The Winston Churchill Memorial Trust

Churchill Fellowship 2000

Investigating the use of liquid feeding in the British pig industry

"I like pigs; cats look down on human beings, dogs look up to them, pigs just treat us as equals."

Winston Churchill

Chris Brewster
Livestock Officer - Pork Products
NSW Agriculture
Yanco, NSW, 2703
ph. 02 6951 2514
fax. 02 6951 2600
e-mail: chris.brewster@agric.nsw.gov.au

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1. Precis and Acknowledgments

This report details the findings from a 2000 Churchill Fellowship visit to England and Scotland investigating the use of liquid feeding in the British pig industry. Specific areas of study included;

- liquid feeding technology and management in the British pig industry
- food industry by-product usage through liquid feeding systems in the British pig industry
- use of fermented liquid feeds to manage disease problems following legislation limiting the use of therapeutic in-feed antibiotics
- liquid feeding options available to small and medium sized herds

My visit to Britain and the invaluable experiences I gained would not have been possible without;

- the financial assistance given to me by Winston Churchill Memorial Trust. In addition to financial support the high regard of Churchill Fellowships helped open many doors that would have otherwise been closed.
- the support and commitment of NSW Agriculture and specifically the Meat, Dairy and Intensive Livestock Program for its financial support and ensuring that staff have opportunities to develop and extend their professional expertise to meet the needs of the agricultural sector.
- the fraternity of pig researchers and producers in the UK and their willingness to share experiences and information.
- my family Anna, Joseph, William and Elaina for their love, support and encouragement through the whole experience; from the original application through to the welcome back on the tarmac.

2. Executive Summary

Name: Chris Brewster
Position: NSW Agriculture, Livestock Officer - Pork Products
Address: Yanco Agricultural Institute
Yanco, NSW, 2703
Contact: ph - 02 6951 2514
fax - 02 6951 2600
e-mail - chris.brewster@agric.nsw.gov.au

Fellowship objective
To investigate the use of liquid feeding in the British pig industry

Fellowship highlights
1. British Pig and Poultry Fair - a two day trade fair and seminar series. Established contacts with liquid feeding equipment manufacturers, pig producers, researchers and industry bodies.
2. Seale-Haynes Campus, University of Plymouth - Joined Professor Peter Brooks and team working on a fermented liquid feeding project. Also investigated the accuracy of AUSPIG (pig growth simulation model) simulations on liquid fed British genotypes.
3. Lammas Resources - Phillip Moore demonstrated use of aerobic digester to convert organic food industry waste into a liquid pig feed.
4. Hampshire Feeding Systems - Martin Bailey and Steve Stokes detailed the range of liquid feeding equipment and emerging technologies.
5. Finnfeeds - Dr Gary Partridge and Dr Howard Simmins detailed use of feed enzymes with particular relevance to liquid feeding.
6. Meat and Livestock Commission - Dr Pinder Gill invited me to MLC's pig research facility at Stotfold. The facility is currently having approx $AUS 2 million upgrade providing it with a new liquid feeding research area.
7. Scottish Agricultural College - Dr Illias Kyriazakis and faculty presented a summary of pig research in progress at SAC Edinburgh.

Findings

There is considerable scope for increasing the adoption of liquid feeding within the Australian pig industry. Potential benefits include;

- improved post-weaning pig growth performance
- reduced feed costs
- ability to utilise food industry by-products and reduce the quantity of by-products disposed in landfill
- access to options such as fermented liquid feeding, reducing reliance on anti-biotic feed additives

Seminars
Invited seminar presentations targetting the potential of liquid feeding for the Australian pig industry will be made at;

- the Western Rivers Foods Co-operative seminar at Forbes, August 2000
- the Grenfell Pork Fair, Grenfell Showgrounds, October 2000.

Publications
It is expected that one refereed article detailing the use of the simulation model AUSPIG for defining liquid feeding recommendations will be published. Several articles for pig industry journals and newspapers are also intended.

Research
Research priorities as identified by this fellowship include;

1. the accuracy of current growth simulation models (ie. AUSPIG) for basing recommendations on liquid feeding pigs.
2. the potential for fermented liquid diets and tactical use of dietary enzymes to reduce the reliance on in-feed antibiotic use.
3. the constraint to increasing food industry by-product utilisation by the pig industry.

Plans for a research program addressing the recommendations from this report are currently being investigated. Several collaborative research proposals investigating liquid feeding are proposed to be conducted at NSW Agricultures pig research facility at Elizabeth Macarthur Agricultural Institute, Camden.

3. Programme

London/Milton Keynes 8 May - 13 May

- Winston Churchill sites
- British Pig Association
- British Pig and Poultry Fair
- Meat and Livestock Commission

Seale-Haynes, Devon 15 May - 4 June

- University of Plymouth, Seale-Haynes campus
- Work with Professor Peter Brooks and group on fermented liquid feed experiment
- Conduct AUSPIG simulations on liquid fed pig growth performance
- Robert Persey, Taunton.

Northamptonshire 5 June

- Lammas Resources, Corby. Mr Phillip Moore

Hampshire/Wiltshire 6 - 8 June

- Hampshire Feeding Systems, New Milton, Hampshire
- Pole family farm, Wiltshire
- Finnfeeds, Marlborough, Wiltshire

Buckinghamshire 9 - 10 June

- Meat and Livestock Commission, Milton Keynes
- Stotfold pig research facility, Stotfold

London/Kent 11 - 13 June

- Chartwell House, Kent

Scotland 14 - 16 June

- Scottish Agricultural College, Edinburgh

4. Introduction

Background
In the Australian pig industry feed represents up to 70% of the total cost of production. Improving the efficiency with which we use feed, is essential to maintain a profitable, competitive pig industry. Access to a wider range of feed ingredients is also necessary to minimise diet costs and reduce the pig industry's reliance on feed grains. Consequently, there are compelling arguments for diverting food industry by-products away from traditional disposal methods (eg. landfill and sewage treatment systems) and utilising them for animal production.

Liquid feeding has been suggested as one means of improving feed use efficiency and accessing lower cost feed ingredients. However, the majority of pigs in Australia are fed dry diets in either a meal or pellet form. Liquid feeding has not been widely adopted by the Australian pig industry due to a lack of expertise within existing industry support services and seemingly large establishment costs.

Liquid feeding in Australia
Estimates of the total number of pig producers liquid feeding in Australia are difficult to make. Australia's largest pig producer, Bunge Meat Industries, has liquid feeding capabilities at several of their units. Bunge, feeds the progeny from approximately 25,000 sows using liquid feeding technology. The large numbers of pigs being liquid fed by one company concentrates liquid feeding expertise, consequently slowing the uptake of this technology by other Australian producers.

Contact with other state pig extension agencies managed to identify less than 15 other Australian farms with liquid feeding capability. Whilst this number is likely to underestimate the total number of farms with liquid feeding it does confirm that the adoption of liquid feeding by the Australian industry has been much lower than our European competitors.

Liquid feeding in Europe
In the UK, Gill (pers comm) suggested that around 20% of pigs were fed liquid diets. Liquid feeding is commonly used on medium sized family farms as one method of reducing production costs, in an attempt to remain competitive in a depressed global pork market. Estimates of the adoption of liquid feeding in Europe range from 30% to 40% in the Netherlands and Denmark, and up to 60% in Sweden.

This Churchill Fellowship allowed me to investigate the use of liquid feeding in the British pig industry. Specifically I was interested in;

1. research in the nutrition of pigs fed liquid diets and quantifying improvement in growth performance.
2. research into the use of fermented liquid diets to reduce reliance on in-feed antibiotics.
3. use of food industry by-products to reduce feed costs.
4. liquid feeding options for small to medium herd sizes.

5. Liquid Feeding Findings

5. 1 Nutrition and Growth Performance of Liquid Fed Pigs

Growth model simulations

The preferred method of establishing nutritional recommendations and evaluating pig growth performance is through growth simulation models (SCA 1987). AUSPIG, described by Black *et al* (1986) is widely regarded as the "gold standard" of pig growth models. AUSPIG allows evaluation of the interactions between nutrition, genotype and the environment on pig growth performance. AUSPIG facilitates economic comparison between production options, improving decision making and highlighting research priorities.
There is very little infrmation available about the application of AUSPIG for liquid fed pigs. Therefore, to evaluate the accuracy of AUSPIG simulations and assess the the growth performance of liquid fed pigs an AUSPIG study of both dry and liquid fed pigs was conducted. Data for the simulations was provided by Professor Peter Brooks from the University of Plymouth, Seale-Haynes campus.

Method

Professor Brooks provided two data sets detailing feed consumption, growth performance and carcass measurements for dry and liquid fed pigs between approximately 20 kg and 90 kg liveweight. An AUSPIG simulation was conducted for the dry fed data set to establish genotype and environmental parameters.

Subsequently, these parameters were used to compare the models predictions of the liquid fed data set. The only variable between each simulation should therefore be the feeding regime.

Results

The dry and liquid fed data sets were the result of experiments conducted at Seale-Haynes. Standard experimental protocol at the time saw pigs being fed "to appetite" twice daily for a maximum of 20 minutes. This intake restriction required adjustment to the standard AUSPIG *ad libitum* intake feeding regime. This was achieved by restricting the *ad libitum* intakes by a percentage value such that actual and predicted intakes were as similar as possible.

Tables 1 and 2 compare the actual and predicted intakes and growth performance for the dry and liquid fed pigs respectively. AUSPIG accurately simulated the dry fed data set (Table1), however, it was more difficult to accurately simulate the liquid fed data set (Table 2). The major difficulty was matching the low digestible energy (DE) intakes with the growth and carcass results reported (AUSPIG 1).

Table 1. Actual vs AUSPIG predicted feed intakes and growth performance for dry fed male pigs.

Measurement	Actual	AUSPIG predicted
Age in (d)	63	
Weight in (kg)	18.5	
Age out (kg)	145	
Weight out (kg)	92.2	92.0
ADG total (kg/d)	0.905	0.895
ADI total (kg/d)	1.85	2.02
P2 (mm)	11.5	9.6
ADG 18-30 kg	0.563	0.553
ADI 18-30 kg	0.967	1.18
ADG 30-60 kg	0.975	0.967
ADI 30-60 kg	1.925	2.13
ADG 60-90 kg	1.208	1.103
ADI 60-90 kg	2.753	2.835

underlined predictions differ noticeably from actual data

Table 2. Actual vs AUSPIG predicted feed intakes (as fed basis, 21% dry matter) and growth performance for liquid fed male pigs.

Measurement	Actual	AUSPIG 1 [1]	AUSPIG 2 [2]	AUSPIG 3 [3]
Age in (d)	63			
Weight in (kg)	20.9			
Age out (kg)	152			
Weight out (kg)	90.5	95.3	95.7	91.7
ADG total (kg/d)	0.783	0.840	0.844	0.797
ADI total (kg/d)	6.818	9.76	9.0	7.03
P2 (mm)	11.1	9.8	9.0	8.8
ADG 21-45 kg	0.563	n.c.	n.c.	0.592
ADI 21-45kg	4.842	n.c.	n.c.	4.95
ADG 45-90 kg	0.951	n.c.	n.c.	0.975
ADI 45-90kg	8.894	n.c.	n.c.	8.81

underlined predictions differ noticeably from actual data

[1] AUSPIG 1 - standard diet, feed restricted
[2] AUSPIG 2 - diet + 0.2 MJ DE/kg as-fed wet basis, moderate feed restriction
[3] AUSPIG 3 - diet + 0.6 MJ DE/kg as-fed wet basis, feed restricted
n.c. - not calculated

Given that genetics and environmental factors were common between the two data sets the changed feeding regime was targeted for investigation. A literature search raised evidence (Barber *et al* 1991) for an increase in dry matter digestibility of diets as water : feed ratios increased. A second simulation was conducted using recommendations from Barber (1992) that water : feed ratios could account for DE increases in the order of 0.2 MJ/kg as-fed wet basis (AUSPIG 2). Simulated results from this second simulation were only slightly more accurate than the previous simulation. Consequently, a third simulation was performed in which DE was increased by 0.6 MJ DE/kg on an as-fed wet basis (AUSPIG 3). The results from this simulation accurately predicted the actual data set measurements.

Discussion

The AUSPIG computer growth simulation model accurately simulated the dry fed pigs data set. However, the liquid fed data set could only be accurately simulated once

significant alteration to the dietary specifications were made and feed intake restrictions imposed. Potential causes for this observation include;

1. differences in the ingredient matrices from the Australian feed industry data base to the matrices used in the formulation of the British diets. This is considered unlikely as both ingredient matrices came up with very similar energy and amino acid values.
2. significant improvements in total dry matter digestibility of the liquid fed diets increasing the energy contribution from the diet
3. a problem with the way the AUSPIG model calculates feed intake limits for liquid fed pigs

Recommendations

It is recommended that further research work be conducted to establish reasons for the discrepancy between AUSPIG simulations of dry and liquid fed pigs. Accurate growth model simulations will allow economic evaluation of alternative feeding strategies such as liquid feeding and facilitate the decision making process for farmers.

5. 2 Fermented Liquid Feed Use

Reduced reliance on in-feed antibiotics

One exciting development in liquid feeding technology is the use of controlled fermentation of diets to improve pig health. This has attracted considerable attention in Europe, where in-feed antibiotic use has been restricted by legislation. Controlled fermentation of liquid diets using different *Lactobacillus* spp prior to feeding reduces dietary pH. *Lactobacilli*, produce lactic acid as a by-product of fermentation and are capable of reducing dietary pH from around 7.0 to 4.1. The reduction in dietary and gastro-intestinal pH controls harmful pathogens such as *Coliform* spp and *Salmonella* spp. The control of pathogenic species improves pig health reducing the requirement for anti-biotic medication.

Increased food safety

Fermented liquid diets are also alleged to improve food safety. The reduction in dietary pH reduces the number of food poisoning organisms like *Campylobacter* spp and *Salmonella* spp surviving in the feed and the pigs gastro-intestinal tract. European abattoir feedback data indicates that fermented liquid feeding is a particularly effective method in reducing *Salmonella* spp levels in pork (Brooks pers com).

Feeding sows fermented liquid diets

During my time at Seale-Haynes, I spent time working with Professor Brooks and one of his graduate students, Vlasta Demeckova on an experiment investigating feeding sows fermented liquid diets before and after farrowing to reduce the incidence of piglet scours. The hypothesis was that fermented liquid diets could be used to alter the gut micro flora of the sow prior to farrowing, thereby to reducing *E. coli* challenges to the piglet. In addition there is evidence that lactic acid bacteria can stimulate the sows immune systems, raising the immunoglobulin levels of her colostrum and giving the piglet further protection against scours.

Other ongoing research at Seale-Haynes is attempting to identify the most successful species of *Lactobacillus* to use in fermented diets. Potential energy sources (eg. simple sugars) are also being screened to preferentially "feed" the *Lactobacillus* and facilitate the fermentation process and the control of harmful bacteria.

Recommendation
In-feed antibiotic use is likely to become the next non-tariff trade barrier affecting exports to some countries. It is recommended that the Australian pig industry conduct research investigating technologies such as fermented liquid feeding to reduce the pig industry's reliance on in-feed medication.

5. 3 Use of food industry by-products

Ingredient flexibility
Liquid feeding systems increase the range of solid and liquid ingredients capable of being used in a mixed diet. Increased flexibility in raw material use provides the potential to lower total feed costs by using low cost food industry by-products. Utilising food industry by-products in a wet form using liquid feeding systems is usually cheaper than drying products into a form suitable for inclusion into pelleted diets. The dry matter content of the by-product, the distance from factory to farm and the cost of alternative disposal will affect the economics of by-product use.

Reducing landfill
In the UK and Europe, the high cost of disposing of food industry by-products in landfill has forced processors to develop more environmentally acceptable disposal methods. Utilisation of food industry by-products by livestock reduces the amount of "waste" material otherwise disposed through landfill and sewage treatment. Utilisation of food industry by-products can provide an alternative income for farmers. In the UK several food processors are prepared to pay farmers to utilise their by-products rather than be charged a greater amount to dispose of their "waste" in landfill or sewage treatment.

The range of food industry by-products available to a producer is limited by;
- the nutritional value of the by-product
- the price (if any) of the product
- the volume available
- the dry matter the by-product
- distance and transport costs from processor to farm

In the UK I saw farms utilising a range of by-products including;
- whey and other dairy by-products
- starch by-products
- bakery by-products
- vegetable processing wastes
- brewery and cider by-products
- non-compliant icecream and other food products
- dessert factory washing

In the majority of cases by-products can be included in rations "as is" but in several instances farmers were required to further process the by-product to make it more suitable. This could range from de-wrapping packaged product to reducing water content from very dilute by-products.

Despite the wide range and utilisation of by-products in the UK, the Netherlands provides the best example of by-product use. In 1996 approximately 2.3 million tonnes of by-products was fed to pigs in the Netherlands, comprising over 25% of total feed requirements.

Fraser (1998) detailed the average dry matter content and maximum inclusion rates for a range of liquid by-products (Table 3)

Table 3. Dry matter content and inclusion rates of food industry by-products in pig feeds (adapted from Fraser 1998).

Ingredient	Dry matter (%)	Inclusion rate (%)
Wheat starch	15-25	30
Sugar molasses	15-20	5
Brewer's spent grain	21	5
Fresh maize gluten	44	5
Brewer's yeast	15	12
Steamed potato peelings	14	15-20
Whey/milk products	5	15
Mycelium and yeast washes	17	5
Oils and fats	35	7
Bakery by-products	65	25-30
Onion juice	10	7

By-product use in Australia

The Australian pig industry is not as well placed as the European industry to take greater advantage of low cost food industry by-products. The majority of food processing industries in Australia are located in and around the capital cities. The pig industry however is primarily located in the grain growing regions of rural Australia. Consequently transport costs from factory to farm will in many cases be greater than the value of the product as a feed ingredient or, alternatively, greater than the cost of traditional disposal methods (eg. landfill).

Development of new piggeries close to cities is not likely to be viewed favourably by planning authorities, despite the environmental advantages to be gained from reducing quantities of food by-products into landfill. The greatest potential for utilising food industry by-products for feeding livestock occurs where food processing industries are located in rural and regional Australia. However, the reduction in transport costs is often offset by correspondingly reduced landfill charges in country areas. Nevertheless, excellent examples by-product utilisation can be found with Murrumbidgee Dairy Producers at Wagga Wagga and Uncle Bens at Wodonga.

Recommendation

Better utilisation of food industry by-products by the pig industry makes obvious economic and environmental sense. Constraints to achieving this include;

1. distance/cost of transporting by-products from factory to farm

2. low cost of envirnonmentally undesirable, traditional disposal methods (eg. landfill or sewage treatment)
3. quality assurance aspects of waste streams being fed to livestock (eg. unacceptable levels of foreign objects and microbiological contamination)
4. lack of knowledge and experience in by-product feeding

Constraints 1 and 2 require government policy changes to improve the economic justification of by-product utilisation. Constraints 3 and 4 require joint funding from government and industry for research and education programs to facilitate by-product utilisation by animal industries.

5. 4 Liquid Feeding Options for Small to Medium Herd Sizes

The economies of scale will always mean that large capital investments, such as liquid feeding systems, are more affordable for farms with large numbers of pigs. Small to medium sized herds may, at present, be unable to justify any major capital expenditure with the uncertain future the industry faces. However, several farmers I spoke to in the UK believed that the cost savings they made through liquid feeding helped keep them afloat through the price crisis of 1998-99. Liquid feeding should therefore be seen as one of a number of technologies available to Australian producers to address their production costs and improve competitiveness.

Justifying investment in a liquid feeding system is easier if a producer has access to a cheap by-product supply, is building from scratch or is in the process of completely replacing an old feeding system. However, for many producers the best way to take advantage of liquid feeding and gradually develop management skills is by using one of the range of portable weaner liquid feeding systems. Several European manufacturers have liquid feeders for weaner pigs that are portable and relatively low cost. The feeders can be used to increase feed intake and growth of newly weaned pigs and then moved to more newly weaned pigs once the transition from sows milk to solid feed is made. Depending on the manufacturer, prices range from A$800 to A$1500 per unit. The manufacturers claim the feeders are capable of feeding approximately 40 pigs/unit. Therefore a 100 sow producer could start liquid feeding weaners for two weeks post weaning from around A$2000 to A$3000. The manufacturers claim increased pig growth equivalent to 2.5 kg of extra carcass weight per pig, producing a pay-back period of around three months for a 100 sow herd.

6. Conclusion and Recommendations

There is considerable scope for increasing the adoption of liquid feeding within the Australian pig industry. Potential benefits include;

- improved post-weaning pig growth performance
- reduced feed costs via ability to utilise food industry by-products
- access to options such as fermented liquid feeding to reduce reliance on anti-microbial feed additives

To maximise the benefits from liquid feeding for the Australian pig industry it is recommended that a coordinated research and development effort be implemented to address;

1. the accuracy of current growth simulation models (ie. AUSPIG) for liquid fed pigs. Accurate growth simulation models represent the cheapest and most effective method for pig producers to evaluate changes to production methods and their impact on pig growth and profitability.

2. the potential for fermented liquid diets and tactical use of dietary enzymes to reduce the reliance on therapeutic use of in-feed antibiotics. In-feed antibiotic use will doubtless become another non-tariff trade barrier limiting access into certain export markets.

3. the constraint to increasing food industry by-product utilisation by the pig industry. These include policy issues such as the relatively low cost of disposing of food wastes in land fill, as well as scientific issues such as quality assurance of waste streams used in animal feeding and developing nutritional data bases for a range of food industry by-products.

An extension effort to address these issues will be conducted and will include pig industry seminars at the Western Rivers Foods Co-operative seminar at Forbes, August 2000 and the Grenfell Pork Fair, October 2000. In addition several collaborative research proposals investigating liquid feeding are being proposed to be conducted at NSW Agricultures pig research facility at Elizabeth Macarthur Agricultural Institute, Camden.

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