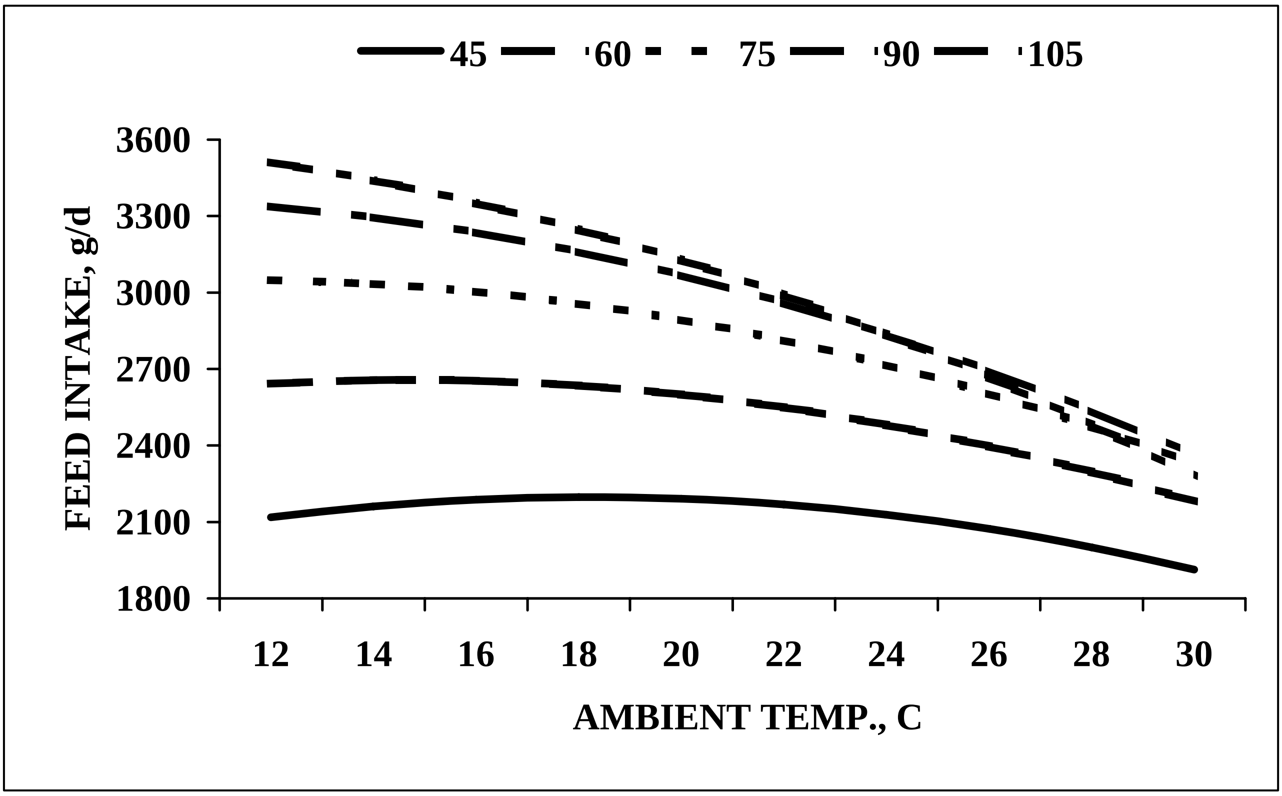
[b] Of those pigs reaching the minimum market weight.

Table 5. Effects of barley, wheat or corn source on weanling pig performance.

Item	Barley-based				Wheat-based			
Init. wt. kg	9.3	9.2	9.5	9.4	9.5	9.5	9.2	9.0
Final wt., kg	19.6	20.2	20.1	20.3	21.8	20.3	20.8	19.0
Daily gain, kg	0.49	0.52	0.50	0.52	0.57	0.51	0.55	0.48
Daily feed, kg	0.87	0.94	0.90	1.05	0.96	0.93	0.91	0.82
Feed:gain	1.75	1.79	1.79	2.00	1.69	1.82	1.64	1.67

Source: Ekpe et al., 2001

Figure 1. Impact of ambient temperature on feed intake of pigs of varying body weights.



High fibre diets for pregnant sows

Laura Boyle and Charlotte Stewart

Introduction

Irish legislation states that sows must be provided with a high fibre diet to satisfy their hunger and motivation to forage and chew. This is to comply with recent changes to European Union pig welfare legislation (Council Directive 2001/88/EC). Feelings of satiety (fully satisfied appetite) promoted by high fibre diets generally lead to a reduction in stereotypic behaviour, increased resting behaviour and in some group housing systems, to a reduction in aggression. Although the implications of these improvements to behaviour for sow productivity and longevity are unknown they are all associated with improvements to sow welfare. However, there are few clear guidelines as to the best sources and inclusion levels of dietary fibre for gestating sow diets.

Benefits of feeding high fibre diets

The performance of stereotypies by gestating sows is one of the most controversial aspects of pig production from an animal welfare point of view. This is because the behaviour is viewed as 'abnormal' and is thought to be indicative of stress. In the early days, stereotypical behaviour was blamed on close confinement of sows in tethers and stalls. Although close confinement plays some role in the development of stereotypies recent research shows a definite link between hunger, the motivation to feed and some of the stereotypies performed by restricted fed pregnant sows.

Sham chewing is a stereotypy where the sow repeatedly moves her jaws as if chewing something although her mouth is empty. The behaviour is often accompanied by copious production of saliva seen as 'froth' around the mouth. High fibre diets reduce this behaviour because the sow's motivation to feed and forage is reduced (Whittekar *et al.,* 1999). This is because the consumption of fibrous material is associated with the continuous release of nutrients due to increased fermentation in the hindgut which prolongs the energy supply (Ramonet *et al.,* 2000). Furthermore fibre fermentation and absorption of increased levels of acetate alter glucose metabolism therefore maintaining satiety for longer (Brouns *et al.,* 1994). An increase in satiety is probably also associated with increased 'gut-fill' due to consuming high levels of dietary fibre (Lawrence and Terlouw, 1993).

Stereotypic behaviour is correlated with standing so a reduction in the time sows spend engaged in stereotypical behaviour results in a reduction in the time spent standing. Indeed high fibre diets appear to promote resting behaviour in sows. This 'calming' effect of high fibre diets is of direct benefit to sow welfare but also indirectly results in a reduction in aggressive behaviour in some group housing systems. High fibre diets also undisputedly reduce vulva biting in dynamic groups (Van Putten and Van de Burgwal, 1990; Whittaker *et al.,* 1999). Nevertheless high fibre diets have no effect on aggression at mixing. Another unexpected benefit of feeding high fibre diets is that water intake is often reduced significantly (Ramonet *et al.*, 2000). Sows on restricted diets with a low fibre level (2.23% crude fibre) often display non-essential drinking where they re-direct their high motivation to feed into excessive drinking behaviour (Robert *et al.,* 1993).

A recently published French study showed that while a high fibre diet of 12.4% crude fibre (sunflower, wheat bran, sugar beet pulp, soyabean hulls and maize gluten) fed during gestation had no effect on the farrowing process or on reproductive performance, piglets' growth rate during the 1st week of life was improved and weaning weights tended to be increased (Guillemet *et al.,* 2007). Fibrous feed ingredients such as corn cobs (Matte *et al.*, 1994), oat hulls (Mroz *et al.*, 1986), alfalfa haylage (Hagen, 1988), and wheat straw (Ewan *et al.,* 1996) seem to cause increases in litter size at farrowing. However, studies involving high fibre diets based on soyabean hulls reported reductions in litter size (Nelson *et al*., 1992; Holt *et al.,* 2006). In the study by Guillemet *et al.* (2006) sows fed the high fibre diet during gestation did not differ in their lactation feed intake from control sows although they were leaner at weaning. However, greater feed consumption has been reported in sows fed a high fibre diet during pregnancy compared with sows fed a standard diet, with differences ranging from 4.4 to 10.4% over a 28-d lactation period (Matte *et al.,* 1994; Farmer *et al.,* 1996; Courboulay and Gaudre, 2002).

Potential disadvantages

In growing pigs increasing dietary fibre levels results in unwanted weight gain and a possible increase in back fat (Ramonet *et al*., 1999). Although Brouns *et al.* (1995) showed that *ad libitum* access to a diet containing high levels (for instance 580 to 650g/kg) of sugar beet pulp provided adequate levels of energy without resulting in excessive weight gain in pregnant sows. Also in growing pigs high fibre levels decrease the digestibility of nutrients in the diet (Wilfart *et al.,* 2007). In the case of sow diets Le Goff *et al.* (2002) similarly found that including dietary fibre reduced the digestibility of energy and nutrients in adult non-pregnant and non-lactating sows. There are several potential practical disadvantages associated with feeding high fibre diets. These may include the need for extra feed storage facilities and owing to the increase in excreta arising from high fibre diets, greater manure storage capacity.

Fibre source, level of inclusion and feeding level/regimes

Sugar beet pulp appears to be more effective in increasing feeding activity and reducing stereotyping in comparison to wheat bran (Ramonet *et al.,* 2000a). A possible explanation for this is that sugar beet pulp is a soluble fibre and hence an effective source of fermentable non-starch polysaccharides (De Leeuw *et al.,* 2004) which are readily digested (Yan *et al.,* 1995). Increasing fermentable non-starch polysaccharide levels in the diet increases water-binding capacity resulting in gastric distension ('gut-fill') therefore promoting post meal satiety and reducing stereotyping (De Leeuw *et al.,* 2005). However, wheat bran fed in conjunction with corn cobs is more effective at promoting resting and reducing stereotypic behaviour than oat hulls and oats or corn and soyabean (Matte *et al.,* 1994). Diets containing wheat bran and corn cobs also increase litter growth (Matte *et al.,* 1994) and reduce constipation (Yan *et al.,* 1995; Wilfart *et al.,* 2007). Although soyabean hulls are widely used as a source of fibre they do not appear to be very effective in reducing stereotypic behaviour (Holt *et al.,* 2006).

Not alone is it difficult to ascertain which is the best source of dietary fibre to use but the optimum level it should be fed at is also uncertain. Significant benefits to sow behaviour were found with diets including between 8.5 and 10.7% crude fibre in comparison to control diets of approximately 2% crude fibre. Although Bergeron *et al.* (2000) found that very high levels of fibre (above 23% crude fibre) were required to show an effect on sow behaviour. These studies show that increasing dietary levels anywhere between 8% and 20% has positive effects on sow welfare. However the optimum level is likely to vary according to the feeding frequency, regime and level used in addition to the fibre source so much more work is required in this area.

Ramonet *et al,* (1999) concluded that the benefits of feeding a high fibre diet were more pronounced in diets with a fibre level above 12% crude fibre. Whereas Bergeron *et al.* (2000) found that very high levels of fibre (above 23% crude fibre) were required to show an effect on sows' behaviour. However Brouns *et al.* (1994a) with a diet including 10.7% crude fibre and Ramonet *et al.* (2000a) with a diet including 8.5% crude fibre found significant differences in sow behaviour in comparison to control diets of approximately 2% crude fibre. These studies show that increasing dietary levels anywhere between 6% and 20% has positive effects on sow welfare. Further investigation is required to determine optimum levels of dietary fibre in concentrate rations for sows.

The simplest method of achieving satiety in pregnant sows would be to offer a suitable diet *ad libitum* (Brouns *et al.,* 1995). However, this requires careful management as sows may become over fat (Kirkden and Pajor, 2006) which causes farrowing and locomotor problems. It is likely that *ad libitum* feeding is not necessary to improve satiety. Indeed it would appear that feeding a high fibre diet once a day is a more effective method of reducing feeding motivation than feeding the same diet twice a day (Robert *et al.,* 2002). Twice a day feeding increases the performance of stereotypies even when sows are fed a high fibre concentrate ration twice a day (Robert *et al.,* 2002). This is because the amount of ration in each meal delivery is reduced with twice compared to once a day feeding. Gut fill effects are also reduced by twice daily feeding.

Wet feeding results in better gut fill than dry feeding (Bergeron *et al.,* 2002; Scott *et al.,* 2007). This could explain why wet fed sows are less active, spend more time lying and are calmer compared to dry fed sows (Bergeron *et al.,* 2002; Scott *et al.,* 2007). Improvements in satiety probably arise from the fact that wet feeding systems include a concentrate ration and water mix which creates larger volumes in each meal delivery in comparison to dry feeding systems. Wet feeding has a further advantage over dry feeding; the pelleting process for dry feeding can affect the diet ingredients. Heat treatment during pelleting causes a shift from soluble to insoluble fibre, which is not as effective in maintaining satiety (McGlone and Fullwood, 2001). However wet feeding can result in poorer hygiene due to the larger volumes or water being ingested and excreted (Scott *et al.,* 2006) and takes longer to consume (Rasmussen *et al.,* 2006).

From research conducted thus far it is sometimes difficult to conclude whether the benefits of high fibre diets are associated with the increase in the fibrous material, the increased feeding levels or the feeding method itself. This is because an increase in the dietary fibre level of the concentrate ration generally means that the overall amount of feed given to the sows is also increased in most experiments.

Recent findings on high fibre diets from research conducted at Moorepark and Hillsborough

Provision of straw as a fibre source

Straw is a source of dietary fibre. Sows on deep straw bedding have up to 20% crude fibre in their diet from a combination of the concentrates and the straw (based on 2.5kg of a concentrate diet of 5% crude fibre and 2kg of straw at 38% crude fibre). Furthermore as straw is manipulable it also meets other EU requirements on environmental enrichment. However, few benefits in terms of stereotypies were found in recent Irish studies where straw was provided to conventionally fed sows in racks (Boyle and Gauthier, 2004 with welfare stalls; Stewart *et al*., 2007a with an ESF split-yard system). In these studies straw usage ranged from only 0.2-0.27kg/sow/day. It is likely that straw needs to be provided in much larger quantities if it is to be effective in reducing stereotypies.

In the study of sows in an ESF split yard system, competition for access to the straw in the racks actually increased levels of aggression (Stewart *et al.*, 2007a). This was probably as a result of the high sow to rack ratio and the shortness of the racks (1.2m) which severely limited the number of animals that could access them at any one time. In a Moorepark study where sows had access to their own personal straw rack in the welfare stalls, straw alone significantly reduced agonistic behaviour (Stewart *et al*., 2007b). However in none of the studies mentioned above was straw successful in reducing aggression at mixing.

High fibre diets provided to sows in static and dynamic groups

In a study at Moorepark sows in welfare stalls fed a high fibre diet based on soya hulls (Table 1) showed greater weight gain (Control: 8.93 *vs.* High Fibre: 18.57kg) during the four week treatment period. However, there were no treatment effects on back fat levels at the end of the experiment so this may have been an effect of 'gut fill'. In contrast ESF fed sows on a high fibre diet (Table 2) in a study conducted in Hillsborough lost body condition during pregnancy (Stewart *et al*., 2007c and Niamh O'Connell *personal communication).* This suggests that a crude fibre level of nearly 15% might be too high for a fibrous diet based on sugar beet pulp and soya hulls.

Table 1. Diet formulations (Moorepark study)

	Diet kg	
	Control	**High Fibre**
Ingredients (g/kg)		
Barley	892.9	742.9
Soya Hulls	0	150
Soya Hi-Pro	75	75
Fat Soya Oil	10	10
L- Lysine HCl	0.5	0.5
Di Cal Phos	5	5
Limestone Flour	11	11
Salt	4.0	4.0
Vit-Mins	1.5	1.5
Phytase 5000 iu/g	0.1	0.1
Formulated Chemical analysis (g/kg DM or MJ/kg)		
Crude Protein	132	133
Crude Fibre	45	89
DE	13.0	11.0
Lysine	6.19	6.70

Table 2: Diet formulations (Hillsborough study)

	Diet kg	
	Control	**High Fibre**
Ingredients (g/kg)		
Barley	534	204
Wheat	100	70
Home milled pollard	75	75
Sugar beet pulp	80	140
GM Hipro soya	100	100
GM soya hulls	-	300
Molaferm (Press)	30	30
Soya oil (Mix)	35	35
Fine limestone	6	6
Mono DCP	13	13
Salt (micro)	4	4
Sow breeder supplement	2	2
Chemical analysis (g/kg DM or MJ/Kg)		
Dry matter	871.45	876.80
Crude protein	134.45	140.73
Crude fibre	50.32	147.33
DE	13.36	10.31

Both of the high fibre diets shown in Tables 1 and 2 were successful in increasing the time sows spent resting (Stewart *et al*., 2007b and c). However only the diet shown in Table 2 was successful in reducing stereotypies. In the Moorepark study it was only when the sows fed the diet shown in Table 1 were also provided with straw in racks that a reduction in stereotypies was found (Stewart *et al*., 2007b). This supports findings in the literature that soyabean hulls are not as effective a fibre source in reducing stereotypies as sugar beet pulp. The high fibre diet shown in Table 2 was also successful in reducing aggression (Stewart *et al*., 2007c). It is likely that the reason no effect of the high fibre diet was found on levels of aggression in sows in static groups of four with full-length feeding stalls (Stewart *et al*., 2007b) is that levels of aggression are already extremely low in these systems once the dominance hierarchy is formed (Boyle and Gauthier, 2004).

Conclusions

In spite of the lack of research on high fibre diets for pregnant sows and the conflicting findings in the literature the fact remains that the fibre content of diets for all gestating sows in Ireland must be increased in order to comply with the legislation. Sow behaviour and welfare benefits considerably from even small increments of fibre in the diet. Given that the better an animals needs are met the better are its chances of a long life it is highly likely that these improvements could ultimately improve sow longevity. However a lot more research in this area is necessary. In addition more information is urgently required on the technical and environmental implications of feeding high fibre diets to pregnant sows.

Getting value from a cash flow in pig farming

Seamus Clarke

A cash flow could best be described as a prediction of our business into the future. They are generally carried out at the request of a lending agency at a time of expansion or development. When we construct the plan, be it for 12 months or 36 months, our goal is usually to secure the loan. We structure the production and cost factors with the most realistic expectations, and based on a profitable outcome. When our loan application is successful the cash flow is thrown into a drawer at best, maybe the dust bin. We seldom check the actual performance and returns against the planned ones!

Well it's time to retrieve the cash flow from its drawer and revisit the areas that have to be altered due to major changes that are occurring as we speak, especially in the feed area.

The first golden rule when planning is ***'be realistic'.*** We should base our plan on recent past performance of our herd, not national figures. Use ***your*** recent 'Teagasc Pigsys' performance figures to construct the cash flow. If you do not have these figures is it not time to obtain them.

Production data as a minimum requirement:

- Herd size
- Litters / sow / year/
- Number born alive
- Pre weaning mortality
- Weaner mortality
- Finisher mortality
- Weaner transfer weight
- Finisher sale weight
- Sow feed usage
- Creep and Link feed usage per pig
- Weaner FCE
- Finisher FCE

Financial data as a minimum requirement:

- Present pig price per kg
- Feed cost per tonne
- Income tax Nov 1st 2007
- Overdraft situation
- Interest rate on overdraft

Monthly costs:

- Repayments
- Leases
- Drawings / family
- Labour
- Energy
- Veterinary
- AI
- Manure handling
- Transport
- Environment costs
- Water charges

We in Teagasc, can make a reasonable ***'attempt'*** at predicting your financial situation over the next 12 months, if you provide us with the data as listed above.

Benefits of constructing the cash flow:

- You can forewarn your lending agency as to your financial requirements over the period.
- You can take steps to alter the herd performance in terms of health, floor space etc.
- You can revisit the feed regime and maybe adopt a more continental one
- You can make long term changes to your management routines

Let us focus on a few areas that will have a considerable affect on your 'overdraft' position over the next twelve months.

Previous two speakers outlined the cost of overfeeding creep, link and weaner to the growing pig, a practice all too often carried out on our farms. Were you to use the national Irish feed usage figures in combination with heavy weaner transfer weights in your cash flow for the next 12 months, the affect on your financial situation would be catastrophic!

The following scenarios are examined. Estimates of the overdraft situation are based on current (mid September) prices for feed and pigs. Changes in either feed or pig price will affect the outcome and the exercise is equally valuable in times of more profitable production.

The scenarios selected involve changes that could be implemented on your unit tomorrow and will have an immediate and significant effect on cash flow. It is assumed that repayments (€72,600), labour (€110,000) and family drawings (€36,000) are being paid from the operation as are feed, healthcare etc.

Change in management	**Amount of overdraft after 12 months assuming zero overdraft today (€)**
Starter and link feed usage	
3 kg and 6kg	47,181
4kg and 7 kg	56,663
5kg and 8kg	66,145
Weaner transfer weight	
32 kg	47,181
37kg	67,260
Finisher feed conversion efficiency	
2.6	28,192
2.7	47,181
2.8	66,170
2.9	85,158

For assumptions see Table 1.

In conclusion we must examine areas that affect our profitability and prioritize action that will help us survive the financial difficulties of the next twelve months. Talk to your Teagasc Pig Production Officer soon! As they say in the mobile phone advertisement ***'it's good to talk'***

Period 2007/2008	Full year	Per sow	Closing balance
Sow No's	**500**		
Total farrowings	1,135	**2.27**	
Born alive	12,486	**11**	
Preweaning deaths	1,124	**9%**	
Weaner deaths	511	**4.5%**	
Finisher deaths	**163**	**1.5%**	
Finisher sales	**10,352**	**20.7**	
Total net returns (A) €	1,139,659	**€109.58**	
Carcass sale wt	**Kg**	**75**	
Carcass price / kg	**€1.43**	€	
Transfer weaner weight	**Kg**	**32**	
Period 2007/2008	**Full year**	**Per pig**	
Repayments			
Repayments €1000/Sow 6% 10 yr	**72,600**	**€7.01**	
Pension & Life cover	**9,000**	**€0.87**	
Income Tax 2006	**0**	**€0.00**	
Insur/ Account/ Law	**10,000**	**€0.97**	
Total feed cost	810,866	**€78.33**	
Non feed			
Labour 3 staff	110,000	**€10.63**	
Family drawings	36,000	**€3.48**	
Energy	36,000	**€3.48**	
Veterinary	40,000	**€3.86**	
Transport	10,352	**€1.00**	
AI	11,000	**€1.06**	
Repairs & maintenance	12,000	**€1.16**	
Environmental costs	25,000	**€2.41**	
Mortalities disposal	2,400	**€0.23**	
Total costs (B) €	1,185,218	**114.49**	
Net balance (A-B) €	-45,559	-4.40	**-€47,181**
Creep feed per pig	**3**	Kg	
Link feed per pig	**6**	Kg	
Weaner FCE	**1.7**		
Finisher FCE	**2.7**		
Effect of c/ kg carcass rise	**0.01**	**€7,764**	**-€39,417**
Effect of € / tonne fall	**€5.00**	**€14,289**	**-€32,892**
Break even cost	**€ / kg**	**€1.52**	
Feed cost / kg carcass		**€1.04**	

Focus on Finisher Feed Efficiency

Michael Mc Keon, Tullamore

The current climate of high feed cost is reducing profit margins and the medium term outlook is for this trend to continue. Pig producers have no control over the world grain markets but they do have complete control over how this expensive input is utilized inside their farm gate. The biggest impact on your feed cost and profit margin may be your simple finisher feeder or feed trough.

A finisher feeder would generally be well down the list in terms of improvements or technical adjustments that could be made in the light of rising feed costs. It could be viewed as too simple and a 'bit old fashioned' but that would be a critical and costly mistake.

Feed accounts for approx 70% of the cost of producing a pig and the finisher period contributes 60% of the feed costs and 40% of total production costs. Your finisher feeder will have the biggest impact on your feed efficiency and profit margin.

As little as a 1% increase in finisher feed wastage will cost €4,700 per year for a 500 sow unit!

<u>It all adds up!</u>

The table below shows the feed throughput of a typical feeder on an average 500 sow unit based on 20 finisher pigs per feeder per pen.

Table 1: Feed throughput per lifetime of feeder

Feed / 20 pigs / day	=	**40 kgs**
(2kg/pig x 20)		
Feed throughput / year / feeder	=	**14.6 tons**
(40 kgs x 365 days)		
Feed throughput / feeder / lifetime	=	**146 tons**
(14.6 tons x 10 year lifespan)		
500 sow unit feed throughput	=	**18,980 tons**
(130 feeders x 10 year lifespan)		

The massive volume of feed throughput shows what a critical effect feeder selection and feeder maintenance could have on feed efficiency.

Feeder selection:

We see that the performance of the feeder may have a dramatic effect on feed efficiency due to the volume of feed passing through it. When building a new fattener house most people will spend time investigating slat type, ventilation systems, insulation etc, but the most critical factor, the feeder is ignored. The selection of a feeder is usually decided by one of the following:

- Replace with similar feeder used elsewhere as they are 'lasting well'.
- Been used by neighbour / other pig unit and seem to work ok
- This is the only feeder supplied by the equipment provider

Or most likely:

- Cheapest feeder

Even though a 10% difference in feed wastage can have a huge cost, nobody appears to ask which feeder has been shown by independent trials to be the most efficient. If feed costs €250 per tonne, **€36,500** worth of feed will pass through a feeder in its lifetime but people will choose a €160 feeder rather than a €180 feeder because it saves €20! **Don't buy a feeder without independent trial results**.

Feeder wastage:

A number of trials in the US have shown that there is a considerable difference in feed wastage from different feeder types. In general wet-dry feeders have less wastage then dry feeders but even within wet-dry feeders there is a considerable difference. Many wet-dry feeders have a solid pad in front of the feeders to reduce wear on the slatted floor. Evidence of feed on this solid area has been shown to indicate a high level of wastage. The table below shows effect on the feed cost per kg and savings per pig depending on the level of feeder wastage.

Table 2: Effect of finisher feed wastage (35-100kg) on feed cost/kg dead

% Feed Wastage	**Feed usage kg**	**Finisher FCE**	***Cost of feed €250 per tonne €***	**Feed cost / kg dead**
2	165.75	2.55	41.43	**101**
4	169	2.6	42.25	**102**
6	172.25	2.65	43.06	**103**
8	175.5	2.7	43.87	**104**
10	178.75	2.75	44.68	**106**
12	182	2.8	45.50	**108**

Based on feed intake from 35 – 100 kg with 76kg dead wt. Other feed costs @ €36.34.

The difference between an efficient and inefficient feeder could amount to 5 – 7 cent / kg dead.

<u>Feeder adjustment:</u>

No matter how well a feeder is designed it will not operate efficiently if not properly adjusted. The vast majority of single space feeders are never adjusted after they are installed. Frequently a build up of feed can be seen in the bottom of the feeder and in front of the feeder which immediately indicates poorly adjusted feeders and at least 12% wastage. The water nipples in many feeders are also leaking which further increases the wastage as feed falling off the shelf is washed out of the feeder and down the slats. The feed opening should be reduced when a pen is filled and then gradually opened up over the following weeks as the pigs get bigger.

As a rule of thumb approximately 50% of the feeder shelf should be visible and there should be little or no feed around the water nipple. Leaking nipples must be fixed immediately as these can have a huge effect on the volume of manure produced as well as on feed wastage.

<u>Feeder Placement:</u>

The position of the feeder in the pen will affect how well the pigs will use it and how often it is adjusted. Ideally a single space feeder should be placed away from pen corners, with the opening at a 90^0 angle to the pen wall and preferably within reach of the passageway to aid easy adjustment. Angle double wet-dry feeders (where the two openings are at 90^0 angle to each other) appear to work better than side by side or back-back feeders, as the pigs appear to 'dirty' the angle feeder less. Feed efficiency has been shown to deteriorate by 4% in side by side feeders then when compared to corner or back-back feeders (Walker, 1994).

Feeder Replacement:

Damaged or worn out feeders should be replaced immediately as the potential savings will pay for the new feeder within 6 months of replacement. Similarly research has shown that a switch from a conventional dry feeder to a wet-dry feeder will increase average daily gain by 5% and reduce the manure produced by 40%.

Optimum feeder feed:

In general feed efficiency should improve by 1.2 % for every 100 micron reduction in particle size but caution is advised as too fine a particle size may lead to an increased risk of gastric ulcers and of feeder bridging. In Denmark grinding feed too coarsely was costing pig producers significant amounts of money. The recommendation is to have 60% <1mm and 40% +1 mm while an 80%/20% target may be realistic for some farms. Feed of grist size 80/20 were shown to convert at 2.7 FU per kg gain compared to 3.15 for feed 35/50/15/5. If there are concerns about ulcers examine the stomachs of slaughter pigs.

Screens and hammers should be checked at least every 6 months as wear over time will adversely increase the feed particle size.

Units buying commercial feed could examine using pelleted feed instead of meal. It may seem ridiculous to be suggesting this in the light of today's exorbitant feed prices but that is exactly the time when pelleting can give a return. Pelleting a diet can improve FCE by 5-8% and average daily gain by 3% due to less spillage. Research in Hillsborough found an improved feed efficiency of 6% in pellets vs meal used in wet-dry feeders (Walker, 1994). This improvement alone would cover the pelleting cost (€15) without even accounting for the average daily gain benefit.

Wet Feeding

Wet feeding also requires careful attention and possible adjustment in order to maximize feed efficiency and minimize wastage.

Long trough feeding: These are now gradually being replaced by probe feeding but many are still in use. The important factors in these houses remain feeder space and in general the correct trough space per finisher is 33cm (13 inches) for pigs 32-92 kgs liveweight. However it is important to remember that in the intervening years since the house was built the slaughter weight may have increased (less sows or additional accommodation) without any change in the number of pigs per pen. If the slaughter weight has increased to 100 or 105 kgs then the trough space required is 35.5 and 38 cm respectively. Insufficient trough space will lead to increased aggression resulting in more feed wastage and larger weight variation at slaughter.

If this system is being fed four times per day then there may be an advantage in having a lower feed allowance in the morning and higher in the afternoon and evening, for example in a 18/18/36/28 feeding split. The feed is better utilized when closely matching the pig's appetite pattern.

Probe feeding:

There are three main advantages with probe feeding. The feed is available ad-lib, feed does not have to flow down a long trough and the pen design is more flexible.

Ad-lib: Having the feed available ad-lib results in less of a feeding scrum and therefore less aggression and wastage at feeding. This also allows more timid pigs to obtain higher feed intakes thereby reducing pen weight variation at slaughter.

Feed Flow: The trough used for probe feeding is usually much smaller than then the conventional long trough system and the feed therefore does not have to flow to the end of the trough. This could allow the water:feed ratio to be dramatically dropped e.g. from 3.5:1 to 2:1, if the feeding system was able to pump it. As a result the feed would be less 'sloppy' and therefore have less risk of splashing and spilling down the slats. Another advantage of the reduced water:feed ratio is that intakes of feed will increase as there is less of a water gut fill effect. This extra feed intake would increase ADG in the modern lean genotype finisher and the volume of manure been produced would also dramatically reduce. On a 500 sow integrated unit, a reduction in the water: feed ratio from 3.5 to 2.5 could reduce the volume of manure produced by **2000 m^3 (440,000 gls).**

Pen design: The shorter trough utilizes less pen floor space and therefore allows the pen length and width to be designed in such a way as to maximize the best use of available space. The lack of a step in probe feeders also eliminates the need to 'train' pigs and allows easier feed access for small pigs on entry thereby minimizing pen weight variation at slaughter.

<u>Top Trough Tips</u>

- Get independent trial results before purchasing any finisher feeder. A typical wet-dry feeder will have €36,000 throughput of feed in its lifetime.

- Feeders will only work properly if they are adjusted properly. For wet-dry feeders reduce the feed inlet when filling pen and increase as the pigs grow. Aim for 50% shelf coverage. 10-12% wastage will cost 7c / kg dead wt.

- Consider carefully where the feeder will be placed in pen: away from corners, near centre passage etc

- Replace dry feeders with wet-dry feeders as they can increase ADG by 5%

- Replace all damaged / worn out feeders **<u>immediately</u>** as the new feeder will pay for itself with 6 months

- If home milling check screens, hammers, discs etc every 6 months for wear.

- Consider pelleting as a way of maximizing the feeds nutrient content

- Long trough – Check pen size and trough space allocation especially if slaughter weights have risen in recent years

- Probe feeding – Aim to reduce water:feed ratio to 2.5:1. Whether this can be done will depend on the cost of adjustment to your feeding system but remember that this cost will be offset by increased growth rate and dramatically reduced manure production.

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Pig Production Costs in Ireland and Europe

Michael A Martin

Profitability in pig production is determined not alone by the price received per kg but also by the cost of production per kg. While producers can exert a limited influence on the price obtained they can, usually, exert a significant influence on the cost of production. The extent to which they are successful in minimising production costs can be established by benchmarking against other units. Benchmarking is essential for individual units but it is also more than useful to compare the production costs in different countries using standardised formulae.

Production Costs in Ireland 2006

In 2006 the average cost of production was 123c per kg dead weight in herds participating in the Teagasc Pig recording System (PigSys) and for which costs were available.

Table 1: Production costs in Ireland 2006

Cost Category	**Cost**	**Cost per kg c**
Feed		79.6
Common	Labour	15.5
	Healthcare	5.1
	Heat, power, light	4.2
	Repairs	3.2
	Manure	2.3
	Others	6.5
	Total	36.8
Herd Specific	Building Depreciation	4.9
	Interest	1.7
	Total	6.6
Total		**123.0**

Source: Teagasc PigSys Report 2006

The herds that participated in PigSys in 2006 represented 30% of the national herd. However, there is a very strong possibility that these are the better performing herds rather than a representative sample of all herds in the country.

The composite feed price for these herds in 2006 was €211.65 and includes herds using by-products as well as home compounders. By early July 2007 the composite meal price for herds using purchased compound feed had increased from an average of €215 in 2006 to €244.40 per tonne. This would have increased the feed cost to 90.6c per kg.

Low building depreciation and interest costs reflect the low level of capital investment in units over the last decade.

These figures provide a standard against which individual units can benchmark. However, this means that accurately calculated costs of production are required for each unit being benchmarked.

Feed Costs Compared

The InterPIG project currently involves 10 European countries who share information on costs of production. Among the countries involved are Denmark, Germany, the Netherlands and France, as well as Great Britain and Ireland. These are all major producers of pigmeat.

Table 2: Feed cost per kg in selected EU countries 2006

Country	Feed Cost per kg dead c	Composite Feed Price € per tonne
Denmark	64.5	173
France	65.5	169
Germany	64.7	164
Great Britain	71.8	187
Ireland	80.3	212
Netherlands	64.0	177

For the main EU pig producing countries the feed cost per kg dead in 2006 was about 65c whereas it was about 80c in Ireland. The composite feed price in Ireland (€212 per tonne) was considerably higher than in Denmark (+€39), France (+€43), Germany (+€48) and the Netherlands (+€36).Some of this difference in feed cost per tonne is due to the lower carcass weight in Ireland. In Ireland finisher feed represents a smaller proportion of the total feed per pig (Table 3).

In any comparison of feed prices between countries account should be taken of possible differences in diet specifications.

Pig feed prices place Irish pig production at a serious disadvantage compared to the main EU pig producing countries. To counteract this

1. Renewed efforts are required to reduce the cost of feed ingredients and of compounding feed.
2. Producers need to focus on using the most cost-beneficial combination of diets
3. Improved feed efficiency on units is a top priority

Table 3: Pig slaughter weights selected EU Countries 2006

Country	Average Dead Weight kg	Finisher Feed as % Total Feed
Denmark	79.4	67
France	88.4	70
Germany	92.1	72
Great Britain	75.4	60
Ireland	74.0	62
Netherlands	88.4	75

Because of the lower slaughter weights the Feed Conversion, expressed on a carcass weight basis, is better in Ireland than in France, Germany and GB but not Denmark or Netherlands (Table 4)

Table 4: Carcass Feed Conversion in Selected EU countries 2006

Country	Carcass Feed Conversion
Denmark	3.74
France	3.88
Germany	3.96
Great Britain	3.84
Ireland	3.78
Netherlands	3.61

Common Costs Compared

Common costs refer to costs that are incurred in most if not all production units. The figures reported for the countries selected vary considerably (Table 5).

Table 5: Total Common Costs and Labour Costs per kg dead weight in Selected EU countries 2006

Country	**Common Costs per kg dead c**	
	Total	**Labour**
Denmark	42.7	15.5
France	43.4	18.3
Germany	50.5	17.7
Great Britain	56.9	19.7
Ireland	38.3	15.4
Netherlands	40.0	16.5

Labour is the single largest cost item after feed. Differences in labour costs per kg do not fully explain the differences in common costs between countries. There a significant difference between countries in some of the other substantial Common costs including Energy, Manure and Repairs (Table 6).

Table 6: Healthcare, Energy, Manure and Repair costs in selected EU countries 2006 (c per kg)

Country	**Healthcare**	**Energy**	**Manure**	**Repairs**
Denmark	4.7	4.0	3.4	9.9
France	5.1	2.5	3.4	1.2
Germany	6.1	6.7	3.1	4.2
Great Britain	4.2	2.2	4.8	11.7
Ireland	5.2	4.2	2.4	3.2
Netherlands	4.0	6.4	4.9	2.8

Healthcare costs are quite similar. Both France (2.5c) and GB (2.2c) report low energy costs per kg. French electricity prices are low while outdoor herds represent a significant component of production in GB and may account for the relatively low energy costs there. Manure costs are highest in the Netherlands (4.9c). The cost of repairs in both GB and Denmark are very significantly higher than for the other countries listed.

Housing Costs Compared

The cost of new housing varies from country to country due to differences in slaughter weights and to differences in production systems. Housing costs are compared on the basis of the cost of depreciation of new buildings. This assumes that 55% of the cost is structure and 45% is equipment (Table 7).

Table 7: Pig Housing and Building Depreciation costs in Selected EU countries 2006

Country	**Building Cost per Sow Place €**	**Building depreciation c per kg dead**
Denmark	5232	20.2
France	5786	20.5
Germany	5705	22.3
Great Britain	3688	18.0
Ireland	4032	17.8
Netherlands	4598	15.7

Total Production Costs

Combining the feed, common and housing costs for the six countries reported the total production costs (excluding financial charges) are lowest for the Netherlands followed by Denmark, France and Germany. These countries all have lower production costs than Ireland. Total costs are highest in GB.

Table 8: Production costs in selected EU countries 2006

Country	**Production Cost per kg dead c**
Denmark	127
France	129
Germany	138
Great Britain	147
Ireland	136
Netherlands	120

Summary

Some of the substantially higher Feed costs per kg deadweight that apply on Irish pig units are offset by lower Common and Housing costs. However production costs are higher in Ireland than in four major pig producing countries viz. Denmark, France, Germany and the Netherlands. Only Great Britain, among the countries reported on, has higher costs of production.

Coping in Periods of Tight Feed Supplies

John F. Patience

Prairie Swine Centre Inc., Saskatoon CANADA

1. SUMMARY

Feed ingredients are increasing in cost and decreasing in availability for a variety of reasons. While the emerging biofuels market is cited as the most common or prominent cause, there is a worldwide decline in stocks of many common feed ingredients; this is a cause for concern because it would suggest that the very high feed costs of today are unlikely to dissipate any time soon. Consequently, pork producers must undertake a thorough review of their feeding programs to ensure they are 1) purchasing ingredients in the most cost-effective manner possible, 2) using those ingredients in diet formulations such that net income will be maximized and 3) adopting new approaches to feeding pigs, through either the use of a flexible array of ingredients or processing existing ingredients to ensure that they are being used to greatest advantage.

The pig has demonstrated over time and in diverse regions of the world that it can adapt to a surprising array of diet composition; when ingredients are expensive, the pig's diet diversity must be exploited to maximum advantage. Furthermore, this is an opportune time to reflect on the manner in which feed ingredients are purchased, to determine if the dollars available for feed are being used most effectively. For example, some off-spec grains are a bargain, provided of course that the grain is still safe to feed.

Diet formulation is often undertaken considering only the nutrient requirements of the pig and the ingredients available in the mill or on the farm. However, there is a third factor that is just as important - economics; the nutrient specification of diets should not be constant, but rather they should reflect the changing economic reality of the marketplace. Diet formulations or nutrient specifications that maximized net income when market prices were strong and feed costs were low are unlikely to be optimal when market prices soften and/or feed costs rise. Consequently, now is a very good time to re-evaluate not only the ingredients being used, but also the nutrient "requirements" applied to each class of pig.

Finally, the current conditions represent an ideal time to consider other approaches to lowering costs or increasing revenues. This could include the use of enzymes, if they are not yet being used. This is also a very good time to re-visit all aspects of one's operation to ensure that the basic principles of pigmanship are being adhered to, that labour efficiency is optimal, that the barn is operating effectively and efficiently and that all costs, no matter how minor, are scrutinized in detail. Most critically, this is a time to ensure that records are being kept on the right items and that decisions are being made on the basis of those records. The oft-cited business mantra that "I cannot manage what I do not measure" applies to pork production as much as to any other business.

It is impossible for the individual pork producer to take on all of these tasks and expect to be successful. It is recommended therefore that first, the easiest items – the low hanging fruit as it is sometimes called –receive first priority, followed by items that are expected to provide the greatest return to the farm.

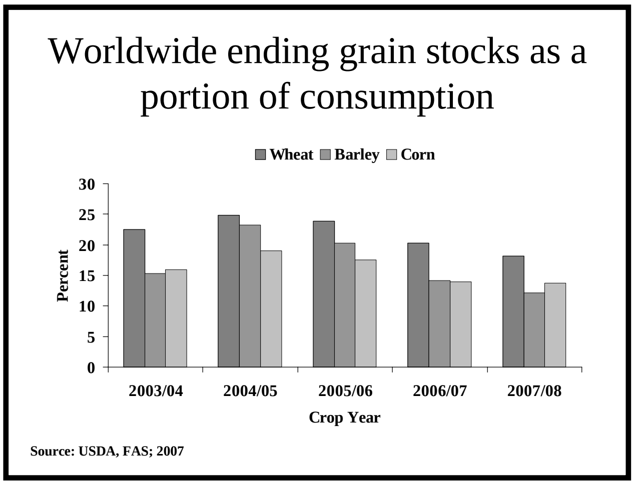
2. INTRODUCTION

Historically, animal agriculture has competed with the human food market for feeding materials; the relatively recent entry into the marketplace of another large and powerful competitor – biofuels - is indeed cause for concern. The livestock sector addressed competition from the human food industry in a number of ways. It produced competitive products (meat, milk and eggs) that were desired by the consumer. It utilized some ingredients that could not enter the human food system due to quality concerns, related in some cases to nutrient profile and in other cases to visual appeal (eg colour, kernel size and shape, etc). Thirdly, the livestock sector utilized by-products of the human food industry, such as whey, bakery by-product, etc. With only the human food sector to contend with, the quantitative demand for raw grains was such that the livestock industry could co-exist by using that portion of the annual crop that was not required by the human food sector. However, a new competitor on the scene, particularly one with such strong political support and growing at such as rapid rate, will most certainty result in change in both the animal feed and human food sectors.

A doubling of the portion of the US corn crop directed to ethyl alcohol, or ethanol, production in the past decade, and the expectation that it will double again within the coming decade, has created concern regarding the availability of corn, wheat and other grains for use in livestock diets in the future. Global ethanol production exceeded 61 billion litres in 2006, an increase of more than 25% in the last two years (RFA, 2007). However, the biofuels sector is not the only reason for the current increase in grain prices.

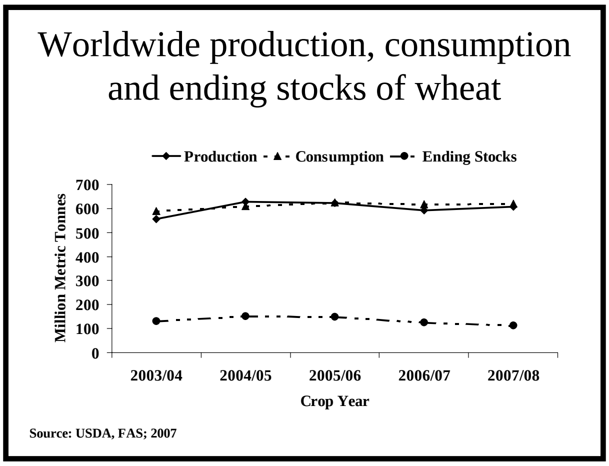
3. WORLDWIDE FEED GRAINS SUPPLY

A number of circumstances have come together to put pressure on global grain supplies, and thus increase prices and challenge supply. Cereal grains are being impacted by a combination of increased demand and poor crops in prominent exporting nations. The accompanying figure (right) shows that ending stocks, presented as a portion of total annual consumption, has declined 4 years in a row for wheat, barley and corn. This does not bode well for near-term pricing, and unless conditions change, high grain prices could be with us for a number of years. Of course, bumper crops in key regions could almost immediately relieve pressure on supply, but if demand continues to rise, even large crops may not be sufficient to lower prices.



3.1. Wheat

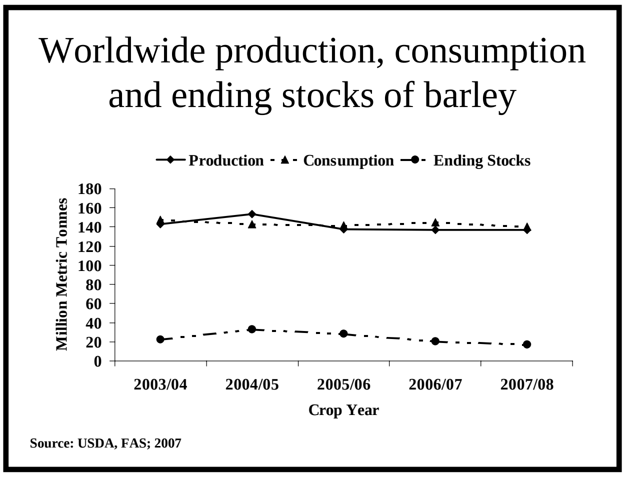
Projections for global wheat production in 2007/08 continue to be projected downward from earlier estimates, as declines in the crops in the EU, Australia and Canada exceed increases in the former Soviet Union. As a result, wheat stocks in the U.S., for example, are expected to be the lowest since 1977/78 (ERS, 2007). Indeed, global consumption has outstripped production in 4 out of the last 5 years (See figure below). Australian exports are projected to be down 1.5 million tonnes, or 10.3%, due to smaller crop prospects arising from continuing dry weather. Canada is also expected to be down by 1 million tonnes, or 6.7%, due to deteriorating crop conditions, namely dry weather during the end of the growing season and rain during harvest. EU exports are projected to be down by 1.0 million tonnes due to very poor weather conditions. On the other hand, Russian exports are projecting upward by 1 million tonnes, or 9.1%, due to an expected good crop and the U.S. is also up by 1.0 million tonnes, or 3.4% (FAS, 2007). The net effect is major increases in wheat prices to levels not seen in more than a decade. For example, the projected farm gate price in the US is expected to range from



US$5.50 to US$6.10 per bushel; the previous record, in 1995/96 was US$4.55 per bushel (E.R.S., 2007).

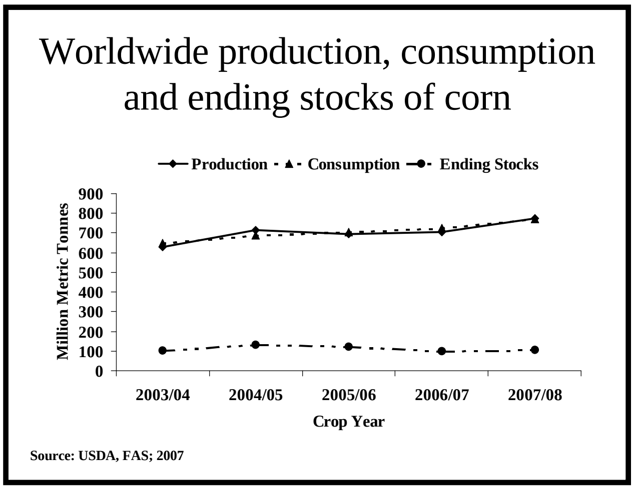
3.2. Barley

Barley supplies are limiting, accounting for recent increases in price; for example, prices in northern Europe rose 25% in August alone. Like wheat, barley consumption has exceeded production in 4 out of the last 5 years (see figure right). The Ukraine, which typically accounts for 16% of total global exports, has a poor crop and therefore has imposed export restrictions to ensure adequate domestic supplies and keep local prices under some degree of constraint. Russia is also expected to impose export controls in the next few months. Finally, Australia, which normally accounts for a third of global barley exports is facing a combination of lower crop projections (500 thousand tonnes or 10%) and declining exportable supplies. Canadian barley exports are projected to increase by 600 thousand tonnes, or 43%, again due to strong global competition; if so, Canada's exports of barley will be the highest in over a decade (FAS, 2007).



3.3. Corn

In contrast to the wheat and barley situations, which are largely supply driven, corn prices have surged on the basis of increased demand, largely in Europe. U.S. corn exports are up 2.5 million tonnes, or 4.6%. The United States is by far the largest exporter of corn at 57 million tonnes, or 63% of the world total. Interestingly, domestic demand for corn in the U.S. has been projected downward in recent months, as ethanol plants appear to be running at something less than capacity and new plants are not coming into production as quickly as expected (E.R.S., 2007). Combined with a larger than expected corn crop with near record yields, and the prospect of softer, or at least stable corn prices in the near future is very real. The 2007 U.S. corn crop is projected to be 371 million tonnes, an increase of 21% compared to 2006 (E.R.S., 2007). Whereas world wheat and barley ending stocks in 2007/08 are



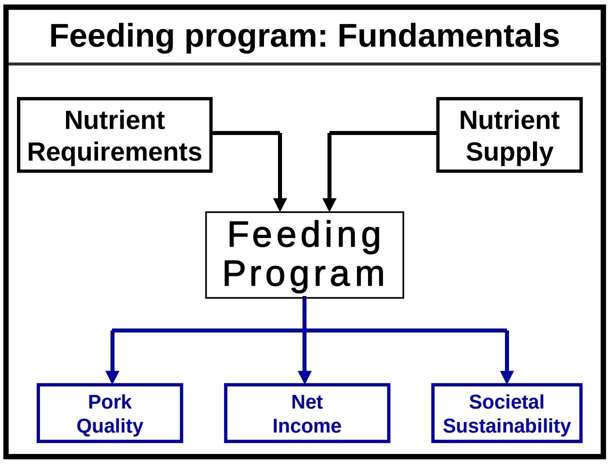
projected to be 84% and 77%, respectively, of that reported in 2003/04, corn stocks may actually be increasing (FAS, 2007). Corn exports from Brazil are projected to increase 1.0 million tonnes, or 14.3%, driven by high feed grain demand in the EU. EU imports of corn are up by 2 million tonnes, an incredible increase of 33% (FAS, 2007).

Of course, the domestic ethanol industry in the US is accounting for an increasingly large portion of their total corn crop. In 2007, ethanol production is expected to consume about 25% of the total US corn crop, up from 20% in the previous year.

There are some concerns regarding the future price of corn, despite the relatively bullish outlook for the current crop year. The increase in both acreage and yield prevented a shortage of corn this year; however, yields are only partly under the control of the grower, and unfavourable cropping conditions in future years could reverse the current situation. The expected yield achieved in the 2007 corn crop of 155.8 bushels per acre is not a record, but it does represent a substantial increase over the 149.1 bushels per acre reported in 2006 and is very close to the record of 160.4 bushels per acre reported in 2004 (NASS, 2007). It is obviously not reasonable to count on near record yields every year, so some uncertainty with respect to supplies remains in the marketplace.

4. INGREDIENT SELECTION: Basic concepts

With market conditions like those present in Europe today, it is a good time to review the basic principles of feed ingredients selection. This generally involves consideration of at least four factors: economics, availability, quality and palatability. The development of feeding programs is going to be most successful when we consider both nutrient requirements and nutrient supply in order to achieve our objectives as they relate to final product quality, financial returns and societal sustainability (see figure below). With this approach fixed in our minds, then ingredients, which are present to satisfy nutrient supply and other pig needs, are easily selected in the context of the overall objectives of our farm. For example, if we are growing crops on our farm, we are faced with the decision of whether to feed that which we already own or to sell the crop and buy back other ingredients that may provide the potential for greater profit.



However, such decisions cannot be made outside the context illustrated on the left, because net income may not be the sole factor to consider. We may be limited in the ingredients we can employ because the buyer of our pigs has placed restrictions on either the type or the nature of the ingredients they allow (eg organic). In any case, ingredient selection cannot occur in a vacuum, but must consider all of the other aspects of our farm.

Also, although it is beyond the scope of this presentation, the nutrient requirements of the pigs on our farm(s) must be well understood. Nothing else will be fully successful if this information is not in place. Many people unfamiliar with our business are surprised when we point out that nutrient requirements not only change with genetics or health, but also with economic conditions. The feeding program that maximizes net income when pig prices are strong and feed cost is low is unlikely to maximize net income when pig prices have slumped and feed costs have risen. In other words, nutrient requirements are not static, but in fact are dynamic across farms and time.

4.1. The pig's needs

The pig has evolved as an omnivore through thousands of years of evolution. As a result, the pig can adapt to a very wide diversity of diet composition and still perform very well (Patience et al., 1995). This is amply demonstrated by the wide array of diets employed in different nations of the world, all of which achieve quite impressive performance. Unfortunately, within nations or regions, there is a tendency to derive comfort – for the producer but not necessarily the pig – from feeding diets that vary little in their composition. One of the strengths of pork production is the ability of the pig to utilize a vast array or raw or processed ingredients, from wheat and barley through distillers grains and wheat shorts.

As an example, much of North America feeds a basic corn-soybean meal diet, while some regions within the continent, such as the Prairies of Canada, feed diets based on cereal grains. Pork producers from the Prairies are sometimes as uncomfortable with corn-soy diets as American producers are with barley-based diets; yet, there is no fooling the pig, which performs equally on both types of diets! Often, ingredient selection has more to do with a producer or nutritionist's experience than it has to do with the digestive abilities of the pig! Fundamentally, ingredient selection should be based less on our perception of the pig's preferences and more on the economics, availability, quality and palatability of the available ingredients.

4.2. Economics and availability

In western Canada, many producers are seriously looking at importing corn from the United States to be used in place of the more traditional wheat, since the price differential, even after paying freight, is in the range of CAD20 to CAD30 per tonne. In this instance, the economics are too compelling to ignore, even if our farms are sitting in the midst of millions of acres of wheat this year!

Economics and availability of the ingredient generally go hand-in-hand; few producers or nutritionists will tolerate uncertain or sporadic availability of an ingredient, no matter how appealing the price. However, if an individual producer has the capacity to deal with such ingredients, they are often priced very competitively, because there are fewer interested buyers.

Local opportunities are often available, particularly if there is an active food processing industry. Common examples include liquid whey, bakery product, various fat sources and wheat milling by-products. Given the popularity of liquid feeding systems in Ireland, I assume that the use of by-products is a very common practice.

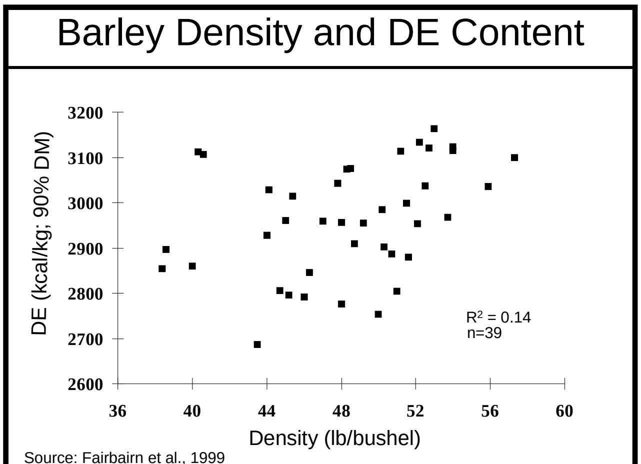
4.3. Quality

Ingredient quality is a much more difficult subject to address, because quality can mean different things in different circumstances. Most feed mills in Canada, including those on-farm, employ purchasing standards for all ingredients. Purchasing standards are essential to ensure that the quality of the product put into the feed is consistent with the quality of ingredient assumed in the formulation of the diets. Errors in something as simple as dry matter content can lead to costly mistakes; they may or may not be seen in animal performance, but they certainly are seen in net income.

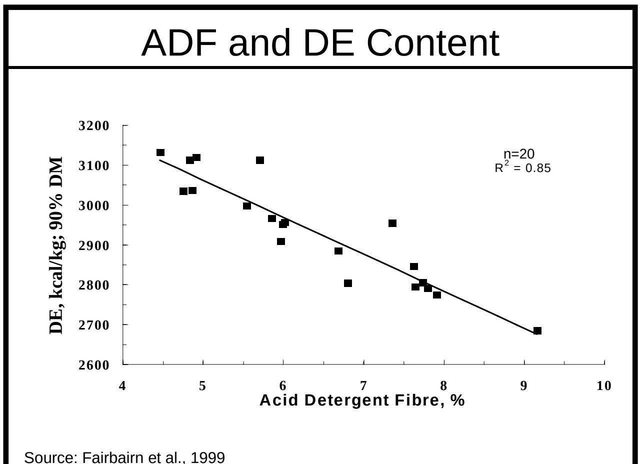
Ingredient quality can generally be considered in the context of 3 broad areas:

✓ Physical characteristics

Physical characteristics include such readily measurable criteria as bushel weight. However, the emphasis we place on bushel weight far exceeds its value in feeding pigs. The following figure illustrates how poorly bushel weight predicts the energy or feeding value of barley to the pig; bushel weight explained only a fraction of the difference in energy content that existed among barley samples. Acid detergent fibre, or ADF, was able to predict the DE



Source: Fairbairn et al., 1999



Source: Fairbairn et al., 1999

content of barley quite well. For example, a 1 percentage point increase in ADF lowers the DE content of the barley by about 3%. We have seen the same results with wheat, except the best predictor of the DE content of wheat is a combination of crude protein and neutral detergent fibre (NDF).

✓ Chemical composition

Chemical composition can be determined directly in a laboratory, or it can be estimated using such technology as Near Infrared Reflectance or NIR (Smelt et al., 2007). We recommend that samples of every new grain crop be analyzed for basic chemical composition, such as dry matter, crude protein and the appropriate fibre component (ADF for barley and NDF for wheat) to determine if the new crop differs from that which was used in the previous year. If differences exist, then adjustments in nutrient profile will be required. For cereal grains, our greatest interest is amino acid and energy content, explaining why crude protein and fibre are the laboratory tests of choice. Crude protein values can be converted to amino acid levels using prediction equations. For example, lysine can be estimated from crude protein using the following equation:

$$\text{Lysine (\%)} = 0.142 + (\%CP \times 0.0227)$$ Source: Degussa, 2006

where CP is crude protein. All calculations are done on an as-fed basis.

✓ Contamination

Physical, biological and environmental contamination represents potential risks to the quality of grain samples (Jones, 2007). Physical contamination, such as with dirt, stones, etc is easily observed and is more of a concern with certain crops, like field peas than cereal grains, due to harvesting conditions.

Biological contamination is worrisome, as it poses a potential risk to the health of the pigs. This includes microbial contamination which poses a threat to the health of the pigs and fungal contamination which may lead to mycotoxins; either can be difficult to detect because moulds and microbes may not be uniformly distributed throughout the bin or truckload and tests for contamination are either slow and expensive or imprecise.

Weed seed contamination can be bothersome, because it is almost impossible to completely avoid, and yet even small quantities of certain weed seeds can put pigs off feed almost immediately.

Environmental contamination is rare, but when it occurs, the impact can be very serious. High profile examples include fertilizer contamination of ingredients, likely occurring during trucking, and dioxin contamination of fat sources (Neuberger et al., 2000).

4.4. Palatability

Anyone familiar with pigs understands that they possess a keen sense of smell, and also of taste. Odour, flavour and other sensory capabilities along the digestive tract of the pig will either stimulate further feed consumption or discourage it (Roura, 2007). Thus, the existence of the ability in pigs to smell and taste is undisputed; however, controversy often occurs when the pig's specific preference in terms of feed taste and smell are discussed by humans. It is an extremely difficult field of science and while virtually everyone has experienced an "off-feed" event in their barn at some time or another, selecting preferred or avoiding disliked ingredients or feed is problematic. Research continues in this area, as breakthroughs in factors stimulating appetite would be extremely valuable to our industry. Table 1 provides an interesting example of such research. In this study, the ileal and total tract digestibility of the dry matter, organic matter and crude protein of 4 cereal-based diets were measured and correlated to the pig's preference for each diet.

Table 1. Pearson's correlation coefficients between feed preferences of four cereal based diets and their ileal and faecal nutrient digestibility.

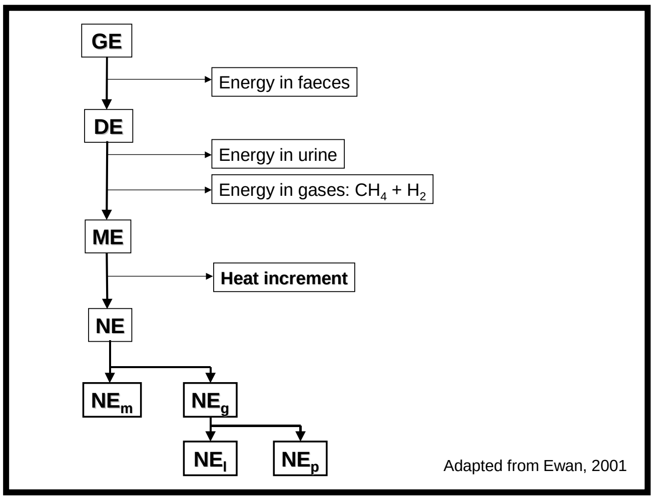
	Dry matter	**Organic matter**	**Crude protein**
Ileal digestibility	0.618	0.618	0.615
Faecal digestiblity	0.910	0.899	0.683

Source: Solà-Oriol et al., 2007.

5. INGREDIENT EVALUATION

5.1. DE vs NE

In order to effectively evaluate feed ingredients, and thus effectively formulate diets, we must have a system in place for measuring their energy content. In Ireland, as in many parts of Europe and North and South America, the digestible energy (DE) or metabolizable energy (ME) systems are most common. However, in continental Europe, the net energy (NE) system has gained popularity. Whereas the DE system adjusts for the portion of the ingredient/diet that is lost in the faeces, and the ME system adjusts also for that lost in the urine, the net energy system also takes into account the widely



differing efficiency with which absorbed components of the diet can be used for maintenance and productive purposes. For example, that portion of fibre and protein which is digested by the pig is used with much less efficiency that that portion of the starch and fat which is digested. The NE system takes this into account.

Table 2 illustrates how the different energy systems will rank ingredients against each other. In this example, the DE, ME and NE content of corn is set at 100 and the energy values of other ingredients are presented in relative terms. For example, the ratio of NE:DE or NE:ME is highest for fat sources, such as tallow, and lowest for high protein ingredients such as soybean meal. Cereal grains will be intermediate between the two. A narrower ratio means that a higher portion of absorbed energy will be available for productive purposes. The ratios in Table 2 show that pricing ingredients as energy sources according to the NE system will be more appropriate than according to the ME or DE systems, which tend to overvalue, in relative terms, some ingredients and undervalue others. It is generally accepted that the NE system is superior to DE and ME in terms of relative pricing of ingredients.

Table 2. Effect of the choice of energy system on the relative energy value of common feedstuffs

Ingredient	**DE**		**ME**		**NE**		**NE/DE**	**NE/ME**
	Mcal/kg	**Index**	**Mcal/kg**	**Index**	**Mcal/kg**	**Index**	***100**	***100**
Corn	3.78	100	3.65	100	2.97	100	79	81
Peas	3.88	103	3.75	103	2.64	89	68	70
Wheat	3.87	103	3.78	104	2.97	100	77	79
Soymeal	3.91	103	3.65	100	1.93	65	49	53
Tallow	7.13	189	7.07	194	7.00	235	98	99

Data from Noblet et al., 1994. All data presented on a dry matter basis. "Index" compares all ingredients to corn, whose respective energy value has arbitrarily been set at 100 for comparison purposes.

To be completely successful, an energy system must also achieve a high degree of predictability in animal performance. In other words, any gains achieved in pricing could be lost if the NE system is inferior to the DE or ME systems for actual diet formulation and achieving optimum pig performance. We are still studying this question, but in the weanling pig, we have already observed that the NE system is no worse than the DE system in this respect and in fact is superior in terms of predicting fat accumulation in the pig (Table 3).

Table 3. Correlations among DE or NE intake and barrow performance between 9 and 25 kg.

Variables	Correlation coefficient	P values
<u>DE intake, and</u>		
- ADG	0.9146	0.0001
- ADFI	0.9858	0.0001
- Gain/feed ratio	-0.1372	0.2218
- Empty body PD	0.9238	0.0001
- Empty body LD	0.8006	0.0001
- Empty body LD:PD ratio	0.6009	0.0001
<u>NE intake, and</u>		
- ADG	0.8971	0.0001
- ADFI	0.9625	0.0001
- Gain/feed ratio	-0.1220	0.2781
- Empty body PD	0.9045	0.0001
- Empty body LD	0.8476	0.0001
- Empty body LD:PD ratio	0.6664	0.0001

Source: Oresanya, 2005. ADG = average daily gain; ADFI = average daily feed intake; PD = protein deposition; LD = lipid deposition.

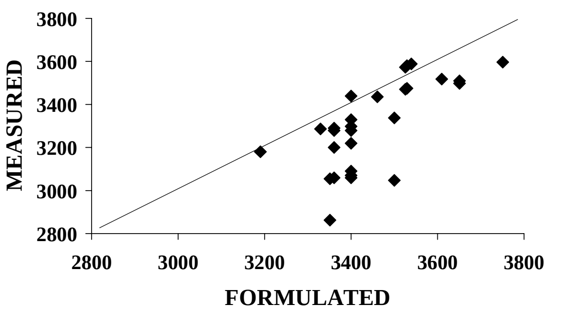
All energy systems are challenged by the variability that exists among individual pigs. This variation may be as overt as differences in body composition, or could be as subtle as differences in maintenance requirements. The challenge is compounded by the impact of the environment on such things as the maintenance requirement and by the interactive effects of diet composition on animal growth.

The composition of growth of the pig, as well as the relationship between maintenance and growth, is an important variable, because the efficiency with which the pig uses energy for lean gain differs from the efficiency of energy used for lipid gain. The energetic efficiency of protein gain has been estimated by the NRC (1998) to be 10.6 kcal ME/kg compared to that for lipid gain of 12.5 kcal ME/kg. The difference in energetic efficiency of protein versus lipid gain is magnified by the much greater quantity of water associated with protein gain as compared to lipid. Thus, the energetic efficiency of lean gain is much greater than the energetic efficiency of fat gain. The net energy system recognizes this important fact, but commercial nutritionists rarely know the composition of gain of their pigs, so that adjustments in energy supply are difficult. Recently, this is changing, as we develop an increased understanding of commercial genotypes.

5.2. Ingredient variability

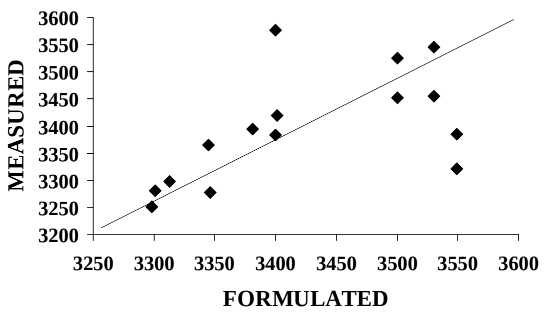
The inherent variability in ingredients remains a challenge, irrespective of the energy system employed. The livestock industries are slowly acknowledging that great variability exists in the energy content of common feed ingredients (Table 4; Fairbairn et al., 1999). All of the feed ingredients commonly used by the pork industry vary much more in energy content that most of us expected. The challenge rests in finding a solution to this problem; certainly bushel weight, the ubiquitous trading standard in the grains industry, must be discarded since for other than extreme highs and lows, it has proven to be a poor indicator of actual value to the pig (Fairbairn et al., 1999).

FORMULATED VERSUS MEASURED DE CONTENT (Kcal/kg) OF DIETS FED TO WEANLING PIGS



Sources: Levesque, 2001; Oresanya, 2003

FORMULATED VERSUS MEASURED DE CONTENT (Kcal/kg) OF DIETS FED TO GROWOUT PIGS



Sources: Lorschy, 1998; Ekpe, 2000

The problem of ingredient variability is clearly illustrated in the two figures below. In each, we have graphed the formulated DE versus the DE actually measured in pigs on experiments conducted at the Prairie Swine Centre. Clearly, we tend to overestimate the energy in weanling diets, but even for growing and finishing pigs, we do not achieve the level of precision in diet formulation that we would like. Errors of this magnitude will definitely have an impact on pig performance.

Table 4. Variation in the DE content of common feed ingredients

Ingredient	Range in DE		Energy Digestibility	Best Indicator	Source
	Mcal/kg DM	%		%	
Barley	3.0 to 3.5	15	73.6 to 78.1	Fibre	Fairbairn et al., 1999
Corn	3.5 to 4.0	13	86.3 to 88.8	Fat	Personal communication
Field peas	3.4 to 4.2	19	84.9 to 93.6	?	Zijlstra et al., 1998
Wheat	3.4 to 4.1	19	80.3 to 88.0	Fibre	Zijlstra et al., 1999

Ingredient variability can be addressed in a number of ways. First, ingredient samples can be appropriately analyzed in order to more precisely define the nutrient composition of a specific sample of grain. This approach is better suited to farms growing their own grain, where the sample will be used over an extended period of time; on farms or in feed mills where ingredients are constantly being purchased, this approach is too slow and cumbersome (Patience and Zijlstra, 1998). Considerable progress has been made in the use of NIR to rapidly sample ingredients; this approach is much faster than traditional laboratory analysis, but is only accurate if the prediction equations are constantly updated (Smelt et al., 2007).

Ingredient variation can also be handled statistically (Evans, 2004). For example, in a simple diet formulation with one grain and one protein source, an error in estimating the nutrient composition of one of the two ingredients could seriously alter the nutrient content of the diet. However, if the diet contains 2 or 3 grains and 2 or 3 protein sources, errors in each ingredient are likely to average out, such that the final diet contains nutrient levels closer to that formulated than would be the case in the simple diet.

Fundamentally, the goal of ingredient evaluation is to identify samples of ingredients with inferior nutrient content, so they can either be segregated according to their nutrient content, or discarded. Within reason, lower quality ingredients can be effectively used in pig feeding programs, provided they can be identified, characterized, priced appropriately and handled easily within the feed milling complex.

6. INGREDIENT PROCESSING

Ingredients are processed for a variety of reasons, listed below. Many of these allow us to utilize ingredients that might otherwise be inappropriate in the diet of the pig, or would be of much less nutritional value to the pig. In any case, processing becomes an important part of any strategy designed to address increasing feed costs and reduced availability of feed ingredients.

✓ To alter the physical form or particle size

Mixing unprocessed grains into a diet with other ingredients, such as soybean meal, minerals or vitamins, would result in a blend that would be almost impossible to mix and keep mixed. The diversity of particle size would virtually guarantee that as soon as the mixture was moved or transported, it would start to "un-mix." The result would be poor and uneven performance.

✓ To improve nutrient availability

The simple act of grinding ingredients such as cereal grains makes them more digestible to the pig. For example, lysine in ground wheat is 12% more available than in rolled wheat. The energy component of ground grains is also more digestible than that of whole grains. Pelleting, extruding and expanding are also used to improve nutrient availability.

✓ To isolate specific parts of the plant or grain

Some grains are increased in value to the pig by removing the less digestible components. As an example, the hull is removed from oats to produce oat groats. Oat grain is a low energy ingredient with limited value in pig diets. Oat groats, on the other hand, is a highly valuable ingredient with high energy and a well balance protein component.

✓ To improve handling

Processing is used to improve the handling characteristics of certain ingredients. For example, pelleting may be used to improve the flow of feeds and to reduce the risk of separation. Much higher levels of fat can be added to pelleted diets than to mash diets. Consequently, even when diets are manufactured on the farm, Stage 1 and Stage 2 starters are often purchased as a crumble or short-cut pellet.

✓ To improve palatability

Certain ingredients in the diet of the pig are not very palatable if offered as a sole product, but are readily eaten if mixed with other ingredients. For example, some amino acids, vitamins and minerals are not particularly palatable, but when added to the diet, are consumed in sufficient quantity to meet the pig's nutrient requirements.

✓ To preserve

Although not a common reason in pig diets, some ingredients are processed to improve their shelf life. For example, in areas where corn is fed in large quantities, the wet grain is ground and placed in a tightly sealed silo to prevent spoilage. Otherwise, wet corn would be susceptible to mould growth. Another option would be to add organic acids, which through the process of acidification impair spoilage.

✓ To detoxify

Grains, and particularly pulse crops, are often cleaned to remove dockage. Dockage may contain highly unpalatable or toxic weed seeds or other contaminants. Soybeans are heated during the production of soybean meal to remove anti-nutritive factors that are heat labile (destroyed by heat). Feeding raw soybeans to pigs will result in poor performance.

✓ To improve feed uniformity

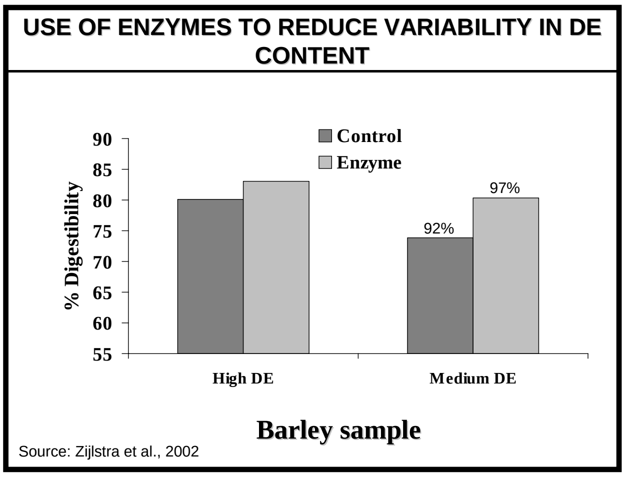
Grinding, mixing and pelleting are three commonly used processes to improve the uniformity of a diet mixture. This is particularly important in the young pig that consumes very small amounts of feed per day, so that each mouthful must contain a balanced mixture of nutrients. Although less sensitive than the young pig, growing pigs and adults also need a reasonably uniform mixture to maximize performance.

Processing ingredients or mixed feeds to improve nutrient utilization can be a particularly important strategy if unusual or low quality feed ingredients are being considered. Increasing the fineness of grind can increase nutrient availability, even in low quality cereal grains.

7. OTHER STRATEGIES

7.1. Use of enzymes

Feed enzymes are becoming increasingly popular in the pig industry; enzyme products have become more consistent in their composition and function, and much more is understood about their application in practical diets. Enzymes can be particularly useful when lower quality ingredients are used. The figure on the left shows that the DE content of medium quality barley was 92% that of a high quality sample; however, when an enzyme was added to the same lower quality barley, the DE rose to be 97% that of the higher quality sample. This figure illustrates that enzymes can be used to enhance the feeding value of lower quality ingredients, and indeed, the response to enzymes is more likely to be economically advantageous when applied to lower quality materials



7.2. Record keeping

Record keeping tends not to be a very popular activity, but as business people, keeping complete and accurate records is essential if proper decisions are to be made. There is an old mantra in management that states "one cannot manage what one does not measure." In other words, good records make good managers, because they have the tools required to make sound decisions. Records on feed utilization and feed costs are not present in many record-keeping systems in North America, and yet it is difficult to imagine making decisions on a feeding program with them.

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