LOWERING FEED COSTS

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… UK practical nutritionist's perspective…

…often with costly penalties!!!

…possibly due to the neglect or misuse of the **"Tools of the Trade".**

BASIC FACT

As recently described by Janice Murphy, almost irrespective of where you are working around the world, feed costs represent 65%-75% of the variable costs of swine production; this fraction is the biggest slice of the cost of production pie and hence is prone to attract the most interest when pressures on profitability or mitigation of loss are being felt. As a result, the level of feed costs always plays a major role in determining the profitability of a swine enterprise and must be foremost in the pig producer's mind. Whilst cereal and extracted soya bean meal are the comfortable industry standards for supplying energy and protein, there are many suitable alternatives that meet nutritional requirements while reducing the cost of the ration.
But nothing is new! The principles are well known.

Sadly, the above comments could be applied just as well when I arrived at the start of my journey in commercial pig nutrition advisory work, 3 decades ago, and they have not altered much since but we have at least gained some useful experience along the way, albeit probably only capable of being mostly described as anecdotal. However, these anecdotal experiences have formed the basis for a rule book on how to proceed but the rule book is always going to be pig enterprise specific and hence the route along the associated road map will vary from unit to unit and country to country. This rule book always demonstrates the key role of the tools of the trade.

At this stage, it is most important that the title of this talk must be extended, first losing the plural "s", leaving the word "cost", and then rolling into the qualifier, "per unit of productive gain, saleable meat or, perhaps, better still, consumer acceptable (and routinely re-purchased) lean tissue". This far better describes the target that the commercial pig nutritionist should be aiming at and hence my own approach to feed cost control is always a holistic one.

Whilst the circumstances surrounding my making this type of nutritional presentation have changed, both in the general audience make-up and the continent on which the lectern is located, the fundamental messages have altered little over those intervening 30 years. It is possible that, in reality, it is merely the volume of my personal plea for greater focussed research funding and testing activity that has changed, even if that research might only take the form of the ultimate in extension studies using the farms in question where the desire to lower feed costs is being expressed.

In doing my homework for this talk, I sought the guidance of a Canadian researcher (formerly of the Prairie Swine Centre), not directly personally but from one of his most recent presentations in his newly adopted research base some 500 miles away from this city, and I found a strap-line which I intend to use on my travels for the next few years. This saying does highlight the key omission which goes some way towards explaining why there has been relatively little progress over these 3 decades, as follows:

"What gets measured gets managed" (attributed to John F. Patience and also being used by Greg in the next presentation) - is this perhaps a positive portent for the future improvements in cost control?

You will find that I reflect on this strap-line a lot as we proceed through the presentation and how the simple day-to-day activities of the humble nutritionist are hampered by a lack of meaningful measurement leading to reliance on anecdotal support rather than good, solid science or statistics.

In general, this talk will be a reflection of my own thought processes as I approach different growing/finishing cost of production challenges in my day-to-day activity in the UK.

Before we can attempt to lower something, such as feed cost per kg gain, we need to know where we are starting from!

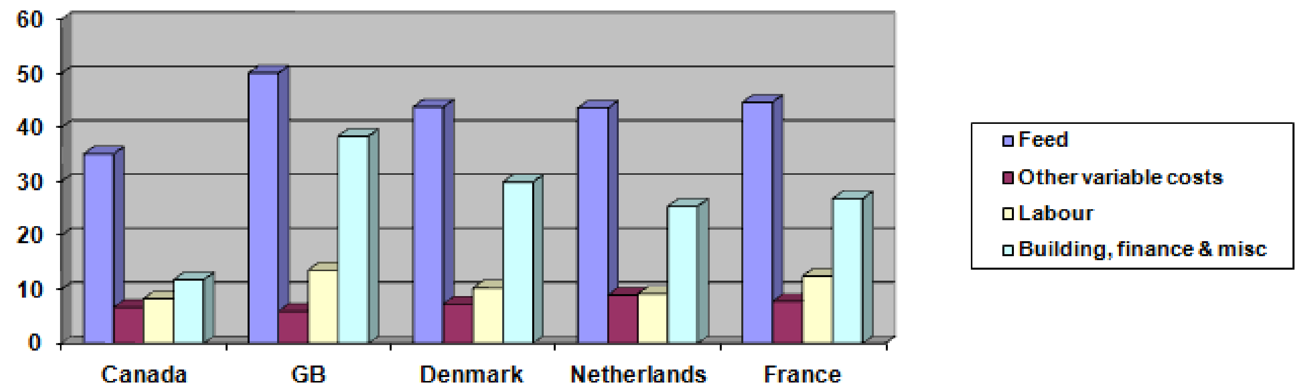
At this stage it is important to appreciate that my stand-point is as an adviser to home mixing producers with a predominant bias towards liquid co-product feeding. This role is genuinely hugely advantageous in potentially delivering influential downward pressure on feed cost per kg gain, as will become evident during the course of the presentation.

As an adviser, you do always try to seek out the start point from which to base any potential cost reduction recommendations and the only unbiased measurement information available to me is often limited to that thrown up by BPEX Ltd. the British Pig Executive, whose mandate is:

…..to represent pig levy payers in England, (being) focussed on enhancing the competitiveness, efficiency and profitability……co-ordinating industry activity that yields a better return for levy payers than they can otherwise achieve individually.

From a global perspective, the problems that the UK pig industry and its nutritional servants face are self evident from the following figures and tables.

Figure 1. Cost of producing 1 kg of pigmeat in pence/kg (2006).



It is easy to see why feed cost reduction might be a primary driver in the UK!!!

Table 1. Performance trends in Great Britain from Agrosoft consolidation.

	2003	2004	2005	2006	2007
Rearing herd					
Weight at start kg	7.3	7.4	7.3	7.3	7.4
Weight of pigs out kg	34.7	36.4	36.3	35.1	35.3
Mortality %	4.3	5.0	3.4	2.5	2.7
FCR	1.77	1.84	1.70	1.71	1.82
DLWG g	462	449	509	493	453
Feeding herd					
Weight at start kg	26.9	27.7	25.9	27.2	26.6
Weight of pigs out kg	96.1	97.9	96.9	98.2	98.8
Mortality %	6.5	6.7	6.5	5.6	4.8
FCR	2.74	2.77	2.74	2.75	2.73
DLWG g	627	630	639	655	673

The data in Tables 1 and 2 are consolidated values from various recording systems and hence you can always say that you can pick and choose which you select to include in the table and there are always difficulties with meaningful comparisons when the carcass weights differ so much. However, if the pig production enterprise goal is expressed as meat sold per sow per annum, with the sow being deemed to be the expensive base unit, the numbers speak for themselves. When 2 tonnes per year is the target, <1500 kg does not cut it, as they say.

In our defence, the top third of UK/GB producers (as assessed by growth rate) will achieve upwards of around 55-75 g/d extra overall in the finishing period, ie.710 g/d in 2006 vs. 654 g/d for the average on 2006 and 733 g/d vs. 660 g/d in 2007. I always feel that we, in the UK, have a much greater range of performance from best to worst than other European countries and I believe that this is probably directly related to lack of re-investment and hence the age of the industry, often expressed in terms of both its buildings and its ownership!!!! This is a broad generalisation and is unfair on those that are investing.

Table 2. Summary of physical performance 2006.

	Canada	GB	Denmark	Netherlands	France
Rearing mortality %	2.0	2.5	3.2	2.0	2.3
Finishing mortality %	3.0	5.6	4.0	2.7	4.4
Finishing DLWG g	826	655	861	772	773
Finishing FCR	2.98	2.75	2.65	2.71	2.90
Live wt at slaughter kg	113.0	99.1	106.8	114.2	115.5
Cold carcass weight kg	90.0	74.3	80.5	88.4	88.4
Carcass meat produced per sow per year kg	1971	1461	1935	2118	2024
Lean meat percentage %	60.0	61.3	60.3	56.4	61.5
Lean meat produced per sow per year kg	1183	895	1167	1194	1245

A huge sum of levy payer money has been thrown at trying to enhance this baseline of production knowledge in the form of bench-marking but the UK has almost singularly failed at this. However, the details from one successful group appear in table 3.

It is purely by accident that the three most interesting farm subjects for grower-finisher performance appear side by side!!!! You should all be aware that data for DFI from weaning does not result from farm generated information. It is merely the result of factoring the data in the previous two rows but as such is still meaningful information. However, it is often the biggest factor in reducing the growth potential of the UK pig production enterprise.

The individual producers are number coded to hide their identity and you will see that there is an average for the group as well as the best (maximum value) and worse (minimum value) performance. On the far right hand side I reproduced the relevant BPEX values from Table 1. Note that the comparison is for weaning weight for the bench-marking group with the weight at the start of the finishing period for the BPEX data. Uniformity of data collecting or lack of it can lessen the value of a tool.

To my way of thinking this table shows the enormous strength of mensuration – always a good word to throw into a practical discussion like this! This also opens up the discussion of lessening feed cost per unit gain into its two component parts, i.e. absolute cost per tonne of feed and the efficiency with which that feed is utilised through the target animal in its particular environment.

Table 3. Bench-marketing group herd performance data – year to end Nov 2007.

Parameter/Producer No	1	2	3	4	5	6	7	8	9	10	11	Average	Max	Min	BPEX data
No Sows	340	400	390	304	606	315	398	506	242	570	358	393.3			
Nos Born alive	12.17	12.6	10.4	11.04	12.42	12.45	13.1	12.58	12.1	11.0	11.98	12.0	13.1	10.4	N/A
Pre Wean Mortality %	10.91	12.9	11.5	8.9	6.42	17.45	11.2	13.3	12.37	10.1	11.9	11.3	17.45	6.42	N/A
Nos Weaned	10.89	11.0	9.2	10.06	11.27	10.28	11.6	10.5	10.7	9.8	10.63	10.6	11.63	9.2	N/A
Litters/ Sow/Yr	2.35	2.35	2.29	2.25	2.32	2.37	2.39	2.34	2.36	2.26	2.38	2.3	2.39	2.25	N/A
Weaned/Sow/Yr	25.63	25.82	22	22.64	26.14	24.32	27.8	24.7	25.25	22.8	25.33	24.9	27.8	22.0	N/A
Wean/Service Interval	5.24	5.7	8.0	5.6	6.42	5.0	N/A	N/A	5.4	6.0	5.4	6.0	8.0	5.0	N/A
Farrowing Rate %	85.9	87.5	88.7	82.9	89.9	76.28	93.0	89.0	89.0	79.0	87.56	86.3	93.0	76.28	N/A
Sow Feed tonnes/yr	1.08	1.15	N/A	1.04	0.96	1.32	1.26	1.27	N/A	1.25	N/A	1.1	1.32	0.96	N/A
Weaning Age d	26.74	28.0	28.0	24.75	26.35	27.82	27.0	26.0	28.0	25.9	28.1	27.0	28.0	24.75	N/A
Av Wean Wt kg	7.8	8.6	6.5	7.5	7.51	8.0	7.3	7.0	7.5	7.5	N/A	7.6	8.6	6.5	26.6
Slaughter LWt kg	110.2	103.7	102.7	115.0	104.5	111.5	101	104.0	100.0	108.3	102.0	107.0	115.0	100.0	98.8
FCE from Weaning	2.72	2.38	N/A	**2.78**	**2.46**	**2.5**	2.6	2.52	N/A	2.6	N/A	2.6	2.78	2.38	2.73
DLWG from Weaning g	617	674	N/A	**672**	**591**	**737.5**	612	655	714	655	N/A	650.6	737.5	591	673
DFI from Weaning kg	1.68	1.60	N/A	**1.87**	**1.45**	**1.84**	1.59	1.65	N/A	1.70	N/A	1.69	2.05	1.41	1.84
Post Wean Mortality %	6.8	3.74	9.0	7.6	6.3	5.15	7.5	5.0	6.0	8.5	N/A	6.6	9.0	3.74	4.8

Short term economics – is this a British disease? I do not travel the globe, it is difficult enough working for a British company and having your headquarters and boss in another country whilst you live in the same nation, but I reckon that short term economics is at least a human condition.

What do I mean by short term economics? Common sense or human nature tends to suggest that it is easier to reduce your feed costs by paying less per tonne today than expecting an improvement in efficiency. The latter, by virtue of its dynamics, means that you need to measure performance over time into some point in the future, i.e. tomorrow, to determine improvement in response to a change. More to the point, today is here now whereas tomorrow, hell, don't they say that that never comes!!!!? This scenario often can determine the producer motivation to drive the desire to reduce the feed cost component of the overall production costs by only one means, much to the chagrin of the commercial nutritionist who then must become a mix of politician, psychologist and wily strategist to direct progress to actually reduce cost per unit of production. I am five pages into the paper and my natural cynicism has only just reared its head!!!

For years we have been directed by the geneticists and the nutritional scientists that there are clear nutrient requirements for pig growth but in the light of this knowledge, why are such vast differences in performance still being seen? The answer, of course, is very simple, namely that commercially it is nutrient ALLOWANCE that determines growth outcomes and not REQUIREMENT. Furthermore, the genetic predictability of growth flies out of the window just as soon as mixed gene lines are used on farm and, in this regard, it is important to note that purchased pooled semen is commonly used on UK pig units. In this regard, one also presumes that growth rate ranks highly on the list of reasons for genetic change whereas most recently in the UK it has been reducing feeding herd mortality, in the face of the combination of PCV and PRRS, that has been the driver of that genetic change, interestingly enough often with little thought being given to production outcomes, until they have come out, if indeed they ever do very clearly.

The ALLOWANCE is an expression of the REQUIREMENT in the singular environment that the growing/finishing pig experiences. From research, the REQUIREMENT has normally been expressed when the variables acting upon the pig have been either controlled or rendered highly predictable. Commercial reality is where the ALLOWANCE rears its head with its myriad of variables often in an uncontrolled fashion.

Hence predictability of outcome can only be achieved by the application of control over the variables or those that are within the realms of control in the circumstances that apply on the farm in question. So, which variables are routinely out of our control as we approach feed cost reduction challenges? A few that come quickly to mind are:

1. The semi-intensive housing that is widely used in the UK ensures that temperature flux and air change are a lottery. We know that oscillation in environmental temperature, even within the "comfort zone" of the pig, produces unpredictable growth and feed efficiency outcomes.

2. The pre-occupation in the UK with the use of an ingredient that, were it proffered to the Health & Safety Executive today, would fail to gain a certificate of approval, but is heavily

promoted for its contribution to animal welfare, namely straw, has an unpredictably negative effect on feed digestibility, respiratory health and the appearance of chemical toxins.

3. The UK has either retained very old pig-sick grower/finishing housing or has gone into large group size systems both of which bring their own variable-ridden issues.

4. Finally, there is disease and how we quantify its degree of debility on pig growth or overall carcass performance, including overt payment for sold weight and penalties via tissue condemnation.

Personally, I do not believe that any of these variables are measured or controlled particularly well in the majority of UK units, if any form of meaningful control has actually been possible.

It is, in part, for the reason of attempting to compartmentalise all of the parameters affecting growing pig performance that I revisit one particular nutritional management tool on a regular basis. However, I have nevertheless struggled to find a place in this commercial nutritionist's armoury for computerised growth simulation when quality farm data are hard to find and time to skilfully pilot the simulator less easy to locate. Not to be beaten, I am just embarking on a project to assist with the refinement of the most recent product of this type to appear in the EU market, namely INRA Porc. This product is as good as they get and I cannot deny that there will be a place for such systems when the predictability of the outcomes can have greater guarantees. Currently adequate expression of disease and group size effects on growth outcomes leaves something to be desired in simulation and we are hopeful that the emergence of an exciting new tool will enhance the accuracy of the simulator.

Until this time, I rely on the best that practical experience and close cooperation with producers brings. So, what happens in practice?

Table 4. Bench-marketing group herd performance data – selected extract.

	1	2	3	4	5	6
Av Wean Wt kg	7.8	8.6	6.5	7.5	7.5	8.0
Slaughter LWt kg	110.2	103.7	102.7	115.0	104.5	111.5
FCE from weaning	2.72	2.38	-	**2.78**	**2.46**	**2.50**
DLWG from wean g	617	674	-	**672**	**591**	**738**
DFI from wean kg	1.68	1.60	-	**1.87**	**1,45**	**1.84**
Mortality %	6.8	3.7	9.0	7.6	6.3	5.2

Back to the bench-marking group and the table above is a snap-shot from the larger database study merely focussing on the feeding herd. It is obvious, without even imposing the actual feed costs onto the chart, that there are widely varying likely outcomes for this parameter. It is awareness of this sort of data set that enables the commercial nutritionist to push for improvement with, in this case, producer 6 setting the pace. So, to demonstrate the approach can we ask why do the other two producers fall short of the mark, where do we look for the costly problem areas and how do push for improvement in what clearly impacts on feed cost? There obviously are interactions and overlaps but, even so, this is a crucial exercise to be conducted if feed cost reduction is to be positively addressed.

FCE FROM WEANING – THE CHECK-LIST

What's to blame for Producer 4 not hitting the target? Is it poor feed utilisation, excessive competition for nutrients or feed (or nutrient) wastage?

Wastage

Clearly poor feeder design, poor feed presentation or simply running with leaky feeders is a basic mistake that is always costly but often is not remedied until the feeders are totally worn out. Short term economics perhaps? Certain ingredients of coarse particle size for which the pig has a craving will lead to the feeder being emptied as the search for the tasty morsels goes on unabated. Good examples here are dietary inclusion of lumpy chocolate and nuts. A failure to mill rape seed "meal" leads, in this case, to negative selective feeding as the pigs shuffle coarse, hard particles of high protein material to either end of the feed hopper.

Excessive Competition for Nutrients – A Selection of Candidates

1. Bugs and health. To what degree does disease elevate maintenance needs and thereby worsen feed efficiency? The fundamental information on the nutrient costs of the repeatedly activated immune system has been generated but do we really know what the £/$ cost of a commercial disease challenge is out in the field? Do we know the cost of inadequate cleaning and disinfection of finishing buildings? The hope is that we work closely with the farm specialist veterinarian on such matters and use post mortem investigation and slaughter line data collection to create a background picture and an impression of trends.

2. Fungi and feed. To what degree does the feed threaten the intended (four-legged) consumer or deteriorate before it reaches the pig? The UK appreciates its temperate climate in that we cannot grow grain maize, which seems to attract more than its fair share of fungal interest around the globe, but we can still suffer the consequences of following crop contamination after whole crop maize. Equally, we have recently benefitted from Chinese genetics in our staple monogastric cereal crop, namely wheat, and with that has come increased fusarium head blight susceptibility with an increase in tricothecene presence, particularly in the form of DON, especially as June seems to involve rain and spore splashing. The geneticists are working to reverse this trend but I am told that we are at least 5 years away from commercial plantings. Hence we must think hard about which arable fungicide programmes to implement and lean on the specialist agronomist. Whilst last years higher fuel oil prices impacted on all down-stream cracking by-product lines, propionic acid was still a very cheap insurance policy against fungal growth in the >15% moisture wheat that came out of the ground during the 2008 wheat harvest. However, what should we make of non-acid treated 17% moisture

grain showing up in store in March 2009? Bulk storage house-keeping should be an essential activity and not an occasional half-hearted consideration.

3. Bugs and feed. My involvement in the UK co-product feeding market tells me that bursting feed pipes and "redecorated" feed kitchens are stock-in-trade. These accidents happen due to the presence of wild (or deliberately included) yeasts and, to a lesser extent, bacterial action. You provide such organisms with resources for growth, i.e. moisture, carbohydrate and nitrogen feed-stock and warmth and they will respond by generating a string of waste products, including carbon dioxide. This gas subsequently increases the pressure in the feeding system until a weak point is found. Arguably the CO_2 is the least of your worries in that feeding system! Keeping to the CO_2 story, where do these yeasts get that gas from? Well, the relevant nutrient supply is in the feed mix, of course! Starch and sugars are rapidly broken down to varying degrees to alcohol and organic acid molecules with loss of dry matter. Worse still is the unbalancing effect that this has on the dietary ideal protein:energy ratio. Hence, upon lab analysis, the uncontrolled liquid feeding system almost always has more protein, oil and ash per unit of dry matter than formulation expectations would predict. Fortunately, there is some rebalancing of the protein:energy account as all microbial matter is predominantly comprised of protein and hence yeast and bacterial replication is demanding of proteinaceous matter. 'Tis a pity that there are toxic nitrogenous metabolites produced as a consequence! Much research activity has been directed at this area and there should be no reason for uncontrolled fermentation in feeding systems but it still occurs all too regularly. Short term economics perhaps?

Poor Feed Utilisation

1. Poorly formulated diets with imbalances in either protein:energy ratio or ideal protein balance still occur due to simple misconceptions, such as weighing by volume, mis-reading conventional for 6-row barley, using soya bean oil as the substitution for soya bean meal in computerised feeding systems, etc. or the sudden appearance of farmer-driven diet formulation or failures to perform simple and routine feed (ingredient) analysis. Computerised feed formulation is the standard tool of the nutritionist's trade and this facility has been around for years and has been perfectly functional since the early 1970's, the days of the QELEQ, but even in its present form, it still does not always guarantee optimum feed utilisation but it will reach a solution quickly!

2. Matrix values – feed formulation activity and accuracy is only as good as the data tables held therein and these must be regularly replenished. To what degree of detail should one go? The following table illustrates the degree to which four decimal place diet formulation should, in theory, be supported by comparably detailed analysis work where even the most stable and trusted commodity should not be regarded as possessing of a single set of nutrient values.

Table 5. Average contents of essential amino acids of soyabeans collected in different Brazilian states (contents as % on an as-received basis). Data courtesy of ADM Specialty Ingredients - 2004.

Nutrient/State	Arg	Phe	His	Ile	Leu	Lys	Met	Thr	Val
GO	2.786	1.880	0.972	1.574	2.798	**2.275[a]**	0.410[c]	1.323[bc]	1.661
MG	2.661	1.950	0.975	1.625	2.868	2.305[abc]	0.402[bc]	1.339[bc]	1.695
MS	2.867	1.904	0.971	1.561	2.820	2.321[bc]	**0.375[a]**	1.274[a]	1.670
MT	2.669	1.925	0.966	1.605	2.831	2.299[a]	0.412[c]	1.328[bc]	1.650
PR	2.670	1.896	0.953	1.575	2.806	2.281[a]	0.386[ab]	**1.256[a]**	1.628
RS	2.735	1.953	0.977	1.635	2.869	2.330[bc]	0.420[c]	**1.355[bc]**	1.680
SC	2.499	1.952	0.955	1.647	2.848	**2.339[c]**	**0.421[c]**	1.303[a]	1.628
Average	2.706	1.926	0.968	1.606	2.838	2.310	0.405	1.315	1.662
SD	0.144	0.050	0.020	0.047	0.053	0.046	0.030	0.063	0.042
CV %	5.323	2.576	2.088	2.916	1.887	1.991	7.326	4.762	2.538

Values in the same column followed by different letters are significantly different ($p<0.01$)

The data in this table have again been selected judiciously with only the three most relevant amino acids, in normal formulation work for growing pigs, being highlighted for their statistical variation via ascribed super-scripts and demonstrating the potential analytical variation by site of harvest. Best and worst values are highlighted. Fortunately for us all there may be less variation between varieties for certain commodities as the following table demonstrates, albeit devoid of statistics as this information is rather hot off the press.

Table 6. Average contents of protein and essential amino acids of different varieties of field beans (*Vicia faba*) [contents as % on an as-received basis] plus relativity to lysine of second and third limiting amino acids. Data courtesy of the GreenPig LINK Project – 2009.

	Protein	Lys	Meth %L	Meth	M+C %L	M+C	Thr %L	Thr
Spring								
Ben	23.78	**1.531**	11.34	**0.173**	30.2	0.462	54.0	**0.826**
Betty	25.27	**1.648**	11.20	**0.185**	30.2	0.498	55.1	**0.908**
Fuego	25.29	1.591	11.29	0.180	29.8	0.474	55.1	0.876
Memphis	24.85	1.595	11.53	0.184	29.6	0.472	54.9	0.876
Nemo	24.92	1.560	11.18	0.174	30.0	0.468	54.7	0.854
Synchro	24.90	1.569	11.43	0.179	30.6	0.480	55.5	0.870
Tattoo	25.34	1.599	11.09	0.177	30.1	0.482	53.9	0.861
Winter								
Arthur	25.25	1.591	11.75	0.187	31.0	0.493	54.9	**0.874**
Clipper	24.21	**1.564**	11.46	**0.179**	29.2	0.456	53.8	**0.842**
Griffin	25.23	1.615	11.72	**0.189**	30.7	0.496	53.8	0.868
Husky	25.90	1.614	11.08	**0.179**	29.7	0.479	53.5	0.864
Sultan	24.42	1.578	11.92	0.188	30.6	0.482	54.1	0.854
Wizard	25.52	**1.621**	11.18	0.181	30.9	0.501	53.8	0.872

Whilst the relationship of the second and third limiting essential amino acids to total lysine value is generally relatively consistent across the varieties and their sowing season, you can see that overall amino acid supply is such that I might just be more of a fan of Betty than I would Ben!!! The best ands worst values again being highlighted. However, this variety choice does always presume that protein yield has predictability by growing site and by season and I dare say that tracking down the Internet link that will emerge as this 4 year GreenPig project matures will reveal this piece of the jigsaw. For the pulse genetics aficionados amongst you, you will know that there is every reason why field beans are potentially rather a poor choice to highlight inter-varietal differences on protein make-up or to hope to expect or find the basis for improvement, with that crop being a natural out-crosser. The pea variety data coming from this same piece of research may prove to be more illuminating provided that beneficial differences are not found in varieties that are destined for more lucrative human markets!

It is easy to become depressed by these complexities that lie within the matrices behind feed formulation, especially if I were vindictive enough to open up the debate of apparent ileal vs standardised ileal digestibility values or digestible vs metabolisable vs net energy systems, which you will be relieved to hear that I am not going to do. However, the next essential tool of the trade of the commercial nutritionist comes to the rescue, namely near infra-red spectroscopy. Whether it is used to characterise the essential amino acid profile of protein raw materials or simply to generate proximate analysis information for any raw material, this modern day all-in-one laboratory is totally essential to getting closer to enhancing the precision of raw material utilisation. This precision becomes all the greater as we break through into supply of regression equations even for digestible nutrients.

3. There has been plenty of research debate over the desired particle size selection for ingredients and particularly for cereals. The precise answer to this question is that it depends on your perspective. The digestibility and hence degree of utilisation of a feed particle must be a function of its surface area: weight ratio with light, small particles having the highest ratio. So let's mill the cereals as finely as possible, shall we? But what about processing cost? What about feed dust levels? What about breadth of modulus of fineness quotient and propensity for feed separation to occur on conveying meal/mash feeds from mixer to silo and silo to pig? However, with potentially in excess of 60% of slaughter pigs in the UK showing some signs of oesophageal ulceration or hyper-keratinisation, which we know to be at least for the most-part caused by abrasive particulate material of a carbohydrate origin roughing-up the stomach lining in concert with acidic reflux, can we get too fine? How can we characterise diets in terms of their functional fibre content where the balance of gut health and efficiency of feed utilisation needs to be made? This is still a point of some debate but at least when armed with a Bygholm Sieve there is a tool of the trade that will provide quantitative guidance.

DAILY FEED INTAKE FROM WEANING – THE CHECK LIST

It is basic stuff but if the pig does not eat enough, it will not grow fast enough. It's trite but it's true and the whole pack of cards stands or falls at that point! If feed intake in one situation is less than 80% of that in another, e.g. producer 5 versus producer 4 and 6 in Table 4, what can we expect to see in terms of relative growth? The outcome is there for all to see.

There are very fundamental systems that drive voluntary feed intake and the principle of appetite determination and I am very, very ill-equipped to take this matter forward in this forum and hence I will leave this to the international gathering of experts that takes place at the pre-symposium workshop in Spain on May 19th ahead of the International Symposium on Digestive Physiology of Pigs (DPP).

I "stole" the following remark from an intra-company publication from an ex-colleague of mind, Dr. Mike Varley, who penned a rather valuable review entitled "Factors affecting the voluntary feed intake of the pig" and this is the opening sentiment from that review:

"The appetite of any living thing is the result of many years and generations of biological selection. Those animals with optimal foraging techniques were well nourished and more likely to survive, thus achieving prime reproductive fitness. Their successful diet selection skills were then passed on to offspring either by inheritance or through training. An ability of animals to select their diet has therefore evolved through a long line of naturally selected progenitors in an **unconstrained** environment".

This review is referred to in the bibliography at the end of this paper and can be supplied upon request. Its strength is probably the fact that its 88 pages are comprised of 68 pages of references! However, I should point out that I recently read a summary note from researchers at Kansas State University that were reviewing some of their pig nutrition studies and comparing VFI values for these trials with comparative extension studies and found that the latter were of the order of 30% lower out in practical conditions. So just how applicable is the pure science?

You will note that I have emboldened the word **unconstrained** within my friend's text as I believe that qualifier is the element that provides us with our biggest challenge to enhancing poor feed intake. Just what is it that is acting as the constraint in any practical systems?

To attack this question, the practical issues that I focus on in the field are to be found in the following list and they tend to concentrate on minimising the negative rather than accentuating the positive:

1. Is there feed in the feeding system and is it always present when the pigs require it? The term "feed outage" was a foreign concept to me until I opened up my investigation into the Barn Reporting system. This is another very valuable tool of the trade for the commercial nutritionist as it is capable of measuring the very basic requirement for growth, i.e. the merging of the animal with its feed, or not!

2. Is the pig able to access feed in the feed dispenser? Time after time I might be commended on how good a formulation might be, especially for the younger pig, only to be hit by the rejoinder…..it's a pity that the pigs cannot get to it as it hangs up in the feeder! That is the penalty for not doing your homework and failing to appreciate that a lot of "*ad libitum*" feeders are designed, if ever they were, to restrict the flow of 3 mm

pellets and hence are not too sympathetic to an oily meal/mash feed! Careful consideration of particle grist size and efficiency of added oil dispersion are essential to provide adequate flow characteristics. In my travels, I have only been able to find one feeder in the UK market that had truly been ergonomically designed around the feeding behaviour of the pig with optimum intake and minimum wastage of meal/mash feed in mind. What does this say to you?

3. Is the pig able to adequately access feed in the feed dispenser? Determining what the provision of adequate feeding space is, is a major problem, especially when one needs to assess the impact of aggressive interactions between pigs, of which in excess of 85% happen around the feeding or drinking point. The other factor to consider here is the eating speed per meal and number of meals that any pig will make in a single day, something that is affected by both feeder design, e.g. dry vs. wet/dry vs. liquid, and diet ingredient make-up but to what degree does it impact? However the fall-back position, in ignorance, is that more feeding space is always better than less, if you can afford extra feeders!!!

4. Is the pig able to access clean feed in the feed dispenser? Floor feeding of finishing pigs still takes place in the UK! Misplacing of feeders still occurs so that fouling of feeders both restricts quality feeding space and also spoils the feed within the face of the feeder. Accumulation of moulds in feeding systems will lead to intake depression, either directly or via their metabolites.

5. Does the feed stay uniformly blended throughout the feeding system? We know that meal/mash feed can become unmixed as it is jogged around a conveying system with heavy, dense (mineral) particles sinking and light, bulky (fibrous) particles floating to the top of a meal/mash mixture in transit. We can also see evidence of particle separation in liquid feeding systems leading to the promotion of the agitator pipe by WEDA with its internal spiral. In this latter regard is the benefit of inclusion of suspending agents into the feed mix, either in artificial form e.g. M-Soup or utilising a property that is inherent within the co-product feed ingredient listing eg potato puree or soya pulp (Okara).

6. Does the diet formulation change on a regular basis, beyond that referred to in point 5 above? The presence of certain anti-nutritional factors (ANF) in various feed ingredients, e.g. glucosinates in rape seed are known to affect rate of eating but how does this vary from animal to animal given the presumed existence of greater ANF tolerances within certain breed lines or litters? Some diet changes are inadvertent but still should be better controlled and these are most often encountered in liquid co-product systems where basic chemical composition can vary from load to load and within the same load of product. The degree of fermentation of some of these materials gives rise to overtly unpalatable components, e.g. acetic acid or the range of toxic amines that will be off-putting to the acute sense of smell that the pig possesses.

7. Given marked effects of ambient temperature on voluntary feed intake what feed formulation strategies are in place to react to negative effects of hot weather?

8. What variation in inherent feed intake exists between breed lines? We should not simply assume that there is one basic feed intake curve for all breeds and the pure-bred Pietrain is a good example of an exception to the rule.

9. In the absence of accurate, short-term, pen-based dry feed usage monitoring equipment, all production systems should run (pre-weighed bagged) feed intake trials throughout the grower/finisher phase. Here there is a crucial demand for a tool of the trade as any nutritionist must own up to only being able to hope to control diet nutrient concentration. It is the knowledge of daily feed intake patterns that should be factored by requirement derived from research data, with some allowance built in, that will determine the correct nutrient density. How do nutritionists formulate correct diets currently then?

10. For liquid feeding systems, there normally is an intake recording facility built into the computation and it will be gathering data every day for every feed valve but remember that these data are structured on a volume passing through the valve per unit time basis. This is not always directly related to a fixed value of dry matter, especially in co-product feeding systems. It is very interesting to garner the feed intake data thus produced and compare its lack of day-on-day uniformity to expectations and seek out the impact of load-to-load ingredient changes.

So, if we simply assume, for now, that we have done our investigative on-farm homework to guarantee optimisation of feed intake and efficiency of utilisation of feed nutrients, what else can the nutritionist do to impact on feed cost? Finally, we can opt for the simple approach of reducing the cost of each tonne of feed. However, the null hypothesis must be retained such that we do not adversely affect intake or feed utilisation.

RATION COST REDUCTION

The generalised European approach to this challenge can be seen to some extent in Table 7 that I have again picked up from the John Patience presentation, this time originally from a recent compilation from Ruurd Zijlstra.

This table, in part, demonstrates the necessity to drive down the usage of the costly (in Europe) staple ingredient, i.e. the starch supplier, with The Netherlands' lack of available fertile arable land per unit of pig production showing that necessity certainly is the mother of invention. There is also evidence of the greater protein content of the diet in EU usage as seen from the higher use of oilseed co-products, something which is being more and more impacted upon by both nitrogen pollution pressure and the sheer cost of crude protein, which will start to affect a reduction in such figures.

If I am honest and can use what seems like a totally unsuitable description, the field of co-product usage is the sexy side of the commercial nutritionist's life! It features a rich array of products and origins, with varying or little legal constraint over their use as feedstuffs, save the obvious one regarding the compulsory avoidance of mammalian protein products. You generally do not know what a customer or supplier will challenge you with next nor, immediately have anything approaching an appreciation of the correct application of the product to pig production nor often never do! It is the area where the upside potential for feed cost control appears to be so undeniably attractive but usually is totally out-weighed by a whole raft of hidden and potentially costly pitfalls.

Table 7. Approximate diet composition (%) by ingredient category and by geographical region.

	USA	Europe	Netherlands
Cereal grains	75	48	19
Oilseed co-products	15	25	32
Food co-products	2	14	32
Fats and oils	3	2	4
Others	5	11	13

The feed industry in the UK specifically has always had a strong tie with both the food and drinks industries with this being most admirably highlighted by the following text drawn from a most learned text on "The History of the British Pig":

"The pig's ability to consume and thrive on almost anything was considered a positive virtue, and the pig of the 17th century has been described by Gervaise Markham, writing in 1683, as:

…the husbandman's best scavenger and the housewife's most wholesome sink…for his food and his living is by that which would else rot in the yard and make it beastly.

Coates reported that some pigs during the 16th century were fattened on peas and beans, dairy and brewery wastes.

The pig's ability to fatten on waste products was increasingly being put to use on a localised but large-scale basis from the mid-18th century onwards. Distillery waste was particularly popular, e.g. brewer's grains, spent wash and dust from the barley stores, and the large breweries in Vauxhall, Battersea, and Wandsworth, for example, fattened some 9000 pigs annually. James and Malcolm, in 1784, quoted: Formerly that refuse was let off into the Thames…….

Waste from starch manufacturers was also considered nutritious, though not as highly as brewery by-products, as it had to be supplemented with peas and beans for adequate fattening.

In 1807, Young described how a Sir Richard Neave had successfully fattened his hogs on a diet including biscuit-makers sweepings.

Dairy waste was also used extensively as a fattening diet and pigs were regarded as an important source of profit for the well-managed dairy well into the 19th century. Thus 20 cows could supply sufficient waste for 12 hogs to be fattened to 20 score each in 1813, ten bacon and 15 pork pigs per annum in 1855. In fact, it was considered that such feeds were essential as the large quantities of grain that would otherwise be required would have been likely to render pig-fattening unprofitable".

So, none of our current enthusiasm for exotic ingredient use is new! The detailed skill in exploiting such materials is normally the subject of a complete day's presentation for me and one that the Swine Liquid Feeding Association meeting in Stratford back in late February would have dealt with admirably so will not be addressed in detail by me now. However, the art of co-product raw material assessment is far and away best commented on in book form by Robin Crawshaw and I commend his text to you.
However, I cannot let this occasion go by without sharing at least some of my experiences of this sector of the industry with you in the form of the list of rules as follows:

1. Nutrient profile – is it consistent upon arrival? Usually no, both in terms of dry matter content and dry matter composition. Hence the essential tool of the trade is at least a basic dry matter testing kit, i.e. accurate set of scales and an oven that is capable of maintaining $100^{O}C$ at an outlay of no more than £200. This process need not take longer than 3-4 hours to produce an acceptable result but faster outcomes can be generated via a £1000 outlay on a Sartorius or Mettler Toledo automated analyser. You can embellish upon the basic oven approach by using a refractometer for use in determining the dry matter of co-products with a known content of sugar in the dry matter but cuts out the electricity use! For co-products with a sizeable volatile component this must be accounted for in the final dry matter calculation. Where that volatile is alcohol, e.g. beer or brewers yeast that is slurried with beer, use a Vin-o-meter to assess the content of alcohol from a settled co-product sample. For co-product dry matter composition, always build up a dossier of analytical data by product and origin and find out as much as possible about the process from whence the co-product originates. Chemical testing of the dried residue of the co-product sample does not lend itself to NIR prediction and must use wet chemistry. This often merely generates historical data on material long since fed and hence the need for dossier generation and production plant auditing.

2. Nutrient profile – does it change over time? Usually yes, again in both dry matter content and composition. The nature and degree of this chemical alteration is product specific. Rapid use of each consignment reduces the impact of this deterioration. Deterioration is almost always problematic and is seen as a simple but costly loss of dry matter or the more insidious production of either unknown or damaging (toxic or appetite-depressing) components. The storage tank contents should be tested over the course of its life on farm for dry matter as well as meaningful but low cost chemical analysis. One positive outcome of co-product deterioration is the conversion of lactose to lactic acid with its consequent anti-bacterial functionality and minimal loss of energy per unit of dry matter.

3. Storage tank uniformity – assuming that sample testing has been derived from the assessment of a representative sample of that delivery then the resultant analysis should be consistently used in complete feed mixes. This can only be achieved in non-deteriorating product that is maintained in a homogeneous state in store. Very few co-products are natural solutions and hence will form sediments or supernatants if not adequately agitated. Any such partitioning will alter the chemical composition of the product in question in its use. Advisable tank agitation is co-product specific. Brewers yeast settles out very quickly but is easily re-suspended with the most rudimentary agitation. Potato products are usually in gel form and almost without exception will not

respond to conventional agitation but are liable to layering storage. Such products can be enhanced through carbohydrase application. Almost invariably, vertical tanks outstrip horizontal tanks for ease of maintenance of co-product uniformity.

4. Detailed nutrient profiling – unless the product in question is guaranteed of on-going supply, in meaningful quantities with significant diet saving, and without overt nutrient negatives, e.g. high salt, high potassium, unduly high laxative properties, e.g. sodium or magnesium sulphate presence or suspected ANFs, in the conventional sense, then proximate analysis would be all that would be justifiable. Even then, analysis is best to be targeted, i.e. don't always test for something that is not expected to be present, concentrate on potential for variation in the nutrients for which the formulation package is selecting its inclusion.. However, do set up a QC regime that expects the unexpected, starting by looking at, smelling and, dependant on your enthusiasm, tasting the product!

5. Palatability – the pig is an omnivore and hence will cope well with food/feed materials that we can deal with ourselves but not if unknown toxins are allowed to be present. It is folly to assume that liquid feeding will enhance dry matter intake. Avoidance of uncontrolled fermentation in the finished feeds is a must and the preferred tool of the trade is to dose the feeding system with organic acid mixtures that are specifically targeted at both yeasts and bacteria. Flushing of feed lines with water or aged low dry matter whey is beneficial to impose additional control. The only clearly beneficial liquid co-products from my limited experience are fruit jams, fruit yoghurts, chocolate and peanut butter! However, remember that sugary co-products can have a sting in the tail!!! Wasps are prone to accumulate.

6. Contamination – co-products are almost always not products of primary production interest and can indeed be wastes and, as such, can bring unwanted elements with them. HACCP planning goes without saying as safety to man and beast and consumer of that beast is of paramount importance. When such materials are not chemical or biological hazards, they can be physical in nature, e.g. broken glass (from bottling plants), stones (inorganic, from skin cleaning processes e.g. potato peelings), stones (organic, from fruit processing), plastic (from toy inclusions in packeted products), etc. all of which can damage conveying equipment and valves even before they reach the consumer! Regularly serviced filters and stone traps are essential.

7. General ease of handling – the easiest product to handle comes in a bulk tanker and flows easily through a 2 inch diameter gate valve, but such materials are not usually the order of the day. Boiled sweets in barrels are cheap as an energy source but not as cheap as margarine in tubs, mayonnaise in glass jars or cream in foil-topped plastic cartons!!! However, again necessity can be the mother of invention, with users of the latter product building crushing plants with hot water sprinkler systems and plastic recovery capability.

Always use the unorthodox missing formulation selection nutrients of "risk" and "hassle factor" in any appraisal of such materials and then strive to do all that you can to mitigate the impact of those elements.

FUTURE DIRECTION - NOW

The final assessment of the suitability of any feed cost reduction strategies must be to evaluate their impact on the physical performance of the pig throughout its growth curve and thence on to the carcass and its overall yield. To my mind, these are areas where tools of the trade are most under-utilised but with *qscan* and *qbox* I believe that we have some distinct benefits to offer to all producers of growing-finishing pigs. The breakout session will reveal all!

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